NĀḌĪ VIJÑĀNA

Ancient Pulse Science

Sarvadeva Upadhyaya

of future work and opens newer vistas for research on ancient pulse science.

Prof. Upadhyaya is one of the noted alumni of Banaras Hindu University. He graduated from this University in early seventees and subsequently obtained his M. D. and Ph. D. degrees from the Department of Kayachikitsa of this University. He is personally known with the reviewer for several years. He is a popular clinician, a keen researcher and a successful teacher. The present work is definitely an outcome of his scholarship and enthusiasm to work for the advancement of Ayurveda. I am happy to write preface for this important work and wish all the best to this publication and the author.

R. H. Singh
Professor and Head.
Deptt. of Kayachikitsa
Faculty of Ayurveda
Banaras Hindu University

Contents

INTRODUCTION

INTRODUCTION

This monograph entitled NĀḌĪ-VIJÑĀNA (Sphygmology) is a humble attempt to re-establish the principles and practice of Nadipariksha on universal basis. Varanasi has always attracted patients to seek the diagnosis and treatment based on Nadipariksha. The national and international reputation of Pandit Satya Narayan Shastri as an expert in Nadi Pariksha diagnosis was too well known for repetition here. The patients who visit Ayurvedic physicians for treatment are still inclined to be diagnosed by Nadi Pariksha. Systematic and comprehensive training of Nadi Pariksha in Ayurvedic colleges could not be standardized due to lack of data based on scientific research. Thus it was thought necessary to plan and conduct research on Nadi Pariksha so that an acceptable model may be constructed for universal application. It is hoped that the work presented in this monograph will pave the way and stimulate systematic and scientific studies on pulse examination a hitherto a less cared area for research in Ayurveda.

A brief account of the current status of Nadi Pariksha in various systems of medicine is presented herewith.

There is in clinical medicine no physical sign more basic or important than the arterial pulse. From ancient times the pulse has been recognised as the most fundamental sign of life. The early physicians paid great attention to the character of the pulse in health and the changes which occurred in disease. Even to-day under emergency clinical conditions the modern physician frequently records the pulse directly through an intra-arterial catheter, and he wishes to gain as much information as possible from inspection of pulse contour. To the modern physician, of course, the study of pulse has got its limited scope in studying the diseases of heart and arteries.

To the ancient physician, irrespective of civilizations of the world, the pulse has always been the subject of great learning in the field of medicine. Perhaps Egypt (B. C. 1550) had been the earliest country of the world which invented the knowledge of pulse only to know the physiological condition of the heart. And from there the rays of knowledge of the same spread all over the world. Galen (A. D. 129) one of the pioneers of Greek system of medicine had written several treatises on pulse

examination. As regards Chinese system of medicine, it has wealth of treatises on the pulse.

The Arabic system of pulse-lore is totally basad upon the Greek system of medicine. And that is why it is known as Greeko-Arabic system of medicine. A great knower of this system of medicine, Avicenna (A. D. 980) had been the physician of repute who by his own experience furthered the knowledge of pulse examination. Though in India the knowledge of pulse examination was not prevalent as a means of diagnosis till as late as the period of Sharngadhara, yet some ancient races of India as Santhalas and Tantriks of India were aware of this knowledge. In Ayurveda, from the period of Sharngadhara onward the knowledge has constantly been added up. Still we find many separare books written on sphygmology and available in various private as well as government libraries of India. In some of the treatises along with the pulse examination, Tantrik source of Nadi is also cited there.

After going through the various literatures of sphygmology of different civilizations of the world and seeing the recent contribution of modern haemodynamics in this field, the present study on Nadi Pariksha has been chosen. No prior standard scientific work was available on Nadi Pariksha, therefore, I have limited the scope of study only to the qualitative and quantitative standardization of Vatika, Paittika and Kaphaja pulses in this monograph.

Besides clinical study of Vatika, Paittika and Kaphaja pulses in terms of rate, rhythm, volume and character etc. pulses have been studied in their graphic forms, particularly to standardize them qualitatively and quantitatively.

As regards studies in giving the practical forms to Vatika, Paittika and Kaphaja pulses, a practical hypothesis has been proposed so that this may have applied form also. The Vatika pulse possesses smallest percussion wave with its conical summit, rudimentary or no dicrotic notch, highest pulse rate and lowest pulse pressure in relation to Paittika and Kaphaja pulses. Paittika pulse has longest percussion wave with its sharp conical summit, marked dicrotism and highest pulse pressure. Kaphaja pulse records medium percussion wave with well sustained rounded summit, gradual and steady fall of dicrotic wave with small dicrotic notch.

This monograph consists of seven parts and eight chapters.

Part one has been divided into two chapters. The first chapter deals with the use of term 'Nadi' in various denotations except the pulse examination in ancient treatises of Ayurveda, i. e. from 600 B. C. to 1200 A. D. In chapter second an account of Nadi Vijnana prevalent as a means of diagnosis in different systems of medicine as Egyptian, Greek, Chinese, Arabic and Tantrik literature has been given. In concluding portion of this chapter it has been shown that Indian physicians of the time derived their conceptual knowledge of pulse from prevalent Indian Tantrik pulse-lore, whereas they shaped the practical aspect of pulse examination along with the contemporary Hakims of Greeko-Arabic system of medicine of the time.

Second part of the monograph has also been divided into chapters namely, third and fourth. The third chapter mentions about the first adaptation of Nadi Vijnana in the extant literature of Ayurveda from the thirteenth century onward. In this section, Sharngadhara-Samhita, Bhavaprakasha, Yogaratnakara, Kanada's Nadi-Vijnana and Ravana's Nadi-Pariksha have been mainly dealt with. In the fourth chapter of this part Ayurvedic pulse examination described in various other treatises of sphygmology by Dr. E. N. Ghosh (1924) has been recorded.

Part third of the monograph is devoted for the description of modern review on pulse. Like Ayurvedic review, this part of modern review has also been subdivided into four chapters, i. e. chapters fifth, sixth, seventh and eighth. Chapter fifth describes about anatomy of radial artery and histology of medium sized arteries of which the radial is also one. Chapter sixth discusses about the physiology of arteries and the general mechanism of pulse formation.

Chapter seventh of third part vividly describes about the law of Poiseuille and its application in vivo, haemodynamics of pulsating stream and its general role in the formation of pulse, peripheral pulses and role of reflected waves and the formation of radial pulse which is used commonly for the means of diagnosis. In addition, this chapter also deals with diseases of arteries, factors affecting pulse pressure and the clinical examination of the pulse. In clinical examination of the pulse, besides describing its rate, rhythm, force, volume, tension, character, the condition of vessel wall etc. various other varieties of pulses have also been enumerated and explained. Lastly, the chapter eight deals with the recent advancement made in the

field of sphygmology i. e. frequency analysis and the current status of spygmology.

By definition frequency analysis is a mathematical technique by which a complex periodic wave can be broken down into a series of sinusoidal waves having a fundamental frequency of the original wave and harmonics having frequencies that are integral multiples of the fundametal frequency. Thus, with the help of frequency analysis, a complex periodic wave like pulse can be broken down into its simpler forms giving the numerical value of each. Recent criticism have also been made on the use of traditional terminology as 'tidal wave', 'dicrotic notch' etc. And thus the current status of sphygmology can be judged in the light of the above facts just mentioned.

Part fourth of the monograph consists of clinical and experimental studies on 120 cases of cardiac valvular lesions, hypertension, jaundice and thyrotoxicosis. Pulses have been studied in their Vatika, Paittika and Kaphaja forms depending upon the predominance of Doshas. Forty normal volunteers have also been studied for standardization of Vatika, Paittika and Kaphaja pulses. In these cases detailed clinical history has been taken and the pulse has been examined from Ayurvedic methodology and point of view. In these cases routine and specific laboratory investigations have also been conducted.

From experimental point of view pulse tracings on smoked papers by sphygmograph has also been done in normal as well as diseased group. And it has been tried to establish correlation. between symptoms and clinical pulse examination, symptoms and pulse tracings and clinical pulse examination and pulse tracings in diseased cases. To be precise, we have limited our study only to four diseases i. e. cardiac valvular lesions, hypertension, jaundice and thyrotoxicosis. These diseases were selected only because cardiac valvular lesions and hypertension belong to cardiovascular system. Jaundice is found to be a more common and prominent disease, whereas the reason for the selection of thyrotoxicosis can be given that here there is an organised clinic for this particular disease.

In the fifth part of the monograph, the observations obtained in the clinical and experimental studies have been described in greater detail. The sixth part of the monograph deals with the conclusions drawn from the result of this study. And the last part i. e. seventh part consists of summary of the work.

AYURVEDIC REVIEW

The purpose of reviewing Ayurvedic literature available so far on sphygmology is to give a critical analysis of pulse examination, and its wide application as a means of diagnosis and prognosis in different civilizations of medical world of remote past. Also, an endeavour has been made to search out the source or sources of origin of Indian pulse-lore. In this connection, after going through the various historical literatures of the subject, a good deal of data have been put forth to furnish the idea that before the introduction of knowledge of pulse examination in Ayurveda, the others of abroad, for example Chinese, Greek etc. were well versed in the knowledge of pulse examination. So far indebtedness to the contribution of the knowledge of the subject is concerned, it was the Hakims of Arab of the time who imparted the practical knowledge of the subject to the then Indian Ayurvedic physicians.

The whole review has been framed in the following order : (1) A complete survey of Egyptian, Greek, Chinese, Greeko–Arabian and Tantrik literatures available on pulse-lore have been made, (2) Classics of Ayurveda—the Vrihatrayee and the later works before the period of Sharngadhara, i. e. thirteenth century have been reviewed thoroughly in order to search out the term 'Nadi' as used in various denotations but the pulse, and (3) The work of Sharngadhara and post Sharngadhara's work upto Yogaratnakara have been fully surveyed.

Chapter I

The Use of Term Nadi in Classical Ayurvedic Literature

A Survey of the various denotations, in which term 'Nadi' has been used in the Ayurvedic texts, reveals that Nadi Vijnana (pulse science) as the means of diagnosis was absent therefrom till as late as the thirteenth century. No doubt the term 'Nadi' occurs abundently therein in many other meanings apart from the pulse. So it will be proper to give a complete history of the term by ransaking the whole gamut of Ayurvedic literature specially ancient ones chronologically in the form of table given below :

S. No.	Term	Section	Verse/Prose passage
1	2	3	4
	Charaka-Samhita		
1	Dhumrapan Nalika	Su. 5	51
2	Nadi Vrana	Su. 13	46
3	Nadi Sweda	Su. 14	32, 33, 39, 43, 44
4	Nadi Shaka	Su. 27	97
5	Dhamani, Sira etc.	Vi. 5	9
6	Navinal	Sha. 6	23
7	Navinal	Sha. 8	44, 45
	Sushruta-Samhita		
8	Nadi Yantra	Su. 7	4, 5, 12
9	Nadi Vrana	Su. 7	11
10	Nadi Vrana	Su. 11	4
11	Nadi Vrana	Su. 12	9
12	Nadi Yantra	Su. 16	49, 52
13	Nadi Vrana	Su. 17	13
14	Channel	Su. 22	7
15	Nadi Vrana	Su. 25	6, 9
16	Nadi Yantra	Su. 27	13

17	Nalika (Tubular structure)	Ni. 2	10
18	Nalika (Tubular structure)	Ni. 7	17
19	Tubular organs carrying urine i. e. ureter	Ni. 3	21, 22
20	Navinal	Ni. 8	10
21	Nadi Roga	Ni. 10	10
22	Danta Nadi Roga	Ni. 16	14
23	Rasavaha Nadi, Navinal	Sha. 3	40
24	Shwas Nalika	Sha. 5	21, 31
25	Garbha Nadi	Sha. 10	8
26	Navinal	Sha. 10	1
27	Nadi Vrana	Chi. 1	41, 42
28	Nadi Vrana	Chi. 8	5, 6
29	Nadi Vrana	Chi. 9	40
30	Nadi Vrana	Chi. 17	Whole chapter.
31	Nadi Sweda	Chi. 22	3
32	Danta Nadi	Chi. 22	26, 27, 28
33	Nadi Sweda	Uttar. 21	5, 7, 56
34	Nadi Yantra	Uttar. 23	7, 10
	Ashtanga-Sangraha		
35	Kala	Su. 4	4, 5
36	Nadikalaya	Su. 7	118
37	Granthi Nadi	Su. 25	12
38	At two places in the sense of hollow wooden material and Nadi Sweda.	Su. 26	10
39	Nadi Yantra	Su. 34	4
40	Karna Nadi	Su. 34	8
41	Nadi Yantra	Su. 34	9
42	Nadi Yantra	Su. 34	10
43	Nadi Vrana and Nadi Yantra	Su. 34	13
44	Nadi Vrana	Su. 39	4
45	Nadi Vrana and Danta Nadi	Su. 40	3
46	Kantha Nadi (Trachea)	Sha. 5	77
47	Shrotas, Dhamani etc.	Sha. 6	50
48	Kantha Nadi (oesophagus)	Sha. 6	69
49	Larynx	Sha. 7	23
50	Mansavahà Nadi	Ni. 2	75

	Ashtanga-Hridaya		
51	Nadikalaya	Su. 6	77
52	Nalika like structure	Su. 17	10
53	Karna Nadi	Su. 25	10
54	Nadi Yantra and other utility.	Su. 25	10
55	Nadi Yantra	Su. 25	13
56	Nadi Yantra	Su. 25	14
57	Nadi Yantra	Su. 25	15
58	Nadi Yantra	Su. 25	20
59	Nadi Vrana	Su. 25	23
60	Nadi Yantra	Su. 28	32, 36
61	Nadi Vrana	Su. 30	3
62	Kantha Nadi	Su. 4	15, 26, 28
63	Dhamani	Ni. 15	17
64	Nadi Vrana	Uttar. 18	17
65	Nadi Vrana	Uttar. 20	23
66	Nadi Sweda	Uttar. 22	4
67	Nadi Vrana	Uttar. 28	26, 27
68	Nadi Sweda	Uttar. 28	29
69	Nadi Vrana	Uttar. 29, 30	Whole chapter.
	Chikitsa-Kalika		
70	—	—	—
	Siddhayogasangraha		
71	—	—	—
	Chakradatta		
72	—	—	—
	Vangasena		
73	Nadi (Nostrils) through which air comes and goes out.	Arishta-dhikar	29
	Gadanigraha		
74	Nadi Vrana	Prayogakhada 1	
75	Nadi Vrana	3rd chapter	Whole chapter

From the above table, it is quite evident that no where from Charaka to Shodhal, there is any mentioning of 'Nadi' as a means of diagnosis. The fourth chapter of second section of Harit-Samhita, available at present, indicates prognosis only in the symbolic form. In this, it has been mentioned that besides

other symptoms such as rapid expiration etc. when Nadi becomes rapid the patient dies very soon. But we must also be aware of the fact that the Harit-Samhita available at present as such is not recognised by scholars of Ayurveda to be an authentic one. And it has been written quite later by some one. That is why some give the nicname to it as pseudo Harit-Samhita.

It is also interesting to note that a misunderstanding prevails about the inclusion of Nadi Vijnana even in the Charaka Samhita in Indriyasthana on the ground that non-pulsation of the always pulsating parts of the body and the cessation of the pulsation of carotid arteries (Manya) imply the said Vijnana in an axiomatic form. But this is untenable for many reasons. In the first place all descriptions in the Indriya section carried on in the third as well as other chapters are prognosticative and not diagnostic. That is why different parts of the body should be palpated with a view to ascertain the expectancy of life in a given patient and that the absence of throbbing/pulsation in those parts of body where normally the throbbing is felt is to be taken to signify an unfavourable prognosis, so far as it is related to life expectancy. But this solitary reference to pulsation in the context of prognosis has, obviously, no bearing on the examination of pulse for diagnostic purposes. Secondly all the conditions enumerated in the third chapter are meant to serve as the measuring rock of the duration of the patient's survival and non-pulsation of the even pulsating organs such as 'Manya' is one of them and as such it can never be misdirected so as to serve the intended purpose, i. e. purpose of Nadi Vijnana. From all that has been discussed above, it can be safely concluded that inspite of the use of word Nadi at several places in various denotations, the Charaka-Samhita is decidedly silent about Nadi Vijnana as the means of diagnosis.

Chapter II

Pulse in Other Systems of Medicine of the World before its Introduction in Ayurveda

In the context of origin of Indian pulse examination, it is perhaps necessary to refer here to the possible source or sources from which the Indian pulse-lore developed or the source or sources which directly or indirectly influenced its developments. There are some scholars who believe that Indian pulse examination ows for its knowledge to the Egyptian medicine and the Chinese medicine, whilst others like Jolly (1951) and Benjamin Walker (1968) believe that the Greek and contemporary Greeko-Arabian medicine might have contributed to the development of the Indian pulse-lore. Also, there is belief prevailing that the knowledge of pulse-lore in Ayurveda has been derived from South Indian Siddhars' work on pulse and not from the other sources. When discussing each point to highlight the present subject, we shall deal first with the Egyptian pulse-lore and the others one by one.

Egyptian Pulse-Lore

It is important to note that there had been two authoritative Egyptian papyrus, the surgical papyrus of Edwin Smith and Eber's papyrus, who had referred to the pulse examination. The former refers to "the probing with the fingers (palpation) or manipulation with the hand. The observation of the heart by means of the pulse 2500 years before the pulse appears in Greek medical treatise". As observed by Sigerest, the references, to the examination of the pulse in this..."are incomplete, mutilated and presented special translation difficulties". The first instruction of Smith papyrus reads thus : "...measuring in when you count anything with fingers (is done) to recognise the way of the heart goes. There are vessels in it leading to every part of the body...when a Sekhmet priest, any swnw doctor...puts his fingers to the head...to the two hands, to the

place of the heart...to the two legs, than he is measuring the heart...it speaks...in every vessel, every part of the body... One measures the vessels of his heart to learn the information that is given to it..."

In the papyrus Ebers, under the heading "The beginnings of *physician's secret; knowledge* of the heart's secret and the heart," the following passage occurs : "There are vessels from it to every limb. As to this, when any physician, any surgeon (lit. sachwet) priest or any exorcit applies the hands or the fingers to the head, to the back of the head, to the hands, to the place of the stomach, to the arms or to the feet, then he examines the heart, because all the limbs possess its vessels, that is, it (the heart) speaks out of the vessels of every limb. Beyond the imperfect references to the pulse vis a vis the heart, in the papyrus there is no information available in them about the procedure of examining the pulse, pulse signs with reference to diagnosis and prognosis etc. From discussion there appears to be no evidence at all to support the view that the Egyptian pulse-lore may have influenced that of the Indian. But simply we can say that Egyptian pulse-lore centres round the heart, its health and functioning as reflected is the arterial pulsation. Now the account of Greek pulse follows.

Greek Pulse-Lore

In Greek system of medicine Galen is seen to have written several treatises on the pulse according to their length, breadth and depth and has described over 27 varieties of them. In addition he has also classified 'unequal pulses according to their rate and mentioned again 27 varieties of them on the basis of 'axioms'. On account of his experience he has mentioned to 'slow' and 'fast', 'regular' and 'irregular', 'strong' and 'feeble', 'wave like', 'ant-like' Caprezens, dicrotic and vibratory. About the palpation of the arteries during pulse examination Galen observes. "The heart and all the arteries pulsate with the same rhythm so that from one you can judge of all; not that it is possible to feel the pulsations of all to the same extent, but only in those areas where the artery is close to the surface... But in all cases, the pulsations of the arteries in the soles of the feet and the wrists are easily felt. Not to distinct, by no means indistinguishable, are pulsations of the arteries behind the ears and in the arms, and others that do not lie deep. But you could

not find any artery more convenient or more suitable than those of the wrists, for they are easily visible, as there is little flesh over them, and it is not necessary to strip any part of the body of clothing, as is necessary with many others, and they run in straight course and this is of no small help in the accuracy of diagnosis. The artery will seem to the touch to be distended in every dimension". Describing normal and abnormal pulse Galen says "In an animal in a normal state of health, you will find the artery quite moderately distended, but in abnormal conditions sometimes the tension in too low, sometimes, too great in every dimension". He has described various types of abnormal pulses in the terms of 'broad', 'long', 'deep', if the pulse is excessive in breadth, length and depth respectively. Similarly, opposite of these narrow, short and shallow pulses have also been described. Taking into account of diminution and augmentation in all these dimensions, 'small' and 'large' pulses have also been described. The pulse is termed to be 'strong' in strength when it repels the touch with force and the reverse is true for the weak pulse. When the pulse appears flesh like to touch it is termed 'soft' and when hard like leather it is termed 'hard'. Abnormality of pulse regarding rate or speed is described by considering the rate of movement, the strength or fullness, on the character of pulsation, the largeness or smallness and the length of the diastole. In the view of Galen, an irregular pulse means an even and unbroken series, whereas irregularity means the destruction of even rhythm in whatever varieties of pulse. For pulse may be irregular in size, rate, violence, feebleness and frequency and so on. Characterising the pulses, Galen says that they may be worm-like (vermifrom). the ant-like (formicans), and the hectic pulses.

It may be easily inferred here that the Galen's description about the pulse and its examination does not make any reference to its counting. In other words, the pulse examination was qualitative and not quantitative. However, according to Galen, Herophilos of Chalcedon (300 B. C.) studied the pulsation of arteries and regarded the pulse as index of strength of the heart, and counted the pulse with Clephydra or water clock. Besides Galen, Ruphos (Rufus) of Ephesus (C. 100 A. D.) of the Roman Empire and paul of Aegina were among the early European Savants who profoundly influenced the

Arabian medicine, specially as regards the pulse. According to professor Ralph, Ruphos was the first man who taught that the pulse was the result of the systole and not of the diastole of the heart. About Paul of Aegina Ralph says, "Paul of Aegina devotes much attention to pulse and describes 62 varieties of pulse. His influence on Arabic medicine was very much". Now the account of Chinese pulse follows.

Chinese Pulse-Lore

The possibility of the influence of Chinese pulse-lore on that of the Indian appears to be even more remote and doubtful. It was through Buddhism that China and India came nearer to each other and developed many contacts. Historically speaking, however, Ashoka's missionaries blazed the trail and, as Buddhism spread in China, there began that long succession of piligrims and scholars who journeyed between India and China for 1000 years. Pandit Nehru in his book 'Discovery of India' mentions that "The first record of an Indian scholar's visit to China is that of Kashyapa Matanga who reached China in 67 A. D. in the reign of the Emperor Ming Ti, and probably at his invitation. Dharmaraksha accompanied him and, in later years, among the noted scholars who went were Buddhabhadra, Jinabhadra, Kumarjiva, Parmartha, Jinagupta and Bodhidharma". These Indian scholars who went to China not only carried many Sanskrit manuscripts with them, which they translated into Chinese, but some of them also wrote original book in the Chinese language. So, we can see how Chinese literature was enriched by the Indian travellers. As Smith, Vincet A. says "India has little affected the Chinese culture except through Buddhism but by this means it has exerted a subtle influence which has permeated the whole Chinese life and thought". So far the impact of Indian medicine over Chinese medicine is concerned, the former does not appear to have made any significant impact on that of the latter. On the other hand, Indian medicine is seen to have travelled to Tibet and the medicine of that country had adopted the former as its basis. Because there was two way traffic between India and China, so many Chinese scholars also came here. Numerous Chinese monks such as Fa Hien (500 A. D.), Sung Yun, Hsuan Tsang (700 A. D.) an I–Tsing (A. D. VII) visited India to do reverence to the sacred spots of the faith and to improve their

knowledge of Sanskrit. During their journey many Indians and Chinese perished on the way (A. D. VII).

I–Tsing's (A. D. VII) claim that "his country was never superceded by any other country in the skill of the feeling of the pulse" is, probably, not an exaggeration. Chinese have wealth of treatises on the pulse and they are considered to be 'utterly disproportionate' to other branches of medicine. According to the opinion of Wong and Wu "Chinese physicians assert that entire superstructure of medical practice is built upon the theory of the pulse...the nature, location, course and treatment of diseases depends upon this alone". As regards the method of feeling the pulse there is, however, some difference between one author and another. According to Ralph, "The physician places his right hand on the right pulse. The first three fingers are placed over the pulse on either side, each finger feeling a distinct pulse, the inch pulse, the bar pulse and the cubit pulse"

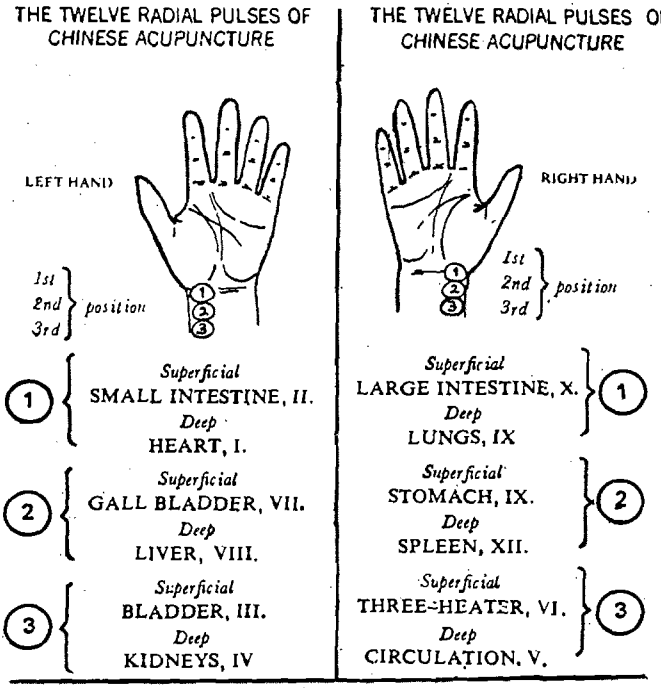


Fig. 1 : Chinese Method of Pulse Examination

(Fig. 1.). On the other hand, Wong and Wu say that, "The examination is made upon both the right and left wrists, his right hand for the left pulse, his left hand for the right. The middle finger is first laid on the head of the radius, then adding the index and ring fingers, whilst the thumb rests on the dorsum of the carpus". The latter version from Chinese medical historians, may perhaps, be considered relatively more authentic and reliable.

As regards time of pulse examination according to most historians of the Chinese medicine, it should be examined at sunrise. Unlike Greek and Greeko–Arabian system of medicine, Chinese system of medicine mentions about the pulse counting. In other words the pulse has been described in its quantitative term also. In the opinion of Chinese medicine, one inspiration and one expiration constitutes one cycle of respiration. The normal ratio is four beats to one respiration. 'Nan Ching' or the 'difficult classic' realises that the extent of the pulse is 'one and nine-tenth of an inch' which is divided into three parts called 'taum' or inch; 'Kwen' or bar, and 'Ch'ih' or cubit. Each of these divisions is stated to have 'two different and distinct pulses' viz; the internal and the external making altogether twelve pulses six on the right and equal number on the left hand. Each of these twelve pulses is correlated to twelve different organs of the body...the normal or abnormal conditions of which it reveals.

DIFFERENT CHINESE VIEW ON THE CORRELATION OF THE PULSE TO VARIOUS INTERNAL ORGANS

Pulse	1. Wang Shu-Ho	2. Nei Ching	3. Golden Chamber	4. Li Shin Chen
		LEFT WRIST		
Inch	**External**—Heart	Heart	Midiastinal visceras	Heart
	Internal—Small intestine.	Mediastinal visceras	Heart	Mediastinal visceras
Bar	**External**—Liver	Liver	Diaphragm and Gall-bladder	Liver
	Internal—Gall-bladder	Diaphragm	Liver	Gall bladder

Cubit	**External**—Kidney	Kidney	Small intestine and urinary bladder	Kidney
	Internal—Urinary bladder	Belly	Kidney	Small intestine
	RIGHT WRIST			
Inch	**External**—Lung	Lung	Thoracic organ	Lung
	Internal—Large intestine	Thoracic organ	Lung	Thoracic organ
Bar	**External**-Spleen	Stomach	Stomach	Stomach
	Internal-Stomach	Spleen	Spleen	Spleen
Cubit	**External**—Gate of life	Kidney	Large-intestine	Kidney
	Internal—San Chise	Belly	Kidney	Large intestine

Besides above types Chinese have mentioned four types as principal pulses, and they are : Fu or the superficial pulse described as, 'a light flowering pulse, like a piece of wood floating on water; Cheng or deep pulse described as a deeply impressed pulse, like a stone thrown into water; Chi'ih or slow pulse, described as 'a pulse with three beats to one cycle of respiration; and Shu or the quick pulse, described 'as' pulse with six beats to one cycle of respiration. The later two are good invidences for the description of quantitative form of the pulse in Chinese system of medicine. In addition to these large number of 'subsidiary pulses' have also been mentioned. According to Li Shi-Chen these pulses are : (1) Hua – alippery, like pebbles rolling in a basin; (2) Se – Small, fine, slow and short, like scrapping a bamboo with a knife; (3) Hau – empty, slow, large and compressible; (4) Shih – full, large and long and slightly tense, felt on both light and heavy pressure; (5) Ch'ang – long, neither large nor Small – the stroke markedly prolonged; (6) Tuan–short, no volume, strikes the finger sharply and leaves it quickly; (7) Hung – overflowing, full, hounding, forceful rising and gradual decline; (8) Wei – thready, very fine and soft, easily obliterated by pressure; (9) Chin – tense, hard and feels like a cord; (10) Huan – tardy, four beats to one cycle of respiration,

equal strength like willow branches swaying to a light breeze; (11) Koung – hollow, superficial, soft and hollow like an onion stalk; (12) Hsein – taut, like a tremulous musical string; (13) Ke–hard, tense, and hollow like the touching the surface of a drum; (14) Lao – wiry, deep, strong – and slightly taut; (15) Ju–soft, superficial and fine like a thread floating on water; (16) Jo – feeble, very soft and deep, felt on light touch and disappearing on pressure; (17) San – scattered, large, irregular like willow flowers scattering with the wind,. (18) Hsi – slender, smaller than feeble but always perceptible, thin like silk thread; (19) Fu – hidden, embedded in the muscles only felt on strong pressure; (20) Tung – tremulous, quick and jerky, pulsations covering a space no longer than a pea; (21) Chich – intermittent, slow with occasional missing beat; (22) Tai – irregular, tremulous, beats occur at irregular intervals. Thus we see that a good deal of descriptions of qualitative form is also there in Chinese system of medicine.

The pulse in Chinese medicine may either belong to Yang or the male principle or Yin, the female principle; and also a variety of combination of these two may occur revealing distinct diseases. For example the Fu or the superficial pulse which is said to belong to Yang or the male principle is considered to indicate complaints contracted through sexual practices, wind cold dampness, heat dryness and fire. Huan or tardy pulse is said to point to rheumatism. A combination of superficial and Ju or soft is stated to denote sun-stroke; superficial and Kung or hollow pulse is stated to indicate haemorrhage. Likewise other examples may also be given.

A Ching or deep pulse, which is said to belong to Yin or female principle, is said to indicate external diseases due to 'seven passions' viz., joy, anger, anxiety, worry, grief, fear and shock. In addition, in case the pulse is deep and slow, it indicates weakness and cold; if it is deep and quick, it is considered to be indicative of latent heat; a deep and sloppery pulse is said to signify indigestion, whereas a deep and hidden pulse is stated to be symptomatic of vomiting and diarrhoea. Numerous other examples of the significance attached to the various modes of combination of different kinds of subsidiary pulses can be enumerated. Chinese medicine attaches considerable importance to the pulse in the prognosis of diseases. Few examples may be

quoted here. "In case of apoplexy, the pulse should be superficial and slow; if, on the other hand, it is firm, rapid and large, there is danger. In typical typhoid fever, if the pulse is superficial, full and over-flowing, no anxiety need be felt, but if it is thready, small and soft it is serious. In cases of diarrhoea, the pulse is deep, strong, large, superficial and quick, fine and small it indicates bleeding in the intestine and the case is hopeless...".

Equally important is the prediction of death by examining the pulse. "If the pulse resembles the peaking of the bird, of water dripping from the crack, extinction of the sleep-pulse and death may be expected within four days. If the pulse resembles feathers blown by the wind, or feathers brushing against the skin, it indicates serious diseases of the lungs and the end will come within three days; it is a sign of fatal kidney trouble and death may happen within four days if the pulse is like the anapping of a cord or like the flipping of the finger against a stone. A pulse scating like a fish or shrimp, darting about in the water, or the pulse like water coming from a spring, is a fatal symptom".

Chinese physicians have also observed the pulse variations under the influence of seasons, age, constitution, temperament and the sex of the subject. Thus "In spring the pulse is taut and tremulous like a musical string in summer, it is full and overflowing; in winter it is deep like a stone thrown into water". From the point of view of constitution, "A thin person's pulse is generally superficial and full; a fat person's pulse is usually deep and quick. Five beats to one cycle of respiration is normal in a hot temperred person but four beats to one cycle of respiration in a person of slow temperament means sickness". Agewise, in the aged, the pulse is mostly empty; in young people, it is large, and in infants, it is rapid about seven beats to one cycle of respiration. This system also observes differences and distinction in the pulse of the inhabitants of the North and the South. 'Northerns often have strong and full pulses while the Southerns soft and weak pulses'. According to sex 'In man, the pulse on the left hand should be large to correspond with the Yang principle, but in the women, it should be opposite, because the Yin (the female) principle predominates on the right hand'. In addition to these the character of pulses in pregnancy, cessation of menstruation have been men-

tioned. The change in the character of Cubit pulse in relation to male and female, and also changes in cubit and Bar pulses in connection with distinguishing male and female child during pregnancy have also been enumerated. As Jurgen thorwald observes "The pulse was checked in the arteries of the head, the foot, and specially the wrist. The pulse too was regarded as a link between cosmos and man. The heavens 'spoke' in the upper part of the human body by means of the arteries of the temples. The man himself, however, 'spoke' from the artery of the two ears".

From foregoing discussion it appears that Chinese pulse-lore is elaborate and complicated. And in this system of medicine a vast literature, over 150 volumes of pulse examination have been identified and studied. But so far as impact of Chinese pulse-lore over Indian pulse-lore is concerned, it appears after having gone through the literature of the former that it leaves no influence over the later system of medicine, i. e. Ayurveda and vice-versa. The points in the favour of this supposition may be that the Chinese medicine describes the pulse in terms of its 'extent' which is one and nine tenth on an inch in length, divided into three parts which are, from above downwards, the 'inch-pulse', the 'bar-pulse' and the 'cubit-pulse'. And these three pulses have been correlated to the various organs of the body instead of the 'humors' even though, there is a mention of accumulated humors in the context of the description of prognosis. The term wind, heat, cold, phlegm and mucous no doubt have been mentioned in the Chinese pulse-lore but there is no authenticity that they convey the same idea as conveyed by the term Vata, Pitta and Kapha of Indian medicine. It may also be noted here that not only Chinese system of medicine but the ancient Greek and the medieval Arabian medicine have also correlated the pulse to different organs of the body. But there is no such mentioning in Indian system of medicine. The description by Indian medicine is after the three doshas viz. Vata, Pitta and Kapha.

Another point against the influence of Chinese medicine over Indian medicine is that the Chinese medicine refers, in its pulse-lore, to the ratio between the pulse and the respiration and its diagnostic and prognostic implication, whereas the Indian pulse-lore has not envisaged any such ratio or the correlation of the pulse with respiration. Next, while the Chi-

nese system envisaged differences and variations between the male and female pulses in both the wrist, the latter has specifically indicated that the pulse in the male should be felt in the right wrist and in female, in the left. A peculiar feature of the Chinese pulse-lore is the correlation of the pulse to the male and female principle respectively, regardless of the sex of the subjects. The last point which can be quoted that the Chinese classification of the pulse and description of the pulse-signs are functional, baring some occasional ones such as 'the pecking of a bird', and 'the darting like fish or shrimp'. On the other hand the Indian description will be seen to compare the pulse-signs with the movement of birds, reptiles, and the creatures as frog, leech etc. Now the account of Arabic pulse follows.

Arabic Pulse-Lore

Arabic system of medicine is of Greek origin which was rendered first into Arabi language and called Unani (Ionian medicine). This system of medicine is also known as Unani Tibba (the Greeian system). The name Tibba (physic) which Avicenna (A. D. 980--A. D. 1036) gave to his medical system is derived from Tabijyata (physics) which denotes that it is based on no dogma or superstitions. The medicine under caption 'Unani' in India is the same Ionian or Greek medicine which was first rendered in Arabic and again rendered in Urdu language.

So far as contact between Greeko-Arabian medicine and the Indian medicine is concerned, it can be divided into two phases. The first phase starts from the invasion of Arabs (A. D. VI) beginning with the incursion into Sind and ending with the invasion of India by Mahmud of Ghazani (A. D. 1000--A. D. 1026-7). This phase corresponds initially to the Omayid, and subsequently to the Abbasid Khaliphetes. The second phase corresponds to the period extending from that of Qutab-ud-din Aibak (A. D. 1206-1210) to that of Firoz Tughalak (A. D. 1351--A. D. 1388). The Arabs were semitics and shaped the islamic culture whereas the Turks gave it ruthlessness. During the period of Abbasids i. e. in the first phase the flow of knowledge of Indian medicine was from India to Bagadad, whereas the period of Turks in India i. e. during the second phase witnessed the flow in the reverse direction of the Greeko-

Arabic medicine into India. As observed by Ishwari Prasad, "The Arab scholars sat at the feet of Buddhist monks and Brahmans Pandit to learn phylosophy, astronomy, mathematics, medicine, chemistry and other subjects of study". In the result the Arabs, in the first phase of their contact (A. D. VI to A. D. 1000) not only imported these subjects to their country but also introduced them to Europe. It is also important to note that during this very phase most of the Indian physicians as Manaka, Ibn-Dhan, Bahal, Bajigar etc. were invited to Bagadad by Khalifas and abode in Bagadad and accepted Islamic religion. The Indian physician Manak, who was invited to Bagadad by Khalifa Harun-al-Rashid treated the Khalifa. Manak is credited with having translated several Sanskrit works in Arabic. He translated Charak-Samhita into Persian, and Sushruta-Samhita in the name of Sushrud into Arabic. Ibn-Dhan, another Indian physician a contemporary of Manak who is said to be a decendent of the Indian Dhanapati was invited to Bagadad by Vahya, the Bramicide and appointed as the director of the Bramicide hospital. He is also credited with having translated several Indian medical works into Arabic, such as Ashtanga-Hridaya, Madhava-Nidana and Siddhayoga in the name of Ashtankan, Nidan Sindhastaq etc. The author of Kitab-Fihirisit who wrote towards the middle of the tenth century A. D. distinctly mentions that under orders of Khalifas Harun and Mansur, standard Indian works on medicine, pharmacology, toxicology etc. were translated into Arabic. From the above discussions we can easily infer that during the first phase of contact the Greeko-Arabian medicine was enriched mostly in all the fields to the greatest extent by the assets of Indian system of medicine. And if the same Charaka-Samhita and Sushruta-Samhita etc. the classics of Indian system of medicine as available today were translated during that period, it is quite evident that excepting other branches of Indian system of medicine the knowledge of pulse examination of medicine must not have been migrated from India to the Arab country. Because from the period of Charaka to the period of Shodhala (A. D. 1200) there is no where mentioning of pulse examination as a means of diagnosis. In the support of this view we can quote Itsing the Chinese traveller who visited India in VII century A. D. and gave his commentary on the means of diagnosis of a given patient prevalent at that time by

saying—"The medical science, one of the five sciences (Vidyas) in India shows that a physician, having inspected the voice and countenance of the diseased, prescribed for the latter according to eight sections of medical sciences. There is indeed no trouble in feeling the pulse". He also observed that Indians preferred to consult a diviner about their fate when there was no trouble at all in feeling the pulse, and this, in contrast to the practice of this art in China which in his view—"In healing arts of acupencture and cautery and the skill of feeling the pulse, China has never been superceded by any country in Jambudwipa". This version of Itsing strongly strengthens the idea that Indians of the time were not aware of the knowledge of diagnosis by pulse examination.

Now, let us see what happened during the second phase of contact. The time bracket of A. D. 1175--1340 was of novel political upheavel and cultural upsurbes. During this period Turkish invaders settled down in India, and carried out their repeated compaigns against Hindu principalities, the annexation of the conqured territories to the expanding sultanate of Delhi, the forcible conversion of Hindus under the threat of the sword. In so far as medical science is concerned, the Turks in the second phase of contact brought with them their own physicians and materia medica a part of which was originally imbibed from Indian medicine. The royal physicians (Hakims) who were brought to India attracted increasingly large number of pupils not only from India but also from various parts of persia where Greek thought reigned supreme. The system of medicine which they followed in India was neither Indian nor Persian but an amalgam of the Arab version of Galen's (Greek) medicine which later came to be know as the Tibbi medicine. Some of the rulers of the time allowed their physicians to translate a few Indian medical works into Persian. One such work was Tibba-Ferozeshahi, published in India in A. D. 1281. It was dedicated to Sultan Ala-ud-din Khilji.

It is seen from 'An account of the physician of Alai period, In Tia-ud-Din Barnis' well known work 'Tarikhe-Firozshahi, that *not only Muslims but also a large numbers of Hindus, the Negroes. Brahmans and Jats'—took to the study and practiced of the Greeko-Arabian medicine.* Barni proceeds to observe further, "During the Ala period, there were such expert physicians that far exceeded Hippocrates and Galen in their skill in

treating diseases. Maulana Budruddin Damasci, the master physician occupied a high rank during the entire Ala period. The physicians of the city always learned the medical books from him. God blessed him with such a skill in medicine that only by feeling the pulse of the patient, he could correctly diagnose the cause of the disease with the cure for it and gave a favourable prognosis of the case. He had such a proficiency in medicine that if the urine of some animals was brought before him, he would at a glance singly say that the urine has intermixed in the bottle (italics anthor's). 'Next to him' says Barani, "In diagnosing from the pulse and urine, no body else in the city was equal (in Status) to Maulana Hameed Motarraz. Proceeding further says Barni, "The Yaminy physician Ilmmuddin, Maulana Aizuddin Badayuni and Badruddin Damasci were all physicians of the Ala period who had great proficiency in medicine and its practice. Similarly, Nagories, Brahmans and Jats were in the city". As Barni says further that "Delhi soon became as important as Bagadad. Many hospitals were established where regular training of Greeko-Arabian medicine was given. There is evidence to show that the Sharak (Charak), Sushrud (Sushrut), Ashtankar (Ashtangahridaya) and Nidan (Madhavanidan) were studied and admired but the interest of Indian Hakims in them appears to have been, more or less academic, and they were left free to adopt what was [illegible] in them.

In the second phase and the centuries that followed so as the practice of the Greeko-Arabian medicine by its Indian practitioners is concerned it is observed that the diagnosis of the disease and the patient was made, almost exclusively by the examination of the pulse (nabs) and the testing of the urine. Regarding pulse examination in Arabic literature, it is important to note that Arabic medical literature assigned to the teacher particualr responsibility in training the student accurately to read the pulse. Part of their medical circular was devoted to the study of the music so that the physician might appreciate the subtleties of the various tones of the pulse beats. 'Rhazes', as he was named by the medieval Latinists, liver between the ninth and tenth centuries. He was an Arabian authority on the pulse who is ranked with Avicenna as one of the foremost Arabian physicians and he is also regarded as probably the greatest and most original of all Muslim physi-

cians as well as one of the most prolific as an author. Another great physician was Haby Abbas or Ali Ibn Abbas Al-Majusi or Zoroastrian from South Western Persia. He lived during second half of the tenth century. He is famous for his alkitab al-Sinnah-al-Tibbiyah which is certainly one of the most complete and concise medical book in the Arabic language. It was the text book of the Arabic speaking world until the advent of Avicenna's Quanun. The another great authority of Arabic medical world was Avicenna (980-1036) who not only systematised the Unani system of medicine but made many original contributions and more so in the field of pulse examination.

One should make a note of it that the Arabian medicine is found mostly on the philosophy, concepts and principles of Greek medicine particularly Galen's medicine inheriting the humoral doctrine of the Greek medicine, the four humours of Arabic medicine are fouring number viz., Khoon, Balgam, Safra and Sanda. But these four humours in the case of examination of the pulse have neither been to the pulse-signs and symptoms nor is the interpretation of the pulse-signs and symptoms made in terms of impairment of the one or the other of or all of the four humours, so far as prognosis and diagnosis are concerned. Instead, the temperament or Mizaj and the vital force or Rooh, among others, are seen to form the basis of the study of the pulse, in ease and disease. Besides, the Arabian medicine, like the Greek medicine, interprets the pulse in terms of the functioning of the heart, the arteries, and the later in relation to the organs with which they are related.

The description of pulse-lore in Arabian medicine is qualitative and an asset of details regarding different signs and symptoms have been furnished. Chief points to be elicited during the examination of the pulse are : (1) length, (2) breadth, (3) height, (4) the needs of the body, (5) hard, (6) soft, (7) irregular, (8) strength. Some among the types of the pulses described by Arabian medicine are : (1) Gazelle pulse, (2) Vermicular pulse, (3) Ant-like pulse, (4) Serratic pulse, (5) Decurtate pulse, (6) Spindle-shaped pulse, (7) Dicrotic pulse, (8) Supernumerany pulse, (9) Cord-like pulse. In addition to these Arabian medicine has observed differences in the pulse with age and sex, temperament, seasons, place (countries), food and drinks, alcohol etc. A significant observation made by Avicenna who has quoted Galen about the

difference between the effects of alcohol and pomegranate juice is that, "the pomegranate juice is a tonic for those with hot-temperament, while honey-water benefits those with cold-temperaments. Similarly, alcohol is beneficial for people and injurious to others according to its hot and cold quality". On the character of the pulse exercise, baths, pregnancy, pain, swellings, inflammations, and the factors enimical to the body have also been described.

The description of main features of the pulse which Avicenna (10 A. D.) has described are of outstanding importance. He has mentioned in his book 'Canon of medicine' that "the physicians have laid down ten features for examining the pulse although these should have been nine only. In this way the pulse varies in respect of its (1) size, i. e. in the degree of expansion as estimated by its height, length, and breadth. The pulse has thus nine simple and a large number of compound varieties. *The nine simple varieties of the* pulse are the long, short, and medium; the broad, narrow and medium. The various compound varieties of pulse are worked out from combinations of the simple varieties. Some of these varieties have special names, others have none. Thus, a pulse which is large in length, breadth, and height is called a pulse of large volume and the one which is small, in these dimensions, is called the pulse of small volume. The average pulse between these two is known as the pulse of medium volume. Similarly, a pulse which is large in breadth and height is known as a bounding pulse and that which is small in this respect is called a thin pulse. A pulse which is average between these two extremes is a medium pulse; (2) strength of the pulse beat as felt by the fingers. The strength of the pulse may be strong, feeble and medium; (3) Velocity of the pulse beat i. e. speed. The velocity of the pulse beat may be quick, sluggish or medium; (4) Quality of the vessel wall. This may be soft, hard or medium; (5) Fullness or emptiness of the artery. The pulse may be full, collapsing or medium; (6) Temperature. The pulse may be hot, cold or moderate in temperature; (7) Rate i. e. frequency. The pulse may be rapid, slow or medium; (8) Consistency or inconsistency regarding the various features; (9) Regularity and (10) Rhythm. Rhythms of the pulse is time relation between two periods of movements and the two periods of rest. The pulse may thus be errhythmic or dysrhythmic. Dis-

rhythmic pulse is of three varieties : (a) pararhythmic in which the rhythm of a child's pulse is like that of the pulse of a young man; (b) heterorhythmic in which the rhythm of a child's pulse corresponds to that of an old man's pulse or (c) erythmic in which the rhythm is so utterly abnormal that it does not correspond to the rhythms of any age. Marked deviations of rhythms indicate gross derangement in the body.

For usual practice, regarding site of examination of the pulse Avicenna has mentioned that pulse is felt by palpating the (radial) artery at the wrist. He has given three possible reasons to be chosen this artery for the examination of the pulse. Firstly, it is more accessible. Secondly, it can be examined without embarrassment to the patient, and thirdly, it is in direct continuation of the heart and quite close to it. Regarding the method of examination he has said that the forearm should be kept in the mid prone position because in thin and weak persons pronation increases the height and width of the pulse, but decreases the length, while supination increases the height and length but decreases the width.

It is also important that the pulse should be felt when the subject is neither angry, nor excessively happy or under stress of exercise and emotions. His stomach should be neither overloaded nor altogether empty. He should also not be out of breath. The subject should neither have given up any of his *long standing habits nor should have adopted new ones.*

In order to make a proper assessment of the various changes it is important that the pulse should be compared with that of a temperamentally well balanced person. Now the account of pulse in Tantrik literature follows.

Pulse-Lore in Tantrik Literature

As regards fourth view, that the pulse-lore of Ayurveda has been derived from Tamil Siddhars, Dwarakanath observes, "In so far as the Indian pulse-lore is concerned its origin and development may have to be treated to the only source which is that of the early Tamil Siddhars of the South". The pulse-lore of the early Tamil Siddhars is seen to have taken its origin from the Shaiva-Agama Tantrism. Very early Siddhars of Yoga school of Tantrism were Tirmular also known as Mular, Adinatha and Mulanatha, Agastyar, Pulipari or Pulipasni Vyagrapadar, Bogar and Patanjali, Shiva Vakkiar, Ramdevar,

Idaikawadar, Konganavar and others. Of these Siddhars, Tirmular, Agastyar and Bogar are recognised as to be the most earliest. All of them had 'already developed alchemy (rasavada), iatro-chemistry (rasatantra/rasashastra), medicine (Ayurveda, Vaidyam) the last mentioned included pulse-lore. Thus the pulse-lore is seen to be an outcome of Yoga which deals among other things with the pulse (nadi) and the control of breath. The knowledge of the pulse became subsequently a part of the medicine of South Indian school of Siddhars–also known as Ayurveda. The following are chronologically the more important Tamil Siddhars who authored works on alchemy and pulse-lore; Nandi, Agastiyar, Tirmular, Shivavakyar, Yugimuni, Theryar etc. Tirmular, has been counted as one among the earliest and great Siddhars. He is said to have come down to the South from Himalayan region. Says Nilkanth Shastry, "The place of Tirmular in the history of Tamil Shaivism is indeterminate. He is believed to have been among the earliest exponents of Shaivism in Tamil Nad of his life. Various dates for him have been assigned, ranging from the first to the ninth century A. D.". According to the another source, the period of Tirmular ranges from the second century B. C. to the seventh century A. D.; yet internal evidence points to six thousand B. C. as the period when he might have flourished. Regardless of the difference of opinion about the period it would appear that he might have flourished a few centuries before the Christian era. The number of Siddhacharyas grew to eighty-four between the eight and tenth centuries. The Brihatsuchipatram (Ayurveda) issued by the Nepal Virra pustakalaya has listed Ramadey as the author of the Rasaratnapradipika on the basis of the Colophons attached to this work. He has also referred to the Tamil Siddhars and the pulse-lore in this work. The two great works of Tirmular are, Vaidyakarukkadai and Tirmular Vaidyam. The former is comprising of 600 stanzas, among which from 17-43 stanzas deal with the pulse-lore. The pulse-lore in the later work is described from the stanzas 20-43.

The more important of North Indian works on the pulse-lore are Nadivijnana by Kanada, who according to Dwarakanath, belonged to XII century A. D.; the Nadipariksha by Ravana of XII century A. D. and Nadichakra and Nadivijnana by an unidentified author belonging to the same period. It may

be recalled in this connection that many unpublished manuscripts on the pulse-lore of South Indian and North Indian schools, the authorship of some of which is unknown and that of very many not, belonging of the early middle and late medieval periods have been listed in the descriptive catalogues of oriental libraries in the South as well as North India. E. N. Ghosh (1924) had published many articles on the topic, "The Nadi system in Ayurvedic medicine, Upanishads and Tantrika literature. In one of the pieces of his articles (Oct. 1924), 'Sphygmology in Ayurveda', he also arrives at the conclusion that "It is specially to be noted that although the general 'Nadichakra' system has nc real bearing on the pulse examination, yet the consideration of the same in works on sphygmology has been considered imperative by most of the authors. The one of reconciling such association is to consider their evolution side by side perhaps in the hands of the same set of workers. One fact remains fairly constant that once the two systems had put together by the earlier authors, the practice continued, and is still extent amongst the present writers". And also in his opinion, "Although a large number of manuscripts are enlisted in the catalogue of various libraries, both private and public, many other works may have been lost for ever and some again are lying in obscurity and may be discovered some day. Again although the names of several authors are known, their works are no longer available". Further giving his final remark, Ghosh says, "The place of the general Nadichakra and Nadi system in treatises on sphygmology can be best accounted for if we assure that the two subjects evolved together side by side in the hands of the same sages of by gone days".

According to Tirmular, there are 72000 Nadis in the human body of which ten are encountered to be useful from the point of view of medicine and the pulse-lore. They are : idai (ida), pingalai (pingala), buzumunai (sushumna), the six chakras viz; muladhara, swadhisthana, manipuraraka, anahata, visuddha, & ajna chakras, and three mandals viz., agni, surya and chandra. The first three which are mentioned in the beginning are known as the three Nadis from which the three Dhatus as Vata from idai, Pitta from Pingalai and aiyyum (Kapha) from the suzimunai, are stated to arise. For this reason idai has been considered as the Pitta nadi and suzimunai as the Kapha nadi. It has been further cited that the Nadi through which the impulses

of all the three Nadis are transmitted is the same. And these impulses are to be felt below the thumb, by the use of the index, middle and ring fingers respectively, for Vata, Pitta and Kapha pulses. With slight amendment the description from the Encyclopedic Dictionary of Indian medical science can be given which gives a broad idea of the origin of the pulses, their regions, nature of their movements, fingers with which they should be felt, the relative ratio of their beats etc. (1) Vatanadi–pulse indicating Vata dhatu; (2) Pittanadi–pulse showing Pitta dhatu; (3) Aiyyum or the slettuma nadi–pulse exhibiting Kapha dhatu; (4) Bhute nadi–pulse felt between the thumb and the fore-finger; (5) Guru nadi–an intermediary pulse felt between fingers (in 1, 2, 3 & 4). Regarding 4 and 5, it has been mentioned that they are more difficult and are not observed in practice from due to 'great intricacy'. Encyclopedia further says "This is a secret which can not be learnt without the aid of spiritual Guru or a Yogi", and it proceeds to observe that "the other three are open to physicians and are availed of in common practice".

In connection with the mode of feeling the pulse, the school of Siddhars has observed that the pulse should be examined by pressing the index, the middle and the ring fingers of the physicians right hand at a place two fingers in length just below the root of the thumb, a little above the wrist. It has also been mentioned that the pulse should be palpated three times by holding and letting loose the patients hand. The natural order in which three Dhatus are indicated are : (1) the pulse indicating Vayu is to be palpated in the first place, below the fore-finger; (2) that of Pitta in the second place, below the middle finger, and (3) that of Kapha, in the third place, below the ring-finger. Regarding sex the pulse in the male should be felt on the right wrist, and in the female in the left.

In addition the pulse movements both in terms of animals as horses, reptiles, amphibions creatures like frog; birds, like peacock, fowls etc. as well in terms of physical signs have also been mentioned. Few examples are : (a) Puzupelural-worm-like movement; (b) Padariyodal-Hastening or very quickly; (c) Kumurihodal–Crooked and shaky movement; (d) Odam-bolodal–moving like a boat i. e. quick–decline due to pressure or low tension; (e) Adnpotrullat–leaping and bounding like movements of goats; (f) Terinduvizal–sudden rebound which

is marked; (g) Talarvayodal–sluggish pulse. Likewise numerous other types can be quoted.

Thus foregoing apart, the Siddhar pulse-lore has referred to pulse according to its nature, action and other characteristics as : (a) Tivranadi–pulse which is faster in rate than the normal; (b) Thallunadi–irregular and bounding pulse–goat leap pulse; Vannadi–hard or wiry–strong pulse; (c) Abalanadi–weak pulse; (d) Nerungiyanadi–Tense and firm pulse–cordy pulse; (e) Gatinadi–flowing and hard pulse; (f) Idaividunadi–interupted pulse with missing beats; (g) Thadangunadi–slow pulse; (h) Ozungunadi–Normal pulse etc.

Besides, the above types of pulses Siddhars of south have furnished numerous other details relating to pulse-variations Dhatuwise, diseasewise, prognosis etc. in their works. The remarkable point is that they have mentioned about the time when the pulse is to be examined in different months of the year. According to Nojin Saram by Agastyar, a work considered to be not only very authentic but also very old, the pulse should be examined in different times of the day and night in different months e. g. (1) Chittiral–Vaikasi corresponding to mid–April to mid June...at Sunrise; (2) Ani and Adi corresponding to mid-June mid...August/Aipari and Kanligi, corresponding to mid October and mid December.....in mid day; (3.) Margazi, Thai and Masi corresponding to mid December to mid March.....at Sun-set; (4) Panguni, corresponding to mid March to mid April; Avani, corresponding mid August to mid September and Purattabi corresponding to mid September to mid October.....in mid night.

It is of interest to note that Saram has also mentioned that when the pulse should not be examined. As Noyin Saram says: "Any diagnosis made by the examination of the pulse when the subject has anointed himself with oil, when the body is wet with water, at the time of eating food, when very hungry and when enjoying sexual pleasure, will be misleading". Not only this much, this work also envisages sex-wise difference in the pulse movements as it is evident from the following chart.

Dhatu	Male	Female
Vata	Peacock	Serpent
Pitta	Tortoise, Leech	Frog
Kapha	Serpent, Frog	Swan

So far we have discussed about some of the salient aspects of pulse-lore of Tamil Siddhars and its Tantrik origin and development by them, and have also learned the various movements of pulse correlated with those of certain animals, birds, reptiles, amphibions creatures etc. along with highlighting the physical signs too. It is a point of remark that many of these movements vis a vis Dhatus/Dosas involved and abnormal and normal states have been mentioned in the works on pulse-lore of the North such as the works of Kanad and Ravana (Ravana Siddha). It may be recalled in this connection that beginning with Nagarjuna and the spread of Mahayanism by about IV century onward, the dividing line between the Buddha and Shakta cults became imperceptable", and both "Fe Haien and Yuan Chawang saw Buddhists wherever they saw Tantrists". It was also seen previously that Tantrism reached its climax between the VIII and X centuries A. D. when the number of Siddhacharyas grew to 84. Thus the period between the VIII century and XIII was one of intense Tantrik activities and in the hands of the same Tantrik sages alchemy (Rasavada). iatrochemistry (Rasa Tantra Vijnana) reached its apogee on one hand and the science of pulse (Nadi Tantra/Nadi Vijnana/Nadi Shastra) on the other. That the both Kanada and Ravana were Tantriks is proved by the fact that Kanada, one of the two has submitted himself to the devotion of lord Shiva, who according to Tantriks, is regarded as the source of knowledge of 'Nadishastra' and 'Rasashastra'. As Kanada in the very beginning of his work under the title 'Vaidyaka Pracharaka' has himself cited that it is the Mahesha only who knows the pulse science etc. and he (Kanada) one of the descendent of remote past in the tradition learned this knowledge to second. Few verses cited by Kanada in the beginning regarding origin of Nadi from tartoise (Kurma) are such that it appears that they are part and parcel of the knowledge of Tantrism. But they convey no scientific meaning of anatomy. Moreover, ambiguity of the knowledge inherited in them does not make it clear that term 'Nadi' used is restricted only to 'artery or veins' but in addition the term includes the sense nerve trunks and their branches etc. Similar, reasoning can also be given for Ravana who also has mentioned n his work the name of 'Nandin', a great knower of pulse-cience and one of the pioneers of South Indian Siddhars of emote past.

Extensive study of Ghosh (1924) on the subject "The Nadi system in Ayurvedic Medicine, Upanishads and Tantrik Literature" also reveals that "the Nadis and Nadi-chakras are found elaborately described in many Upanishads, Puranas, Samhitas, and Tantras and also in many works on sphygmology". The site of the origin of Nadis has been variously stated in different works. The short accounts we find in nearly all the treatises *mostly to nerves*, although *vessels* might be referred to in some of them. In the large number of treatises on sphygmology we find the Nadis (the origin of the Dhamanis as depicted in several treatises is also included in the origin of Nadis) have been said to have had taken their origin from the region of the umbilicus. Giving remark on overwhelming importance attached to the umbilicus by Indian sages, Benjamin Walker (1968) says,"...the whole physiological system is believed to centre around the region of the navel and heart, which moistens the body as a stream moistens a garden". There is sprout like-lump at the level of the umbilicus, created by God. 72,000 Nadis take their origin from this lump. It is also said that the Kundalini Shakti, placed in the navel, is shaped like coils of snake. From this (or from this place) arise 10 upcoursing and 10 downcoursing Nadis where reside the 10 Vayus. Two on each side are lateral coursing. These are the 24 main Nadis which are concerned in the 10 vital forces (Vayu). And also the navel is placed in the Madhya Chakra in the body. All the Dhamanis spreading in the body, arise from it. They are 24 in number. In others are descriptions that those Siras which are distributed in the body of a man are all bound to the navel and extend on all sides. Arising from below the navel 10 pass upwards and 10 downwards, 2 pass lateral-wise on each side; these are 24 Siras of the body and also, the Siras and Dhamani are placed in the navel; they lie in the body by spreading in all directions. The treatises on sphygmology in which 72,000 Nadis are mentioned are : (1) Nadyutpatti, (2) Nadipariksha, (3) Nadishastra-samgraha, (4) Nadinidanam, (5) Nadichakrabhedi and (6) Nadivijnaniya. In Nadivijnaniya the Nadis have been classified into male, female and neuter. There are 30,000 male and 30,000 female Nadis and 12,000 neuter Nadis.

The Nadis on the left side are called female, those on the right side are called male and those in the middle are called neuter. Thus there are altogether 72,000 Nadis. There are 14

Nadis enumerated in Shiva-Samhita, Nadishastrasamgraha and Nadinidanam. These are as followes : (1) Sushumna, (2) Ida, (3) Pingala, (4) Gandhari, (5) Hastijhwa, (6) Kuhu, (7) Saraswati, (8) Pusha, (9) Sankhini, (10) Payaswini, (11) Varuni, (12) Alambusha, (13) Viswodari, and (14) Yashaswini.

In Shiva Samhita, it is distinctly noted that, of these, Pingala, Ida and Sushumna are the principal Nadis; again of these three, Sushumna is the principal Nadi. All the Nadis of the body arise from this (Sushumna). In both Nadi Shastra Samgraha, Nadi Vijnana and Nadi Chakrabhedi, we have the same note regarding the Sushumna, Ida and Pingala, the first one being referred to as a Brahma Nadi. Similar sets of Nadis are also mentioned with some change in numbers in Nadi Vijnana, Nadi Pariksha and Nadyutpatti etc. Though, we find that anatomical classification and functions of Nadis are amalgamated, yet in many treatises on sphygmology and general Sanskrit works, we find the Nadis differentiated into Siras and Dhamanis, different characters (including functions) being assigned to them. The Nadis are divided like the veins of a leaf are fine, are distributed in the body, are provided with various colours and are placed in 7 Dhatus. They are carriers of derangements, are holders of functions and are running like creepers. They are stout, cylindrical and knotted; they are gradually narrowed down from a broad base, and are apparently scattered, provided with a calibre are fine at the terminals and extended to all parts of the body in a downward, lateral and upward course and are continued to all the joints. Such a definition can only be applied to a vessel.

And also the Pran Vayu travels in the calibre of all the Nadis. They indicate health, if free from any derangement, but are carriers of diseases, if affected with derangements. Of these 5 are the principal ones, and are placed in the body trunk. Of these 3 are eminent owing to being carriers of 3 types of derangements and being capable of giving an idea of the derangement. Those which are directed upwards and downwards are connected with the wrist and are known as 'Sutrapanchaka' 5 cords. There is undoubted confusion between a pulsatile vessel and a nerve cord in this passage. The first five lines indicate an artery, whereas the last line points to a cord, a solid structure. Elsewhere, these 'Sutrapanchaka' have been

used namely for Ida, Pingala, Sushumna, Subla and Bala. But above all, one thing we can derive is the idea inherited in few lines that derangement of Doshas are carried by Nadis and if they are examined they are capable of giving an idea of derangement of Vayu, Pitta and Kapha. Ghosh in his articles has quoted pulsatile Nadis as studied by the authors of the various treatises on sphygmology and they are : (1) There is a Nadi in the Brahmarandhra to be found pulsating in the infant. The pulsatile anterior fontanallae is evidently meant by this; (2) There is a Nadi on each temple. This refers to some large branches of the temporal artery; (3) The nasal arch of the two angular arteries of the facial artery is referred to as a Nadi between the two eyes brows capable of being examined in young persons; (4) There is a Nadi infront of the ear. It occupies two fingers breadth. It corresponds to superficial temporal artery; (5) There is a Nadi on the undersurface of the tongue on each side. The pulsation can be easily felt behind a fingers breadth from the tip; (6) There is a Nadi in the neck on each side, two fingers breadth above the root of the neck. It is common carotid artery; (7) There is a Nadi in the middle of the hand on each side. It refers no doubt to the brachial artery at the bend of the elbow; (8) There is a Nadi at the wrist which is considered as the most suitable one for clinical examination. It occupies three fingers breadth on the wrist at the base of the thumb; (9) The pulsation can be felt over the heart; (10) There are two Nadis in the neighbourhood of the navel; (11) There is pulsation which can be felt over each Kukshi; (12) There is a pulsation which can be felt on the sides. It is very difficult to locate the actual position from the vague note as Paraswadesa; (13) There is Nadi on either side of the genitals. It evidently corresponds to the femoral artery; (14) There is a Nadi on the back of the thigh. Perhaps it refers to the popliteal artery; (15) There is Nadi in the ankle. It occupies 2 fingers breadth below the ankle. It refers to the posterior tibial artery as it lies behind the inner melleolus.

Considering the importance of manuscripts related to sphygmology and their classification, Ghosh may be referred again. According to him, works on sphygmology with short notes on each can be divided into three main groups, namely, (a) works finding a place in the general treatises on Ayurvedic medicine such as Nadipariksha by Sharngadhara and Nadipariksha by

Bhavaprakash etc; (b) works forming independent treatises on sphygmology and (c) compilation works of the present time in printed form. In the present context we mainly restrict ourselves to the works finding a place in the second group of classification. This group contains treatises which treat of the general 'Nadichakra' system (nerve and nerve plexus) fully, in addition to the study of pulse from clinical standpoint. The works are enumerated in an alphabetical order for convenience and they are :

(1) **Nadibheda** : A small manuscript of 34 shlokas, deposited in the library of His Highness the Maharaja of Alwa. The manuscript is interesting from the fact that the pulse characteristics in various conditions have mostly been named after animals, the movements of which the pulses resemble. A short note is given in the beginning on the general Nadi system.

(2) **Nadivijnana** : A small treatise said to have been composed by sage Kanada. There are three printed editions of the work, one from Bombay and the others from Calcutta. The Bombay edition contains explanatory notes in Hindi. The two Calcutta editions were published by Kaviraja Devendra Nath Sen and Gangadhar Kaviraja respectively. The first was in Bengali character. A manuscript was also available from east Bengal. The edition by Gangadhar Kaviraja is very valuable, due to exhaustive explanatory notes and quotations from various authors. The names of Gautam and Vasishtha occur in the notes.

(3) **Nadivijnana or Nadichakra** : A manuscript deposited in Tanjore state library. A copy has also been deposited in the Bangiya Sahitya Parishad. It is a large treatise of twelve chapters and is ascribed to Shiva explaining to Parvati. The data of original script is Sambut 1417. The whole script has been divided into 12 chapters. In the first chapter the means of diagnosis as by touching, asking question and by sight have been mentioned. Second chapter deals mainly with origin of Nadis division into male and female Nadis, description of vital force (Pran Vayu), five main nerve cords and different kinds of respiration. Third chapter deals with longevity of man; number of years ascribed to Vayu, Pitta and Kapha (33 years 4 months of each); position of pulsatile arteries to be felt in several domestic mammals and 3 kinds of bodily derangements. Fourth chapter deals with diagnosis of bodily derange-

ments by pulse examinations, position of pulsatile Nadis for diagnosis of diseases and according to the age of the patient. Fifth chapter describes pulse character in different parts of the day, in different seasons, after partaking of food of different testes (Swad Rasa Sevya Kalah) etc. Sixth chapter deals with pulsatile vessels (Jivanadi) their position and their relation to some bodily conditions.

(4) **Nadigrantha** : A manuscript deposited in private library in the Madras Presidency. It is not available.

(5) **Nadivijnana** : It is a large manuscript on clinical methods deposited in the library of Asiatic Society of Bengal. There are section of which the first section consists of 47 Shlokas and deals with pulse examination. The section on pulse examination is characterised by detailed notes on pulse conditions in relation to unfavourable prognosis and in connection with prediction of death time (passage derived from Ravana). The author mentions the names of Nadin, Trimalla and Ravana.

(6) **Nadipariksha** : There are two works both ascribed to Ravana. One has been printed in Bombay and several manuscripts are available. One has been deposited in the library of Asiatic Society of Bengal. The second work consists of about 25 verses and is also deposited in the same library. The first work gives the name of its author Nandini. The second work gives detailed notes on the time of death as ascribed by the pulse characteristics. These passages are practically identical with those in Nadivijnana of Kanada. The author of Nadiprabodha quotes the same passages from Ravana with recognition.

(7) **Nadipariksha** : A manuscript ascribed to Dattatraya, deposited in the private library in N. W. province. The copy is not available. The name of the author is referred to Nadiprabodha.

(8) **Nadipariksha** : A manuscript by Nandina. It was deposited in some private library in the Bombay Presidency. The copy is not available. The name of the author and many passages from his work are seen in many treatises on pulse examination. A few passages from his work are seen quoted in Nadivijnana. His name is also found mentioned by Ravana.

(9) **Nadipariksha** : A manuscript of 15 verses without authors name and deposited in the Tanjore state library. Most of the verses are identical with those in the Nadipariksha of Sharngadhara Sangraha. The work is available.

(10) **Nadipariksha :** A manuscript by Karkandeya. It is deposited in some private libraries at Ahmedabad, Bombay. The copy is not available.

(11) **Nadipariksha :** A small manuscript of about 28 Shlokas, without authors name and deposited in the Benaras Sanskrit College library. The author refers to Kanada and quotes a few passages from his work. The work is available.

(12) **Nadipariksha Nidana :** A manuscript of about 57 verses without authors name and deposited in the Bangiya Sahitya Parishad. The author quotes passages from Ravana without recognition. The work is available.

(13) **Nadiprabodhan :** A large manuscript by Kapil Mishra dating back to Sambat 1807. It is deposited in the library of the Asiatic Society of Bengal and Bangiya Sahitya Parishad. It is a comprehensive treatise with an excellent arrangement of the subject matter and very useful explanatory notes. The author quotes many passages from various sources, nearly all having gained at the recognition. We get names of Yajnavalka, Agneya, Vasishtha, Mandanya, Gautam, Dattatreya, Ravana, Ramaraja and Sankarsen.

(14) **Nadiprakarana :** A manuscript of about 30 verses, without authors name and deposited in the Asiatic Society of Bengal. The treatise consists of pulse condition in various diseases. It is the only work of its kind. The manuscript is available.

(15) **Nadiprakasha :** A treatise by Sankarsen. It has been printed in Calcutta. Manuscript has been deposited in various parts of India. It is a common treatise used by the students of Ayurvedic medicine in Bengal. The printed book has got explanatory notes in Sanskrit by the author himself. Sankarsen refers Ramaraja.

(16) **Nadipariksha** : A manuscript by Ramaraja. The work is not available. It has been quoted by Sankersen and Kapil Mishra.

(17) **Nadishastrasangraha :** A large manuscript with three chapters, without author's name, deposited in the MGOML. The treatise is ascribed to 8 days who derived the subject as revealed by Shiva to Parvati. The first chapter contains 9 verses and is a sort of introduction. The second chapter consists of 75 verses dealing with 'Nadichakra' system. The third chapter consists of 34 verses dealing with pulse exami-

nation. The last verse gives the name of Kashyapa, Kaushika, Vasishtha, Kumbhasambhava, Bharadwaja and Markandey from whose work the present work was compiled.

(18) **Nadyutpatti** : A manuscript in Telgu script, deposited in Tanjore state library. A copy has been deposited in the Bangiya Sahitya Parishad. The name of the author is Shreeram. It consists of 57 verses (Shlokas) and deals with the 'Nadi-chakra' system more elaborately than the pulse. Other numerous manuscripts are also available but are not being quoted here.

Moreover, it would not be out of place if we quote here the view of Jaggi (1973) to show the oldness of the knowledge of pulse-lore as was practiced and is still being practiced in barbarians–the Santhals. Jaggi in his book "Folk Medicine" has stated that among Santhala, one of the oldest race of India and still barbarian, the knowledge of pulse examination is quite prevalent. Certainly this knowledge is part and parcel of their culture. They mostly believe in devils and damons for the causes of diseases, and by examination of pulse they ascertain which type of devil is responsible for the particular type of disease in a particular person. Not only pulse examination, but also they were and still are acquainted with the knowledge of urine examination to diagnose the diseases. As Jaggi observes "Among the Santhals, after the preliminary enquiry, the medicine-man (Ojha) looks at the face of the patient and asks him to put on his tongue in order to examine it. Then he sits down beside the patient and feels the pulse at his wrist. A good Santhal Ojha is said to be able to distinguish as many as 23 different types of pulse in each of the arms. Interpretation of the pulse tells him the cause of the disease. If the pulse comes towards the thumb, or the index finger, it is a sign that Bongas, the Orak Dongas (that is the house Bongas) or some other Bongas are at work. If the pulse comes towards the middle finger the Abge (a kind of tutelary, but rather, uncertain and feared Bonga) is 'hungry'; if towards the ring or little finger a spirit of the field or of the village out Kirts is at work. The pulse is further supposed to reveal whether the complaint is due to "sudden fright", inflammation, or poison, and so on. On the basis of his diagnosis, the Ojha treats the patient with incantations, Jhar (cleansing) etc. And also "Among the HOS, if the medicine man (Deonwa) finds any difficulty in

coming to a diagnosis, he resorts to Dukidamal, examination of urine. A small quantity of Dukida or urine is brought in a leaf-cup early in the morning by the patient or any of his relations. The deonwa puts a drop of mustard oil on it and studies the reaction carefully. It is from the nature of this reaction that he makes the diagnosis whether the disease is caused by Najom (a sort of poison).

In foregoing pages we have tried to emphasize that the pulse-lore of Ayurveda found its source of origin in the other works of Sanskrit literature and particularly in Tantrik one. After summerising the whole discussion to support the above view, following points may be noted down : (1) Abundence of independent existance of treatises on sphygmology, not merely dealing with the pulse-lore, but also 'Nadichakra' along with the source of origin of Nadis from the structure like tartoise and the others as cited in Tantrika literature; (2) Repeated enumeration of the names of same sages as Kanada, Ravana, Yajnavalkya, Karnik, Gautam etc. of by gone days in some of the treatises on sphygmology leaves no doubt about orientalism of the subject; (3) Moreover citation by Kanada in the verse forty nine of his work that the pulse indicating death within certain limited period is only known by certain intellectuals and the knowledge of it is obtained with great difficulty even in the heaven. Further, utterance that the konwledge should be preserved with great care and not be given to those who are unfit for it, is not only sufficient to prove the oldness of the knowledge of the subject perhaps only known to the sages of India, but also indicates that the knowledge was completely confined to the hands of same sages; (4) In the available works of Kanada and Ravana they have often quoted, "Muneyoh Nadigati Jnaninah", "Manisina", "Purvacaryaihi", "Nadinatatwavedina", "Janiyacchavichakshant", but no where they have mentioned the word like, "Vaidya", contributing the knowledge of the subject to others; (5) The work, "Nadipariksha" of Nandin, one of the Siddhars of ancient time is available and deposited in the private library of Bombay Presidency; (6) The work of Kaviraja Gangadhara on "Nadivijnana" of Kanada is available with exhaustive explanatory notes with enumeration of the names of Gautam and Vasishtha; (7) The work is available in the name of 'Nandivijnana or Nadichakra' and was written in Sambut

1417 or roughly we may say in A. D. 1359 which corresponds to the period a bit later to Sharngadhara; (8) In this connection the independent opinion of Ghosh, derived after vast study of the subject scattered in the other works of Sanskrit as Upanishadas and Tantras, that the "Nadichakra and Nadi system in treatises of sphygmology evolved together side by side in the hands of same sages of by-gone days" can be quoted; (9) The derivation of the idea that in case of male the pulse should be examined of right wrist while in cases of female that of left wrist has been totally derived from idea of Tantrism; (10) Diagnosis made by pulse examination as prevalent among Santhals is also convincing that though the feeling of pulse was not adopted by the scientific world of Ayurveda, but some barbarian races of the time were aware of the knowledge. And they were utilising the knowledge according to their own tradition.

Though according to Jolly (1951), Virsimha (1383) mentions in his work–Virasimhavaloka, the name of Tisatacharya that he has mentioned about pulse examination in his work Chikitsakalika which was composed in 10th century A. D., yet in available Chikitsakalika at present there is no such mentioning.

Further, Jolly and Benjamin Walker giving their own remark say that the pulse feeling perhaps originated among the Arabeans or Persians.

Moreover, it is also clear from the saying of I-tsing (7 A. D.) during his journey in India that the Indian physicians were not able to diagnose the diseases by means of feeling the pulse by that time.

Nadi Pariksha

Among the existing opinion between East and West regarding the source of origin of Indian pulse science, following synthetic views can be offered about the fact, why the Indian physicians before the period of Sharngadhara could not include examination of pulse to their literature : (1) The Indian physicians a little anterior to Sharangadhara were mostly overwhelmed with the idea of greatness and validity of classics of Ayurveda. And they were so stuck to the idea with firm conviction that what had been told therein is the final. And they hesitated to add anything new from without. (2) Most of

them were commentator and redactors. (3) Due to absence of knowledge of pulse examination in the literature, the physicians of the time perhaps had no faith that by, mere examination of the pulse, the diagnosis of diseases could be revealed. (4) During Mohammadan Sultanat, the Indian physicians realised it inevitable to change themselves with the march of the time. They saw that the Hakims were well versed in the knowledge and art of pulse examination. This was not only challenge for Indian physicians, but their conscience was also shaked. And they found that in Tantrik literature there was also mentioning of pulse. Thus they derived their conceptual knowledge from Tantrik literature, whereas they learned the practical knowledge and art of pulse examination from Hakims of Greeko-Arabian medicine.

This fact can be concluded on the ground that (a) A manuscript--Nadivijnana or Nadichakra has been found written in Sambut 1417 i. e. about 1360. This period corresponds more or less to the period of Sharngadhara (b) In Greeko-Arabian system of medicine pulse has not been correlated with the derangement of humour like Sofra and Sauda etc., instead, the temperament or Mizaz and the vital force or Rooh, among others are seen to form the basis of the study of the pulse in ease and disease. Moreover, during examination of the pulse the stomach should be neither overloaded nor altogether empty. In contrary in Ayurveda, the pulse should be examined in the morning hours on empty stomach. (c) The pecularity of Indian pulse is that its various characters have been correlated with the movements of birds, amphibians etc.

Because the knowledge of pulse was first introduced by Sharngadhara and that was too for the physicians of meagre knowledge. That is why the description of Sharngadhara is elementary in knowledge and depicts only the introductory portion of the subject. According to Sharngadhara from this much knowledge of pulse the physician of a meagre knowledge can assess the deranged conditions of Vayu, Pitta and Kapha.

Part Two

Ayurvedic Review : Applied Literature

Chapter III

Pulse from Sharngadhara Onwards

Sharngadhara

History does not reveal the clue as regards the determination of the period when Sharngadhara flourished exactly. But this much is definite that his period may be considered as the post classical period of Indian medicine, and it corresponds to the Muslim period of India. Sartan believes that Sharngadhara flourished not later than the thirteenth century. In the opinion of Jolly he must have flourished at the latest in the thirteenth century B. C. Ray dates him in A. D. 1363. However, among controversies prevailing, it seems improbable to assert the exact period as to when Sharngadhara was at the height of fame. The only compromising way appears to be to assure that he flourished in the terminal phase of thirteenth century. Because Vopadeva, one of the commentators of Sharngadhara Samhita, was well acquainted with the famous minister Hemadri. And the period of Hemadri as Jolly has decided is between A. D. 1260 to A. D. 1309. Sharngadhara's contribution to medicine may be aptly described as the reaction of the classical Indian medicine to internal developments that were slowly taking place between the tenth and the thirteenth century.

Sharngadhara Samhita

Sharngadhara wrote his work on medicine, known as Sharngadhara-Samhita. The work gained considerable authority and a great popularity, so much so, it found a place as the number two in "light–triad" or "laghutrayi". In the words of P. C. Ray (1956) "Its popularity is that it is based upon the Ayurvedas (the Charaka etc.) on the one hand and the Tantrik chemical treatises on the other". This work may be considered as the first standard work of iatro-chemical reforms in India. Adhamala has written commentary on this work which is considered to be very authentic. In the present context it has been consulted for explanatory notes given on various movements of the pulse. Whole of Samhita has been divided into three main parts which comprise of thirty two chapters and 2600 verses.

The first part comprising of seven chapters, deals with weights and measures under two separate standards of units–Kalinga and Magadha, different times for drug administration, the abnormal spread and normalization of Doshas in the body, qualities of medical stuffs, effects of seasons, anatomy, physiology, merits and demerits of dreams etc.

The second part of Samhita has been framed by the union of twelve chapters and deals with the pastes (Awaleha), powders, pills, electuaries (Paka), medicated ghees, liquors (Asava and Arishta), cold preparations (Him), various food preparations like Yawagu etc.

The third part is composed of thirteen chapters and deals with practical methodology of Panchakarma, medical and surgical aspects of treatment, surgical procedures for blood leting and method of cure like snuffing, smoking, oil gargalling, eye fomentation, instillation of eye drops etc.

As regards pulse examination, it has been described in the third chapter of the first part of Samhita. Most of the portion of the chapter is comprising of description on pulse examination; and it is for the first time in the history of Ayurveda that Sharngadhara has included pulse examination in his work as a means of diagnosis.

Pulse Examination

Sharngadhara's description to pulse examination is condensed only in eight verses (Shlokas). First verse of the beginning deals with anatomical position of the artery showing its clinical significance as the pulse. Rest verses deal with fifteen types of pulses which can be categorised as below: (a) pulse in certain physiological states of the body. (b) pulse in certain mental states. (c) pulse in certain pathological states of the body. The points mentioned above can be read in following passages.

As regards anatomical position, the artery found at the root of the thumb (Fig. 2) is evidence of life, and scholars ascertain the healthy state or diseased condition of the body by feeling the movement of it. As regards physiological conditions in a person, who has good hunger and appetite (Diptagni, Kshudha) the pulse is light (Laghwi) to touch, tremulous (Chapala) and fast; and after the satisfaction of hunger (Triptavastha), it becomes steady (Sthira) and in a healthy person the pulse is steady and strong. As regards mental states, in

case of lust (Kama) and anger (Krodha) the pulse is repid; in case of anxiety (Chinta) and fear (Bhaya) it is feeble.

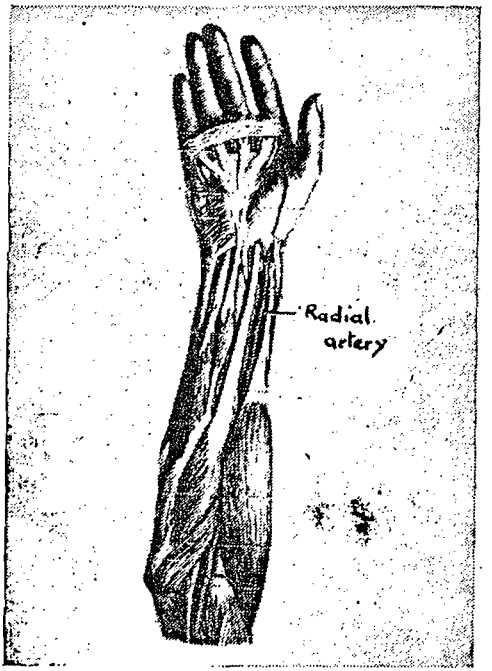


Fig. 2 : Radial Artery.

As regards pathological states, in the condition of poor appetite (Mandagni) and cachexia (Kshinadhatu), the movement of the pulse is slow. In case of profound intoxication (Amadosha), it is heavy (Gurvi) to touch; and when full of blood (Raktapurna) it is heavy and hard to touch and moderately warm (Koshna). In case of fever it is very hot and fast. In case, when the one or the other of the three Doshas and all of them are involved, the movements of the pulse in these conditions are correlated with those of the birds, reptiles and amphibians. Thus, in the case when there is excitement of the Vayu, pulse resembles to the movements of serpent (Sarpa) (Fig. 3) and the leech (Jalauka) i. e. it assumes the curvilinear motion like them. In the case of excitement of the Pitta, its movement resembles to those of the sparrow (Kulinga), crow (Kaka) and the frog (Manduka) (Fig. 4), i. e.

the pulse becomes jumping; when the Kapha is excited the movements of the pulse resemble to those of the swan (Hansa)

Fig. 3 : Snake.

Fig. 4 : Frog.

and the pigeon (Parawata) (Fig. 5), i. e. the pulse moves slowly. In case in which any two of the three Doshas are involved the movements of the pulse is alternately slow and fast. In case in which all the three Doshas are equally involved

(Sannipata) the movement of the pulse resemble to those of the lark (Lava), quail (Varti) and the patridge (Titter) i. e. the pulse becomes speedy (Sottalagati).

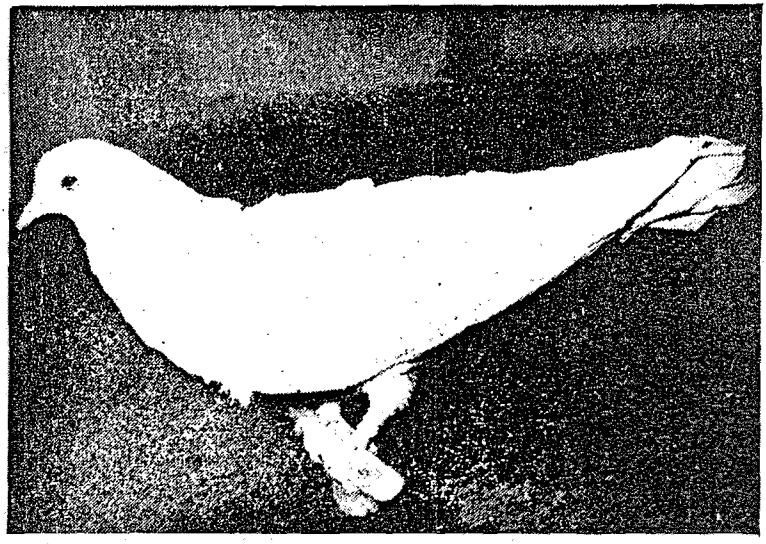


Fig. 5 : Pigeon

When the pulse slips from its normal position (Sthan Vichyuta) or moves slowly and slowly, indicates death. And also, when it becomes very thin like lotus fibre (Bisatantuvata commentary on Atikshina) and cold to touch, indicates death. Various characteristics of pulses described above are given below in table form.

Types of pulse in different conditions	Characteristics of the pulse	Ayurvedic terms	Simile of animals
1. Healthy pulse	Steady and strong.	Sthira and Balawati.	—
2. Good hunger and appetite	Light to touch, tremulous and fast.	Laghwi, Chapala and Vegawati.	—
3. Satisfaction after hunger	Steady	Sthira	—

4. Lust and hunger	Rapid	Vegavaha	—
5. Anxiety and fear	Feeble	Kshina	—
6. Poor appetite and cachexia	Slow	Mandatara	—
7. Intoxication	Heavy	Gurvi	—
8. Full of blood	Full, heavy and tepid to touch	—	—
9. Vatika	Curvilinear	Tiryakagati	Snake and leech.
10. Paittika	Jumping	—	Sparrow, crow and frog.
11. Kaphaja	Slow	—	Swan, pigeon
12. When any two Doshas are in combination (Dwandaja)	Alternately slow and fast.	—	—
13. Sannipatika	Speedy	—	Lark, quail and patridge.
14. Fever	Very hot and fast	—	—
15. Death	Slips from its normal position, slow and thready.	—	—

When summarising the discussion of foregoing pages on pulse examination and comparing it with those written in the later period, we find that the description in Sharngadhara Samhita is elementary, and it was an important attempt in the direction of introducing the knowledge of pulse examination. In other words it does not seek to diagnose the specific diseases, like Atisara, Grahani etc.

Bhavaprakasha

Bhavamishra, according to Jolly flourished in the sixteenth century A. D. He was a famous physician of his time. His work is popularly known as Bhavaprakash.

Bhavaprakasha

One of the authentic work of Ayurvedic literature, occupying a place in "lighter-triad" is divided mainly in three parts (Khanda), namely; first part (Pratham Khanda), middle part (Madhya Khanda) and terminal part (Uttar Khanda). First part is again divided into two sub-parts (Bhagas), first and the second. First sub-part (Bhaga) is composed of six specified sub-divisions (Prakhandas). These sub-divisions deal with the origin of medicine, cosmology (Srishti Utpatti), anatomy, embryology, pediatrics (Kaumarbhritya), dietetics, pharmacology etc. Middle part has been further subdivided into four sub-divisions and deals with the special pathology and the therapy. The terminal part of the book of only eleven pages deals with aphrodisiacs (Vajikarana) and elixirs.

So far as pulse examination is concerned, it has been described in the sixth specified subdivision of the first part under the heading "Rogipariksha", the examination of the patient. Alongwith the pulse, examination of eyes, tongue and urine has also been mentioned.

Pulse Examination

Bhavamishra has condensed his work related to pulse examination in twelve verses. Fifteen types of pulses have been described. The whole of the verses can be read under the following heads : (a) specification of sides for pulse examination in male and female, indication of three fingers to examine it, and unfavourable conditions when it is not examined, (b) relation between the fingers and different positions of Doshas, (c) pulse in physiological conditions of the body, (d) pulse in mental states, (e) pulse in pathological states. The points mentioned above are hereby explained below :

The physician should examine the pulse at the root of the thumb in the left hand in case of female and that of right hand in case of male. By applying three fingers over the pulse during examination, the physician can ascertain the ease and diseased condition of the patient. The pulse should not be examined, when the patient has taken his bath immediately or is thirsty or has come just from the Sun or is tired due to exercise.

As regards relation between different fingers and the positions of the Doshas, Vata when vitiated becomes prominent under the ring finger, the Pi tta under the middle finger and the

Kapha under the ring finger. When Vata and Pitta are at fault together the pulse is appreciated in between index and middle finger, while it is felt in between ring and index finger when Vata and Kapha are deranged. In case of vitiation of Pitta and Kapha the pulse is felt in between middle and ring fingers. And when all of three are equally involved, the pulse is appreciated under all the three fingers.

As regards the physiological conditions, the pulse of healthy person is steady and strong. In case of appetite it is stremulous and is steady after its satisfaction. As regards mental states, it is rapid in lust and anger; while it is feeble in anxiety and fear.

As regards the pathological conditions, the pulse in fever is very hot and fast. In case of loss of appetite and cachexia it is slow. It assumes curvilinear motion when Vata is deranged and is jumping when Pitta is at fault. In the case when Kapha deviates from its normal position, it becomes slow; and when all the three Doshas are at fault the pulse becomes speedy. When Vata and Pitta are at fault together its movement becomes curvilinear and jumping. In the case when Vata and Kapha are at fault, its movement becomes curvilinear and slow. The pulse becomes jumping and slow when there is vitiation of Pitta and Kapha. When the pulse slips from its normal position and becomes slow and extremely feeble and cold to touch, it indicates death. Various characteristics of pulse are given below in table form :

Types of pulse	Characteristics of the pulse	Ayurvedic terms	Simile
1. In health	Steady and strong	Sthira and Balawati	—
2. Appetite	Tremulous	Chapal	—
3. Satisfaction after appetite	Steady	Sthira	—
4. Lust and anger	Fast	Vegavaha	—
5. Anxiety and fear	Feeble	Kshina	—
6. Vatika	Curvilinear motion	Vakragati	—
7. Paittika	Jumping	Utplutya	—

8. Kaphaja	Slow	Mandagati	—
9. Sannipatika	Speedy	Atidrata	—
10. Vata Paittika	Curvilinear and jumping	—	-
11. Vata Kaphaja	Curvilinear and slow	—	—
12. Pitta Kaphaja	Jumping and slow	—	—
13. Fever	Very hot and fast	—	—
14. Poor appetite and cachexia	Slow	—	—
15. Death pulse	Slow, slips from its position extremely feeble and cold to touch	—	—

While summarising the discussion of foregoing pages, we can say that Bhavamishra has added the knowledge after Sharngadhara and they are : (1) Bhavamishra indicates clearly about the use of three fingers namely, index (Tarjani), middle (Madhyama) and the ring (Anamika) for pulse examination. These fingers indicate the condition of Vata, Pitta and Kapha respectively. (2) There is a clear cut indication for specific sites for the examination of pulse in case of female and male. (3) Bhavamishra has not correlated various movements of pulse with those of birds, reptiles and amphibians, but has only mentioned the different types of movements such as Vegawati, Mandagati etc. experienced directly under the fingers. And thus he has made the subject more objective and practicable. (4) Bhavamishra has analysed different characteristics of pulse produced by combination of any two of the three Doshas. (5) He has omitted out certain types of pulses as full of blood, auto-intoxication (Amadosha) and good hunger (Diptagni). In describing qualitative forms of pulses in the conditions of poor appetite (Mandagni), fever (Jwara), cachexia (Kshinadhatu), appetite (Kshudha), satisfaction after appetite (Triptawastha), lust (Kama), anger (Krodha), anxiety (Chinta), fear (Bhaya) and healthy condition (Swasthawastha), Bhavamishra has practically followed Sharngadhara.

Yogaratnakara

The name of the author of this work is unknown. The period when it was composed, faces various controversies. According to P. K. Gode its period lies between 1650 A. D. and 1725 A. D. According to Jolly this work should have been composed not later than 1746. In the opinion of Singh, its period is 1676. However, since the work quotes Nirnayasindhu (1611) and Bhavaprakash (16th century), therefore it is certain that the work must have been composed after Bhavaprakash. And on the ground of the above date, its period can presumably be placed about in the middle part of the eighteenth century.

Among the existing works related to Ayurvedic medicine, Yogaratnakar occupies one of its position. The work can broadly be divided into two major parts namely, the first part (Purvardha), and the second part (Uttarkhanda). The work deals with four necessary elements (Padchatushtaya), as physician, drugs, nursing staffs and the patient; different regimens to be followed up in the day, night and seasons. Besides, there is description of drug preparations like liquors, paste, medicated ghees etc. And also there is enumeration of different metals and the process of their calcification. There is description also about dietetics, Other means of diagnosis such as stool, urine, eye etc. are also indicated.

So far as description about pulse examination as means of diagnosis is concerned, it has been described in the first chapter of the book under the heading "Rogipariksha" examination of the patient.

Pulse Examination

Description of pulse in Yogaratnakara is condensed within forty eight verses. Thirty three varieties of pulses are of clinical importance, among which fourteen types are completely devoted to described bad prognosis and death. One type indicates good prognosis. Eighteen varieties deal with the characteristics of pulses in some physiological and other general pathological conditions. The whole pulse-lore can be considered under the following heads : (a) Indication sides and the method of pulse examination. (b) Pulse in physiological conditions and mental states. (c) Pulse in pathological conditions. (d) Pulse indi-

cating bad prognosis. (e) Miscellaneous descriptions related to pulse.

(A) Indication of Sites and Methods of Pulse Examination :

Physician after attaining himself the state of mental stability and peace of soul and mind, should examine by his right hand the pulse below the left thumb in case of female and that below the right thumb in case of male. Particularly in case of female, the physician is advised to examine also the pulse of left leg by applying the knowledge gained from the classical literature, tradition and self experience. The pulse below the thumb detects the ease and diseased conditions of the patient.

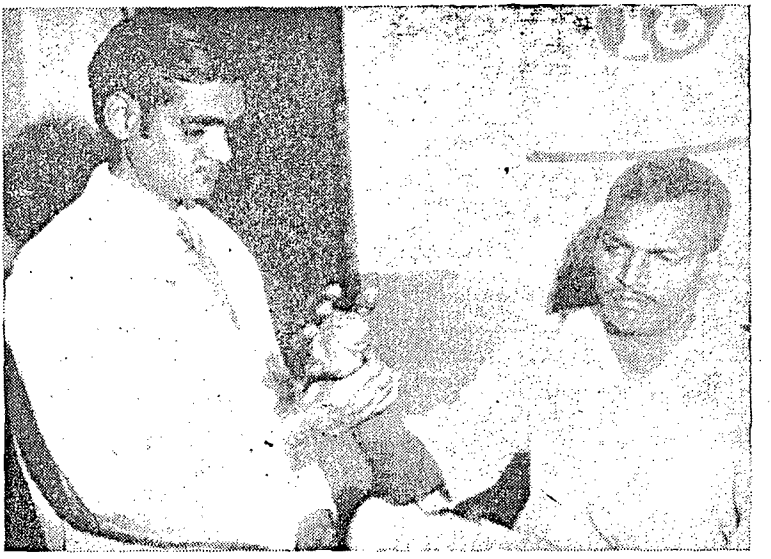


Fig. 6 : Ayurvedic Method of Pulse Examination.

As regards methodology and allied aspects of pulse examination, first the elbow (Kurpar) of patient should be slightly flexed to the left and the wrist slightly bent to the left with the fingers distended and dispersed (Fig. 6). In this position the physician should examine the pulse in the first three hours (Aik Prahar) of the morning. Physician after attaining concentration of mind should examine himself the pulse repeatedly for three times by giving and releasing the pressure alternately over it. By this procedure he should decide the condition of Doshas in

their respective places and the conditions of the pulse whether the pulse is slow, medium or fast; and also whether they are involved singly, or in combination of the two or all of the three are at fault together. This way the physician may be able to know the good and the bad prognosis of the patient. The pulse should not be examined just after the bath, in hungry or thirsty states or during sleep and just after awakening and the patient has anointed with oil. Repeated practice of pulse examination makes the physician perfect in the art and science of it.

(B) Pulse in Physiological Conditions and Mental States :

Good hunger	—Fast and light	—Vegavati and Laghwi.
Appetite	—Tremulous	—Chapala
Satisfaction after appetite	—Steady	—Sthira
Lust (Kama)	—Fast	—
Anger (Krodha)	—Fast	—
Anxiety (Chinta)	—Feeble	—Kshina
Fear (Bhaya)	—Feeble	—Kshina

(C) Pulse in General Pathological States :

Various characteristics of pulse in these conditions can be given in the table form :

Types of pulse	Characteristics of pulse	Simile to movement of animals	Relation to fingers
1. Vatika	—	Snake and leech.	Index finger.
2. Paittika	—	Crow, lark and frog	Middle finger.
3. Kaphaja	—	Swan, pigeon, cock.	Ring finger.
4. Vata-Paittika	—	Snake and frog	—
5. Vata-Kaphaja	—	Snake and swan	—
6. Pitta-Kaphaja	—	Monkey and swan	—
7. Sannipatika	—	Moves very fast with intermittent pause, like	—

		the acts of wood-pecker (Kastha-kutta) when cutting the wood.	
8. Fever	Very hot and fast.	—	—
9. When carrying flesh (Mansyaha)	Heavy	—	—
10. Poor appetite and cachexia	Slow	—	—
11. Full of blood. (Raktapurna)	Heavy and hot.	—	—
12. Auto-intoxication	Heavy	—	—
13. Vatika fever	Curvilinear and tremulous and cold.	—	—
14. Kaphaja fever	Slow, steady, cold and slimy (Picchila)	—	—
15. Kapha Pitta fever	Fast; long and simple	—	—
16. Vata Paittika fever	Curvilinear, a bit tremulous and hard.	—	—
17. Vata Kaphaj fever	Slow and slightly.	—	—
18. Pittakaphaja fever	Weak, steady and cold.	—	—

(D) Pulse Indicating Bad Prognosis :

Periods indicating death.	Characteristics of the pulse
1. Death within three hours.	Pulse moves like fringe of shawl, coinciding with respiration, and cold.
2. Death within a day	Pulse appears and disappears alternately and moves like drum which is shaped like an hour glass (Damaru).

3. Death within two days.	Pulse carrying excessive amount of metabolites and cold to touch indicates death within two days.
4. Death within three days	Pulse not felt at the proximal end, cold in the middle and appears tired at the terminal part.
5. Death within seven days	Pulse becomes speedy at the proximal end, sometimes cold and sweaty and slimy skin, indicates death within seven days.
6. Death within fifteen days.	Pulse is hot, fast and the body is cold and patient takes mouth breath.
7. Patient nearly dead.	Pulse extremely weak, runs very fast and cold.
8. Sudden death.	Pulse adopts curvilinear motion like that of lightning and alternately appears and disappears. Pulse with intermittent pause indicates bad prognosis. Slow, tremulous with intermittent pause, weak, visible sometimes in the finger, indicates death. It is a Sannipatika pulse. Pulse first Vatika, then Paittika and then Kaphaja, and assumes the circular movement and horrible, weak, and disappers from its place, indicates bad prognosis. Pulse excessively tremulous, too much jumping appearing beneath the fingers indicates bad prognosis. The pulse which is amalgum of the three Doshas, indicates bad prognosis. Pulse, moves Zigzag (Tiryaka) and also like snake, hot and fast and the throat of the patient is full of cough, indicates death.
9. Pulse indicating good prognosis.	The pulse moves like swan and elephant and the patient is happy. If the pulse beats 30 times in its place in one "Man" the patient shall survive otherwise not.

(E) Miscellaneous Descriptions Related to Pulse :

In hyperbolic language just to give emphasis on the importance of the pulse examination, it has been cited that as the

instrument made of by the union of fine wires (Sitar) emits out the various melodic tunes when it is striked, similarly the pulse of the hand is sufficiently able to tell the various diseases of the body. Therefore, the pulse should be examined by the physician to know the condition of deranged Doshas in beginning and the end. And the physician is also advised to examine the pulse first, and subsequently eyes, tongue and urine, and then treat the diseases accordingly. The physician who does not follow this rule, kills the patient and gains bad reputation. In pulse specific places for gods have been alloted, as Vata for Brahma, Pitta for Shankar and Kapha for Vishnu. Different synonyms of 'Nadi' have also been enumerated in the work e. g. Dhamini, Tantuki, Jivitajna, Dhara, Hinsra, Snayu.

Thus in describing pulse examination, Yogaratnakar enumerates certain more points of importance than its previous works as Sharngadhara-Samhita and Bhavaprakash. First, there is indication that besides examining left hand in case of female, stress has also been given to examine the pulse of the left leg in this case. Secondly, he has clearly mentioned the importance of mental peace to reach at the diagnosis accurately by exmining the pulse. Thirdly, there is mentioning of detailed anatomical position of the forearm including wrist during pulse examination. Fourth, there is indication of the fixed time when pulse should only be examined. Fifth, there is description of quantitative form of the pulse as thirty times. Sixth, there is indication to examine the pulse repeatedly for three times in the same period. Seventh, the work advocates for the practice of pulse examination as much as it can be to get the mastery over the science. Eighth, there is clear cut indication of acquiring the knowledge by self experience. This is indicative of that the knowledge of pulse examination can only be achieved by constant practice and applying one's own thinking. Ninth, there is enumeration of greater numbers of pulses indicating bad prognosis and death. Ofcourse, the work does not mention about the pulse of a healthy person. In the end there is instruction to the physician to wash his hand after examining the patient.

Nadivijnana by Kanada

No data is available as to decide when Kanada came into existance. The period is buried in oblivion. But on the ground

of internal evidences, one can dare to say that he was a Tantrik. Kanada's whole pulse-lore is ascribed to one hundred and sixteen verses. And they can broadly be divided into the followings : (a) General consideration of origin of 'Nadi' and examination of pulse (b) Characteristics of pulse after taking different kinds of foodstuffs. (c) Characteristics of pulse in physiological condition. (d) Pulse in mental states. (e) Pulse as a prodromal symptoms. (f) Pulse in general pathological conditions and diseases. (g) Pulse indicating bad prognosis. (h) Pulse characteristics though appearing apparently of bad prognosis but really not so. (i) Pulse of good prognosis.

(A) General Consideration of Origin of Nadi and Examination of Pulse :

There are three and half crores of Nadis, thick and thin in nature lying in the body. They are tied in the region of umbilicus (Nabhi Pradesh) from where they spread obliquely, downwards and the upwards. Again, seventy two thousands of them are thick and are attributed to convey the essential elements of five sense organs. These are known as arteries (Dhamani). Among these arteries again there are seven hundred veins (Sira), which are hollow inside and contain countless microscopic pores which poure out the essential constituents of food required to the body. And also, these veins having been spread in every directions in the body tie the whole body like a drum (Mridanga)—a musical instrument. The other description for the origin of Nadis is, that in the region of umbilicus there lies structure like tortoise whose head is to the left, the left hand and the left leg above, the right hand and the right leg downwards, and the tail to the right side of the body. From this structure the whole Nadis take their origin. His mouth, tail, hands and feet are also the seats of origin of Nadis. Two from his mouth, two from his tail and five from his hands and feet separately take their origin. Thus they form twenty four in total number.

Regarding pulse examination it has been described that among seven hundred veins, only twenty four are quite prominent. And again, out of these twenty four only one, which spreads in the right hand and the right leg, should be examined. In the morning after being free from his daily routine, the physician should examine the pulse. In addition to pulse examina-

tion of right hand and left hand, there is clear-cut indication that particularly just to ascertain the expectancy of life of the patient, the pulse of right leg and in case of female of left leg, must also be examined.

During examination, the physician should rub slowly with his left hand the portion of the elbow of the patient, where the artery lies and becomes prominent. Again, putting the three fingers of his right hand at the root of the thumb of the patient, examine the pulse of Vata and the other Doshas. The pulse of Vata is felt at the proximal end, i. e. under the index finger and that of Pitta and Kapha is felt in the middle and the end i. e. under the middle finger and ring finger respectively. There is also mentioning that Pitta occupies the middle position while the Vata lies in the end. The pulse at the root of the thumb is evidence of life. The pulse should not be examined when the patient has taken his meals or has anointed with oil or is sleeping. Normally, the pulse is smooth in the morning, hot in the noon and the fast in the evening.

(B) Characteristics of Pulse After Taking Different Foodstuffs :

Different foods	Characteristics of pulse	Verse No.
1. Oil, molasses and substances like molasses.	Strong (Pushta)	62
2. Meat	Lika rod steady (Lagudakriti, Sthir)	62,76
3. Sweet food	Jumping like frog.	62
4. Banana,Molasses cake prepared from pulses etc. dry foods & meat	Sometimes curvilinear. sometimes jumping, resembles the pulse of Vata Pitta but maintain no order.	63,77
5. Parched grain, flattened rice.	Steady and slow (Sthira and Mandatar)	74
6. Gourd (Kushmanda) Radish (Muli).	Slow (Mand)	75
7. Green leaves stems roots	Resembles the movement of the pulse filled with blood.	75
8. Molasses, cakes, milk.	Steady and slow (Sthir and Mand)	76

9. Liquids	Hard (Kathin)	73
10. Solids	Soft	73
11. Frozen	Sometimes hard and sometimes soft	73
12. Sweet taste	Resembles the movement of peacock	64
13. Bitter taste	Moves like earthworm	64
14. Acid taste	Slightly hot and jumping, cold	64,74
15. Pungent (Katu)	Resembles the movement of sparrow	64
16. Astringent	Hard and tight (Jada)	65
17. Salt	Straight (Sarala) and rapid	65
18. Mixture of all	*Multiple movements*	65

(C) Characteristics of Pulse in Physiological Conditions :

Types of pulse	Characteristics of pulse	Verse No.
1. Healthy pulse	Steady (Sthir)	104
2. Good hunger	Light and fast	106
3. Appetite	Tremulous	104
4. After sexual enjoyment	Hot like flame of a candle	84
5. In the morning	Smooth (Snigdha)	79
6. In the noon	Hot	79
7. In the evening	Fast	79
8. In the night	Less prominant than day time	79
9. In normal condition of Vata	Uniform, fine, steady and slow (Samya, Sukshma, Sthira and Manda).	85
10. In Bravery	Moves like pigeon	114

(D) Pulse in Mental States :

Types of pulse	Characteristics of pulse	Verse No.
1. Lust	Fast (Vegawati)	93
2. Anger	Fast (Vegawati)	93
3. Anxiety	Feeble (Kshina)	93
4. Fear	Feeble (Kshina)	93
5. Agitated condition, anger, fear, anxiety and giddiness.	Feeble (Kshina)	97

(E) Pulse as Prodromal Symptom :

Types of pulse	Characteristics of pulse	Verse No.
1. Lassitude and slight pain in the body when fever is to occur.	Slow and jumping	80
2. If fever is about to increase	Jumping forcibly	80
3. Sannipata	Miscellaneous movements	81

(F) Pulse in General Pathological Conditions and Disease :

Types of pulse	Characteristics of pulse	Verse No.
1. Vatika	Curvilinear motion	22
2. Paittika	Tremulous	22
3. Kaphaja	Slow	23
4. Vata Paittika	Moves sometimes like snake and sometimes like frog.	24
5. Vata Kaphaja	Sometimes like swan and sometimes like snake	25
6. Pitta Kaphaja	Weak, cold and steady	26, 27
7. Sannipatika	Slow and fast alternately	29
8. Fever	Very hot and fast	82
9. Vatika fever	Curvilinear	83
10. When Vata is excessively predominating.	Thick (Sthul), hard (Kathin) and very fast.	85
11. Paittika fever	Straight (Saral), long (Dirgh), beating rapidly.	86
12. Paittika fever associated with excess metabolites	Hard, as if the pulse come out of the skin.	86
13. Paittika fever when metabolites are reducing gradually.	Light and beats rapidly.	86
14. Kaphaja fever	Very fine to touch like thread and slow.	87

29. Patient of fever when takes Kanjee and sour substances.	Slow and hot.	100
30. Exercise, anxiety, grief and just after recovery from fever.	Pulse assumes miscellaneous movements.	101
31. Indiges tion	Hard and tight (Kathin and Jada)	102
32. After recovery from indigestion.	Slow and light (Pushtihina), light, soft and fast.	102, 103
33. Full of blood	Tepid and heavy	103
34. Autointoxication (Sam)	Heavy	103
35. Poor appetite	Slow	104
36. Cachexia	Slow, moves like swan	104
37. When the stomach loaded excessively with good qualities of food.	Moves like hood of a snake	105
38. Grahani (Malabsorption)	In the leg moves like swan i. e. slow, but in the hand like frog i. e. jumping.	107
39. In more advanced stage of Grahani.	Feeble, very slow felt beneath the fingers with great difficulty	108
40. Atisar (chronic diarrhoea)	Weak, feeble and slow	108
41. Bilambika	Mostly weak but sometimes jumping.	108
42. Amatisar (Dysentry)	Thick (Prithula) and tight or rigid (Jada).	108
43. Voluntarily retention of urine and stool.	The Dosha which predominates during this stage, leads the movement of the pulse.	109

44. Cholera and gastro-interitis.	Jumping like frog.	109
45. Anaha (abdominal distention) and urethritis (Mutrakrichha).	Heavy	110
46. Vishtambha	Curvilinear	113
47. When Vata predominates in Vishtambha and Gulma.	Pulse assumes curvilinear motion and appears as if it is displaced from its original place.	113
48. Pain due to Vata	Always curvilinear	111
49. Pain due to Pitta	Hot	111
50. Pain associated with the distention of abdomen (Adhman).	Strong (Pushtirupa)	111
51. Diabetic conditions.	Beaded	112
52. Diabetes associated with autointoxication.	A bit hot.	112
53. Abscess when not filled with pus etc.	Paittika i. e. jumping	115
54. Fistula	Hot and curvilinear	115
55. After vomiting beaten with stone or after extraction of spear etc.	Slow like swan's movement.	116
56. Pulse in poison	Jumping	113

(G) Pulse Indicating Bad Prognosis :

Types of pulse	Characteristics of pulse	Verse No.
1. When all the three Doshas are at fault at the same time.	Slow, tremulous, steady, very feeble (imperceptible), disappering form its place and reappearing is due to derangement of all the three Doshas at a time and indicates unfavourable condition of the patient.	30
2. When all the three Doshas are at fault at the same time.	Pulse looking quite prominent very slow, thick like rod, feeble, moves obliquely is due to derangement of all the three Doshas at a time and is indicative of unfavourable condition.	31
3. When all the three Doshas are at fault at the same time.	When the body is too hot and the pulse is cold and vice versa, and the pulse assumes the miscellaneous movements, the death is certain.	32
	Sometimes jumping like Paittika pulse, sometimes curvilinear like Vatika pulse and sometimes slow like Kaphaja pulse and when sometimes beneath the index finger, sometimes beneath the middle finger and sometimes beneath the ring finger, i. e. assumes the circular motion, the pulse indicates unfavourable condition.	34
4. Death in one day.	Beats very rapidly and stops suddenly, like the movement of large black bee.	39
	The pulse appears beneath the index finger like flash of lightning after intervals, causes death within a day.	41
5. Death within	The pulse impinges two finger's	43

half and an hour (Ardha Prahar).	breadth below from the root of the thumb.	
6. Death within four and half an hour (Dedh Prahar)	The pulse runs in straight line one finger's breadth below from the thumb.	44
7. Death within four and half an hour (Dedh Prahar).	The pulse runs in straight line one finger's breadth below from the thumb.	44
8. Death within eighteen hour (Six Prahar)	The pulse appears merely like a streak two finger's breadth below the rest of the thumb and more often disappears.	45
9. Death within 36 hours (Twelve Prahar)	Pulse, when for the most period in most does not appear at the root of the thumb and sometimes appears feeble and sometimes strong is indicative that the patient will die within 36 hours.	40
10. Death within three days.	If the pulse appears $1\frac{1}{4}$ finger's breadth below the root of the thumb, indicates death within three days.	46
	When the patient suffering from derangement of the three Doshas at a time and is restless due to temperature and the pulse is cold, he will die within 3 days.	37
11. Death within four days.	The pulses of both the legs and the wrist are felt beneath the index finger only.	38
	The pulse runs with temperature $1\frac{1}{4}$ finger's breadth below the root of the thumb.	
12. Death within five days.	The pulse moves very slowly $1\frac{1}{4}$ finger's breadth below the root of the thumb.	48
13. Death within seven days.	The pulse beats rapidly for a period and suddenly disappears and	

	if there is no swelling in the body, the patient will die within seven days.	
13. Death within one month.	If chronically ill patient becomes extremely cachexic or fatty and if his pulse is thin and smooth like earthworm moves slowly in Zigzagway and in case when the pulse is thick and hard like snake and becomes imperceptible after its fast and curvilinear motion, the patient will die within one month.	35

(H) Pulse Characteristics though Appearing Apparently of Bad Prognosis but Really not so :

Types of pulse	Characteristics of pulse	Verse No.
Pulse apparently of bad prognosis	Always due to habit of carrying load, fainting, fear and grief, if the pulse becomes fine or appears after every long pause, the man still survives.	50
	Due to fall injury, plastering of fractured bone, diarrhoea and maximum loss of semen, it the pulse does not appear, if does not indicate death.	51
	When the man is captured by evil spirit etc. and the pulse mimic the picture of derangement of the three Doshas at a time, is does not indicate that the patient will die.	52
	In grief, being victim of severe cold or in case when one falls from the height or jumps to a height, if the pulse does not beat it indicate that the man will survive.	54

	In case when Pitta is deranged maximum in comparison to Vata and Kapha, the pulse of Pitta appears first and runs more vigorously than that of Vata and Kapha. In such condition one should not be mislead that all the three Doshas are at fault at a time, and treat the case for excessive derangement of Pitta.	75
	As long as the pulse impinges at the root of the thumb, the patient will survive inspite of all the grave symptoms whatsoever may be.	56

(I) Pulse of Good Prognosis :

Types of pulse	Characteristics of pulse	Verse No.
Good prognosis	If the pulse is quite thin appearing like thread but does not leave its original position i. e. it beats just below the thumb, it indicates good prognosis, if the patient is treated properly.	57
	When the pulse resumes its normal position in relation to its time etc., it indicates good prognosis.	60
	When the characters of the pulse coincide with the orders of accumulation, vitiation and normalization of Doshas, the disease is durable and it is indication of good prognosis.	61
	Pulse is clear, soft, beats in its normal position, being neither fast nor excessively slow.	58

Giving concluding remark about the work of Kanada, it can be said that it is independent work on sphygmology which has the following characteristics : (I) There is indication that before the examination of pulse at the root of the thumb, the

pulse found at the elbow joint should be rubbed lightly. (2) Varieties of pulses have been described after taking of food-stuffs of different qualities. (3) A good number of diseases to be diagnosed by means of pulse have been enumerated. (4) Similarly various types of pulses have also been mentioned to assess the prognosis of the patient. (5) Different types of pulses which apparently appears clinically to be of serious type may be misleading, but really are not so have also been cited. (6) Four different types of pulses indicating good prognosis are also found in the work. (7) The important thing to be worth recording is that work mentions differently in verse eighteen about the traditional change regarding location of Vata, Pitta and Kapha. The Pitta occupies the uppermost position, the Kapha in the middle whilst the Vata is felt in the terminal part from about downwards respectively.

Nadi-Pariksha by Ravana

Like Kanada, the period of Ravana is also in dark. And yet, no data are available, when he flourished. Ravana in his treatise "Nadi-Pariksha" has mentioned the name of 'Nandin' the one of the oldest Siddhars of the South, and who was well versed in the knowledge of pulse examination. Ravana was a Tantrik. It is proved by his some verses and the style in which these verses have been cited. For example, in the verse eighty nine besides other things, there is description also that when the patient does only breath through the left side of the nose, and does breath through the right one, it is one of the indicatives that the patient is nearly died. In Yogik language or so to say in Tantrik language two sides of the nose through which one inhales are known as "Dahina Swara", and the "Vayan Swara".

Nadi-Pariksha

The whole treatise is attributed to pulse examination, "Nadi-Pariksha". And all the descriptions related to pulse examination are condensed within ninety six verses; which for convenience can be studied in the following heads : (a) General description. (b) Pulse, after taking certain diets. (c) Pulse in certain physiological conditions. (d) Pulse in certain mental states. (e) Pulse in general pathological conditions and diseases (f) Pulse in prognosis.

(A) General Description :

It includes the enumeration of other means of diagnosis in addition to pulse; the anatomical description of the artery to be examined as pulse selection of sites related to both sexes and the method of examination; the positions of the Doshas, and their relations to the fingers; these can be read in the following passages.

In the very beginning in the verse second, other than pulse examination, have been mentioned to examine the given patient. They are urine, stool, tongue, sound, touch, eyes and countenence. So far as, pulse is concerned, in the next verse emphasis has been laid upon its importance, and has been cited that as the light of a candle helps in recognising the materials lying in the dark, likewise with the help of the pulse, various conditions of Doshas, whether they are deranged singly or in combination of any two or all of the three are involved at the same time, can be elicited out.

In the next verse, in describing the anatomical position of the pulse (Nadi) name of Nandin and the reference of the veterans of the subject of remote past have been given. Quoting Nandin, Ravana says that according to him among other Nadis at the wrist, there exists a Nadi at the root of the thumb which is evidence of life, and particularly it should be examined to know the conditions of the body.

As regards method of pulse examination, the pulse lying one finger in breadth below from the root of the thumb should be examined carefully. The artery at the root of the thumb is evidence of life and by examining it, the physician can know the ease and diseased conditions of the body. In case of female the pulse of the left hand and that of the left leg, and in case of male that of the right hand and the right leg should be examined. And in the leg one finger below the great toe and also below the malleoli towards the side of the great toe, the pulse should be examined. Further, supporting with his left hand to the elbow of the patient's hand to be examined, the physician should press the artery lightly with his three fingers and examine it by applying his knowledge gained from the classical literature of the subject, tradition and his self-experience.

As regards the relation between the positions of Doshas to that of the fingers, the condition of the Vata is detected under

the index finger and that of Pitta and Kapha under the middle and the ring fingers of the physician respectively. In Vata Paittika condition the pulse is felt under the index and the middle fingers. In Vata Kaphaja condition the pulse is felt under index and the ring fingers. And in the condition of Pitta Kaphaja the pulse is felt under middle and the ring fingers. In Sannipatika condition the pulse is felt under all the three fingers.

(B) Pulse in Physiological Conditions :

The pulse indicating no abnormality moves towards the thumb and appears to be equally moving. Other varieties of physiological pulse are given in the table form.

Types of pulse	Characteristics of the pulse	Verse No.
1. Vayu in its normal place	Slightly tremulous.	39
2. Pitta in its normal place	Strong, straight (Saral) and tremulous.	39
3. Kapha in its normal place	Feeble but prominent and cold to touch.	39
4. When Vayu is in normal condition.	Soft, feeble, steady and slow.	42
5. When Vata and Pitta in normal condition	A bit tremulous, curvilinear and hard.	42
6. When Kapha and Vata are in combination and in normal condition.	Thick (Sthula), tremulous, cold to touch and slow.	43
7. When Pitta and Kapha are in combination and in normal condition.	Feeble, cold to touch and steady.	43
8. Healthy pulse	Steady and strong.	27
9. Good hunger	Light and fast.	27
10. Appetite	Tremulous	28

11. Satisfaction after hunger and appetite	Steady	28
12. Pregnancy	Heavy and Vatika pulse	34
13. Matured pregnancy	The light and heavy conditions of Vatika and Paittika pulse	34
14. Dead foetus	Paittika pulse and light	34
15. During sleep	Strong, prominent and slow	38, 47
16. In Wet condition.	Feeble and slow.	38
17. Forceful laughing	Pulse does not become prominent	35
18. After exercise	Pulse does not become prominent	35
19. Nocturnal emission (loss of semen)	Fine like thread and moves fast	49
20. In winter	Pulse moves like a leech	61
21. Desire for sex and after its satisfaction.	Curvilinear motion like vatika pulse	46
22. After describing certain course	Curvilinear motion like Vatika pulse.	46
23. Due to voluntary control of urges of micturition etc.	Pulse resembles the character of Paittika pulse.	46, 47
24. Pulse of infants	Paittika in nature	46, 47
25. Getting a thorn pierced.	Paittika in nature	46, 47
26. Pulse of a fatty person and after meals.	Slow, Kaphaja in nature	47

(C) Pulse in Mental States :

Types of pulse	Characteristics of pulse	Verse No.
1. Lust	Hot and fast	24
2. Agitated condition	Hot and fast	24

3. Anxiety	Feeble	24
4. Fear	Feeble	24

(D) Effect of Diet on Pulse :

Types of pulse	Characteristics of pulse	Verse No.
1. Flesh	Heavy to touch	36
2. Pungent and bitter	Tremulous due to excess of Pitta.	44
3. Dry foods causing vitiation of Vata	Rough (Ruksha) and beaded.	44

(E) Pulse in General Pathological Conditions and Diseases :

Types of pulse	Characteristics of pulse	Simile of the movements of the animals	Verse No.
1. Vatika	Assumes curvelinear	Snake and leech	
2. Paittika	Tremulous and jumping vigorously.	Crow and frog	15, 17, 40
3. Kaphaja	Steady and slow; straight (Sarala); fine like thread and moves slowly and cold to touch.	Swan and pigeon	15, 16 40, 45
4. Vata Paittika Vata Kaphaja, and Pitta Kaphaja.	Sometimes fast and sometimes slow.	—	58
5. Sannipatika	Combining movement of all the three Doshas.	Patridge and lark	16, 18
6. In reduced ratio of Kapha	Moves like Vatika pulse.	—	41
7. In reduced ratio of Pitta and Vata and excess of Kapha.	Beats after every pause.	—	41

8. Full of Kapha but without auto-intoxication (Niram)	Fine (Sukshma)	—	50
9. Vata paittika pulse when light food is taken.	Slow (Manda)	—	51
10. Pulse with cold.	Very fine like thread, slow and cold to touch.	—	50
11. Hot blooded pulse.	Jumping	—	51
12. Cachexia	Very slow (Mandatar)	—	25
13. Poor appetite	Very slow	—	25
14. Auto-intoxication (Sama)	Heavy (Gurvee)	—	26
15. Indigestion	Hard and tight (Kathina and Jada)	—	29
16. Rasajirna	Tremulous, long (Chapala and Dirgh)	—	29
17. Improper metabolism of Rasa	Smooth, causing fainting.	—	31
18. Incomplete metabolism of metabolites (Malajirna)	Uniform and feeble	—	48
19. Residue left after incomplete metabolism of metabolites (Malashesha).	Irregular, hard and heavy (Visham, Kathin and Sthula)	—	48
20. Full of blood	Hot and heavy	—	26
21. Excess of flesh (Mansvriddhi)	Assumes the character of fever and chronic diarrhoea.	—	
22. Full of blood indigestion, vomiting, diarrhoea, noctu-	Pulse appears like thread and feeble.	—	49

rnal emission, loss of blood, dizziness, poor appetite.			
23. In blood disorder.	Long, perceptible under all the three fingers and fast.	—	52
24. Fever	Hot and fast	—	
25. Fever of sudden onset and intermittent fever.	First slow becoming gradually forceful, indicates sudden fever and chill.	—	56
26. Fever due to evil spirit.	Not detected by pulse	—	56
27. Vatika fever.	Curvilinear and tremulous, relatively cold to touch (Vakra and Chapal).	—	53
28. Paittika fever.	Fast, straight and long (Druta, Saral and Dirgh).	—	53
29. Kaphaja fever.	Slow, steady, slimmy and cold (Mand, Susthir and Picchil).	—	54
30. When metabolites are reduced in Paittika fever.	Fast	—	54
31. When excessive Vata.	Thick and hard (Sthul and Kathin).	—	55
32. Internal fever	Pulse is too hot but body is cold.	—	95
33. Diabetes, Piles and excess metabolites.	Beats rapidly.	—	33
34. Piles.	Steady and slow and sometimes curvilinear and straight.	—	61
35. Grahani (Malabsorption)	Like a dead snake (quote slow and feeble).	—	62

36. Excess deposition of flesh (Mansa Vriddhi)	Pulse assumes the character of fever and chronic diarrhoea.	—	62
37. Rakta Pitta	Slow, hard and straight (Mand, Kathin and Riju).	—	59
38. Kaphaja Kasa (cough predominated by Kapha).	Steady and slow (Sthir and Manda).	—	59
39. Asthma (Shwasa)	Fast (Tibra)		59
40. Tuberculosis	Moves slowly	Elephant	60
41. Madatyaya	Fine, hard and tight (*Sukshma, Kathin* and Jad).	—	60
42. Chronic diarrhoea (Atisara)	Slow.	—	61
43. Dribllling of urine (Mutraghata)	Jumping	—	63
44. Diarrhoea	Jumping	—	63
45. Diabetes (Prameha)	Fine, tight and beats increases repeatedly (Sukshma & Jad).	—	63
46. Anaemia (Pandu)	Fast, sometimes visible sometimes not.	—	64
47. Leprosy	Hard and steady (Kathin and Sthir).	—	64
48. Disease related to blood.	Pulse in both the hands appears hard and hot (Kathin & Soshna)	—	67
49. Vatika diseases.	Steady (Sthir)	—	65
50. Vata when covered by Pitta.	Like Pitta etc. the pulse is associated with all the symptoms.	—	65
51. In Kaphaja diseases	Fine and fast (Sukshma and Drut)	—	65

52. Sannipatik diseases.	Moving very fast for certain beatings and stops suddenly and repeats the same process again and again.	Wood peaker	76
53. Diseases of hand and neck.	The disease should be diagnosed with the help of pulse by keeping into the mind the Doshas involved and their intensity.	—	66

(F) Pulse Indicating Bad Prognosis :

Types of pulse	Characteristics of pulse	Verse No.
Bad prognosis	Sometimes slow, sometimes fast, sometimes jerky, sometimes fine and sometimes quite slow indicates bad prognosis.	20
	If the pulse is distinctly visible on the surface and very fast and is clammy indicates bad prognosis.	21
	Pulse sometimes cold, sometimes hot and sometimes quite feeble and again fast, indicates bad prognosis.	68
	Cold, clammy and fast.	68
	Jerky movement indicates bad prognosis.	69
	Extremely feeble and cold.	69
	Moves like an hour-glass like instrument (Damaru), and towards, upper side the pulse is quite fine and slow and towards lower side it is curvilinear.	71
	If the pulse appears quite prominent and looking and resembles in character like the pulse of after taking the meat i. e. hard and thick moves slowly and is feeble and	72

	curvilinear indicates bad prognosis due to derangement of all the three Doshas at a time.	
	If the pulse is trembling and is fine like thread and feeble and touches the finger repeatedly, it indicates bad prognosis.	77
	First day fast next day after becoming cold comes down slow is indicative of death due to Sannipata.,	

(G) Pulse Indicating Death Within Limited Period :

Types of pulse	Characteristics of pulse	Verse No.
1. Death within one day.	When the force of the pulse is gone but still it is beating and is hardly perceptible it indicates death within one day.	84
	When the pulse passes through the various stages of extremely feebleness (Hardly palpable), fastness, wet and heavy to touch is indicative of bad prognosis.	86
	If the pulse moves slowly and slowly and is tremulous and steadily disappears for a while and is displaced from its normal position, again occupies its original position, indicates bad prognosis.	74
	If the pulse of Sannipata first moves like Paittika pulse, i. e. jumping and again like Vatika pulse, i. e. curvilinear and again like Kapha i. e. when the order is not maintained in its movement; and sometimes appears beneath the middle finger, sometimes beneath the index finger, sometimes slow and gradually becomes very fine, it indicates bad prognosis.	75

	If the pulse impinges beneath the middle finger and tremulous, the patient will die within a day.	
	If the pulse moves beneath the index finger like hour-glass instrument tremulous in nature, kills the patient in a day.	85
	If the pulse suddenly impinges like lightning flash underneath the index finger, the patient survives only one day.	73
2. Death within two days.	If the pulse suddenly being interrupted does not appear at all beneath the index finger, death of the patient is sure within two days or the patient shall die within 2 days.	83
3. Death within three days.	If the pulse of a healthy individual comes down from the root of the thumb when the patient does not extend his palm, and again reappears at the root of the thumb when the hand is extended it indicates death within three days.	87, 88
	If the pulse does beat beneath the index finger and is cold beneath the middle finger and is fine and slow, it indicates death within three days.	80
4. Death within four days.	If the patient is victim of severe fever just a day before and his pulse constantly appears like flame only beneath the middle finger, the patient will die within four days.	82
5. Death within seven days.	If the pulse appears like a flash of lightning when the hand is raised up, the patient will die within seven days.	88
	If the pulse impinges fast beneath the index finger and sometimes becomes cold and there is sweating the patient will die within seven days.	78

6. Death within fifteen days.	If the pulse is quite hot and runs very fast and the body is cold and there is mouth breathing, the patient will die within 15 days.	79

(H) Pulse Indicating Good Prognosis :

Types of pulse	Characteristics of pulse	Verse No.
Good prognosis	If the pulse beats thirty times at its normal place, the patient will survive.	94

(I) Pulse Apparently of Bad Prognosis but Really not So :

Types of pulse	Characteristics of pulse	Verse No.
Due to heavy load, fear, grief, dizziness and after Lathi charge.	If the pulse stops its beating, the patient will survive and will not die.	32

Like Kanada's work, Ravana's Nadipariksha is also an independent work on sphygmology. It is written in the same form as the work of Kanada. And almost covers the same range as the later in describing diseases and prognosis to be diagnosed and assessed by means of feeling the pulse. The work of Ravana also describes the character of pulse in infants.

Chapter IV

Pulse in Other Treatises of Sphygmology

Ghosh (1929) after his extensive research have had published a good series of articles on the subject "The Nadi system in Ayurvedic medicine, Upanishads and Tantrik literature". Besides Sharngadhara, Bhavaprakash etc. various other books on sphygmology have also been consulted. Among the various aspects of the subject a good deal of description has also been given about the importance of pulse in assessing the expectancy of life of the patient.

Pulse in Prognosis

Pulse in prognosis as described in other books of sphygmology may be dealt with under three headings : (a) Pulse conditions indicating a favourable prognosis. (b) Pulse conditions indicating a favourable prognosis (here may also be considered a group of cases where the pulse condition, seemingly unfavourable do not indicate any unfavourable prognosis and (c) Pulse conditions revealing the time of death.

(A) Pulse Conditions Indicating a Favourable Prognosis :

Types of pulse	Characteristicis of pulse
Good prognosis	Pulse beats uniformly at the root of the thumb, it indicates no defects. If the pulse is not displaced from its own site and seems to be slender, there is fear of his death and the disease will also go away. Pulse beats like the progression of a quail at the site of Pitta indicates good health. Pulse beats like the progression of a goose, peafowl (Mor or Morani) at the site of Kapha indicates good health. Pulse beats like the progression of an aquate animal (evidently fish). The curve produced by the movement of fish in water is more or less wavy and may be likened to a normal pulse.

(B) Pulse Conditions with Unfavourable Prognosis :

A large number of pulse characters have been recorded in various treatises. In most cases the condition is produced as incurable. A number of pulse conditions have been mentioned severally so as to give a general idea of the bad conditions. The following pulse conditions are indicative of bad prognosis.

Types of pulse	Characteristics of pulse
1. Unfavourable prognosis.	Rapidity. Hardness (this indicates that the pulse is felt between the beats). Extreme slowness of the pulse. Crookedness of the pulse. Extreme smallness. This evidently refers to a "running pulse". Displacement of the pulse from its normal state. Imperceptibility of pulse. Irregularity of the rhythm.
2. Unfavourable prognosis indicated by single sign.	Displacement of the pulse. The pulse displaced from its normal position indicates death. The pulse which gradually leaves its normal position means death. Extreme slowness of the pulse. The pulse which beats slowly indicates death. Extreme softness of the pulse. The pulse which is very soft (nearly imperceptible) indicates death. In case when three Doshas at fault at the same time, the pulse becomes imperceptible at the time of death. If the pulse be deep-seated (that is scarcely perceptible) indicates death. The arrhythmia of the pulse. If the pulse beats in the wrist and then again has no movement beneath the (examining) fingers, the condition of the patient should be considered hopeless. The pulse beating like the progression of a sparrow (i. e. which beats quickly and by

jumps for a number of times and then stops beating for while) indicates a condition curable with difficulty.

The running pulse. If the pulse beats with extreme rapidity, this indicates a hopeless condition.

The disappearance of the pulse. If there is no pulse, there is a great doubt for the life.

3. Unfavourable prognosis indicated by two signs.

If the pulse is very weak and very soft, it indicates death.

If a pulse is tranquil (i. e. nearly imperceptible–perhaps indicating extreme slowness) and is very soft (low), it indicates death.

If the pulse is slow and soft it soon kills the patient.

If the pulse is very fine and is very soft (nearly imperceptible), it indicates death.

The pulse, which is fine (i. e. beats are minute) and is very quick or very soft (i. e. scarcely perceptible) then the physician should know that the patient will die.

If the pulse is very fine (i. e. the beats are minute) and is very quick or very soft (i. e. scarcely perceptible) then the physician should know that the patient will die.

If the pulse beats very slowly and becomes displaced from the normal site, it indicates death.

If the pulse, beating in the moderate rate at the base of the thumb, unfortunately leaves the site and slowly becomes forcible, it indicates death.

If the pulse displaced from its site, be felt or not and if there is severe pain in the heart, the life exists long as the pain is there.

If the chest, noses, thigh and legs are cold, and the pulse is very quick and fine (thready), the patient will not live for a moment.

If the pulse goes down like a flash of lightning and is felt at one moment and not at another the patient dies as if st uck by lightning.

If the pulse is trembling (tremulous) and beats very quick (or thread like) and again strikes the finger, there is no hope for the life of the patient.

If the pulse gradually becomes very slender (very small) and feeble (forceless), the patient does not live.

If the left pulse (pulse on the left hand) beats really in a curved manner and if it is like Sakra (i. e. strong like Indra–hard and feeble), the death is to be considered to take place soon.

4. Unfavourable prognosis recorded by signs.

The extremely soft (i. e. nearly imperceptible), very slender (fine) and quick (running) pulse is for rapid death.

The pulse which is very quick (i. e. running) or very deep-seated in the flash (i. e. nearly imperceptible) and is fine (thready) and curved, indicates death.

If the pulse is felt in the leg, but not in the wrist and there is an anxious look, there is little hope of his life.

If the pulse becomes soft in high fever and it becomes hard, forcible in a cold body and if the pulse beats irregularly, there is no doubt of his death.

If the pulse is slow at one time and quick at another, it indicates that the three Doshas are at fault together; and if the pulse is displaced from its normal place, it means death.

If the pulse is very soft in patient with high fever, it indicates that three Doshas are at fault.

5. Unfavourable Prognosis by 4 or 5 signs.

If the pulse is very rapid (running) or is very deep-seated (i. e. nearly imperceptible) and it is fine (thready) and curved, it indicates death.

If the pulse is rising obliquely and if it is frequent like the progression of a snake and if Kapha collects in the throat, there is no hope of life.

If the pulse beats with a sharp rise, is very slow and deep-seated and if it is fine and crooked (with low rise), there is no hope of life.

If the pulse is seen rising up from beneath the skin, if it is very slippery (i. e. slips beneath the examining fingers) it indicates unfavourable prognosis.

If the pulse is slow at one time, frequent at another and is missed at times and if it is fine at one time and large at one another, there is no hope of life.

If pulse is agitated (i. e. beats are not unifrom), very soft and slow, the beats are repeated by long gaps and if the pulse gradually leaves it normal site. it indicates death.

If the pulse is displaced to the width of one finger and a quarter from the wrist and is curved, the patient will die in 15 minutes.

If the pulse is displaced to the breadth of one finger and a half from the wrist and if it is crooked, the patient will die in 15 minutes.

(C) Pulse Conditions Revealing the Time of Death :

Types of pulse	Characteristics of pulse
1. Indicating death in 18 hours.	If the pulse is displaced to a quarter of a finger's breadth and remains imperceptible, it means death in 18 hours. If the pulse becomes imperceptible upto the middle examining finger, the patient will die in 18 hours.
2. Indicating death in 21 hours	If the pulse beats crookedly beyond the first examining finger (or beyond one finger's breadth), the patient will die in 21 hours.

3. Indicating death in 24 hours (one day)	The pulse beats slowly on the inner side of the space of one finger's breadth from the wrist, the patient will die in 24 hours. If the pulse beats rapidly for 4 days, the patient will die in 24 hours. If the soft or slow pulse is felt at one time and not at another, the patient will die in one day. If the pulse at wrist beats like an hour-glass drum (that is the pulse becomes thready and running), the patient will die in one day. If the pulse beats like the progression of a hornet that is the pulse becomes very small and thready, the patient will live for one day. The pulse beating like the progression of a leech in a patient with bodily pain, indicates death in one day. Very slow, sometimes displaced from its position, very small and soft.
4. Indicating death on the second day.	If the pulse becomes irregular at the base of the thumb, it is felt upto the place of the middle examining finger, then becomes very small for a little while and then beats, as before the same number of fingers, the patient lives for the day and night and die on the next day. If the extremely slow pulse appears like the flashes of lightning, the patient will live for one day and will die on the second day. If the pulse remaining at the wrist strikes the examining finger like a flash of lightning the patient will live for one day and will die next day. If the rapid pulse at the end of delirium is attended with very high fever, the patient will live for a single and will die on the second day.
5. Indicating death in 27 hours.	If the pulse remains very soft (nearly imperceptible) beyond one finger's breadth from the wrist, the man will die in the course of 27 hours.

6. Indicating death in 30 hours.	If the pulse beats rapidly beyond less than $\frac{1}{4}$ of a finger's breadth from the wrist, the patient will die in 30 hours.
7. Indicating death in 33 hours.	If the pulse remains jerky within less than $\frac{1}{4}$ the finger's breadth from the wrist, the man will die in 33 hours. If the pulse remains soft within less than $\frac{1}{4}$ finger's breadth from the wrist, the man will die in 33 hours.
8. Indicating death in 36 hours.	If the pulse remains soft and curved (that is of very low ascent) within less than 1/4 (i. e. 3/4) the finger's breadth from the wrist the patient will die in 36 hours. If the pulse often remains imperceptible in the wrist and then strikes the finger's breadth from the wrist, the patient will die in 36 hours. If the pulse remains very soft within quarter of a finger's breadth from the wrist, the patient will die in 36 hours. If the pulse becomes very quick, with the beats distinct from one another and if it is accompanied by high fever at the end of the day, the patient will die in 36 hours. If the pulse remains very soft and crooked within 3/4th of the finger's breadth from the wrist, the death will occur in 36 hours. If the pulse remains within 3/4th the finger's breadth from the wrist, the death will occur in 36 hours. If the pulse of Pitta character is not found in the right leg (ankle), then death will occur in 36 hours.
9. Indicating death in 39 hours.	If the pulse is very soft and is felt at half the breadth of a finger from the wrist, the patient will die in 39 hours.
10. Indicating death in 42 hours.	If the pulse is displaced to half the width of a finger from the wrist and if it is jerky and rapid, the patient will die in 42 hours.

11. Indicating death in 45 hours.

If the pulse is displaced to half the breadth of a finger from the wrist and if it is very rapid, the patient will die in 45 hours.

If the pulse is displaced to a quarter of a finger's breadth from the wrist and if it beats very rapidly, the patient will die in 45 hours.

If the pulse beats frequently at one and half a finger's breadth from the wrist, it means death in 45 hours.

12. Indicating death in 48 hours.

If the pulse is simple and is displaced to a quarter of a finger's breadth from the wrist, the patient will die in 48 hours.

If the quick and low pulse be accompanied by high fever in the middle of the day, and it becomes imperceptible, the death occurs on the second day.

If the pulse is very slow at the wrist and is sometimes not felt at all, the patient will die on the second day.

If the pulse is having the characteristics of Pitta, Vayu and Kapha successively, remains in its place, sometimes leaves it is attended with high fever and then becomes very quick and soft, it indicates death on the second day.

13. Indicating death in 3 days.

If the three Doshas are deranged the same time, the pulse becomes very soft and indicates death in 3 days.

If the pulse is imperceptible at the wrist (beneath the first examining finger), and is very feeble on the other side (beneath the last examining finger), and if the pulse is thready, the patient will not even live for 3 nights.

If the pulse which was originally slow in the natural position, becomes fine (thready) and very quick it indicates death in 3 days.

If the pulse is very soft (nearly imperceptible) is attended with high fever, has the individual beats indistinct due to derange-

ment of the three Doshas at a time, it indicates death in 3 days.

If the pulse is displaced to a quarter of finger's breadth from the wrist and if it becomes quick and curved, it indicates death.

If the pulse is not felt in the right leg but is uniformly beating in the wrist, it indicates death in 3 days.

If the pulse leaves its site by half the length of a barley grain, the patient will die in 3 days.

14. Indicating death in 4 days.

If the pulse is displaced to a quarter of a finger's breadth from the wrist and if it becomes jerky and quick, it indicates death in 4 days.

If there was high fever on the last day and if the pulse beats continuously like the progression of a quail at the wrist patient, he will die in 4 days.

If the pulse is not full in right leg (ankle) and in the hand, but it beats continuously at the wrist, the patient will live for 4 days.

If the Pitta becomes snake like, the Vayu becomes crooked and if the beats are distinct at night the death will occur in 4 days.

15. Indicating death in 5 days.

If the pulse beats very slowly after having been displaced to a quarter of a finger's from the wrist, it indicates death in 5 days.

If the pulse in the leg is displaced for half the width of a barley grain from the wrist, the patient lives for 5 days.

16. Indicating death in 7 days.

If the pulse becomes frequent at one moment and infrequent at another, it indicates death in 7 days.

It the pulse beats forcibly at the wrist at one time, becomes very soft (nearly imperceptible) at another and if it is attended with clammy sweet, the patient will not live for 7 days.

If increased rhythmic movement of the novel, death occurs in a week.

	If the pulse is frequent at one moment and infrequent at another and if there is no dropsy, the patient dies in 7 days. If the pulse in the raised hand resembles a flash of lightning, the patient dies in 7 days (the pulse suddenly appears and disappears). If the pulse is not at the root of the hand, the patient lives for two weeks only.
17. Indicating death in 8 days.	If there is perspiration in fever and breathing by the mouth, the patient will die in 8 days.
18. Indicating death in 15 days.	If the pulse is very frequent, the body is cold and the respiration is hurried, the patient lives for half a month.
19. Indicating death in 1 month.	If the pulse beats like the progression of an earthworm and again like that of snake, if it is slender and fine (that is thready), the patient dies at the end of a month.
20. Indicating death in 5 weeks.	If the pulse is infrequent and crooked (curved), the patient will die in 5 weeks.
21. Indicating death in 6 weeks.	If there is no pulse between the brows and a fine pulse at the root of the neck, the patient will live for 6 weeks.
22. Indicating death in 3 months.	If there is no pulsation in the cardiac region or the pulse is fine in the armpit, the life is for 3 months.
23. Indicating survival more than 5 years.	If the pulse at the root of the hand (at the bend of the elbow) is felt as a short slender, the man will live for more than 5 years. If the artery in the left axilla is felt as a long slender cord, the man will live more than 50 years.

In several old treatises most of which are now lost and are only known by passages quoted from them by later authors, we find the pulse conditions mentioned in connection with longevity as is mentioned in 22 and 23 in last two passages.

MODERN REVIEW

The aims of furnishing the modern review of literature on sphygmology are (a) to describe the mechanism of pulse formation with the description of anatomy and histology of radial artery, (b) to mention the common arterial diseases, and (c) to discuss the clinical importance of pulse examination. Regarding the mechanism, effort has been made to explain the mechanism of pulse formation on the fundamental principles of haemodynamics. First of all the antomy of radial artery has been described. This is followed by the description of physiology in which the histology of radial artery and the principles of haemodynamics etc. have been mentioned. Next, the discussion about the pathology of arterial diseases has been made. Last portion deals with the clinical section of the review.

Chapter V

Anatomy and Histology of Radial Artery

Anatomy of Radial Artery

For clinical examination of the pulse the radial artery is chosen, because it is easily accessible and lies against the bone. Gray (1973) describes that the radial artery than its contemporary ulnar artery is the more direct continuation of the brachial trunk. It begins at the division of the brachial, about 1 cm. below the bend of the elbow (Fig. 7), and passes along

Fig. 7 : Radial Artery

the radial side of the forearm to the wrist, where its pulsation can readily be felt in the interval between flexor carpi radialis tendon medially and the salient lower part of the anterior border of the radius laterally. The radial artery is divisible into three parts, one in the forearm, a second at the wrist, and a third in the hand.

The part of the radial artery which lies infront of the lower

end of the radius and on the lateral side of the tendon of the flexor carpi radialis is used clinically for observation of the pulse. Sometimes the origin of the radial artery is higher than usual. In that circumstance it then branches more often from lower part of the latter. In the forearm it is sometimes superficial to the deep fascia instead of beneath it. In turning round the wrist, it is occasionally superficial instead of deep to the extensor tendons of the thumb.

Histology of Arteries

Bel et al (1967) mention that all the blood vessels of whatever size have smooth inner lining of flattened endothelial cells joined edge to edge. This inner lining is continuous from the arteries through the capillaries to the veins and to the internal lining of the heart. Therefore, the whole blood vascular system, from the finest vessels up to and including the heart, have one structural component in common, namely, a smooth lining throughout of a single layer of endothelial cells which in the heart from the endocardium, the innermost lining.

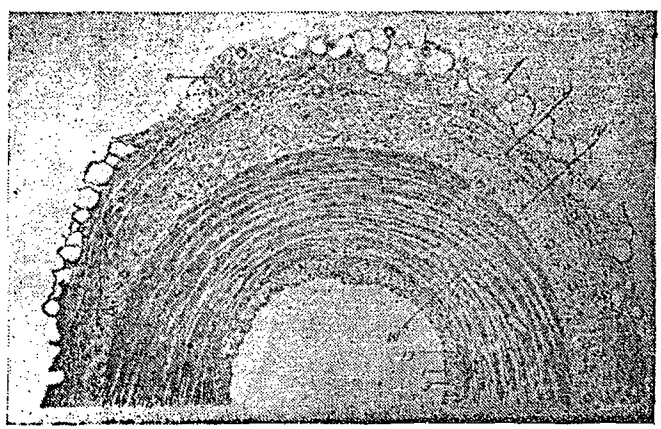


Fig. 8 : Histology of Medium Sized Artery

The arteries have three main coats from within outwards (1) the tunica intima, (2) tunica media, and (3) tunica adventitia (Fig. 8). The following description refers mainly to a medium sized and small arteries, of which the radial is also one. The tunica intima or inner coat consist of a single layer of elongate endothelial cells, arranged longitudinally the outer surfaces of which are covered with a typical basal lamina closely abbuting upon the internal elastic lamina. The internal

elastic lamina is a fenestrated elastic membrane which appears in the transverse section as a high refractile zone which due to agonal contraction of the muscular media, is thrown into characteristic wavy fold as shown in the figures. Since tunica media or middle coat is having less elastic tissue than the larger vessels as aorta, the internal elastic lamina stands out in sharp contract.

The tunica media in medium and smaller arteries consists mostly of smooth muscle cells with scattered elastic membranes and a few collagen fibres. That is why medium and smaller sized arteries are mostly muscular in their structure and in this way they differ from the larger artery such as aorta, and its main branches. Because the latter are mostly of elastic type and also they differ a bit in their histological appearances and so in their construction so far as tunica intima, tunica media is concerned.

The tunica adventitia consists of collagenous and elastin fibres which run predominantly in a longitudinal direction. The outer portion is somewhat loosely arranged, merging into the surrounding areolar tissue and so allows considerable movement between the artery and the neighbouring structures. Immediately adjacent to the smooth muscle of the tunica media the adventitia contains much elastic tissue which here constitutes the fenestrated external elastic lamina.

So far as large arteries of the elastic type such as aorta and its main branches are concerned they differ a bit in their histological appearances and so in their construction, so far as tunica intima, tunica media and tunica adventitia is concerned. The larger arteries, and particularly the aorta, contain a relatively greater proportion of elastic tissue in their walls than do the smaller arteries. The walls of the smallest arteries of all, the arterioles, are almost entirely muscular. We should remember here that the architectural differences between aorta and its branches and the medium and smaller arteries are quite analogous to their function.

The arteries are supplied with blood vessels called Vasa vasorum. These are also known as nutrient arteries. They arise from the branches of artery itself or of neighbouring vessel. They ramify in the loose areolar tissue connecting the artery with its sheath, and after forming a dense capillary network in the adventitia, supply the outerpart of the media. The nutritional requirements for the remainder of the vessel wall are

obtained by diffusion from the blood in the lumen of the vessel, and it is thought that the fenestrations in the elastic lamina are important in this regard. Minute veins return the blood from these vessels. They imply themselves into the vein or veins accompanying the artery. Lymph vessels are also present in the outer coat.

The majority of nerves supplying the arteries are non-myelinated but some are myelinated. The non-myelinated fibres are mostly efferent and constitute the vasoconstrictor nerves to the vessels along which passes the continuous flow of impulses responsible for the variable 'Vasomotor tone' of the vessels. The nerve fibres ramify in the adventitia and then approach the outer layer of the medial smooth muscle cells through the fenestrations in the external elastic lamina. The terminal area of non-myelinated nerve fibre is extensive. The myelinated fibres are believed to afferent and are distributed to the outer and inner coats where they terminate in expanded and varicose endinge. The significance of afferent nerve fibres in the general systemic arterial tree is uncertain, but some may mediate pain impulses under certain pathological and traumatic states.

The majority of blood vessels do not receive a vasodilator innervation and in these, neurogenic Vasodilations follow a reduction of sympathetic vasoconstrictor tone. However, nerve-mediated vasodilator action is seen (1) in skeletal muscle vessels which secure a cholenergic sympathetic innervation; (2) in various exocrine glands following secretomotor activity with the secondary release of the vasodilator bradykinin; (3) in the skin following afferent nerve stimulation, the collaterals of which ramify on neighbouring blood vessels and form the structural basis for the so-called 'axon reflex'. Unlike the largest trunks which receive branches direct from the sympathetic ganglia, the smaller arteries such as brachial etc. receive their supply in peripheral nerves coming of in a series of small branches. Besides nervous control of vasodilatation there are also chemical substances produced in increasing amount due to increased metabolic activity of the tissue. Thus summarising, we can say that the vasodilatation of parts of the vascular system can be achieved in mainly two ways : (1) nervous and (2) chemical and further nervous mechanisms of vasodilatation can be : (a) reduction of sympathetic constrictor tone; (b) specific activation of vasodilator nerves.

Chapter VI

Physiology of Arteries and Mechanism of Pulse Formation

Physiology of Arteries

As regards functions of the vessels, distensibility of the vessels is governed by their content of elastic and collagen tissue and smooth muscles. We have seen in the previous discussion that larger, medium and smaller vessels have a prominent component of elastic tissue with special reference made to aorta that it is endowed with highly elastic tissue. Samson Wright (1971) says that due to high elastic property, aorta and its large branches are termed as windkessel vessels. 'Systolic ejection distends aorta and its large branches, subsequent to the closure of the aortic valve at the termination of the systole of left ventricle of the heart. The elastic recoil of the vessels sustains the pressure head better and renders the blood flow to the periphery steadier that it would otherwise be. Potential energy thus stored during cardiac contraction by the elastic tissue of the aorta and its branches, is reconverted into kinetic energy for the circulation during the diastolic phase. Degenerative changes in the media of large vessels cause a loss of arterial elasticity and a high pulse pressure (systolic pressure minus diastolic pressure) results owing to the lack of the windkessel effect.

The peripheral vessels like radial, femoral etc., as we know, have predominance of smooth muscle fibres arranged circularly, which by virtue of their shortening can reduce the lumen of these vessels considerably. Such a set-up permits adaptation to accomodate changing volumes of circulating blood. This is initiated by heat, cold, trauma and many other physiological events and thus may affect the pressure-volume curves.

The arterioles which are almost muscular provide the great majority of peripheral resistance, changes in their radius moreover, determine the blood supply of the different regional circuits.

Considering about various pressures and their role in a cylindrical blood vessel, Bel et al (1970) mention that in a cylindrical blood vessel the intravascular pressure (P) tending to increase the size of the vessel is opposed by the tissue pressure (P T) tending to limit dilatation. The difference between the two is the transmural pressure (P T M) the total force tending to expand the vessel. This expanding force is encountered by the tension in the vessel wall (T C) which itself has two components, namely elastic tension (T E), dependent mainly on elastin and collagen fibres, and active tension (T R) due to the state of the smooth muscle in the vessel walls and independent of stretch.

Alteration in the calibre of the vessels are automatically adjusted by variations in elastic tension over a wide range of transmural pressure. If, however, the transmural pressure is reduced to the level at which the elastic fibres are no longer stretched at all, then they can contribute no elastic tension and the system becomes unstable. Should the transmural pressure fall any further then Tc/r (r vis the radius of the vessel) becomes greater than P T M and the vessel closes (critical closure). The transmural pressure at which critical closure takes place is known as critical closing pressure (C C P) or flow cessation pressure.

Mechanism of Pulse Formation

The mechanism responsible for the generation of pulse can be better explained through the interpretation of diagrams. As shown in the diagram (Fig. 9), there is a tube fastened with

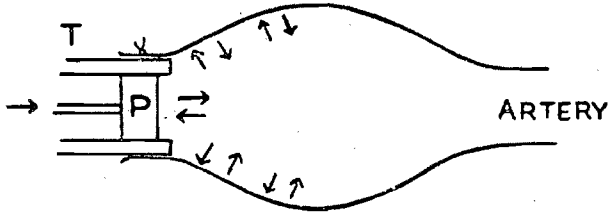


Fig. 9 : Mechanism of Pulse Formation

the piston and tied into an artery. Suppose, if piston is pushed forward towards the right into the tube the vessel distends locally. This occurs simply because the blood is incompressible. This immediate incompressible column of blood producesa

local increase of pressure that has little effect on the advancing piston, which is in fact a mass of incompressible blood. Instead the next section of the artery is stretched so that a wave of pressure travels along the vessel wall without involving actual transmission of blood. Similarly the largest arteries, such as the aortic arch, innominate and subclarian arteries are highly distensible and so the expelled blood is really accomodated in them. This wave of distension is transmitted along the arteries and what we feel as the pulse. This means that the pulse is actually a wave set-up in the walls of the vessels by the systole of the ventricle and it is not due to the passage of blood along the arteries (Fig. 10).

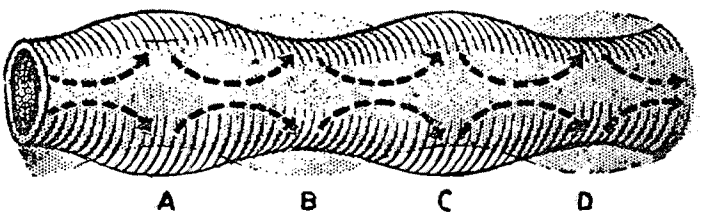


Fig. 10 : Mechanism of Transmission of Pulse Wave.

In the figure 10, it has been shown that sudden ejection of large quantity of fluid into a distensible tube, such at point A causes bulging of the tube at the point of ejection, and the pressure in the area of the tube rises. Immediately after the vessel wall is distended at point A the elevated pressure at this point forces a small amount of fluid along the vessel, as illustrated by the arrows. This causes the vessel wall to distend at point B, while at the same time the vessel begins shrinking at point A. Consequently, the vessel wall at point B continues to distend and the pressure continues to rise while the vessel at point A continues to shrink and the pressure continues to fall. After point B is well distended, the elevated pressure at this point causes fluid to flow to point C, distending the vessel at point C and relaxing the vessel wall at point B. This process is repeated by small increments along the entire length of the vessel until the pressure wave reaches the end of the vessel. So it is very clear that the elastic property of the arterial wall takes the part in the generation and transmission of the pressure wave of the pulse.

Peterson (1952 and 1954), the first scientist who raised the question against the problem that if there would be an appreciable lag time between the pressure pulse and the fluid displacement or movement of pulse wave from segment to segment. In his article first published, he introduced the idea of 'large lag.' Spencer (1958) stated that in the upper aorta pressure and flow start together, but it was not supported by any figure. Again Remington (1963) hypothesized and supported the view of Peterson that there appears to be a true lag of about 5 msec. and further stated that after initial delay between vertical and ascending aorta, the pressure pulse seems to be propogated at a steady rate through the aorta. Gregg (1967) states that almost simultaneously the acceleration of blood occurs with the rise of pressure pulse in the aorta and arterial tree. This is to be naturally expected since the latter occasions the former. However, whereas the pressure wave travels in the term of meters per second i. e. 7 meters per second the movement of the red cells or plasma is much slower at 10 to 20 cm. per second. Thus although the pressure wave or pulse may reach the vessel of the foot in 0.2 second, it requires several heart beats for the blood which enters the ascending aorta to reach the foot vessel. This is because the speed of the blood depends on such factors as the blood pressure gradient, viscosity and cross sectional area of the blood vessel. So far as rate of flow versus cross section is concerned, it varies inversely as the total cross section of the vascular bed. And as the sum of the cross sectional area is concerned, it increases progressively as the arterial system divides and redivides. So naturally the velocity of blood in aorta is 0.8–1.0 meter per second and about 0.5–1.0 millimeter per second in capillaries. As regards velocity of the pulse it is determined almost entirely by the elasticity of the wall.

Also, it would be appreciable here to throw light on the velocity of the pulse wave. Bramwell and Hill (1922) demonstrated that the velocity of the pulse increases with the age closely following the rise in blood pressure, which occurs as one grows older. In the same year Hickson McSwiney showed that the pulse wave velocity varied with respiration. Bramwell et al (1923) pointed out that pulse wave velocity varied with the pressure within the artery and with the extensibility of the arterial wall. Bazette and Dreyer (1923) demonstrated that pulse wave velocity was slower in larger vessels–4 meter per second

in artery as brachial compared with 8.5 meters per second or more between the elbow and the wrist. Starling (1968) says that the pulse wave velocity is independent of the output of the heart with each stroke and so is a better indication of the elastic behaviour of the arteries than is the pulse wave.

Here one should be very clear in his mind as also foregoing discussion under the head 'mechanism of pulse formation' proves that the phenomena taking part in the formation of pulse chiefly concern with the mechanism of haemodynamics of cardiovascular system, and this mechanism can be explained in the light of Poiseuille's law—a physical law concerns with the branch of hydrodynamics which shows the interrelation between the pressure, flow and the resistance in a rigid tube.

Chapter VII

Poiseuille's Law; Haemodynamics; Peripheral Pulses; Formation of Radial Pulse; Diseases of Arteries; Factors Affecting the Pulse Pressure and Clinical Examination of Pulse

Poiseuille's Law and Its Application in Vivo

In the branch of heamodynamics it was the Poiseuille (1884) and Hagen (1939) who invented that pressure, flow and resistance have definite relation to each other and showed in vitro that volume (F) of a fluid flowing through a capillary tube increase with the pressure head (P), and decreases with resistance (R) to flow as indicated by the equation $F=\frac{P}{R}$ which after extension can be written in the form of $F=(P_1-P_2).(\frac{\pi r^4}{8L})(\frac{1}{V})$. Here F stands for the flow per unit in the tube; P_2 is the pressure at a down stream point in the tube; Thus P_1-P_2 represents the pressure head or pressure gradient, is 3.1416. The π is important in the formula because we are dealing with a cylindrical tube. The 8 arose in the process of Hagen's integration. V is fluid viscosity, Finally, after further dilatation of the above formula it was established that flow varies directly and resistance inversely with the fourth power of the radius. And flow varies inversely and resistance directly with the viscosity of the fluid. Thus considering only the fourth power of the radius, if other things such as viscosity and pressure remain unchanged, a decrease to half a radius will actually decrease the flow to a sixteenth of the original value. In other words the resistance to flow is increased sixteen times.

While applying Poiseuille's law to the circulating blood in vivo, we should bear in our mind that it is mostly applicable in vitro to the Newtonian fluid flow through a rigid tube under steady pressure head. By definition Newtonian fluid means a simple viscous fluid which viscosity is unaffected by flow rates and remains constant at different rates of streamlined flow. So,

in vivo Poiseuille's law have but restricted application. The reason is that in living body the heart beats rhythmically and ejects blood phasically into a system of elastic tubes and moreover the blood is not a perfect fluid but a two phase system of liquid and cells. Thus we may say that the physical principles are of value only when used as an aid to understanding what goes on in the body rather than as an aid in themselves. In the living subject, so far as steady head of the pressure, which fulfills one of the criteria of Poiseuille observation, is concerned it is achieved approximately by the combined effect of elasticity of larger vessels and resistance offered by the arterioles. And thus the pulsatile ejection of the heart is converted into a steady outflow. Yet there are some factors which would seem to be immediately complicating to help in achieving this goal.

Considering about Newtonian fluid in relation to blood we know that it is made of both liquid and cells and has anomalous viscosity as observed in vitro. In vitro when measured at moderate or high shear rates, blood shows a relative viscosity of 4–5. And when measurements are made at very low shear rates the viscosity is greatly increased. But the condition in vivo is rather different, because variation of temperature affects the viscosity. Cooling raises the viscosity of blood. There are other certain metabolic conditions which increases the viscosity of blood and they are: (1) large amount of fat in the blood, (2) polycythemia, (3) acidosis. (4) hyperglycaemia, and (5) hypercalcaemia. But it is to be noted here that in normal conditions throughout most of the physiological range of flow, viscosity does not change appreciably with flow. In general, viscosity of blood in vivo is lower and in capillaries unaffected by temperature changes, it is similar to that of plasma. And the blood behaves approximately as a Newtonian fluid. Haynes (1957) also proved by his experiment that in the physiologic range of blood flow, blood behaves as if it were a Newtonian fluid. Thus we see that in vivo the criteria such as 'steady pressure head' and 'Newtonian fluid' of Poiseuille experiment is mostly satisfied at the normal physiologic range.

From foregoing discussion it is now evident that Poiseuille's law may also be applicable in vivo. And its application to the circulation depends on whether resistance is independent of pressure and flow. In the vitro the resistance would be constant

because both the viscosity and the geometry of the tube were unchanged and did not change with the rate of flow of pressure. But in circulating system peripheral resistance is a measure of the totality of the factors affecting blood flow. These include change in apparent viscosity (which is known to occur with increase in perfusion pressure, occasioned by the movement of the red cells to form a central axial rod. Also, perfusion pressure in relation to blood flow numerically means the mean intraluminal pressure at the arterial end minus the mean pressure at the venous end). Besides viscosity other factors are the existance of stream-lined versus turbulent flow, the length of the vessels and the cross sectional area of the blood vessels which is determined by the extravascular pressure provided by surrounding tissue; by mechanical dilatation with perfusing pressure; by opening of new capillaries and vessels with change in metabolism and with rising perfusion pressure; and by active change in the state of contraction of the muscular walls through vasomotor nerves, humoral substances and metabolic products.

We know that in the body arterioles play major role in causing the peripheral resistance and the smooth muscle in their media having the quality of distensibility also reacts actively to stretch by contracting. In the case of vessels such as arteries and veins which are having smaller resistance, a given pressure head would increase their internal radius and would correspon-

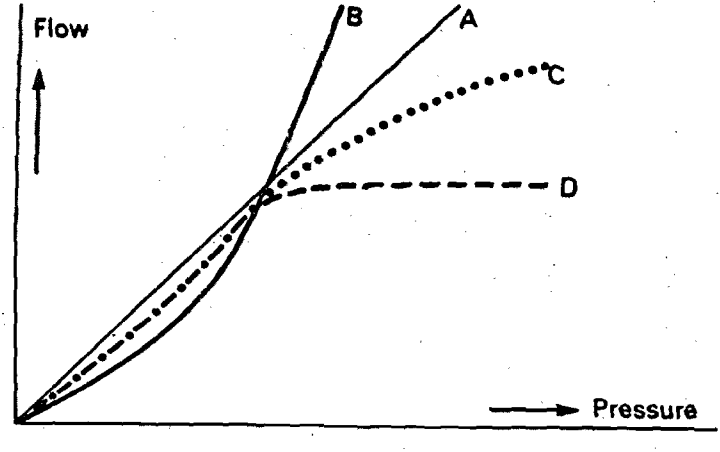


Fig. 11 : Flow-Pressure Curve Relation in Rigid Tube and in Blood Vessels.

dingly cause a raised flow at that pressure. This is not the situation in arterioles due to their myogenic property. So the pressure flow relationship in distensible vessels and the vessels having myogenic element will be different. And therefore, flow-pressure curves obtained with blood in vascular beds are quite different from those obtained in the artificial system used in Poiseuille's experiment. These differences are described diagramatically (Fig. 11).

In (A) when the tube is rigid and the viscosity and the length changes are ignored the relation between pressure and flow is linear as would be defined by Poiseuille's formula in vitro. But in (B) where the tube is elastic such as arteries the increase in flow as a result of a rising pressure head is greater than in A. In it the initially collapsed vessels are distensible. In B it is obvious that the vessels can not be ultimately distensible because the adventitia etc. contain enextensible fibro-collagenous element. So at high pressure the flow would again be linear. In (C) the myogenic contractile response to stretch is depicted as affecting the 'elastic' effects exerted by the pressure rise. The curve is concave to the pressure axis. Curve (D) shows the result when the myogenic elements of the wall even exceed the 'elastic' effects of a raised pressure. Superimposed on the physical features are the additional effects caused by an increased sympathetic vasoconstrictor discharge to the resistant vessels. Such discharge constricts the lumen of the innervated vessels mainly the arterioles and thereby decreases the flow of a given pressure head.

Wright (1971) says that two possible explanations may be given for the deviations of the curves and they may be (1) the geometric factor of Poiseuille's law is not constant but varies with distensibility of the blood vessels, and (2) blood has anomalous viscosity.

As far as role of anomalous viscosity in pressure-flow relationship is concerned, apparently it is a minor factor in large (non-capillary) blood vessels. As it has also been pointed out already that throughout most of the physiological range of flow blood behaves as if it were Newtonian fluid. Now the only remaining factor in consideration to curve deviation is the distensibility of the blood vessels. In this context it can be said that while experimental evaluation is difficult, it does appear that vessel distensibility is the major factor responsible for the devi-

ation of in vivo pressure-flow curves from Poiseuille's law. This in turn is related to the active tension or contraction of smooth muscle in the vessel walls and collagenous fibres in the architecture of the vessels.

In summarising the entire discussion, we can say that the resistance and distensibility of the vessels have definite relations to the flow of the blood throughout the body; and as it has been shown in the diagram of pressure-flow relationship that the factor of overwhelming importance is the distensibility of the blood vessels for the shape of actual flow-pressure curve in vascular bed.

Haemodynamics of Pulsating Stream and Its General Role in the Pulse Formation

After a brief survey of pressure, flow, resistance and the significant role of elasticity in effecting the flow of blood through an elastic tube, we shall now explain their applied aspect in causing the pulse. The factors responsible for the production of pressure wave or pulse are three in numbers, namely: (1) the intermittent inflow of blood from the heart i. e. stroke volume output, (2) the resistance to outflow of blood from the arterioles into the capillaries, and (3) the elasticity of the arterial walls. The role of these factors will be explained in a better way through the medium of curve (Fig. 12) which represents the pressure and flow relationship during systolic ejection.

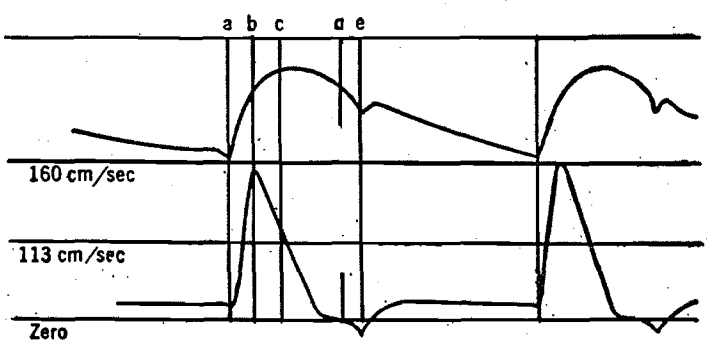


Fig. 12 : Haemodynamics of Pulsating Stream and its General Role in the Pulse Formation.

During each ventricular contraction or systole, a definite quantity of blood is ejected into the aorta; and in man this

quantity averages about 62 cc. The interval of ejection is short, about 0.25 second in man. Moreover, the output is by no means constant over this period. Fully two third of systolic discharge volume is displaced into the aorta in less than 0.1 second, and very little is ejected during the last 0.05 second. Because the arteries are already comfortably distended with blood at the moment of maximum ejection, additional room must be made quickly. The creation of additional room is accomplished by two ways—by moving the column of blood, and by distending the arterial walls and increasing the capacity of the vessels. In moving the column of blood only 1 per cent. or less of the total energy developed by the left ventricle acting as the source of pressure head is utilized. Hence, fraction of the total energy is utilized as kinetic energy. The rest energy developed by left ventricle contraction is stored in the form of potential pressure by causing distension and increasing the capacity of arteries. When left ventricle pumps, it increases the radius and length of the aorta and its large branches to store potential energy as tension in the arterial walls. Here, it is worth recording that the arterial tubes, because of its elasticity and distensibility of their walls, are better adopted for an efficient utilization of cardiac energy than for the faithful transmission of small pressure oscillations. And in doing so the arterial tubes subserve four

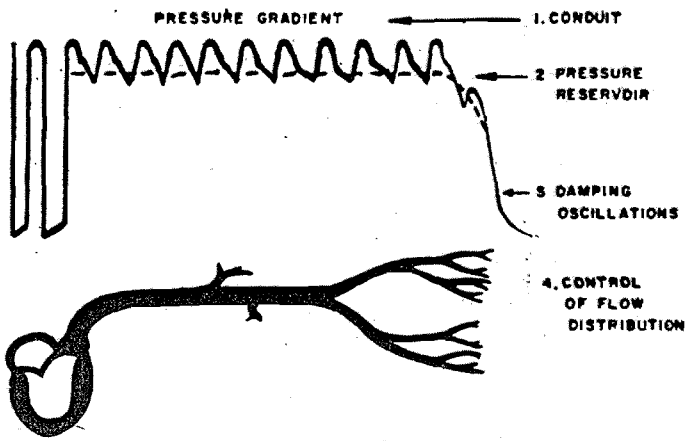


Fig. 13 : Arterial Tube Acting as Conduits, Dampers of Oscillation, Pressure Reservoir and Flow Regulating Valves.

distinct functions namely; (1) conduits, (2) dampers of oscillations, (3) pressure reservoir and (4) flow regulating valves as shown in the diagram (Fig. 13).

Again coming to the original pressure and flow curve (Fig. 12) we find that there occurs a great forward movement of blood together with steep increase in pressure about 0.04 second after the onset of ejection (a–b). During the next period (b–c) which occupies nearly 0.04 or 0.05 second, the pressure mounts with a slower gradient to a summit but the velocity of flow gradually decreases. During remainder of systole (c–d), both pressure and flow decreases. The latter approaching that during previous diastole. The time of closure of semilunar valves demarcates the beginning of diastole as shown at d–e. It is accompanied by a sharp drop in pressure and a transient reversed flow which is indicated by a fall of the velocity curve below the zero line. Here, we can safely infer that the pressure energy represented at this moment by the pressure curve is gradully used to move the blood stored in the distended arteries through the arterioles into the capillaries. This accounts for the slow decline of the pressure curve during diastole and the constant velocity indicated by the straight trend of the velocity curve during the same period. Therefore, it is quite obvious that the conversion of potential energy stored during systole into kinetic energy of flow during diastole increases reasonably continued flow through the capillaries.

By dilating upon the above facts, we can say in other words that during each stroke of the ventricular systole all amount of fluid forced into the arteries does not escape at once owing to peripheral resistance. Instead, part of the force of the pump is spent in distending the walls of arteries, and part of the fluid that was forced in remains for a time into the arteries. The distended artery tends to empty itself and force out the fluid which over-distends it before the next stroke of pump occurs. So now the output may be divided into two parts. One part which is forced out by the immediate effect of the stroke of the pump. And another part which is forced out by the elastic recoil of the artery between the strokes i. e. during the period of diastole. If the strokes be rapidly repeated before the artery has time to empty itself thoroughly, it will get more and more distended. Greater distension means stronger elastic reaction, and therefore a larger output of the fluid between the beats. This

distension goes on increasing till the fluid forced out between the strokes by the elastic reaction of the wall of the artery is exactly equal to that entering at each strokes. And this flow becomes continuous.

From the above statement it is quite evident that resistance mainly offered by arterioles and elasticity of the arterial walls inspite of producing pressure wave or the pulse, are responsible side by side also for maintenance of the continuity of flow of blood and thereby diastolic pressure. At the usual diastolic pressure, that exists, the walls of the arteries are stretched and by virtue of their elasticity they tend to recoil against the distending force driving the blood onwards in a continuous stream between the heart beats, otherwise the pressure would fall to zero after each stroke. However, it should be noted that with a pressure below from 30 to 40 mm. of mercury elasticity does not come into play. And below this level of pressure there would be little stretching of the walls of the arteries which would then behave like a system of rigid tubes. It is also interesting to note here from the pressure flow curve (Fig. 12, 14) that beside the production of pressure wave, flow waves are also produced due to flow of blood. And it is also evident that the flow close to the heart rises very rapidly to a peak velocity and then falls to zero at the end of the systole and remains very low throughout

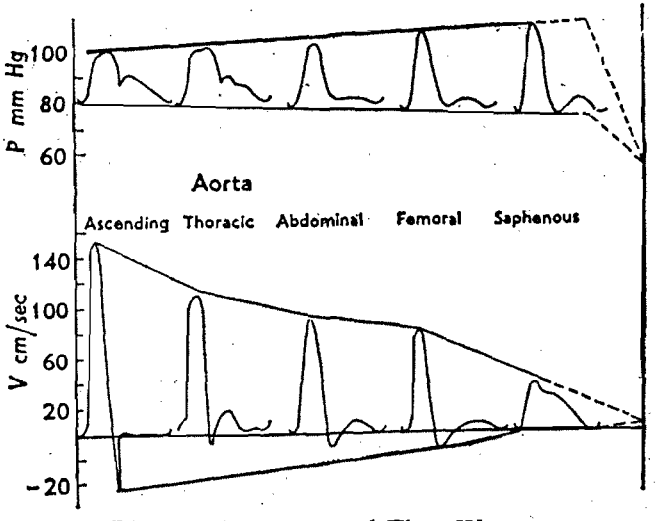


Fig. 14 : Pressure and Flow Waves.

diastole. But we find a change in the pattern when flow is recorded at greater distance from the heart. Where we find that the systolic peak velocity is reduced and a secondary period of forward flow develops in diastole. This fact is quite clear from the diagram (Fig. 14), where behaviour of pressure and flow pulses has been shown.

Finally, we also get from pressure and flow curve that the pressure in the aortic arch reaches a maximum during midsystole and minimum of the end of diastole. These are referred to as systolic and diastolic pressure respectively and the numerical difference between the two is known as the pulse pressure. The registration of pressure in radial, femoral and pedis etc. shows that the numerical values for systolic pressure increase in larger vessels causing greater pulse pressure as shown in diagram (Fig. 15). It is also clear from the diagram that the pulse pressure in still smaller vessels diminishes progressively due to rapid fall of systolic pressure than diastolic.

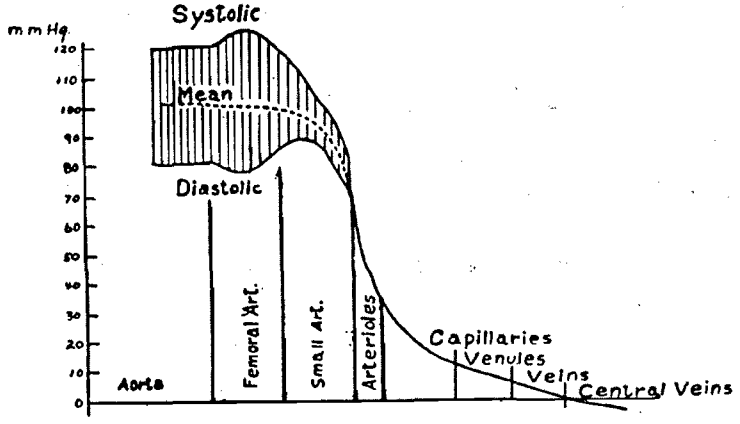


Fig. 15 : Numerical Values for Systolic Pressure Increase in Larger Vessel Causing Greater Pulse Pressure.

Regarding explanations of increased numerical values for systolic pressure and decrease values for diastolic one in larger vessels there is controversy among different physiologists. However, possible explanations are given as : (1) progressive decrease of compliance i. e. the total distensibility (the total quantity of blood that can be stored in a given portion of the circulation for each mm. high pressure rise) of more distal portion

of the large arteries. What happens actually in this that during transmission the pressure pulse is characterized by a high level of momentum of the blood in the advancing edge of the pressure wave. When this wave suddenly reaches the less compliant areas of the arterial tree, much of the kinetic energy of this momentum is changed into pressure, resulting in augmentation of pressure; (2) the transmission of certain parts of the pulse wave at more rapid rates than other parts. As for example, the high pressure portion is transmitted more rapidly than the low pressure portion, because the arterial distensibility is less at high pressure than at low pressure. This causes crowding of certain portions of the wave and therefore, "peaking" of the pressure pulse as illustrated in the diagram (Fig. 16).

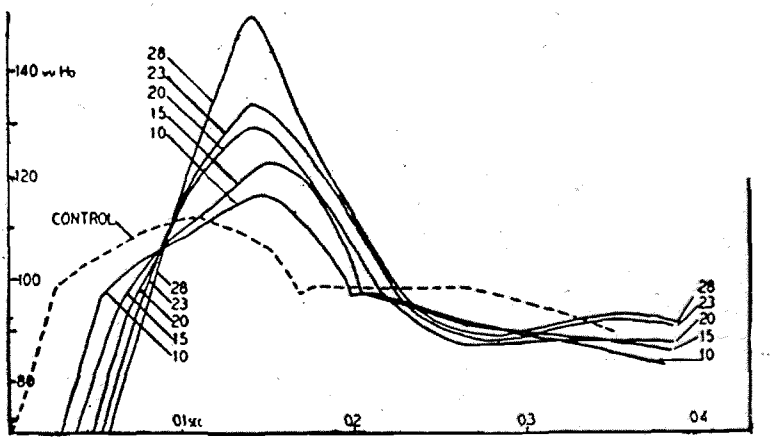


Fig. 16 : Peaking of Pressure Pulse.

The arterial pulse wave becomes distored as it moves along the arteries. These changes can be seen well in the superimposed records in this diagram taken from the root of the aorta and from sites 10, 20 and 30 cm. downward from the root. Characteristically there are delay in upstroke due to transmission time, and a more rapid rise of pressure to a higher and sharper peak followed by oscillations in pressure; (3) role of reflected and standing waves produced as a result of reflection of pulse wave at the points where arteries bifurcate. The reflected and standing waves will be dealt with further under the separate head.

Peripheral Pulses and Role of Reflected Waves

As the name itself reveals that the pulses which are recorded from the peripheral arteries than the aorta are known as peripheral pulses. The important peripheral arteries which are usually used in clinical practice are the radial, femoral etc., though the pulse tracing is usually done from the radial artery in human being. Like peripheral pulses, intermediate pulses are recorded from the distal part of the carotid or the brachial artery, whereas the central pulses are recorded from central aorta. So far we dealt with the general role of haemodynamics in the pulse formation, mainly in the aorta and the descriptions were centred to the central pulse for the sake to give an elaborate idea of pressure wave—the pulse formation. Now we shall deal with the greater details of the qualitative form of peripheral pulses of which the radial is also one.

One should be very clear with the fact that the peripheral pulses are nothing but the mere continuation of central and intermediate pulses with a bit changes. So at the outset it is necessary to give an account of the qualitative form of central pulse, intermediate pulses and then switching over to the peripheral pulses. Owing to architectural characteristics of the aorta and its branches and different distensibilities of various portions, the haemodynamic factors which determine the form of pulses in vessels arising from the aortic arch and abdominal aorta are somewhat different.

Contour differences between a central and a peripheral pulse were recognized before the time of Frank by low frequency manometer. Frank (1903) developed high fedelity manometer to establish the difference between a central and a peripheral pulse in precise terms. The instrument, having pressure sensitive capsule when applied to an artery records only the general shape of the pulse wave without in any way measuring the pressure involved. The instrument was further refined by Wigger, Hamilton, Lilly and others and used in man by Cournand and Ranges. Now-a-days more exact information is being achieved by using an electronic manometer communicating through a needle with the inside of the artery. Older curves (Fig. 17) shows that the shape of arterial pulse wave change when it passes progressively from centre to periphery. These older curves are quite familiar in text books. But the recent recordings

(Fig. 18) show that the curves are smoother than many of the older ones. Laszt and Muller (1952) recorded pressure waves in the dog and they are very similar to those recorded in man. Modern recordings as shown in the diagram, reveals that the curves are smoother than many of the older ones. Laszt and Muller were the first man who made the revolution in modern tracings of pressure wave in the dog and they are very similar to those recorded in man.

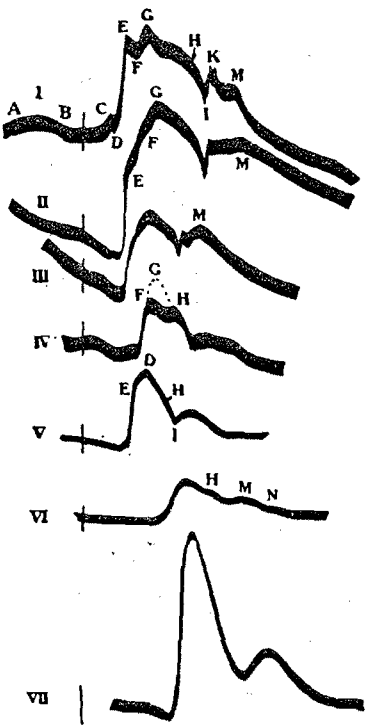


Fig. 17 : Tracings of Older Curves

The main features of central pulse recorded from the proximal aorta (curve 1, Fig. 17) shows a sharp initial rise, then a dome like top terminated by a short sharp trough called the incisura. The time from the foot of first rise to incisura is a measure of the length of systole. This short dip is due to the momentary reflux of blood through the aortic valves as they close at the end of systole. The rising limit is usually known as the anacrotic phase and any superimposed oscillations on it are

called anacrotic waves. In the second curve (Fig. 17) there is a slight dip in the systolic plateau which is termed as anacrotic notch. Following the incisura a small rebound is usually seen and thereafter the pressure falls fairly steadly during diastole.

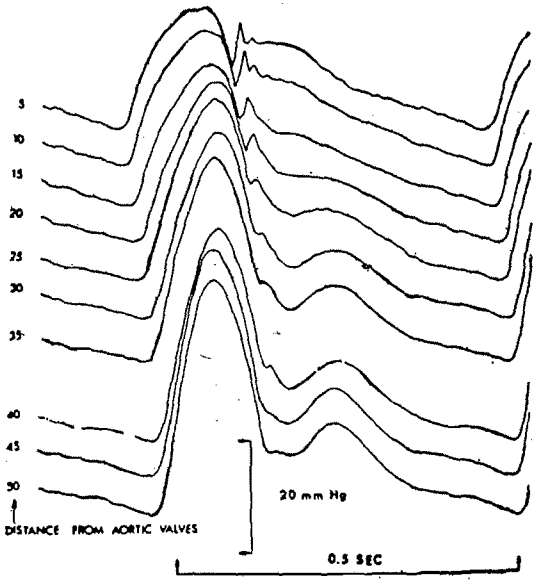


Fig. 18 : Recent Tracings of Pulse Waves.

As the waves are recorded further and further away from the heart, it is seen that not only they are shifted because of the time taken up in transmission but the form of the wave is altered markedly. In the figure typical representative of peripheral pulses is the recording taken from femoral artery. Here the rise in pressure is due to systole is now peaked in shape and the total rise is considerably greater causing a steeper curve. Also, the sharp discontinuity of the incisura has been damped out and we now find that the falling limb of pressure i. e. the dicrotic phase drops during diastole. These damped incisura and dicrotic phase are called dicrotic wave respectively. Ramington (1963) giving his argument for the change in the shape of peripheral pulses states that the central pulse propagated is not intact and the pulse contour during its propagation is modified from damping or from poor matching between the frequencies of the volume input curve and those set

by the distensibilities and flow resistance of each arterial segment or from an augmentation of "matched" frequencies or even from super position of a wave reflected from the periphery i. e. reflected and standing waves upon the incident wave. Starling (1968) also accepts the view that the cause of these changes may be attributed to the effects of damping and the reflection of waves in the arterial tree.

The role of reflection in determining the form of the pulse wave is more complex and has been the subject of much controversy. The simplest demonstration of a reflected wave can be made in a rubber tube filled with water. Suppose if a syringe is attached to one end and a sudden push on the plunger will cause a pulse to travel along the tube. If the remote end is clamped, the pulse will return in the same sense, i. e. a positive pressure pulse is positive after reflection. The same effect will occur if the end is constricted without being totally blocked, but only part of the wave will be reflected and part will pass through the constriction. If instead of clamping the end of the tube, it runs into a large reservoir, the wave will still be totally reflected but will be inverted i. e. a positive pulse will return

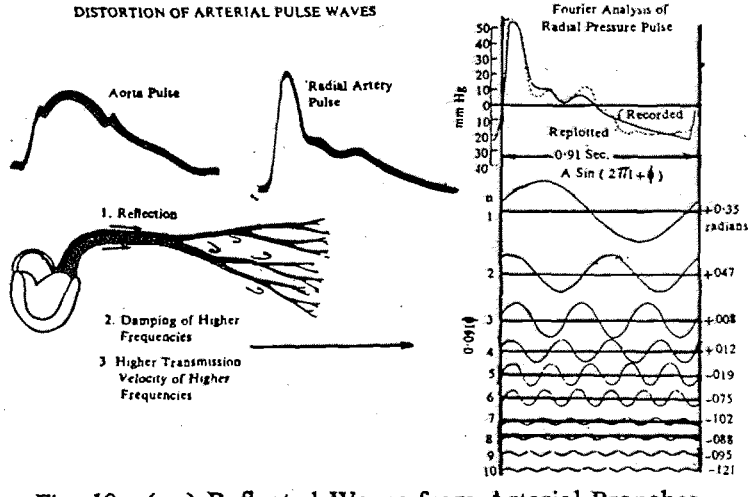


Fig. 19 : (a) Reflected Waves from Arterial Branches.
(b) Arterial Pulse Composed of Many Frequencies.

as a pulse of negative pressure. Such type of positive and negative pressure waves also occur in the arterial system. Very close to the point of reflection at a closed end the reflected wave will

fuse with the incident wave and the added waves will give a total of double the samplitude. This is known as the summation effect. By the same reasoning the incident and reflected waves will cancel each other out at an open end. If the pressure wave travels with increasing velocity toward the periphery and reflected back from regions where many branches occur over a short distance, the oncoming pressure wave distorted, attaining a high peak pressure and wide fluctuations following the peak (Fig. 19).

The main site of reflection appears to be in the arteriolar bed because its effects are greatly increased by vasoconstriction and diminished by vasodilatation. Theoretically, every time an artery branches, a reflection will be created, but it appears that for the larger branches the dimensions are such that reflection is minimal. The fact that small terminal branches are acting like a partially obstructed end due to the much greater viscous drag of the blood. McDonald (1960) and Attinger and McDonald (1967) suggested that normally some 60-70% of the incident wave is reflected at the arteriolar beds of the pelvis and hind limbs. In the fore part of the body it is probably the same. No sign of any reflected wave of any significant size can be detected in the ascending aorta or a short distance away from it. At slow heart rates the oscillations set up by one systolic ejection have almost completely died away before the next heart beat. In summarising the phenomena played by reflected waves, we can say that these waves are responsible to the greatest extent in bringing out the real architecture of peripheral pulses which are nothing but are mere modified form of central and peripheral pulses being distorted by reflected waves.

Formation of Radial Pulse

Among the peripheral pulses, the radial pulse is most commonly used in clinical diagnosis. In previous section much has been discussed about the peripheral pulses. Therefore, it is essential at this moment to deal with separately in a greater detail of the radial pulse. Looking into the complexities of role played by reflected waves etc. in the construction of peripheral pulses so to the radial pulse, it appears that even with an ideal recording device, interpretation of the form of the wave is difficult. However, we get more exact information by using an

electronic manometer communicating through a needle inside the artery. Where this type of facility is not available, pulse wave is recorded by indirect method by applying a pressure sensitive capsule to the artery. Dudgeon's sphygmograph (Fig. 20) which was used more prevalently before the invention of latest instruments is now out of date. But where there is extreme lack of facilities in using the advanced technique, Dudgeon's sphygmograph is the only means to record the pulse tracings

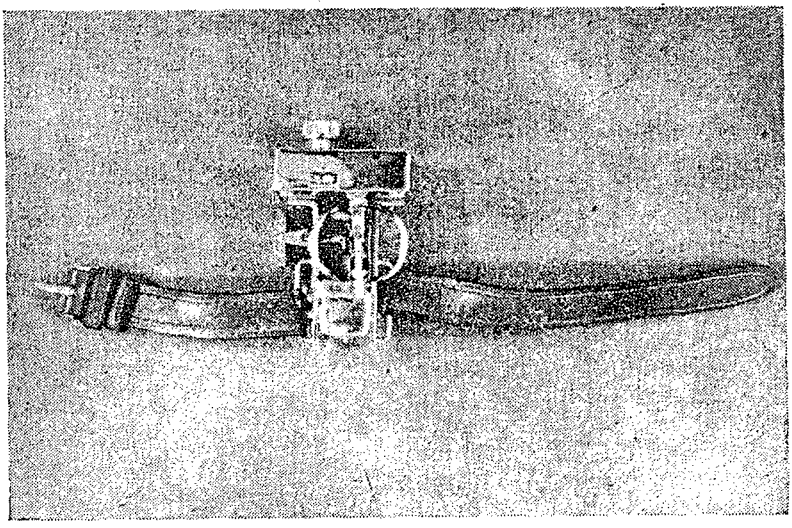
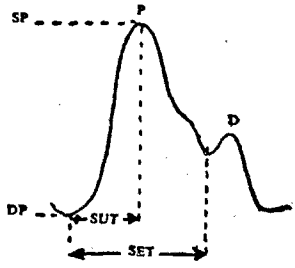


Fig. 20 : Dudgeon's Sphygmograph.

Adams (1942) states that there is considerable variation in the character of the pulse, even in normal person. Tracings of normal radial pulse have been illustrated diagramatically (Fig. 21, 22). To the trained fingers normal pulse wave appears to rise fairly sharply but not abruptly. It is sustained for a moment and then disappears. As it appears from the diagram (Fig. 21) that there are two waves P and D which can be easily distinguished. P wave is the percussion wave which rises fairly rapidly without any interuption on it and having rounded peak. The percussion wave first rises due to rapidly transmitted shock of left ventricular contraction and then fells towards the end of systole. The initial rise which causes expansion of the artery not

only represents the rapid shock of left ventricular contraction but also it represents that the escape of the blood into the capillaries is not as rapid as the ejection of blood into the blood vessels. The fall towards the end of systole is due to the redu-



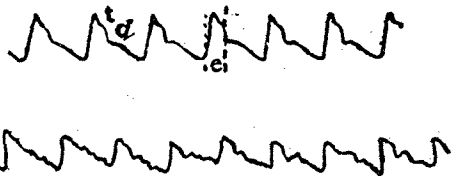


Fig. 21 : Normal Pulses.

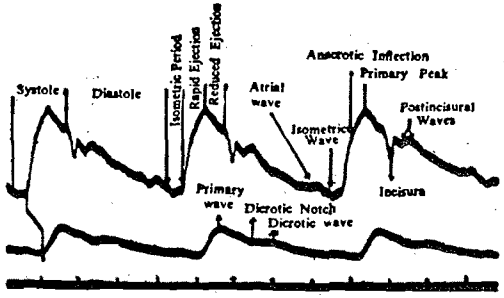


Fig. 22 : Normal Pulses.

ced ejection phase of the ventricle delivering less blood than is passing out the arterioles. It is also clear from the diagram that sometimes after a slight depression from the peak there may be another systolic wave, the tidal wave (t) near the peak between the percussion and dicrotic wave. Wood (1956) and Friedberg (1969) state that the tidal wave is caused due to the summation of the uncompleted percussion wave and waves reflected from the periphery. But Hurst and Logue

(1966) are in the opinion that it is caused by continued but slower ventricular ejection in addition to reflected waves from the periphery.

The discending limb of the pulse is usually less steep and it is due to a more gradual fall in pressure corresponding tb the elastic recoil of the arterial walls. As it is also clear from the figures that the discending limb is interupted by incisura which is produced by closure of the aortic valve, and it is known as dicrotic notch. It is also seen that the discending curve, is not smooth but contains several minor oscillations. The most constant of these is the dicrotic wave (d), the largest wave on the discending limb of the trace. Difference of opinion also exists here regarding the mechanism taking part in the formation of this wave. Wood says that it is produced due to the shock of aortic valve closure. Friedberg realizes that it is formed due to shock of closure of the aortic valve with consequent rebound of blood 'plus' peripheral factors, whereas Hurst and Logue say that it is constructed mainly due to reflected waves from the periphery. Bel et al (1968) state that this wave together with other smaller subsidiary waves often observed, represents oscillations of the aorta and its own natural frequency. The normal pulse is called catacrotic pulse.

Further, if we go through figure 21, it appears that the systolic upstroke time (S U T) is measured from the onset of the upstroke, or ascending limb to the summit of the pressure pulse and it is not more than 0.14 second in normal pulse. The systolic ejection time (S E T) is measured from the onset of upstroke to the incisura or dicrotic notch. It is about 0.30 sec.; but one thing to be noted here that for (S E T) measurement is commonly corrected for heart rate by dividing the measured internal by square root of the cycle length in seconds. Although in general the systolic upstroke time is shorter in peripheral tracings, the systolic ejection period is longer. The (S P) which is peak of the percussion wave represents systolic pressure and the (D P) represents the diastolic pressure which is measured from the beginning of the ascent (Fig. 21). Regarding interpretation of contour of the pulse and diastolic blood pressure, there are some curious and erroneous statements in the clinical texts. The most common relates to the lowest point on the wave the diastolic blood pressure. Many consider peripheral resistance to be uniquely related to diastolic pressure rather than to mean

arterial pressure. Pickering and Dexter pointed out that peripheral resistance is related through cardiac output to mean arterial pressure and that systolic and diastolic pressures represent simply the highest and lowest points of oscillation around this mean. Yet Wood goes so far as to state that conditions characterized by a low diastolic pressure, including aortio incompetance and heart block (and sometimes arteriosclerosis) are associated with peripheral vasodilatation.

Making an attack on terminology, Michael Rourke (1971) says that the terms "percussion" wave, "tidal wave", and the diastolic or dicrotic wave are confusing, because this terminology is not consistent. In his opinion "percussion" appears to refer to a mechanism, "diastolic" describes timing in relation to the cardiac cycle, while "tidal" has no clearly relavent meaning. Giving interpretation of "dicrotic" wave, he says that literally it means twice beating, but at the same time when observed in the central aortic pressure wave recorded in a normal dog, it is found that the diastolic wave is actually the third undulation on the pulse. Giving his remark on "diastolic", he says that this term is not always appropriate, because the diastolic wave moves out of diastole into the systolic portion of the pulse when blood pressure rises.

About the conventional belief that the incisura or dicrotic notch separates the systolic from the diastolic part of the pressure wave and is caused by aortic valve closure, he says that there are two notches found in curves recorded at 5 cm. intervals between the aortic arch and iliac artery (Fig. 18). The first or two incisura is short and sharp, most prominent in proximal vessels and is synchronous with aortic valve closure. Whereas the second–the true dicrotic notch–is more gentle, most prominent in peripheral vessels, and represents the foot of the diastolic wave. Their relationship varies with sites in the arterial tree and with mean arterial pressure. Thus it is obvious that they represent different events and that each has a different significance.

Further stressing upon the point of rationalization, he feels that the terminology like "percussion", "tidal", and "dicrotic" waves should be discarded, and should be replaced by a system which refers entirely to timing or entirely to mechanism. In relation to time the "percussion", "tidal", and "dicrotic" waves may be termed as "early systolic", "late systolic", and "dia-

stolic" respectively. And in relation to mechanism these waves may be termed as "impact", "cephalic reflected", and "caudal reflected". The nomenclature based on timing rather appears simpler and better.

The Diseases of Arteries

The diseases of the arteries which admit of clinical recognition are : (1) Arterio-sclerosis, a term used to describe a group of degenerative diseases. The main diseases which lie under this group are : (a) athero-sclerosis, (b) medial sclerosis, including the Monckeberg type, (c) arteriolar sclerosis and hypertension; (2) Thrombo-angitis obliterans; (3) Polyarteritis nodosa; (4) Chronic and acute endarteritis; (5) Aneurysmal dilatation; (6) Compactions such as an embolism and thrombosis; (7) Functional disease of the arteries.

1. (a) Athero-sclerosis : (Sign Atheroma, intimal sclerosis) starts as a patchy thickening of the intima of the larger arteries. It is often found in early adult life, but becomes more marked after middle age and then becomes more or less wide spread.

(b) Monckeberg's Medial Sclerosis is a diffuse form of arterial disease which occurs after 50 years of age. It is characterized by fibrosis, fatty degeneration and later on calcification of the muscle coats of the larger arteries of the limbs and their branches. It does not involve the aorta. This happens as a result of ageing and it causes lengthening, tortuosity and hardening of the arteries but it does not reduce their calibre. In the leg it occurs in more advanced form, and it is particularly here that calcification often in the form of encircling plaques or rings can be demonstrated on X-ray films.

Both atheroma and medial sclerosis are commonly associated. In older people we observe gross signs of medial sclerosis with thickened tortuous brachial, radial and temporal arteries and a raised systolic pressure, causing no ill effects over many years. Physical signs particularly related to cardio-vascular systems are : (i) thickening of the palpable arteries, (ii) increased pulse pressure, generally associated with a rise in systolic pressure, and (iii) alteration in the second aortic sound.

(c) Diffuse Arterio-sclerosis : (Syn. Diffuse hyperplastic

sclerosis, arterio-capillary fibrosis.). It is responsible for persistent hypertension. In contrast to atheroma, which is localized, the lesion in arteriolar sclerosis (hyperplasia) is diffuse. In contrast to arteriosclerosis, in which the lesion affects the media as well as the intima, in arteriolar sclerosis the intimal thickening (or hyperplasia) is the distinctive pathological feature. Further in arterio-sclerosis the main incidence of the lesion is in the conducting arteries, whereas in arteriolic sclerosis it is in the arterioles. The organ distribution is characteristic. The lesion is always found in the kidneys or spleen, and generally in both. It is commonly found in the brain, pancreas, and suprarenals, and rarely in the liver or digestive tract. It does not occur as a complete lesion in the heart of skeletal muscle.

Persistent hypertension or essential hypertension developed due to diffuse arteriolar sclerosis is further sub-divided into (i) benign hypertension, and (ii) malignant hypertension. In benign hypertension kidneys are not involved the blood pressure is persistently 180 mm. systolic and 100 mm. diastolic or more. It may be much higher, reacting 260 mm. systolic and 120 mm. diastolic or more. The radial pulse is hard and resists compression. The artery is generally thickened and it may be tortuous.

3. Polyarteritis Nodosa : It is a collagen arterioles disease of smaller arteries and arterioles which is usually generalized and produce wide spread effects.

4. Chronic and Acute Endarteritis is due to syphilis and other causes. Syphilis affects arteries in two ways : (1) a proliferation of intima of small vessels reduce their lumen. This condition may also be responsible for thrombosis in the affected vessels (2) weakening of the muscular coat of the large vessels.

7. Functional Diseases of Arteries and Arterioles : Under this heading can be placed Raynand's disease migraine, alternate flushing and pallor, cold hands and feet dead hands, chil blains, various other arythematous conditions, paroxysms of copious urination and itching.

Factors Affecting the Pulse Pressure

The pressure pulse contour in addition to representing its qualitative form also signifies the values of systolic and diastolic pressure (Fig. 23). The factors affecting pulse pressure are :

(1) stroke volume, (2) the compliance i. e. total distensibility of the arterial tree. From clinical point of view we can say that the factors affecting pulse pressure are : (1) change in

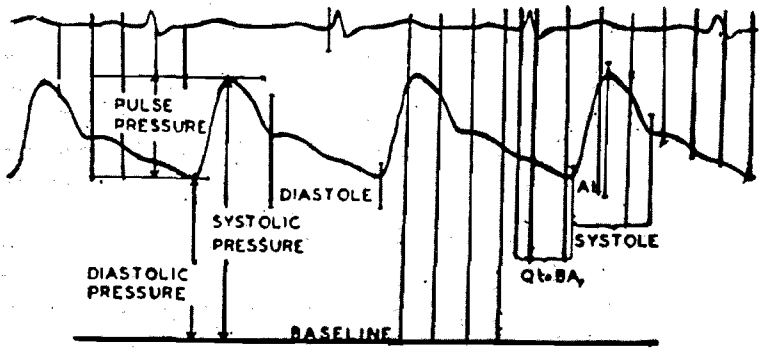


Fig. 23 : Assessment of Systolic and Diastolic Pressure Values from Pressure Pulse.

mean arterial pressure, and (2) pathological changes that affect the distensibility of the arterial walls. In regard to compliance and distensibility one should be very clear that compliance and distensibility are quite different. A highly distensible vessel which has very slight volume may have for less compliance.

1. Stroke Volume : In general, the greater the stroke volume output, the greater is the amount of blood that must be accomodated in the arterial tree with each heart beat. And, therefore the greater is the pressure rise during systole and the pressure fall during diastole. Thus a greater pulse pressure will be the net result. On the other hand, for a given stroke volume of blood pumped into the arteries, the greater the compliance of the arterial system the less will be rise in pressure. On the other hand, the greater the compliance of the arterial system the less will be rise in pressure for a given stroke volume of blood pumped into the arteries. In effect then the pulse pressure is determined nearly by the ratio of stroke volume output to compliance of arterial tree. Naturally any condition of the circulation that will affect stroke volume or compliance of the arterial tree will also affect the pulse pressure.

There are many different conditions which change the stroke volume output but only a few need explanation here, and they are : (a) an increase in heart rate while the cardiac output remains constant causes the stroke volume output to decrease

in inverse proportion to the increased heart rate; and the pulse pressure decreases accordingly, (b) a decrease in total peripheral resistance allows rapid flow of blood from the arteries to the veins. This increases the venous return to the heart and increases the stroke volume output. Therefore, the pulse pressure is also greatly increased, (c) an increase in mean circulatory pressure, if all other circulatory factors remain constant, increases the rate of venous return to the heart and consequently increases the stroke volume output. Here, again the pulse pressure is accordingly increased, (d) the character of ejection from the heart affects the pulse pressure in two ways : (i) if the duration of ejection is long, a large portion of the stroke volume output runs off through the systemic circulation while it is being ejected into the aorta. Therefore, the magnitude of the stroke volume output effect on pulse pressure is increased, (ii) sudden ejection of blood from the heart causes the pressure in the initial portion of aorta to rise very high before the blood can run off to the more distal portions of the aorta. Therefore, sudden ejection causes a greater pulse pressure than does more prolonged ejection.

2. Compliance : As it has already been stated that the compliance or total distensibility is the total quantity of blood that can be stored in a given portion of the circulation for each mm. of Hg. pressure rise. As arterial pressure rises from low to high values, the compliance decreases slightly. Therefore, in the low pressure range considerably more blood can be accomodated for a given rise in pressure than in the high pressure range. For this reason, in a person, who has high arterial pressure but a normal stroke volume output, the pulse pressure is considerably increased.

So far as pathological changes affecting distensibility are concerned, in old age the arterial walls lose much of their elastic and muscular tissues; and there are replaced by fibrous tissue and sometime even calcified plaques that can not stretch a significant amount. These changes greatly decrease the compliance of the arterial system which in turn causes the arterial pressure to rise very high during systole and to fall greatly during diastole as blood runs of from the arteries to the veins. Thus we see that how the mean arterial pressure is changed which is of overwhelming importance in affecting the pulse pressure.

Two factors determine the over all capacitance of the arterial system : (1) the distensibility of each segment of the arterial tree, and (2) the volume of the arterial tree. It is quite obvious that decreased distensibility of any segment tends to decrease the distensibility of the entire arterial system. On the other hand, if the volume of the arteries is greater than normal, even though the distensibility of each segment of the arteries is less than normal, the two factors are likely to nullify each other. Thus, in old age, the distensibility of each segment of the arteries is tremendously reduced, but the pulse pressure is not increased as much as it might be, because the arteries also become considerably dilated in old age. The diastolic pressure also rises slightly in arterio-sclerosis and in old age. The reason for this is not totally known but it usually rises coincident with the occlusion of vessels in old age.

Samson Wright (1968) describing the percussion wave of radial artery in terms of cardiac output, heart rate and resistance states that a large percussion wave is due to (1) large cardiac output, (2) slow heart rate, and (3) low peripheral resistance. And a small percussion wave is due to : (1) small output, (2) high peripheral resistance from increased arterial tone, and (3) impaired elasticity of the vessels. He further says that in a circulating model the descending limb of the curve falls more steepy if the diastolic pressure is low, the arterial wall thick or if aortic regurgitation is present. In aortic regurgitation in man and on stimulation of the aortic nerve in animals to produce relaxation of the arterioles, a rapid down stroke is observed.

Seeing the importance of cardiac output in determining the configuration of percussion wave it appears rather necessary to highlight the factors which are responsible for its decrease and increase. By definition cardiac output is the quantity of blood pumped by the left ventricle into the aorta each minute. A low resting cardiac output with an inadequate response to exercise results either from inadequate ventricular filling, as in mitral or tricuspid stenosis or constrictive pericarditis, inadequate ventricular emptying as in pulmonary or aortic stenosis, or both filling and emptying are inadequate due to impaired myocardial contractility associated with left ventricular failure.

The commonest mechanism leading an increased cardiac ou tput is a decrease in peripheral vascular resistance. In this

condition cardiac output is increased in order to maintain a normal blood pressure. Another important factor which influences the cardiac output is the need of the tissues for oxygen. In hypoxic states such as anaemia, and in chronic cor-pulmonale, the cardiac output must rise in order that the tissue may receive sufficient oxygen. In hypoxic state there is an increased secretion of adrenaline. Other factors affecting the cardiac output include the effect of the sympathetic nervous system, alteration in blood viscosity, variations in body temperature, and the effects of harmones and other chemical substances such as those produced by phaeochromocytoma or carcinoid tumours. Physiological conditions responsible for increased cardiac output are : (1) exercise, (2) warm, humid environment, (3) anxiety state, (4) the hyperkinetic heart syndrome, (5) fever, (6) pregnancy. Pathological conditions responsible for increased cardiac output are (i) anaemia (ii) thyrotoxicosis, (iii) anoxic cor-pulmonale, (iv) carcinoid syndrome, (v) hepatic disease, (vi) an acute glomerulonephritis, (vii) polycythemia vera and (viii) beri-beri.

An increase in cardiac output may be accomplished either by increasing the heart rate or the stroke volume or both. In addition to tachycardia and raised jugular venous pressure, when the stroke volume is increased as a result of a decrease in peripheral resistance typical clinical signs are produced including a strongly beating heart with a forceful apical impulse and an increase in systemic pulse pressure giving rise to bounding or 'water-hammer' carotid, radial and femoral pulses. The decrease peripheral vascular resistance results in vasodilatation with a warm flushed skin and distended forearm veins.

Clinical Examination of the Pulse

There is in clinical medicine no physical sign more basic or important than the arterial pulse. The pulse reflects disease of the heart and arteries from which most patients succumb. For clinical examination of the pulse, the radial pulse is generally chosen, since it is easily accessible and lies against the bone (radius). Examination of the pulse provides evidence of great value both as to the state of the circulatory system and the general condition of the subject. Whatever examination is to be made, palpation of the pulse is the first observation to make. If the subject is nervous or emotionally disturbed, or has lately

hurried, the observation is repeated later when the pulse has settled. For accurate record the pulse is always taken under similar conditions as to posture, time of day, relation to meals etc. To feel the pulse three fingers are placed over the course of the artery, the index finger nearest the heart. During examination of the pulse the patient's forearm is pronated and the wrist slightly flexed. In cases of non-cardiovascular disease, it is usually sufficient to feel the radial pulse at the wrist, but in cardiovascular disease the physician should also feel the other radial, brachial, carotid, femoral, popliteal, posterior tibial, dorsalis pedis, temporal and facial pulses of both sides, and also abdominal aorta. According to Savill (1964) the clinical features to be studied in palpation of the pulse are its (1) frequency (speed, rate), (2) rhythm, (3) force, (4) volume (amplitude), (5) tension, (6) character (quality, form), (7) the state of the arterial wall. Wood (1968) excluding only 'force' has included the rest point in his book. Hutchison (1968) has excluded out the examination of 'tension' and has added upto examine the presence or absence or delay of the femoral pulses compared with the carotids. Giving remark on examination of 'tension' Hutchison states that estimates of the 'tension' of the pulse, that is of the blood pressure within the vessel by palpation, are quite unreliable. Oram (1971) has advised only for the examination of (1) rate, (2) rhythm, (3) form, and (4) condition of the arterial wall. He says that attempt to estimate the blood pressure by the degree of pressure required to obliterate the pulse at the wrist are a waste of time.

Rate :

The rate of the pulse is stated as so many beats a minute. It is counted, not when the fingers are first laid upon the pulse, but when any quickening due to nervousness of the patient has subsided and the pulse has resumed its normal rate. Counting of beats is not made less than half minutes. We should remember that in other cases as in atrial fibrillation, the pulse rate counted at the wrist may not indicate the true rate of ventricular contractions. In all such cases, the rate of heart beat should be counted by auscultation at the apex, and the difference between this rate and the pulse rate at the wrist should be recorded. This difference is referred as pulse deficit. During the counting of beats per minute we should be cautious whether the pulse is

abnormally fast or abnormally slow. In normal human too the heart rate varies considerably and it is due to variations in the rate of impulse prodution in the normal pace-maker (the sino-auricular node). This is called sinus tachycardia. The normal pulse rate is 70 per minute. A few people have pulse rates under 60 or 80 but such must not be accepted as within normal limits without careful consideration. Rarely a pulse rate of 50 or just under or of 90 or just over, is compatible with perfect health. The American Heart Association accepts between 50 and 100 beats per minute as the normal range. Frequency of pulse also varies according to the sex and ages. It is faster in the female than in the male.

In the foetus and new born infant its average rate is 140 per minute; under I year, 120; under 3 years, 100; from 7 to 14, 90; from 14 to 21, 80; from 21 to 65, 70; and in old age 80 per minute. The pulse is normally more rapid during the menstrual period and menopause. It is also more rapid in the evenings and after meals. After a severe illness and in asthenic states the pulse more easily becomes rapid. Change in the posture also plays important role in causing variation in the rate of the pulse. Such as when the tachycardia is due to simple causes, not the result of myocardial changes, the number of the beats falls ten to twenty per minute when the patient alters his position from standing to lying. Other physiological causes responsible for tachycardia are : exercise, emotion, meals, sleep. These features differentiate simple tachycardia from paroxysmal auricular tachycardia, in which the pulse rate is unaffected by posture, exercise etc. Other cardiac conditions in which an increased rate forms the most striking feature are : auricular flutter, paroxysmal ventricular tachycardia, auricular fibrillation.

Pathological Causes of Sinus Tachycardia :

The pathological causes of sinus tachycardia are numerous. (1) Pyrexia is the most common. (2) Early tuberculosis should always be born in mind. Any other bacterial infection is a common cause e. g., streptococcal and penuniococcal infections, whether generalized or local. Pulse frequency is increased in the acute specific fevers, especially in scarlet fever. (3) Of endogenous toxaemias : (i) Grave's disease is the most common; close observations for larval forms of this disease should be made in any obscure case of tachycardia; (ii) uraemia; (iii) malignant

disease, especially when under going degenerative changes, (iv) all blood diseases with moderate and severe anaemia, (4) Exogenous toxaemia includes a large variety of drugs and poisons, such as tobacco, alcohol, tea, coffee, thyroid extract, belladona and atropine. (5) Nervous states include ordinary emotional disturbance, often of trivial kind, neurasthenia, anxiety neurosis and neuro-circulatory asthenia for common cause in which the border-line between physiological and pathological disturbance is hard to define. (6) Most forms of heart disease, toxic, inflammatory or degenerative, and whether acute or chronic. Increased pulse rate is an important sign of heart-failure.

Bradycardia : Besides increased heart rate (tachycardia), which has been dealt with so far, the other abnormal condition of the heart rate is decreased heart rate, i. e. bradycardia. A slow pulse should be verified by counting the frequency of heart beats on listening to apex. A frequency of 60 per minute or under requires careful consideration. As it may be the first consideration of serious organic disease such as heart block or cerebral tumour. A slow pulse rate may be a personal idiosyncracy and is compatible with perfect health. It is sometimes familial. A slow heart rate is an advantage because it allows of an increased cardiac output without of increase of heart rate. In healthy subjects, bradycardia is due to a slow rate of impulse production in the sino-auricular node. It is known as sinus bradycardia.

The pathological causes of sinus bradycardia may be : (1) the result of reflex neuros effects, via the vagus nerve; e. g. with an overactive carotid sinus; (2) bradycardia is one of the cardinal features of myxoedema, and other states of lowered metabolism, such as exposure to cold, starvation, anorexia nervosa, cachexia and melancholia except in the terminal stages of these conditions. It is associated with a low basal metabolic rate. (3) Toxic conditions : (a) endogenous, such as jaundice, diabetes and uraemia, and (b) exogenous, such as may be due to diabetes, stropanthus and opium. At first tobacco may slow the heart; (4) bradycardia is not uncommon in convalescence from acute infection, e. g. influenza, and in exhaustion states. A low pulse rate in proportion to the fever is found with infections by the typhoid and salmonella group, E. coli, and sometimes staphylococcal infections and influenza; (5) increased intracranial pressure of whatever etiology. A slow and

irregular pulse may also occur in meningitis. Bradycardia in heart disease is generally due to heart block. When the vagus is pressed there occurs temporary slowing of the pulse rate and characteristically in an ordinary fainting (Vaso-Vogal slowing).

Rhythm :

It tells whether the pulse is regular or irregular. If it is irregular, it is seen whether it is completely irregular or the irregularity has a recurring pattern, or whether an otherwise regular rhythm is occasionally interupted by some slight irregularity. The most common regular irregularities are : (1) sinus arrhythmia (where the pulse speeds up during inspiration, and slow during expiration), the slowing is vagal, and the irregularity is physiological; (2) pulsus bigeminus or pulsus trigeminus (where the pulse beats in twos or threes followed by a pause), the result of regularly occurring premature beats; and (3) pulsus alternans (where big beats and little beats alternate at regular intervals), indicative of left ventricular failure.

The commonest irregular irregularities are : (1) The consistently irregular pulse due to auricular fibrillation. Here the beats not only follow one another at irregular intervals, but are of unequal strength and volume. In addition the pulse rate may differ from the apex rate. The great clinical test of the presence of auricular fibrillation is that the irregularity is increased by exercise; (2) the irregularity due to irregularly occurring premature beats or extra systoles. This indicates myocardial hyper irritability, resulting from fatigue, inflammation or degeneration. This irregularity is in most cases abolished when the rate is increased by exercise.

The Force :

It is estimated by the impact against the finger. It depends upon the rapidity of the filling and emptying of the artery, e. g. in aortic regurgitation, hyperthyrodism, anaemia and in certain febrile conditions, the force is considerable.

The Volume :

The volume, estimated by the lift and duration of the wave provides a useful estimate of left ventricular output per beat i. e. stroke volume. It is modified by local conditions such as a sclerotic or anatomically small artery. Hutchison says, "provided that the arterial wall is normal this is measure of the pulse pressure". If the vessel becomes rigid, however, commonly

the pulse-pressure may widen whilst the pulse-volume on palpation may appear normal. The volume of the equivalent pulses on the two sides should then be compared.

The Tension :

The tension is estimated by the obliterative forces and it indicates systolic blood pressure. To estimate the tension the pressure is exercised by the forefinger in order to obliterate the pulse wave and prevent it reaching the middle finger. In case there is a return pulse wave through the palmer arches it may be necessary at the sametime to obliterate the pulse with the third finger. The diastolic pressure can also be estimated roughly by noting the degree of hardness (high tension) or softness (low tension) of the pulse between beats. The pulse of low tension appears to collapse so that nothing is felt. The pulse of high tension is perceptible between beats as a cord which can be rolled beneath the fingers.

The Character :

It is worthy to note here that problems regarding classification of abnormal pulses have been recognized for many years. When one goes through the various text books from the time of Mackenzie (1905) till now, we find that there exists differences of opinion in the interpretation of the contours of various abnormal pulses and mechanism involved in their formation. Mackenzie claims that he could be able to record anacrotic, dicrotic and bisferiens pulses from normal individuals also. This may be attributed to the faults lying in the process of recording. Following Mackenzie, Lewis and Osler did not mention the terms anacrotic and dicrotic. Likewise controversy also prevails among the modern authorities like Wood, Hurst and Logue and Bramwell regarding illustrations of some of the curves of abnormal pulses. When we have a glance over there curves, we find that Wood's illustration of bisferiens pulse is very similar to the anacrotic pulse in the text-books of Hurst and Logue. Similarly, bisferiens pulse of Hurst and Logue is apparently like Bramwell's water-hammer pulse and so on. Regarding mechanism of formation such as of dicrotic pulse Osler and mechanism of formation such as of dicrotic pulse Osler and Machenzie are silent on the point that prominent dicrotic wave is a sign of vasodilatation. Wood correlate it that it is due to vasodilatation.

Above all these facts, the diagnosis made by experts by direct examination of the pulse i. e. with the help of the fingers is still undoubtful and unchallenged in the clinical branch of the medicine, and that is why even today the clinicians of repute like Savill, Wood, Davidson, Friedberg, Hutchison, Oram (1971) etc. have confidently described in the latest editions of their books about the various character i. e. qualitative form of abnormal pulses. The character (the term character refers to the nature of the pulse wave, to its rise, summit and fall) of the pulse wave is most satisfactorily appreciated by palpating a large vessel, e. g. the carotid artery. One very important thing to note is that it is not usually possible to detect the waves of the normal pulse, or slight variations from the normal. But in certain diseases the character of the pulse is detectably abnormal. Below descriptions are made of abnormal pulses most commonly found in the diseases of cardiovascular system. (1) Anacrotic pulse. This is a greek word which comprises of two syllable, Ana means up, and krotos means beat. Such type of pulse occurs in aortic stenosis, which gives rise to a slow ejection of blood from the left ventricle. The resulting pulse-

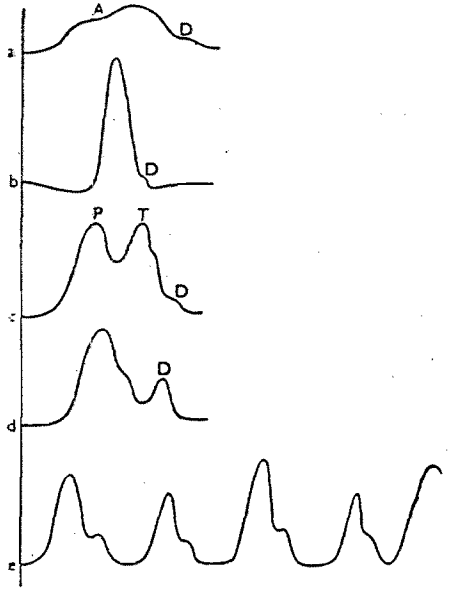


Fig. 24: Pulses of the Diseased Condition.

wave has a slow upstroke, an anacrotic wave on the upstroke and the pulse is of small volume (Fig. 24, a). (2) Water-hammer pulse. The percussion is abrupt, has an ill-sustained crest and the collapse of the pulse is also rapid (Fig. 24, b). The collapse occurs during systole prior to the second sound and not during diastole. Dicrotic notch may be recordable displaced towards the baseline. The systolic pressure is usually raised and the diastolic lowered, and in fact may reach zero. It occurs when there is an abnormal leak from the arterial system for example (1) (a) aortic regurgitation, (b) potent ductus arteriosus, (c) arterio-venous fistula, and (d) mitral incompetence. It is also felt in heart block and hyperkinetic states. It is best felt when the patients arm is elevated and the wrist is grasped with the palm of the observer's hand against its palmer surface. The amplitude if the pulse varies considerably, being greater in aortic incompetence, heart block and hyperkinetic state and low in mitral incompetence. Such a pulse implies a low filling resistance in the reservoir into which the left ventricle is pumping; so that often there is peripheral vasodilatation generally responsible for increased cardiac output. In the condition of peripheral vasodilatation the arteries are too full in systole and too empty in diastole, (3) Pulsus bisferiens. It is a combination of the anacrotic and collapsing pulses occurring in combined aortic stenosis and incompetence. It may also be possible to bring out the bisferiens characteristic by exercise, the valsalva manoeuver. As shown (Fig. 24, c) two components are P and T. T is a tidal wave, and according to Bramwell is due to the head of the percussion wave P, reflected back before it tail has passed. The meeting of the returning tidal head resulting in a summation effect. Here, a point of clinical importance is that if the amplitude of P is greater than T, aortic stenosis is dominant. If the amplitude of P is less than T, then incompetence is the more severe lesion. (4) Pulsus paradoxus. The pulse becomes smaller, or even disappears at the end of inspiration, when the patient breaths deeply. This sign is found in pericardial effusion and in constrictive pericarditis. In addition to above conditions it may occur in obstruction to the superior venacava. The responsible factor in causing pulsus paradoxus is dropping of systolic pressure more than normal value of 10 mm. during inspiration. Normally during inspiration the fall of systolic pressure is mainly due pooling of blood into the

pulmonary vessels as a result of expansion of the lung and the more negative intrathoracic pressure. Transmission of the negative intrathoracic pressure to the aorta and great vessels may also be the contributing factors. (5) Pulsus alternans. This is characteristic of failure of the left or right ventricle. It may be detectable at the wrist but this uncommon, although it can be brought out by gently compressing the brachial artery above whilst the radial artery is felt below. Rarely, the weak may not be palpable at the wrist and this termed "total alternans". It is evident from the diagram (Fig : 24, e) that in the radial tracings are seen alternate large and small beats at equidistant. This condition is often discovered when the systolic blood pressure is taken, and the rate of sounds suddenly doubles as the pressure in the cuff falls. It may be both produced and abolished by exercise. This type of pulse is found when the heart muscle is severely damaged. Ofcourse, the heart rate is moderate and no abnormal rhythm is present. (6) Pulsus parvus. A pulse of small amplitude but normal configuration indicates that the blood flow is diminished in the vessel concerned and is generally due to a low cardiac output due to vasoconstriction. Pulsus parvus also indicates that the pulse pressure is reduced. It is a characteristic of a serious obstruction or leak in the circulation proximal to the aortic valve, poor cardiac filling, and any form of low output failure.

Physiologically it can occur as a result of cold and anxiety. Pathological conditions causing pulsus parvus are : (a) thrombosis or coarctation of the aorta where there is partial occlusion, (b) severe hypertension, (c) aortic stenosis, (d) cardiac infarction, (e) mitral stenosis, (f) extreme pulmonary hypertension, (g) severe pulmonary stenosis, (h) tricuspid stenosis, (i) constrictive pericarditis, and (j) pericardial effusion. (7) Pulsus parvus et Tardus. It is a small pulse with delayed systolic peak. It is a characteristic of severe or moderate aortic stenosis. (8) Dicrotic pulse. Normally in health the dicrotic wave is impalpable at the wrist. However, in fever, classically typhoid, the peripheral resistance is low and blood pressure is also giving a form of double pulse felt at the wrist (Fig. 24, d). (9) Bounding pulse. The wave swings sharply upward, usually reaches a small level higher than normal, and disappear quickly. It is due to a shortened ventricular systole and concomitant diminution of peripheral resistance. Bounding pulse is found

in severe febrile states, thyrotoxicosis, emotional disturbances, and other disorders causing peripheral vasodilatation. An extreme form of the pulse is corrigan pulse (water-hammar pulse). (10) Thready pulse. The rate is rapid, the wave appears quickly, giving the impression of very little strength. This is found in some cases of severe myocardial failure and in peripheral circulatory collapse. (11) Pulseless disease. Occurs more commonly in Japan than elsewhere, as the result of progressive obliterative endarteritis of the vessels to the head, neck and arm, producing absent brachial and radial pulse.

An absent or greatly diminished radial pulse now-a-days is usually found as the result of left heart catheterization but may occur on one side as a result of a displaced radial artery, the lower end of which runs along the back of the radius, or it may result from an aberrant origin or course of the left subclavian artery. Pressure of aortic aneurysm is also one of the causes. The aortic arch aneurysm is the usual cause where the pulse is absent at both wrist and the neck.

The Condition of the Vessel Wall :

The condition of the vessel wall i. e. thickness is estimated by rolling the artery on the underlying bone of the wrist, but before doing so the radial artery should be emphied by pressure on the brachial artery in the bevipital groove against the humerus. This can also be done by obliterating the pulse by pressure with all three fingers, the wall of the artery is felt by rolling the empty vessel under them. In young persons, the arteries can not be felt or are soft. In older persons, they are more easily palpable. In arterio-sclerosis they may feel hard like whipcard and may be tortuous. Oram remarks "even if the thickness can be estimated the implication is that the particular inch or so of radial artery being palpated is thick, and no other conclusions concerning that or other arteries may be made from this sign"

Delay of Femoral Compared with the Carotid Pulse :

This is found in coarctation of the aorta. The typical pulse of a healthy adult man is described in the following ways : The rate is 70 per minute. The beats are regular in rhythm and equal in volume. The pulse is of normal volume and is not collapsing in character, the arterial wall is just palpable but is neither thickened nor torturous. After the description of rate,

rhythm, force etc. and their extreme importance in diagnosis the case, a bit explanation is required here to assess the importance as a whole by describing its role in relation to prognosis and treatment of disease. Indeed there is so much to be learnt from palpation of the pulse by the experienced fingers that it should always be the first step in the general examination of the patient. The pulse frequency in febrile diseases should be charted four-hourly, so that it may be read in conjunction with the temperature and respiration rate. In an adult pulse frequency increases 8 to 10 beats per minute for each degree rise of temperature. In toxic myocarditis a pulse frequency increased out of proportion to the rise of temperature, and a pulse rate over 130 per minute in pneumonia is evidence of severe toxyalmia. In case of children pulse frequency increases by 12 to 15 beats per minute with each degree rise of temperature.

In relation to fever if the pulse frequency is slowing it may be indicative of heart block. A sudden drop of pulse, temperature and respiration rates together in cases of pneumonia is indicative of crisis. But without a fall in pulse rate or even a slight increase in pulse rate with the fall of temperature is evidence of complication. In abdominal conditions if the pulse is rapid it indicates perhaps that the patient is suffering from some inspection, whereas in colieky pain the pulse rate is slow. An increase of pulse rate with fall in temperature in abdominal conditions occurs in intestinal haemorrhage, perforation of bowel, profuse diarrhoea complicating typhoid fever. In cases of appendicitis the pulse rate is of outstanding significance. In doubtful cases, when the patient looks ill, has definite abdominal discomfort but no localized pain, and a soft abdomen, an increasing pulse rate may be the deciding factor for immediate operation. In Grave's disease the pulse rate (specially during sleep) and the height of the pulse pressure with the patient at rest in bed provide a fair index of the basal metabolic rate and the toxaemia. A rapidly rising pulse rate is a common turminal event in both febrile and afebrile diseases. In emotional reaction there is transient increase in the frequency of pulse rate. The pulse is diagnostic measure of cardiac efficiency by its response to exercise and the time taken for its return to normal. A full bounding pulse is characteristic of an acute febrile illness and arthenic state. The pulse is small and thready in states of stock, both medical and surgical.

Amber and Brooke (1966) in their book "The Pulse in Occident and Orient" have given a good deal of information about the varieties of pulses which were used in the past by the modern medical men to diagnose diseases. The book has been divided into eleven chapters. The first deals with the historical survey of the subject. Second, third and the fourth chapters are devoted for the description of pulse-lore in Chinese, Ayurvedic, Arabic and Unani systems of medicine. Chapter fifth describes about the definition, examination and technique of taking the pulse in the above said cultures. Among the other chapters which mention about the normal pulse, Ayurvedic and Unani examination of the pulse, Chinese examination of the pulse, the Western examination of the pulse, and the disease, and the pulse have been described in the chapters seventh and the tenth respectively. Some of the different types of pulses are enumerated below :

P., Abdominalis : The soft compressible, but usually regular p. occurring in certain abdominal diseases.

P., Accelerated : A common symptom in all fevers. The pulse of the adult rarely exceeds 150 beats per minute even in acute inflammatory infection; in prostration it runs above.

An accelerated pulse may be due to valvular defects of the heart except in aortic stenosis, in which case the pulse will be slow. It is usually found in instances where compensation fails.

In the absence of cardiac condition or fever, early phthisis, Addison's disease, exophthalmic goiter, locomotor ataxia, pernicious anaemia may be suspected.

P., Allorhythmic : Irregular in rhythm. Among the arrhythmia beats are : (1) Extra systoles (2) Auricular fibrillation (3) Paroxysmal tachycardia (4) Heart block (5) Premature contractions (6) Inequality of the pulses (7) Sinus arrhythmia.

P., Angry : Wiry pulse. A small, rapid, tense pulse which feels like a cord, seen in acute peritonitis.

P., Asymetrical radial : May result from an anomaly of distribution, size and division of the vessels; aortic aneurism; embolism; an atheromatous plate within a vessel; fracture; luxation causing compression of a vessel; or compression of a vessel by tumour within or without the thorax; cervical rib.

P., Ardent : Artery seems to raise itself to a point in order to strike the finger at a single point.

P., Bamberger's bulbar P. : Observable in the bulbar of the jugular vein and synchronous with the systole; occurs in tricuspidal inadequacy. A pulse may also at times occur in a vein in a vascular organ, as in the case of the liver.

P., Breath : A peculiar audible pulsation of the breath corresponding to the heart beat. Seen in cases of dry cavities of the lung with thick walls not separated from the heart by permeable lung tissue.

P., Bigeminus : Paired beats. The strong beat and the following weak beat are coupled.

P., Bigeminal : Two regular beats followed by a longer pause. It has the same significance as an irregular pulse.

P, Caprisans : An irregular, peculiar weak pulsation succeeded by a stronger one. A bounding leaping pulse irregular both in force and rhythm.

P., Goat leap : Imperfect dilatation of the artery being succeeded by a fuller and stronger one. Artery seems to leap.

P., Celer : A pulse beat swift to rise and fall, particularly that associated with high blood pressure in aortic regurgitation.

P., Changeable : Denotes nervous derangement and sometimes organic heart disease.

P., Bounding or Collapsing : Due to a shortened ventricular systole and a concomitant diminution of peripheral resistance. Found in febrile states, thyrotoxicosis, emotional disturbances and disorders causing peripheral vasodilatation. Pulse feebly strikes the finger, then subsides abruptly and completely. Aortic regurgitation chief sign.

P. Contracted : Indicates a capillary obstruction and intense engorgement. Epidemic cholera. Nearly the opposite of the full pulse, pulsation being narrow, deep, and somewhat hard.

P., Convulsive : Unequal frequency or unequally hard.

P., Cordis : The apex beat of the heart.

P., Critical : The subsidence of irritation results in a more perfect equilibrium in the circulation and a general improvement in the patient's condition. After having been irregular or abnormal in respect to the diseased condition, the pulse returns to normal with the subsidence of the irritation and as it return to normal, the pulse feels free, open, and soft.

P., Debilis : A weak pulse.

P., Deep : Pertaining to the situation of the artery. Cannot be felt without difficulty nor without strong pressure.

P., Deficient or Flickering : A feeble beat which seems every instant about to cease. Lack of a beat due to the failure of the heart to contract.

P., Depressed : Weak and contracted; deep.

P., Duplex : Dicrotic pulse.

P., Durus : A hard incompressible pulse, indicating arterial hypertension.

P., Entroptic : The subjective illumination of a dark visual field with each heart beat. Sometimes noted after violent exercise; due to the mechanical irritation of the rods by the pulsating retinal arteries.

P., Jerking : Marked by a quick and rather forcible beat followed by a sudden, abrupt cessation, as if the direction of the wave of blood had been reversed, indicates that structural disease of the valves of the heart may be present. A pulse in which the artery is suddenly and markedly distended. Aortic regurgitation. Artery from a state of emptiness is suddenly filled with blood.

P., Laboring : Blood seems to be partially emptied at each pulsation.

P., Languid : Slow and feeble.

P., Large : Open and full beat.

P., Long : One in which the duration of the systolic wave is comparatively long.

P., Low : Pulsation scarcely perceptible.

P., Low tension : One with rapid onset, short duration, and rapid decline especially noted in degeneration of the heart, collapse, debility, fevers, and low state of nervous system.

P., Magnus : A large full pulse.

P., Mollis : A soft easily compressible pulse.

P., Monneretis : A full slow and soft pulse-jaundice.

P., Monocrotus : Grave condition of the circulation and impending death. Sphygmograph shows a simple ascending and descending uninterrupted line and no dicrotism.

P., Parvus : A small pulse.

P., Pistol shot : Pulse produced by rapid distention and collapse of an artery as occurs in aortic regurgitation.

P., Plateau : One slowly rising, but which is maintained. A prolonged pulse usually with an anacrotic interruption. Aortic stenosis.

P., Resistant; Hard, Firm : When it resists compression, it is said to be hard, firm, or resistant. Tense. Offers nearly as great a resistance at first as a strong pulse, but yields more easily and completely to strong pressure.

P., Running : A very weak frequent pulse with low tension in the arteries, one pulse wave running into the next with no apparent interval; seen in haemorrhage.

P., Small : Debility with more or less local irritation. Unites the character of the weak or feeble with the contracted pulse. Small and rapid as seen in great prostration from wasting diseases or haemorrhage.

P., Soft : Not marked by active inflammation or much debility; one which may be stopped by digital pressure.

P., Steel Hammer : Abrupt and energetic as the rebound of a blacksmith's hammer; observed in arteries near a joint in rheumatism.

P., Tense : When artery resembles a cord fixed at each extremity, a hard full pulse. When it feels still harder and smaller, it is called wiry. Excessive irritation with considerable debility.

P., Thready : A scarcely appreciable one as observed in syncope. Rate is rapid; wave appears quickly, is small, and disappears quickly. Myocardial failure and peripheral circulatory failure.

P., Vacuus : A very weak pulse hardly distending to the arterial wall.

P., Tremulous : A feeble fluttery pulse, one in which a series of oscillations is felt with each beat. Extreme nervous debility with violent irritation or excessive internal congestion. Tea, snuff, alcohol, tobacco are among its common causes.

P., Trigeminal : Three regular beats followed by a pause.

P , Undulatory : Resembles that of a wave.

P., Vagatonia : 66 beats per minute.

P., Vibratory : Jarring, like the motion of a musical instrument.

P. Weak : Denotes impoverished blood and an enfeebled condition of the system. When pulse is said to be small as well as hard, it is called weak. Debility. Beats lightly against the finger ceasing entirely on very slight compression.

The common diseases and their characteristics pulses described in the work of Amber and Brooke are given below : *Alco-*

holism. Full pulse. *Appendicitis.* Proportional to temperature; serious if increasing rapidly. *Intestinal obstruction.* Rapid feeble pulse. Includes the following, all of which have the same rapid feeble pulse : intussusception, volvus bands, hernia strangulated. *Peritonitis.* Small, hard, and rapid pulse, at first wiry; later thready. *Pneumonia, T. B., Lobar form.* Rapid pulse. *Rheumatic fever.* Soft, rapid pulse 100–120. *Tuberculosis, Miliary.* Rapid, feeble pulse. *Yellow Atrophy of Liver.* Rapid pulse. *Angina Pectoris.* High tension pulse. *Anxiety.* Pulse feeble and of low tension. *Atropin poisoning.* Heart beats rapidly in proportion to the amount of atropin injected; due to the peripheral vagus paralysis. *Bacillary Dysentery.* Rapid and small pulse. *Meningitis Pneumococci.* Slow cardiac rate in relation to temperature is basic characteristic of the disease. *Meningitis Tuberculosis.* Rapid at first and later irregular and slow. *Myxedema.* Pulse 40 to 60, but regular; usually low tension. *Pregnancy.* During later part and puerperium, pulse may be slow, regular, usually low tension. *Uremia.* Heart rate may be slow. *Bronchial asthma.* Small, rapid, irregular, intermittent pulse. *Catarrh Jaundice.* Slow pulse. *Goitre, Toxic.* Tachycardia pulse. *Hepatic diseases.* Rapid pulse. *Hypertension.* Fast pulse. *Hypotension.* Slow and small pulse. *Indigestion.* In physiological disturbances, intermittent pulse. *Malaria.* Slow pulse. *Sunstroke.* Rapid full pulse. *Typhoid Fever.* Pulse slow compared with other febrile diseases; infrequent, slow pulse during post-febrile stage. *Ulcerated Colitis.* Rapid pulse. *Perforated peptic ulcer.* Strong pulse increasing steadily. *Smallpox.* Hard pulse. *Renal Coma.* Hard full pulse. *Sepsis.* Rapid pulse.

Chapter VIII

Frequency Analysis and Current Status of Sphygmology

Frequency Analysis of the Pulse

By definition, Fourier analysis is a mathematical technique by which a complex periodic wave can be broken down into a series of sinusoidal waves having a fundamental frequency equal to the frequency of the original wave and harmonics having frequencies that are integral multiples of the fundamental frequency. The major contribution in this field was the classic paper of Hamilton and Dow (1939). Both performed their experiment on the dog. They recorded pressure waves at intervals between the ascending aorta and femoral artery. They explained pressure wave contour in different vessels in terms of wave reflection between the aortic valves and peripheral sites. Later on McDonald and Taylor made revolution in this field. Frequency analysis has long been a standard procedure in the physical sciences and is used widely in electrical and acoustic engineering and in other fields. Such type of analysis is done by the help of computer. Thus in addition to distortion of the wave form resulting from reflected waves from a wide variety of peripheral points, changes in the pulse wave form can be visualized in terms of its frequency content. Any pressure pulse can be considered as the sum of a number of sinusoidal wave form. Each harmonic component has a definite modulus or amplitude and a definite phase or delay from a set point of reference (Fig. 19). Given amplitude or modelus and phase of the different harmonics of the pulse one can resynthesize the original wave. The most precise information about functions of the arterial system has come from quantitative studies of the arterial pulse. Thus the advantage of harmonic analysis is that it enables one to describe the arterial pulse in quantitative terms. We can calculate vascular resistance by measuring and relating mean values of the waves and thus we can interpret the resistive properties of the vessels downstream. In the same way one can compare corresponding frequency components of pressure and flow—the first harmonic of pressure with the

second of flow, the second harmonic pressure with the second of flow...and so on. Frequency analysis thus enables us to describe a wave in precise mathematical terms and to define the relationship between different waves. We now in the light of quantitative analysis of the pulse, can explain the contour of the pulse under abnormal conditions.

Hypertension and Arterio-sclerosis :

In hypertension and arterio-sclerosis amplitude of the aortic pressure pulse is increased, the tidal wave is prominent, and the diastolic wave is absent. In these conditions pulse velocity is increased so that the wave traverses the arterial system more quickly. All features of the pulse can be explained on the basis of increased wave velocity. The wave reflected from the lower part of the body returns to the proximal aorta not during diastole but during the later part of systole where it merges with the echo from the upper body reflecting sites to augment the tidal wave and increase systolic pressure. These changes in wave contour can be seen to develop and regress during and after intravenous infusion of a drug which increases mean arterial pressure.

In these conditions there is less evidence of reflected waves as discrete components of the arterial pulse than under normal conditions. This finding can be explained on the fact that the pressure wave is more widely spread over the arterial system at any one point in time when wave velocity is high than when it is lower. Under these conditions incident, reflected waves are blended and not recognizable as discrete events.

The above events are also found in central aortic and peripheral pressure pulses hypertension and arterio-sclerosis. Here also pulse velocity is increased and the amplitude and contour is the same as mentioned above. In central vessels there is less delay between incidence and reflected waves so that summation effect is nearly as great as at the periphery. On palpation of finger we find that in hypertension the amplitude of the pulse fell smoothly during diastole from a prominent systolic peak and which is associated with continued palpability of the artery throughout diastole.

Aortic Coarctation :

In aortic coarctation the normally placed lower body reflecting site is replaced by another much closer to the heart. The

pressure wave traverses the arterial system more quickly because of its smaller dimensions as well as its increased distending pressure. Central aortic pressure waves in coarctation are similar to those seen in arterio-sclerosis and severe hypertension.

Hypotension :

Pulse wave velocity is decreased in hypotension, the impulse traverses the arterial system more slowly so that in the aortic pulse the tidal and diastolic waves are further displaced from the percussion wave. The tidal wave is frequently less obvious than usual because it occurs so late in systole when pressure is falling steepy. On the other hand, the diastolic wave is frequently more obvious than usual. This can be attributed to the fact that with slow wave velocity the disturbance generated by ventricular ejection is at any time more discretely localized in space and so at any one site more discretely localized in time. This tendency for the diastolic wave to be exaggerated in hypotension is potentiated by shortening of the ejection period and by vasoconstriction.

Aortic Valvular Disease :

The characteristic pressure pulse of aortic stenosis can be attributed to two factors of which prolongation of ventricular ejection is probably less important and venture effects in the aorta, more important.

Current Status of Sphygmology

The pulse is a pressure wave that travels along the vessel wall. The factors responsible for the pulse are three in numbers, namely (1) the intermittent flow of blood from the heart, i. e. stroke volume output, (2) the resistance to outflow of blood from the arterioles into the capillaries, and (3) the elasticity of the arterial walls. In transmission of pressure wave through the arterial wall, elasticity of the wall plays the main role. The pressure wave is different from flow wave which is produced merely from the flow of blood. And also the pressure wave travels through the arterial wall with much more velocity than the flow wave. The pressure wave travels 7 meters per second whereas the movement of the red cell or plasma is 10 to 20 cm. per second. The pulse wave velocity is slower in larger vessels.

What we feel as a pulse in the radial artery is one of the peripheral pulses which are nothing but mere continuation with

certain modifications of central pulses produced in the aorta and its greater branches. Modifications in the contour of peripheral pulses are mainly brought by reflected waves produced at the sites of branches of arteries. A normal arterial pulse consists of "percussion" wave, "tidal" wave, "dicrotic notch" and "dicrotic" wave.

Latest commentary has come up regarding the terminology of pulse wave for normal and abnormal arteriogram. According to Rourke in normal arteriogram the terminology 'percussion', "tidal", and "dicrotic" waves are confusing. Because this terminology is not consistent. "Percussion" refers to a mechanism, "diastolic" describes timing in relation to the cardiac cycle, while "tidal" has no clearly relevant meaning. In his opinion the terminology should be best replaced either entirely in relation to timing or entirely in relation to mechanism. In relation to former one may substitute "early systolic", "late systolic", and "diastolic" for "percussion", "tidal", and "dicrotic", and in relation to later "percussion", "tidal", and "dicrotic" waves may be replaced by "impact", "cephalic reflected", and "caudal reflected". Between these two, the nomenclature based on timing appears simpler and better.

Similarly more familiar terms of abnormal such as "anacrotic", "bisferiens", "dicrotic", and "water-hammer" are neither descriptive nor informative. Therefore, these terms should be described in simple terms, i, e. instead of an "anacrotic" pulse in aortic stenosis, a pulse with slow rise and low amplitude in aortic stenosis; instead of a "bisferiens" pulse, a pulse with two systolic peaks, and so on, should be described.

Certain advancement has also been made in the field of clinical examination of the pulse. Oram has advised that the pulse should be examined only for (1) rate, (2) rhythm, (3) form, and (4) condition of arterial wall. The attempt to estimate the blood pressure by the degree of pressure required to obliterate the pulse at the wrist are a waste of time. Hutchison, also states that the estimates of the "tension" of the pulse, that is of the blood pressure within the vessel are quite unreliable.

Frequency Analysis :

The most important advancement in the recent years in the field of pulse examination has been made, is the quantitative analysis of the pulse. This is done by frequency analysis of the

pulse. In this type of analysis, the pulse is considered to be regularly repeated as a series of harmonics. Actually the conventional approach to analysis of the pulse suffers from the disadvantage of being only descriptive and qualitative. While it is perfectly acceptable to describe a phenomenon such as the pulse in terms of its easily identifiable features, this approach is quite restrictive when one wants to describe features that are not easily identifiable, or which are mixed with or obscured by other features, or when one wants to investigate underlying mechanism.

The early physicians paid great attention to the character of the pulse in health and the changes which occurred in disease. To the modern physician the pulse is beginning to assume even greater importance. In attempting to follow changing cardiovascular status under emergency conditions the modern physicians frequently records the pulse directly through an intra-arterial cathetor, and he wishes to gain as much information as possible from inspection of pulse contour.

While importance of the pulse is undisputed and its increasing significance can hardly be denied, it is almost incredible that text books have shown virtually no change in their descriptions and explanations of arterial pressure pulse contour over the last seventy years. This failure of progress is not due to lack of headway in subsequent years, but rather is a consequence of the complicated nature of the subject and the inability of clinicians to absorb all the advances that have been achieved by workers in the paramedical sciences.

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Part Four

Clinical and Experimental Studies on Nadi Pariksha

Clinical and Experimental Studies

The aim behind to conduct study on pulse-examination is its traditional use as an important means of diagnosis. The tradition is still being practiced by Vaidyas and Hakims of India. And some of Vaidyas claim even to-day to be the master of this science in diagnosing all kinds of diseases only with the help of pulse-examination. Secondly, the importance of this science can only be judged that plenty of old literature in different languages of India is still available on the subject. Thirdly, in the present time, modern medical men limit its scope as a means of diagnosis only to the cardiac diseases, though its wide scope has been described in books of sphygmology. And fourthly, recently O'Rourke (1971) has published an article showing that haemodynamics certainly can bring about a revolutionary change in the way of thinking and quantitative interpretation of different curves of pressure waves. These were important points that stimulated to conduct study on Nadi-Pariksha, both in normal and diseased groups. Because in the field of Ayurveda, this is the first work of its own kind. Therefore, we limited our study only to certain groups of diseases namely, (1) Cardiac valvular lesions, (2) hypertension, (3) jaundice and (4) thyrotoxicosis.

In the present study, due to lack of highly advanced technical help, mainly the clinical aspect has been touched in detail. And also, the effort has chiefly been made in the direction of correlation of the triad, i. e. symptoms in relation to predominance of Doshas, pulse-examination, and the pulse tracings done with the help of an instrument known as Dudgeon's sphygmograph.

Methods and Materials

To conduct the study on Nadi-Pariksha in normal and diseased groups, selection of 160 cases have been done. Out of the total cases, 40 were normal volunteers and the rest were diseased persons.

Selection of Normal Volunteers :

These belonged only to male sex. And they were students and teachers of Industrial Training Institute of Varanasi. They

were selected in different range of age groups, varying from 17-40 years. And their body weight varied from 48 Kg. to 75 Kg. Before taking under study, these cases were subjected to a careful case taking and thorough investigations.

During case taking they were interrogated for their appetite, digestion and condition of bowel. Enquiry was made also about states of psychology, any drug taking or habit of taking alcohol or tranquillizer or sedative etc.

Physical and Systemic Examination :

After completion of taking the history, volunteers were put under the physical examination. In this examination their pulse rate, respiration, blood pressure, body temperature and body weight were recorded. Next, their general examination was started to see the condition of teeth, tongue, head, body built, nutrition, eyes, ears, nose and lips etc.

In systemic examination, every system of volunteers was examined thoroughly under the heads, inspection, palpation, percussion and auscultation. The systems examined were cardio-vascular, respiratory, gastro-intestinal, urogenital and the nervous to confirm whether the volunteers have any kind of even minor abnormality or not. Next, the volunteers were subjected to their laboratory and other shorts of investigations.

Investigations :

This included two types of investigations, the laboratory and the rediological. In laboratory investigations, volunteers were subjected to routine investigations of stool, urine and blood. The stool was examined for any kind of ova and cysts. And the urine was examined to check for the presence of phosphate, albumin, sugar, bile pigment, red blood cells and casts. Blood was examined for total and differential count, and erythrocyte sedimentation rate. For radiological examination MMR was done. After putting under these investigations, when it was confirmed that no one was suffering from any kind of disease, these volunteers were selected for the purpose of further study.

Selection of Diseased Cases :

This group of cases were selected from indoor, outdoor and special clinics of Sir Sunder Lal Hospital. Banaras Hindu University. Total number of cases taken under study were 160, comprising of both sexes. Out of total cases, 50 were of cardiac

valvular lesions including both mitral and aortic of average age of 27; 30 cases of hypertension of average age of 50; 20 cases of jaundice of average age of 42; and 20 cases of thyrotoxicosis of average age of 27. In this group also, before taking under study, all cases were subjected to a careful case taking and thorough investigations.

Clinical History :

This was completed under the heads (a) chief complaints and the process of development of disease (b) past history of any disease or diseases to show the relation with the present illness and (c) personal history.

In chief complaints, the history was noted down in chronological order to know the process of development of disease. In the process of development, it was also noted down whether the disease developed incidiously or suddenly or in phases of exacerbation and remission. And if treated what was the effect of treatment.

In noting down the past history, the patients were interrogated for rheumatic fever, typhoid fever, measels and veneıeal diseases. This was done so, because the diseases of valvular lesions usually happen to occur due to rheumatic fever and venereaı diseases.

In personal history, quality of diet, married status, states of psychology of the patient, any drug taking or habit of taking alcohol or tranquillizer, sedatives and analgesics, state of appetite and digestion and condition of bowel were noted down. After recording the clinical history, physical and systemic examinations were performed.

Physical Examination :

This included full general examination of the patient. The general examination was started with the physical verification of the stated age and sex of the patient, followed by a survey of the general condition of the patient. And this included the recording of pulse rate, respiration. blood pressure, body temperature. And also included the examination of facial expression, attitude, gait, decubitus, built, nutrition, anaemia and pallor, cyanosis, anamolies of pigmentation, jaundice, clubbing, spoon-shaped nails, dyspnoea, oedema, neck glands, neck veins, supra-clavicular fossae, hairs, head, eyes, ears, nose, lips, teeth, gums, tongue and faucies.

Systemic Examination :

This examination was conducted classically under the heads (a) inspection, (b) palpation, (c) percussion and (d) auscultation. In each case besides examining the particular system related to disease, other system were also examined.

During inspection, in valvular lesions, the cases were searched for location of apex beat in normal or abnormal position, pulsations in praecordial region, epigastric region and the neck. Neck was also searched for venous engorgement.

During palpation, the presence of thrill and heave were searched out. If the thrill was present, it was correlated in terms of systole and diastole of cardiac cycle.

The percussion was conducted to know the superficial and deep cardiac dulness of the heart and thus to localize the boundry of the heart.

In auscultation, the character of murmurs was correlated in relation to the cardiac cycle. It was observed whether the murmur of systolic or diastolic. And if any of the two was present, it was seen whether the murmur is pre-systolic, mid systolic or late systolic. Similar study was also done in case of diastolic murmur. Investigation was also done for ejection click and gallop rhythm. To exclude out the presence of congestive heart failure, auscultation of lungs was also done. Other systems were also examined in brief.

In hypertensive cases besides examining the other systems, cardiovascular system was full examined. In inspection, inspection of apex beat and in palpation, localization of apex beat was confirmed. Under percussion area of the borders of the heart was decided. And in auscultation the character of the first sound was confirmed to know whether it was accentuated or not.

In rest two diseases, i. e. jaundice and thyrotoxicosis, the same pattern of examination like previous cases was followed-up.

Before starting the laboratory investigations a synopsis of the clinical findings of the case taking and physical examination was prepared and a provisional diagnosis was made. Then the routine and special laboratory investigations and the other investigations were started.

Laboratory and Other Investigations :

In addition to the careful history taking and a thorough physical examination, as mentioned earlier, the cases were subjected to certain routine investigations and several special investigations specific to the diseases. It may be pointed out here that the investigations which were done in these cases as would be described hereunder have not been selected due to any other reason, but because they were simpler, were relevant also and were conveniently possible in our set up. It may be specifically mentioned that the investigations done in the present study could give sufficient information about the clinical condition and to some extent about the status of the systems involved.

Routine Laboratory Investigations :

This comprises of routine examination of stool, urine and the blood. The stool was examined to exclude out the presence of ova and cysts. The urine was examined to exclude out any presence of phosphate, albumin and the sugar, red blood cells and casts. And the blood was subjected to investigate the total and differential count, any abnormality of the red cell as anisocytosis, poikilocytosis, punctate basophilia and also to see the size of the cell as microcytosis and macrocytosis. Erythrocyte sedimentation rate was also done to know the severity of the disease.

Special Investigations :

Certain special investigations were also performed in certain diseases. For example in cases of jaundice, urine was examined for the presence of bilirubin, urobilin and urobilinogen. Stool was also examined for stercobilinogen. And the serum was examined for serum bilirubin, Vandenbergh reaction, thymol turbidity, total serum protein, albumin and globulin ratio, S. G. O. T. and S. G. P. T.

In cases of thyrotoxicosis, radioactive iodine uptake was done. And in cases of hypertension, the level of serum cholesterol, blood sugar, blood urea and urine for albumin and casts were investigated. In cases of valvular lesions, E. C. G. and V. D. R. L. were done.

In other investigations, MMR was done in every case. Particularly in cases of valvular diseases, it proved to be of significance to see the condition of the heart, i. e. its dilatation, pulmonary conus and mitralization of the heart.

Experimental Study

In the present work our experimental study was limited. And in the present context, really this study has been specified particularly to the tracing of pulse waves propagated through the wall of radial artery in normal as well as diseased groups taken under the study.

Experimental study has been performed by tracing the pulse waves on smoked papers. And further the tracings have been studied in their qualitative and quantitative forms. Before taking the actual tracings of pulse waves on smoked paper, certain procedure was adopted to prepare the smoked papers.

First of all a rectangular piece of thick smooth paper was taken. And a thin layer of gum was applied over the four corners of the paper to stick it over the drum. After fixing the rectangular piece of paper over the drum, the drum was allowed to rotate with a constant motion. Next a lamp was used to prepare smoked papers and was kept a little away from the drum in such a way that the whole smoke produced by the lamp could completely cover the rotating surface of the paper. When the complete paper turned black, the drum was allowed to stop and the smoked paper was detached from the drum with the help of knife. Now this smoked paper was fully prepared for the further use.

Before taking the graph of pulse over smoked paper, a small rectangular piece of it was taken out with the help of the scissors. The small rectangular piece was cut in such a way that its whole width could be fitted in between the two pulleys of sphygmograph.

Pulse Tracing :

Dudgeon's sphygmograph (Fig. 20) was used for tracing the pulse wave, both in normal and diseased groups. It is a small quadrangular instrument which is tied over the radial artery on the wrist like a wrist watch.

This instrument is equipped with a starter on its upper surface, two pulleys at the two ends of a small rotatory bar, a freely hanging needle and a key which is set in the back of the body of instrument and that performs the action like the key of a wrist watch. By giving full rotations to the key in anticlock direction, the instrument is prepared for the work.

To record the pulse wave a rectangular piece of smoked paper is fitted in between the two pulleys to record the pulse wave over it generated by the movement of the radial artery. As soon as, the starter is set at work, pulleys start their working by rotating the small bar so that the smoked paper is moved forward and the pulse is recorded over it by means of the hanging needle.

The pulse tracing in normal cases was performed in different conditions i. e. in the morning at the basal condition of the body; before and after meals and in the evening. Every time the pulse was examined by the classical method as described in Ayurvedic texts. First, the individuals were asked to sit peacefully. Next, the forearm was slightly flexed with the little flexion and a bit medial rotation of the wrist with the fingers dispersed and extended. Then with the help of expert Ayurvedic physicians having good knowledge of pulse examination, the various character of the pulse was determined in the terms of Vata, Pitta and Kapha. The pulse was studied every time in relation to its rate, rhythm, volume, force, tension and the condition of the arterial wall.

After fulfilling these basic necessities, Dudgeon's sphygmograph was put over the radial artery in such a way that the brass leaf lying at the base of the instrument should cover the width of the radial artery. Then, as stated already, the starter was set at work causing forward movement of smoked strips of the paper with simultaneous recording of the pulse wave over it. As soon as the starter was set at work, the stop watch was also brought into the action to note the time. And when the pulse waves were recorded over the full length of smoked paper, the time was immediately noted down by the stop watch. Ultimately, the strip of the paper was dipped into the fixing solution in order to fix the tracing permanently. Same process of pulse recording was also adopted in diseased cases. In diseased cases recording was not done in relation to various times. But was only done in the morning hours at the time of pulse examination.

Qualitative Study of the Pulse :

In studying the qualitative form of the pulse, as a parameter various movements of birds, reptiles and amphibians described by Sharngadhara was chosen. For example, the form of Vatika pulse has been standardized with the movement of the

leech (Jalauka) and snake (Sarpa). The form of Paittika pulse has been standardized by correlating it with the movement of frog (Mandooka). And the form of Kaphaja pulse has been standardized with the movement of goose (Hans). It should also be noted here that taking of graphs of movements of various birds, reptiles and amphibians etc. to standardize Vatika, Paittika and Kaphaja pulses could not have been possible. Therefore, whatever subjective ideas we could derive from various movements of birds, amphibians and reptiles, those have been tried to be explained as far as possible in terms of rate, rhythm and character. Details of these have been given in discussion.

First of all the pulses were studied for their rate, rhythm, volume and character etc. The rate of the pulse was counted as beats per minute. It was counted not when the fingers were first laid upon the pulse, but when any quickening due to nervousness of the patient had subsided and the pulse had resume its normal rate. The rate of the heart beat was also counted by auscultating the apex beat of the heart in order to see any pulse deficit.

Rhythm was studied to observe whether the pulse was regular or irregular. If irregular, whether it was completely irregular or irregularity had a recurring pattern or whether an otherwise regular rhythm was occasionally interrupted by some slight irregularity.

In studying volume, the amplitude of the movement or lift of the vessel wall during the passage of pulse wave was observed.

By studying the force the level of systolic blood pressure was assessed. The radial artery was pressed against the underlying bone with the more proximal of the two palpating fingers till the pulse was no longer felt with the distal finger.

By studying the tension the level of diastolic pressure was assessed. The artery was palpated between the successive pulse waves to know that it was full or emptied out. To exclude out the presence of enequality, the pulse at both the wrist was counted.

Attention was particularly paid to the character of the pulse. In the character of the pulse wave, the manner of its ascent, summit and descent were studied. It was observed whether the ascent or increase of pressure was sudden, moderately rapid or slow. Whether the pulse was well sustained. Whether having

reached its height, it fell off abruptly or whether the descent or fall of pressure was rapid, gradual or slow.

To know the condition of the vessel wall sufficient pressure was exerted on the brachial artery to abolish pulsation in the radial artery and it was rolled beneath the fingers against the underlying bone.

Quantitative Study :

Vatika, Paittika and Kaphaja pulses in normal as well as diseased groups were studied quantitatively in terms of pulse rate, pulse pressure and the other measurements of length etc. The later i. e. the study by measurements etc. include the calculation done to take out the mean values of the followings : (1) time taken by each pulse wave, (2) length of percussion wave from the point of its start to the highest point of its top, (3) distance between two nearest top points of the waves, (4) time of percussion wave from the point of start to the point of its top, (5) angle of deviation of percussion wave and (6) distance of dicrotic notch from the base line.

Time taken by each pulse wave was calculated by dividing the standard time 60 seconds by the pulse rate counted in 1 minute. Length of percussion wave was measured by metric scale upto 5 mm. i. e. 0.5 of cm. Distance between two top points were also measured with the help of metric scale. Time of percussion wave from the point of its start to the point of its top was calculated by multiplying the length of percussion with time of each pulse wave and divided by the distance between the two nearest top points.

Deviation of angle of percussion wave has been calculated by putting the satisquare such that its base line pessed through the lower end of the percussion wave and the perpendicular line passed through upper end of percussion wave. Thus the distance from lower end to the perpendicular on the base line was measured. This distance is taken to be as the base and the length of percussion wave as hypotenuse of right angle triangle for the angle of deviation

$$\text{So, } \cos\theta = \frac{\text{base}}{\text{hypotenuse}}$$

calculation was done upto 5 points of decimils. By means of natural cosine table we calculated the value of θ. Distance of dicrotic notch from the base line was also measured by means of satisquare.

Observations

As it has been mentioned earlier the study on pluse examination has been conducted in normal volunteers as well as diseased cases, the study of pulses in their *Vatika*, *Paittika* and *Kaphaja* characters has been performed in their qualitative and quantitative forms. Total number of volunteers and diseased cases taken under study are 160. Out of total number, 40 are normal volunteers and the rest belong to diseased group. Regarding sex and age of normal group, they are all males varying from 17–40 years in their ages. In this group pulses have been found of *Vatika* character in 9 cases, of *Paittika* character in 20 cases and of *Kaphaja* character in 11 cases (Fig. 25). Character of pulse in the morning and in the evening has also been studied in 20 cases of normal group and in 20 cases the character of pulse has been studied before and after meal.

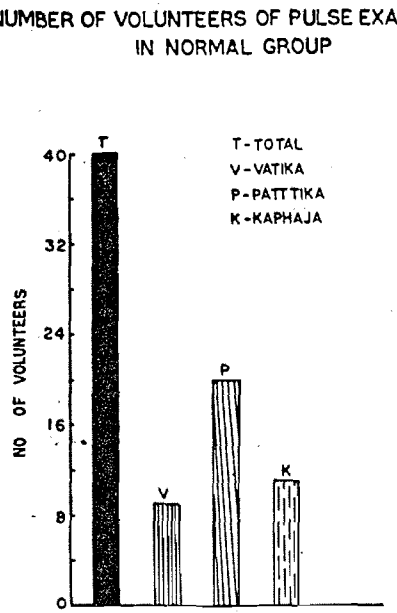

Fig. 25 : Number of Normal Volunteers.

Ramaining 120 cases belong to diseased group. And in this group criteria of putting the pulses into Vatika, Paittika and Kaphaja characters are based upon the predominance of Do-

shas found in symptoms and pulse examination during the time of history taking. Out of total number of 120 cases, 50 belong to different valvular lesions including mitral and aortic stenosis, aortic incompetence and congestive heart failure. In the valvular lesions group, 14 cases possessed the pulse of Vatika character, 22 of Paittika and the rest 14 possessed the pulse of Kaphaja character (Fig. 25). Average age in this group was 20 years.

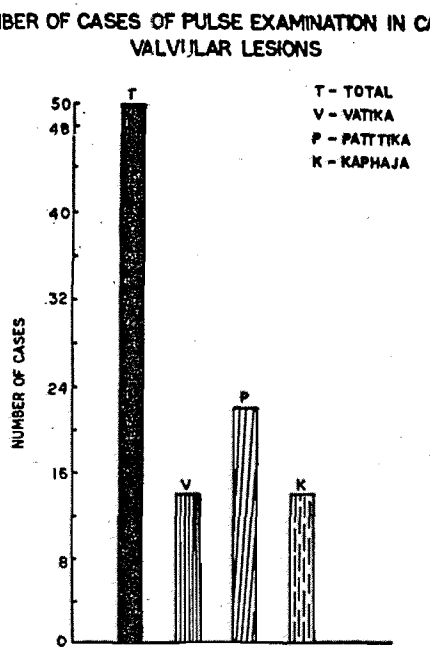

Fig. 26 : Number of Cases of Cardiac Valvular Lesions.

In total 30 cases of hypertension, 6 were having Vatika pulses, 12 Paittika type and the rest 12 were having Kaphaja character of the pulse (Fig. 27). Average age of the patients in this group was 50 years. Out of 20 cases of jaundice, Paittika character of the pulse was found in 11 cases, and the character of the pulse in 9 cases was of Kaphaja nature (Fig. 28). The average age in this group was 42 years. All the 20 cases suffering from thyrotoxicosis of average of 27 belonged to Paittika group only (Fig. 29).

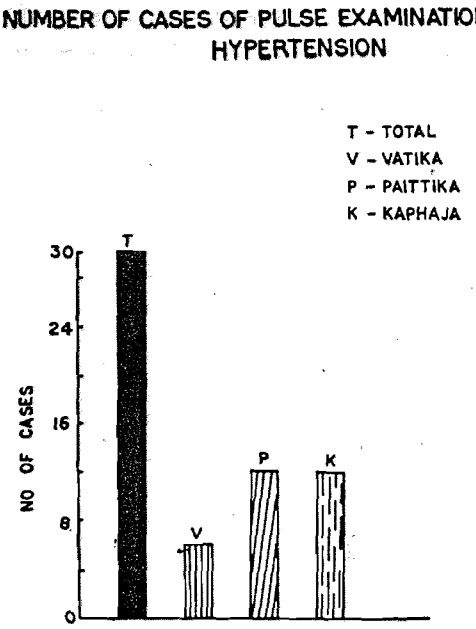

Fig. 27 : Number of Cases of Hypertension.

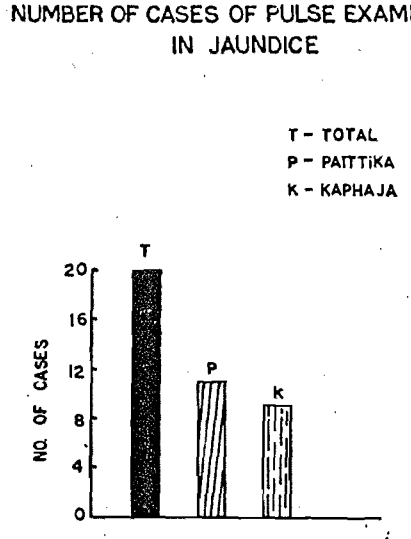

Fig. 28 : Number of Cases of Jaundice.

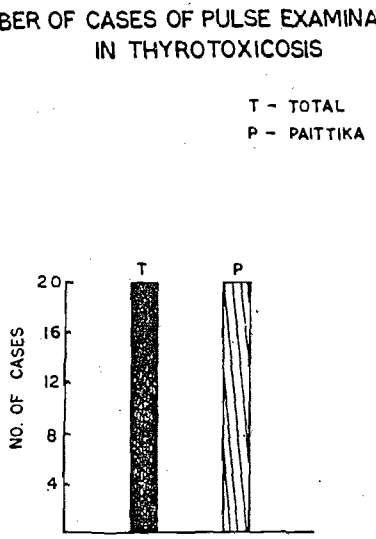

Fig. 29 : Number of Cases of Thyrotoxicosis.

Normal Group :

Total cases studied in this group were 40. Out of this, 9 were of Vatika, 20 were of Paittika and remaining 11 were having Kaphaja nature of pulses.

Qualitative Study :

On examination, *Vatika pulses* were found to be increased relatively in their rate than Paittika pulses. And the rate was more increased in relation to Kaphaja pulses. The rhythm was found to be regular i. e. the pulses were beating every time after definite intervals. Volume was small. Because the time interval between appearance and disappearance of pulse wave underneath the fingers was small. Force and tension were also found to be on lower side in relation to Paittika and Kaphaja pulses. As regards character, the percussion wave was found to be of short duration underneath the fingers. And the summit underneath the fingers was found to be of slightly sustaining nature.

Paittika pulses were found to be increased in their rates in medium range i. e. the rate of Paittika pulse was slower than Vatika pulse, but was increased than Kaphaja pulse. Rhythm was regular. Volume in this group of pulses was found to be

more than Vatika and Kaphaja varieties. Force was a bit more. As regards character of the pulse, the rise of percussion wave felt beneath the fingers was moderately rapid and summit was found to be of a bit sustaining nature. Therefore, the time taken between onset and disappearance of percussion wave in this case was a relatively more than Vatika pulses. The whole impact felt beneath the fingers was of jumping nature.

In *Kaphaja* pulses, the rates were found to be slowest of all. The rhythm was regular, but the time interval between two successive waves was found to be maximum in this group of pulses. Regarding tension and force, there was found no appreciable difference than Paittika group of pulses. But both were more than Vatika group of pulses. As regards character of the pulse, the rise of percussion wave was of longer duration and took maximum time than the rest two varieties of pulses. The summit in this group of pulses was of sustaining nature.

As regards configuration of *Vatika* pulse (Fig. 30) it is found to have appreciably small percussion wave. The summit is a bit conical. In some tracings slightly visible dicrotic notch is present and in some of the tracings, it is completely absent. The fall upto dicrotic notches is quite rapid and most of the part of dicrotic wave assumes more or less horizontal position immediately. Due to more small distance between two points of onset of percussion wave, the tracings of the pulse appear to have curvilinear motion and the look of the tracings as a whole gives the wavy appearance resembling to the movement of the snake.

As regards Paittika type of pulses (Fig. 31) it is found to have an appreciably large percussion wave. The summit is quite conical. In few tracings where the fall of dicrotic wave is quite rapid, the dicrotic notch has been found at the lower level. But in cases where the fall is not so rapid, the notch is found to be situated relatively a bit higher. The distance in between the onset of two points of percussion wave is relatively greater than Vatika type of pulse. At a glance the general appearance looks to be of jumping character resembling the movement of frog.

The *Kaphaja* pulses (Fig. 32) of this group are found to have quite distinct percussion waves with the height occupying an intermediate position in between Vatika and Kaphaja groups. The summits in few tracings appear to be of sustaining nature and therefore, are of more rounded character. In some

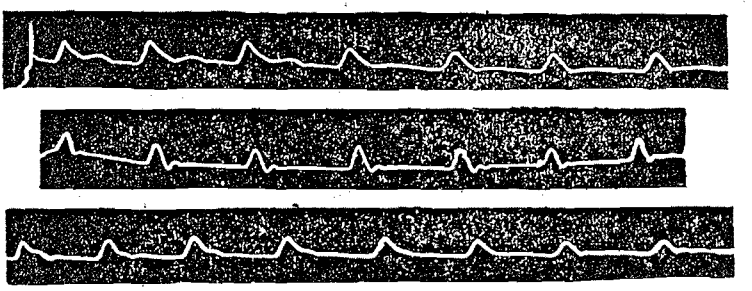

Fig. 30 : Normal Vatika Pulse.

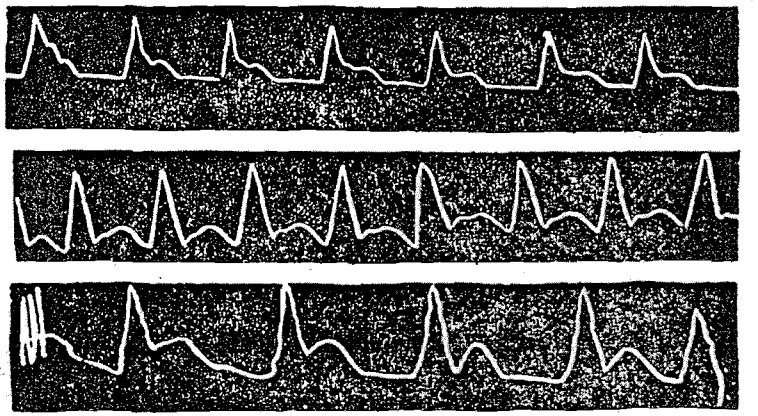

Fig. 31 : Normal Paittika Pulse.

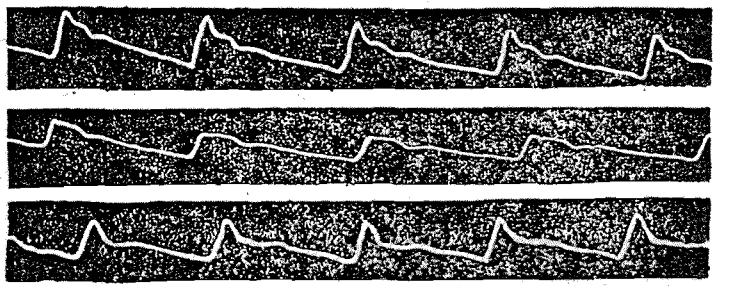

Fig. 32 : Normal Kaphaja Pulse.

tracings the summit is not so rounded. In relation to Vatika and Paittika pulses, the dicrotic notch is found to be situated at higher level. And the fall of dicrotic wave is more steady and gradual than the other two varieties of pulses. The distance between two points of onset appears to be more than the rest varieties of pulses. The slow and steady character of the pulse coincide more to the movement of the goose.

The character and general appearance of *morning pulse* (Fig. 33, a) resemble to those of *Kaphaja pulse*. And the character and appearance of *evening pulse* (Fig. 33 & 34 a, b) resemble to those of *Vatika pulse*. And the configuration of the pulse after *taking meal* appears to be of relatively *Paittika* nature than the pulse traced before meal (Fig. 35, 36).

Quantitative Study :

This has been accomplished under two heads, namely (1) statistical and (2) other mathematical studies. The later study has been limited to normal Vatika, Paittika and Kaphaja pulses to show the relative values among them and has not been done in morning and evening pulses and pulses before and after taking meal.

(1) Statistical Comparison of Normal Group :

Mean pulse rate (MPR) of normal *Vatika* pulse was found to be 84 ± 3.6 and that of *Paittika* pulse to be 74 ± 5.5 respectively (Table 1). Statistical comparison between the above two groups shows that MPR of Vatika pulse is significantly more than Paittika pulses ($t=4.761$; $P<0.001$).

TABLE 1

Statistical Analysis of Rate of Normal Vatika, Paittika and Kaphaja Pulses.

Group	Mean±S. D.
Vatika pulse rate	84 ± 3.6
Paittika pulse rate	74 ± 5.5
Comparison between above two	$t = 4.761^{***}$
	$P<0.001$
Vatika pulse rate	84 ± 3.6
Kaphaja pulse rate	65 ± 3.9
Comparison between above two	$t = 11.216^{***}$
	$P<0.001$

Paittika pulse rate	74±5.5
Kaphaja pulse rate	65±3.9
Comparison between above two	t = 4.805***
	P ∠ 0.001

***Significant at 0.1% level of probability.

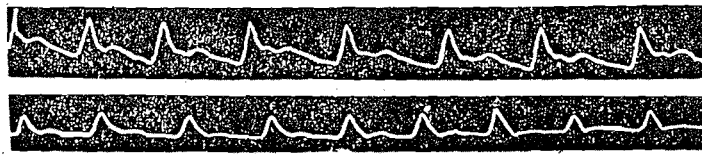

Fig. 33 : (a) Morning Pulse (b) Evening Pulse.

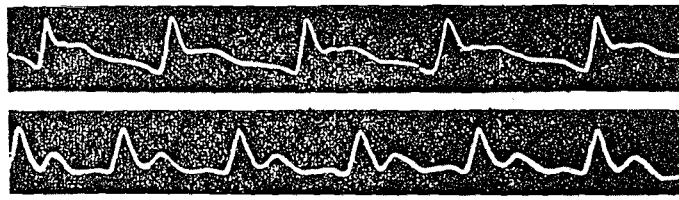

Fig. 34 : (a) Morning Pulse (b) Evening Pulse.

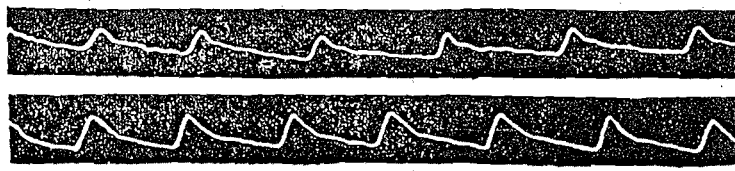

Fig. : 35 : (a) Pulse Before Meal (b) Pulse After Meal.

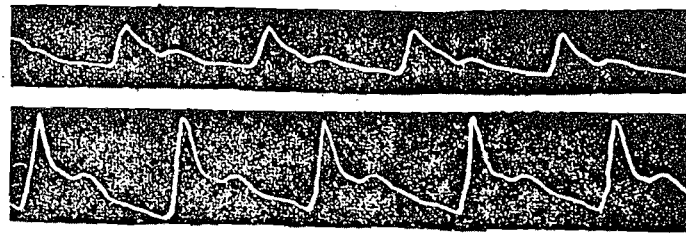

Fig. 36 : (a) Pulse Before Meal (b) Pulse After Meal.

Mean pulse rate (MPR) of normal Vatika pulse is found to be 84±3. 6 and that of *Kaphaja pulse* to be 65±3.9 respectively. Statistical comparison between the above two groups shows that Vatika MPR is significantly more than Kaphaja pulses (T = 11.216; P ∠ 0.001).

Mean pulse rate (MPR) of normal *Paittika pulse* is found to be 74±5.5 and that of normal Kaphaja pulse to be 65±3.5 respectively. Statistical comparison between the above two groups shows that Paittika MPR is found to be more significant than Kaphaja pulse rate (t = 4.805; P ∠ 0.001).

Mean pulse pressure (MPP) in normal *Vatika pulse* is found to be 35±4.9 and that of normal Paittika pulse to be 49±6.9 respectively. Statistical comparison between the two shows that Paittika pulse pressure is significantly higher than Vatika pulse pressure (t = 5.475; P ∠ 0.001).

Mean pulse pressure in normal Vatika pulse is found to be 35±4.9 and that of Kaphaja pulse to be 42±6.0 respectively. Statistical comparison between the two shows that Kaphaja pulse pressure is significantly more than Vatika pulse pressure (t = 2.412; P ∠ 0.05).

Mean pulse pressure in normal Paittika pulse is found to be 49±6.9 and that of Kaphaja pulse to be 42±6.0 respectively. Statistical comparison between the two shows that Paittika pulse pressure is significantly more than Kaphaja pulse pressure (t = 2.825; P ∠ 0.05).

TABLE 2

Statistical Analysis of Normal Vatika, Paittika and Kaphaja Pulse Pressures.

Group	Mean±S. D.
Vatika pulse pressure	35±4.9
Paittika pulse pressure	49±6.9
Comparison between two	t = 5.475***
	P ∠ 0.001
Vatika pulse pressure	35±4.9
Kaphaja pulse pressure	42±6.0
Comparison between two	t = 2.412*
	P ∠ 0.05

Paittika pulse pressure	49±6.9
Kaphaja pulse pressure	42±6.0
Comparison between two	t = 2.825*
	P∠0·05

* Significant at 5% level of probability.
*** Significant at 0.1% level of probability.

The mean pulse rate of normal persons in the morning is found to be 67.45 with its standard deviation as ±8.01. The mean pulse rate of same persons in the evening is found to be 72.15 with its standard deviation as +3.0.

Statistical comparison between morning and evening pulse rate shows a significant rise in evening pulse rate (t = 2.459; P∠0.05).

Mean pulse pressure and its standard deviation is found to be the same in the morning and evening as 45.55±4.52 (Table 3).

TABLE 3
Statistical Analysis of Pulse in the Morning and Evening in Normal Group.

Group	Mean±S. D.
Pulse rate in the morning	67.45±8.01
Pulse rate in the evening	72.15±3.0
Comparison between above two	t = 2.459
	P∠0.05*
Pulse pressure in the morning	45.55±4.52
Pulse pressure in the evening	45.55±4.52
Comparison between above two	t = 0.0
	P>0.05

* Significant at 5% level of probability,

Mean pulse rate with standard deviation before meal is found to be 66.1±5.73 and after meal is found to be 73.0±7.42. On comparison, pulse rate after meal is found to be significantly increased (t = 3.289; P∠0.01).

Mean and standard deviation of pulse pressure has been found to be same before and after meal as 48.60±5.46. (Table 4).

TABLE 4

Statistical Analysis of Pulse Before and After Meal.

Group	Mean±S. D.
Pulse rate before meal	66.1±5.73
Pulse rate after meal	73.0±7.42
Comparison between two	t = 3.289
	P < 0.01**
Pulse pressure before meal	48.60±5.46
Pulse pressure after meal	48.60±5.46

** Significant at 1% level of probability.

(2) Other Mathematical Studies :

In this group Vatika, Paittika and Kaphaja pulses of normal persons heve been studied in relation to their time of each pulse, length of percussion wave, length between two top points, time of percussion wave, angle of deviation and distance of dicrotic notch from the base line (Table 5).

The time of each pulse of Vatika, Paittika and Kaphaja varieties of pulses is found to be 0.73 sec., 0.81 sec. and 0.94 sec. respectively. The result shows that time taken by Kaphaja pulse is maximum and the minimum value stands for Vatika pulse. The Paittika pulse occupies the intermediate position.

TABLE 5

Mathematical Calculations of Vatika, Paittika and Kaphaja Pulses.

Type	Time of each pulse in sec.	Length of percussion wave in cm.	Length between two top points in cm.	Time of percussion wave in sec.	Angle of deviation in degree	Distance of dicrotic notch in cm.
Normal :						
Vatika	0.73	0.40	1.40	0.21	65	0.15
Paittika	0.81	1.40	1.50	0.76	81.48′	0.8
Kaphaja	0.94	0.62	2.10	0.27	77°30′	0.30′

In relation to length of percussion wave the respective values for Vatika, Paittika and Kaphaja pulses are 0.40 cm. 1.40 cm. and 0·62 cm. Here it is observed that maximum height is achieved by Paittika pulse and the minimum height is of Vatika pulse. The Kaphaja pulse occupies the intermediate position.

As regards time of percussion wave the respective valuse for Vatika, Paittika and Kaphaja pulses are 0·21 sec., 0.76 sec. and 0.27 seconds. As the result shows that the maximum time is taken by Paittika pulse and the minimum time by Vatika pulse. The Kaphaja variety here also occupies the middle position between the two extremes.

The angle of deviation of percussion wave in case of Vatika, Paittika and Kaphaja pulses has been found 65, 81°48′ and 77°30′. The result shows that the bent of percussion wave in case of Vatika pulse is more towards the horizontal base line.

The respective values for distance of dicrotic notch in Vatika, Paittika and Kaphaja pulses are 0.15 cm., 0.8 cm. and 0.30 cm. Here the maximum value stands for Paittika pulse and the minimum for Vatika pulse. The Kaphaja pulse occupies the intermediate position.

Diseased Group

In every disease of this group the study related to symptoms, Pulse examination and pulse tracings in Vatika, Paittika and Kaphaja group has been further conducted to show the complete, partial and no correlation at all among these three. And thus, the result in percentage has been assessed.

Out of total 50 cases of cardiac valvular lesions (Table 6) in 14 cases having Vatika character of pulse, symptoms and pulse examination were found to be completely correlated to each other (64.26%). And in 5 cases (35.74%) correlation was found to be partial. The result of complete (64.26%) and partial (35.74%) correlation was found to be the same in case of symptoms and pulse tracings. And total 14 cases (100%) in this group were having complete coincidence of pulse examination to the pulse tracings.

In 22 cases of Paittika group of valvular lesion, no correlation was found between symptoms and pulse examination and the symptoms and pulse tracings. All 22 cases (100%) were found to have complete correlation between pulse examination and pulse tracings.

TABLE 6

Comparative Studies of Pulse Examination in Valvular Lesions.

Observations	Complete		Partial		Negative	
	No.	%	No.	%	No.	%
Vatika (14 cases) :						
Symptoms and pulse examination.	9	64.26.	5	35.74	0	0.0
Symptoms and pulse tracing.	9	64·26	5	35.74	0	0.0
Pulse examination and pulse tracing.	14	100.0	0	0.0	0	0.0
Paittika (22 cases) :						
Symptoms and pulse examination.	0	0.0	0	0.0	0	0.0
Symptoms and pulse tracing.	0	0.0	0	0.0	0	0.0
Pulse examination and pulse tracing.	22	100.0	0	0.0	0	0.0
Kaphaja (14 cases) :						
Symptoms and pulse examination.	0	0.0	8	57.14	6	42.86
Symptoms and pulse tracing.	0	0.0	8	57.14	6	42.86
Pulse examination and tracing.	14	100.0	0	0.0	0	0.0

In 14 cases of Kaphaja group of this disease, there was found to be no correlation between symptoms and pulse examination. But 8 cases (57.14%) were found to have partial and 6 cases (42.86%) were having no correlation at all. Regarding symptoms and pulse tracings, same percentage was found in partial (57.14%) and negative group (42.86%). Pulse examination and pulse tracings were found to be completely correlated in all 14 cases (100%).

Out of total 30 cases of hypertension (Table 7), in 6 cases of Vatika group, regarding symptoms and pulse examination 3 cases (50%) were found to be completely coincided, 2 cases (33.3%) partially coincided and 1 (16.7%) belonged to negative group. Regarding correlation of symptoms and tracing 3 cases (50%) in complete group and 3 cases (50%) in partial group were kept respectively. Regarding pulse examination and pulse tracing all 6 cases belonged to complete group.

In 12 cases of Paittika group of this disease symptoms and pulse examination were found to be completely correlated in 5 cases (41.5%), 2 cases (16.6%) remained to be partially correlated and again 5 cases (41.5%) belonged to the negative group. Similarly regarding symptoms and pulse tracing there was found complete correlation in 5 cases (41.5%), 2 cases (16.6%) happened to belong to partial group and again 5 cases (41.5%) were kept in negative group. All 12 cases (100%) were having complete coincidence with pulse examination and pulse tracings.

TABLE 7

Comparative Studies of Pulse Examination in Hypertension.

Observations	Complete		Partial		Negative	
	No.	%	No.	%	No.	%
Vatika (6 cases) :						
Symptoms and pulse examination.	3	50.0	2	33.3	1	16.7
Symptoms and pulse tracing.	3	50.0	3	50.0	—	—
Pulse examination and pulse tracing.	6	100.0	—	—	—	—
Paittika (12 cases) :						
Symptoms and pulse examination.	5	41.5	2	16.6	5	41.5
Symptoms and pulse tracings.	5	41.5	2	16.6	5	41.5
Pulse examination and pulse tracing.	12	100.0	—	—	—	—
Kaphaja (12 cases) :						
Symptoms and pulse examination.	—	—	5	41.5	7	58.5
Symptoms and pulse tracings.	—	—	5	41.5	7	58.5
Pulse examination and pulse tracing.	12	100.0	—	—	—	—

In this disease 12 cases were having Kaphaja pulses. Out of 12 cases, 5 cases (41.5%) were found to be partially correlated regarding symptoms and pulse examination, and 7 (58.5%) were having no correlation at all. Regarding symptoms and pulse tracing, 5 cases (41.5%) were kept in partial group, whereas 7 cases (58.5%) were found in negative group. Regarding corre-

lation of pulse examination and pulse tracing, the result belonging to complete group was hundred percent. No result was found in partial and negative groups.

In 30 cases of jaundice (Table 8), 11 cases were found to have Paittika pulses. As regards correlation between symptoms and pulse examination in this group, only 3 cases (27.0%) beonged to complete group, 1 case (9.0%) belonged to partial group and the 7 cases (64%) were found to be related to negative group. Regarding correlation between symptoms and tracings, 3 cases (27%) belonged to complete group, 1 (9%) belonged to partial group and 7 cases (64%) belonged to negative group. All 11 cases (100%) were found to have complete correlation regarding pulse examination and pulse tracing.

In this group of disease, 9 were having Kaphaja pulses. Out of 9, 6 cases (66.6%) were found to have complete correlation regarding symptoms and pulse examination. And 3 cases (33.3%) belonged to partial group. Regarding symptoms and pulse tracing, 6 cases (66.6%) were found related to complete group, 2 cases (22.2%) were related to partial group and remaining 1 case (11.1%) was related to negative group. But all 9 cases (100%) were found to have complete correlation between pulse examination and pulse tracing.

TABLE 8

Comparative Studies of Pulse Examination in Jaundice.

Observations	Complete		Partiai		Negative	
	No.	%	No.	%	No.	%
Paittika (11 cases) :						
Symptoms and pulse examination.	3	27.0	1	9.0	7	64.0
Symptoms and pulse tracings.	3	27.0	1	9.0	7	64.0
Pulse examination and pulse tracing.	11	100·0	—	—	—	—
Kaphaja (9 cases) :						
Symptoms and pulse examination.	6	66.6	3	33.3	—	—
Symptoms and pulse tracing.	6	66.6	2	22.2	1	11.1
Pulse examination and pulse tracing.	9	100.0	—	—	—	—

In thyrotoxicosis (Table 9 : all 20 cases 100%) were found to have complete correlation regarding symptoms and pulse examination, symptoms and pulse tracings and pulse examination and pulse tracings.

TABLE 9

Comparative Studies of Pulse Examination in Thyrotoxicosis.

(20 cases)

Observations	Complete		Partial		Negative	
	No.	%	No.	%	No.	%
Symptoms and pulse examination.	20	100.0	—	—	—	—
Symptoms and pulse tracings.	20	100.0	—	—	—	—
Pulse examination and pulse tracing.	20	100.0	—	—	—	—

Qualitative Study :

Regarding qualitative interpretation of contour of different pulses in diseased group it should be noted down here that cases of this group also have the same configuration in general as normal Vatika, Paittika and Kaphaja pulses have but with the difference of dominance or diminution of one or the other factors as shown in their respective figures.

Cardiac Valvular Lesions :

In Vatika pulses of this group, percussion waves have been found significantly small (Fig. 37) than those of Paittika and Kaphaja pulses and have more lateral bending towards the base line. The summit is a bit angular and does not have rounded tip. The fall of dicrotic wave has been found quite rapid. And in most of dicrotic waves, dicrotic notch has been found completely absent. The distance between two points of onset of percussion waves has been found quite short.

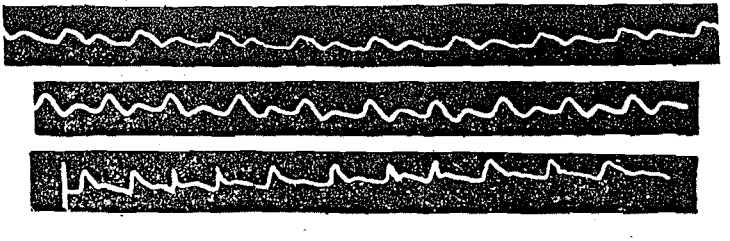

Fig. 37 : Vatika Pulse of Valvular Lesion.

The Paittika pulses (Fig. 38) of valvular lesions are found to have tallest and straight percussion wave of sharp rise. The summits of percussion waves have been found quite angular with rapid wavy fall of dicrotic waves. On dicrotic waves dicrotic notches have been found significantly marked. The distance between two onset points of percussion waves is found to be greater than that of Vatika pulses.

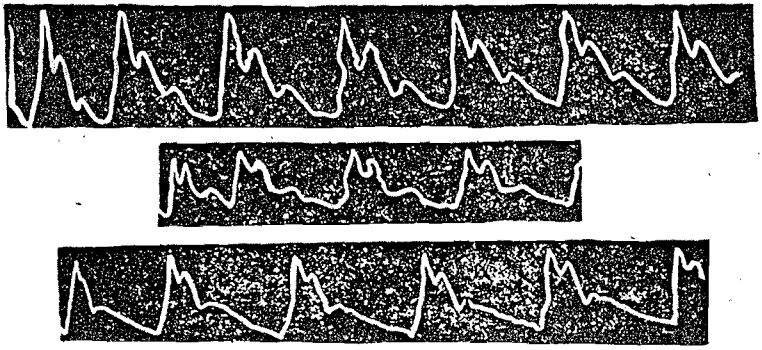

Fig. 38 : Paittika Pulse of Valvular Lesion.

In Kaphaja pulses (Fig. 39) of valvular lesion, the length of percussion waves has been found relatively a bit taller than Vatika type of pulses. And in the cases where Kapha has been found quite dominating the bent of percussion wave from perpendicular has been found much more with the significant rounded summits of percussion waves. The fall of dicrotic wave in such types of pulses has been found quite gradual. The dicrotic notches have been found a bit significant, and in some cases quite rudimentary. The distance between two points of onset of percussion waves has been found greatest of all.

Hypertension :

In Vatika pulses (Fig. 40) of this group, the percussion waves have been found completely in rudimentary form having insignificant summits. The dicrotic notch has been found absent in most cases and in few cases it has been found slightly visible.

In Paittika pulse (Fig.41) percussion waves have been found rising steeply with marked angular summits and marked dicrotic notch. The percussion wave has been found much more taller than Vatika pulses. The distance between two onset points of percussion waves in also greater.

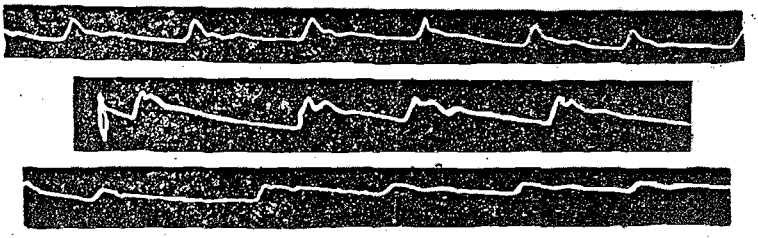

Fig. 39 : Kaphaja Pulse of Valvular Lesion.

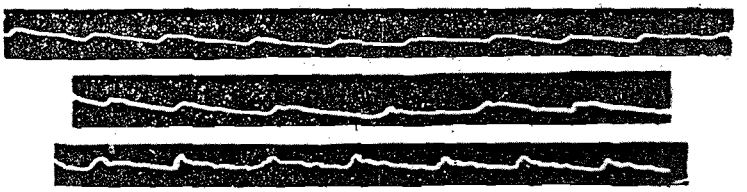

Fig. 40 : Vatika Pulse of Hypertension.

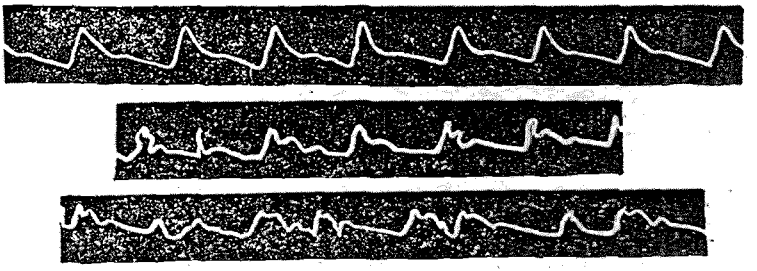

Fig. 41 : Paittika Pulse of Hypertension.

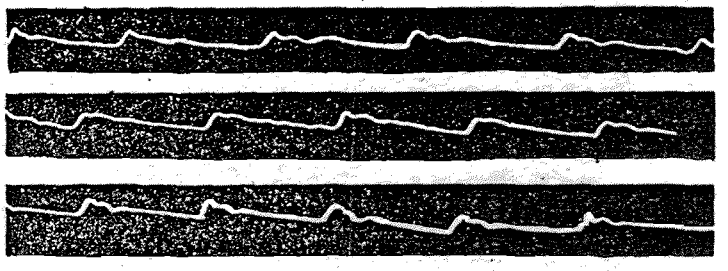

Fig. 42 : Kaphaja Pulse of Hypertension.

In Kaphaja pulses (Fig. 42) the percussion wave has been found more deviated away from perpendicular. And the length of it occupies a middle position in between the Vatika and Paittika groups. The summit has been found rounded and the fall of dicrotic wave is quite gradual. The dicrotic notch has been found a little significant. And the distance between two onset points of percussion waves is significantly more.

Jāundice :

Paittika pulses (Fig. 43) in this group also have the taller percussion wave than the Kaphaja pulses. The rise is quite straight. And the summit is appreciably angular with the rapid fall of dicrotic wave. Dicrotic wave possesses over it the dicrotic notch which is quite visible. In some tracings the notch is found to be below than its usual site.

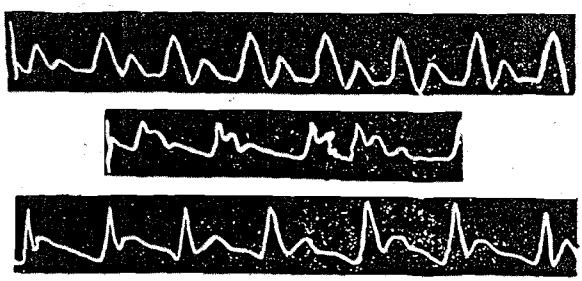

Fig. 43 : Paittika Pulse of Jaundice.

Kaphaja pulses (Fig. 44) have been found to possess smaller percussion wave with rounded summit and gradual fall of dicrotic wave with a bit significant or without dicrotic notch. The distance between two onset points of percussion wave has been found appreciably greater.

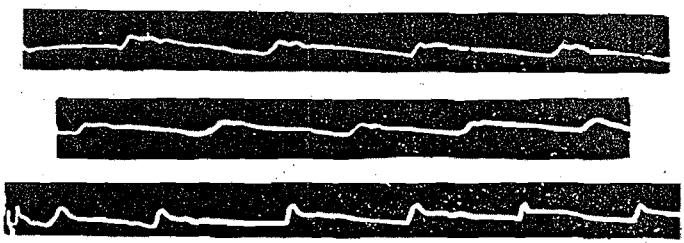

Fig. 44 : Kaphaja Pulse of Jaundice.

Thyrotoxicosis :

All the cases of thyrotoxicosis have been found to possess Paittika pulses (Fig. 45). The percussion wave is quite straight like a perpendicular with appreciable angulation at the summit. The summit is not rounded and the fall is rapid with marked undulations over the dicrotic wave. Therefore, the dicrotic notch is quite prominent.

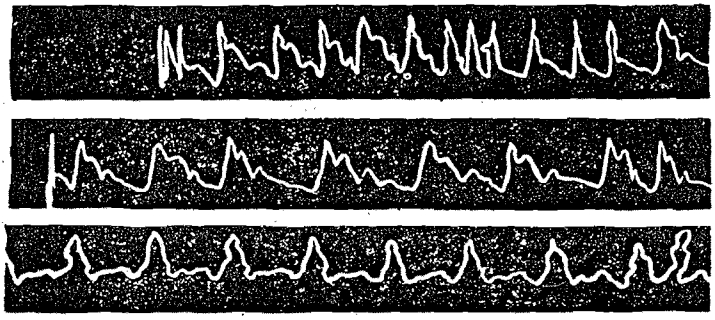

Fig. 45 : Paittika Pulse of Thyrotoxicosis.

Quantitative Study :

Like normal group, this study has also been conducted under two heads namely (1) statistical comparison with normal group and (2) other mathematical studies (*Table 10*).

TABLE 10

Statistical Comparison Between Normal and Diseased Groups.

Group	No. of cases	Pulse rate Mean±S. D.	Comparison with normals	Pulse pressure Mean±S.D.	Comparison with normals
Vatika :					
Normal	9	84±3.6	—	35±4.9	—
Valvular lesions	14	108±5.2	t=12.63*** P∠0.001	30±5.2	t=2.304* P∠0.05
Hypertension	6	108±13.9	t=5.02*** P∠0.001	56±12.0	t=6.06*** P∠0.001

Paittika :					
Normal	20	74±5.5	—	49±6.9	—
Valvular lesions	22	78±11.6	t=1.405 P>0.05	70±21.2	t=4.23*** P∠0.001
Hypertension	12	87±7.4	t=5.7*** P∠0.001	76±16.2	t=6.59*** P∠0.001
Thyrotoxicosis	20	103±10.5	t=11.37*** P∠0.001	51±7.3	t∠1 P>0.05
Jaundice	11	73±3.8	t∠1 P>0.05	52±11.7	t∠1 P>0.05
Kaphaja :					
Normal	11	65±3.9	—	42±6.0	—
Valvular lesions	14	69±7.2	t=1.64 P>0.05	35±4.2	t=3.46** P∠0.01
Hypertension	12	68±6.0	t=1.40 P>0.05	62±17.4	t=3.64** P∠0.01
Jaundice	9	62±3.4	t=1.79 P>0.05	33±8.0	t=2.87* P∠0.02

* Significant at 5% level of probability.
** Significant at 1% level of probability.
*** Significant at 0.1% level of probability.

(1) Statistical Comparison with Normal Group :

Valvular Lesions : In Vatika group mean pulse rate (MPR) in normal and valvular lesions groups are 84.0 and 108.0 respectively. It is observed that mean pulse rate is highly increased in valvular lesions group (t = 12.63; P∠0.001).

Mean pulse pressure (MPP) in normal and diseased groups are 35.0 and 30.0 respectively. It is observed that mean pulse pressure is significantly reduced in valvular lesions group (t= 2.304; P∠0.05).

In Paittika group, mean pulse rate in normal and diseased groups are 74.0 and 78.0 respectively. There is no significant difference in these two groups (t=1.405; P>0.05).

Mean pulse pressure in these respective groups are 49.0 and 70.0 These two values are differing significantly (t = 4.23; P∠0.001) i. e. pulse pressure is significantly more in diseased group.

In Kaphaja group mean pulse rate in normal and diseased groups are 65 and 69 respectively. There is no significant difference in these groups (t = 1.645; P∠0.05).

Mean pulse pressure in the above two groups are 42 and 35

respectively. It is observed that mean pulse pressure is significantly low in diseased group (t = 3.460; P ∠ 0.01).

Hypertension : In Vatika group mean pulse rate in normal and hypertensive groups are 84 and 108 respectively. Mean pulse rate is found highly increased in hypertensive group (t = 5.02; P ∠ 0.001).

Mean pulse pressure in normal and diseased groups are 35.0 and 56.0 respectively. It is observed that mean pulse pressure is significantly increased in hypertension group (t = 6.06; P ∠ 0.001).

In Paittika group mean pulse rate of normal and hypertension groups are 74.0 and 87.0 respectively. Mean pulse rate is found highly increased in diseased group (t = 5.7; P ∠ 0.001).

Mean pulse pressure in normal and hypertension groups are 49.0 and 76.0 respectively. Mean pulse pressure is found highly increased in hypertension group (t = 6.59; P ∠ 0.001).

In Kaphaja group mean pulse rate of normal and diseased groups are 65.0 and 68.0 respectively. There is no significant difference between two groups (t = 1.40; P > 0.05), i. e. both groups are nearly the same.

Mean pulse pressure of normal and diseased groups are 42.0 and 62.0 respectively. Pulse pressure is found to be highly increased in diseased group (t = 3.64; P ∠ 0.01).

Jaundice : In Paittika group, mean pulse rate in normal and diseased groups are 74.0 and 73.0 respectively. There is no significant difference in pulse rate of two groups (t ∠ 1; P > 0.05).

Mean pulse pressure of normal and diseased groups are 49.0 and 52.0 respectively. There is no significant difference in pulse pressure of two groups (t ∠ 1; P > 0.05).

In Kaphaja group, mean pulse rate in normal and diseased groups are 65.0 and 62.0 respectively. No significant difference is found in two groups for pulse rate (t=1.79; P > 0.05).

Mean pulse pressure in normal Kaphaja and diseased groups are 42.0 and 33.0 respectively. pulse pressure is significantly reduced in diseased group (t=2.87; P ∠ 0.02).

Thyrotoxicosis : Mean pulse rate in normal as well as diseased Paittika groups are 74.0 and 103.0 respectively. It is observed that pulse rate is highly increased in diseased group (t=11.37; P ∠ 0.001).

Mean pulse pressure in normal and diseased Paittika groups are 49.0 and 51.0 respectively. There is no significant difference between two groups for pulse pressure (t ∠ 1; P > 0.05).

(2) Other Mathematical Studies :

Similar to normal group, in diseased group also, Vatika, Paittika and Kaphaja pulses of different diseases have been studied in relation to their time of each pulse, length of percussion wave, length between two top points, time of percussion wave, angle of deviation and distance of dicrotic notch from the base line (Table 11).

Valvular Lesion : In this group time taken by each pulse was found to be 0.54 sec., 0.74 sec. and 1.00 sec. in Vatika, Paittika and Kaphaja types of pulses. This indicates that the pulse of Vatika group occupies the lowest position and the Kaphaja pulses occupy the highest position.

The length of percussion wave is found to be 0.30 cm., 2.10 cm. and 0.80 cm. in Vatika, Paittika and Kaphaja pulses respectively. These values indicate the highest length of percussion wave in Paittika group and the smallest length in Vatika group.

The time of percussion wave is 0.12 sec., 0.75 sec. and 0.32 sec. in Vatika, Paittika and Kaphaja groups respectively. This indicates the highest value of time taken by percussion wave of Paittika pulse in describing the course from its point of start to its top.

The angle of deviation in Vatika, Paittika and Kaphaja groups of pulses has been found to 70°30′, 84°24′ and 75°30′ respectively. The data indicate the highest value in Paittika type of pulse, and most acuteness of the angle in Vatika pulse. The Kaphaja pulses occupy the intermediate position.

TABLE 11

Mathematical calculations of Vatika, Paittika and Kaphaja Pulses in Diseased Group.

Type	Time of each pulse in sec.	Length of percussion wave in cm.	Length between two top points in cm.	Time of percussion wave in sec.	Angle of deviation in degree	Distance of dicrotic notch in cm.
Valvular lesions						
Vatika	0.54	0.30	1.20	0.12	70°30′	0.20
Paittika	0.74	2.10	2.00	0.75	84°24′	1.00
Kaphaja	1.00	0.80	2.50	0.32	75°30′	0.40

Hypertension :						
Vatika	0.63	0.20	1.10	0.12	45°12′	0.19
Paittika	0.70	0.70	1.30	0.35	88°25′	0.40
Kaphaja	0.89	0.40	2.40	0.15	60°	0.25
Jaundice :						
Paittika	0.75	0.80	2.10	0.49	89°17′	0.45
Kaphaja	1.03	0.30	3.10	0.10	48°12′	0.28
Thyrotoxicosis :						
Paittika	0.63	0.90	1.50	0.38	83°36′	0.50

The distance of dicrotic notch from the base is found to be 0.20 cm., 1.00 cm., and 0.40 cm. Vatika, Paittika and Kaphaja pulses respectively. The result shows the greatest distance in Paittika group and the least distance in Vatika group.

Hypertension : In Vatika, Paittika and Kaphaja pulses the respective values of time for each pulse is found to be 0.63 sec., 0.70. sec. and 0.89 sec. respectively. Here also Kaphaja pulses are found to take more time and the Vatika pulses the least time.

Similarly in relation to length of percussion wave the values for Vatika, Paittika and Kaphaja pulses are 0.20 cm., 0.70 cm. and 0.40 cm. respectively. Thus the percussion of Paittika group has been found to be largest and of Vatika group smallest of all.

Regarding time of percussion wave, respective values in Vatika, Paittika and Kaphaja pulses are found to be 0.12 sec., 0.35 sec. and 0.15 sec. respectively. The result indicates the greatest time taken in Paittika group and the least time taken in Vatika group.

The respective values for Vatika, Paittika and Kaphaja pulses as regards angle of deviation are found to be 45°12′, 88°25′ and 60° respectively. The result indicates the least angulation in Paittika group and the most angulation in Vatika group.

The values calculated for the distance of dicrotic notch from the base has been found to be 0.19 cm., 0.40 cm. and 0.25 cm. for Vatika, Paittika and Kaphaja pulses respectively. As it is evident from the data that the distance occupied by Paittika group is more and the Vatika group is less. Kaphaja group occupies the intermediate position.

Jaundice : The time of each pulse wave for Paittika and Kaphaja groups has been calculated to be 0.75 sec. and 1.03 sec. respectively. The time taken by Kaphaja pulse is more.

The length of percussion wave in Paittika and Kaphaja groups has been calculated to be 0.80 cm. and 0.30 cm. respectively. Therefore, the length of percussion wave of Paittika pulse is taller than the Kaphaja pulse.

Similarly regarding time taken by each percussion wave in Paittika and Kaphaja groups has been found to be 0.49 sec., and 0.10 sec. respectively. Here also the value for Paittika pulse is more.

The values calculated for angle of deviation are 89°17′ and 48°12′ respectively for Paittika and Kaphaja pulses. Between the two, more acute value has been found in case of Kaphaja group.

Regarding distance of dicrotic notch the calculated values are found to be 0.45 cm. and 0.28 cm. respectively for Paittika and Kaphaja pulses. The distance has been found to be more in case of Kaphaja pulse.

Thyrotoxicosis : In this group, only Paittika pulses have been found. The time for each pulse is 0.63 second, the length of percussion wave is found to be 0.90 cm., the time of percussion wave is found to be 0.38 second, the angle of deviation is 83°36′ and the distance of dicrotic notch is 0.50 cm.

The comparative studies in terms of time of each pulse and the length of percussion wave etc. of Vatika, Paittika and Kaphaja pulses in diseased group and the results obtained show that like normal group here also the relative values bear the same order. And we find that time taken from onset of one pulse to the next is greatest in Kaphaja variety in all diseases taken under study. The length of percussion wave has been found to be largest in Paittika group and the smallest in Vatika group. Therefore, the time taken by percussion waves from the point of onset to the top in these both types of pulses has been found to be greatest and the smallest respectively. The angle of deviation has been found most acute in Vatika group. And the distance of dicrotic notch has been found to be greatest in Paittika group while it has been found smallest in Vatika group. As regards length of percussion wave, time of percussion wave, angle of deviation and the distance of dicrotic notch, these values have been found occupying intermediate position in Kaphaja group of pulses.

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Part Five

Discussion

Discussion

Conceptual

Sharngadhara has been the first Ayurvedic physician who included the knowledge of pulse examination but in the primitive form as a means of diagnosis and prognosis, and certainly it was a revolutionary contribution of its own kind to the traditional means of diagnosis in the field of Ayurveda. The radial pulse has been described as the usual site of pulse examination. Later works on the subject have indicated to see the pulsation of other sites and the foot to assess the expectancy of life of the patient. In addition these works have also mentioned about the followings : (1) to examine the pulse of left hand in case of females and that of right hand in case of males (2) the use of three fingers—the index, the middle and the ring to detect Vata, Pitta and Kapha from above downwards respectively and (3) anatomical position of the hand of the patient at the time of pulse examination.

As regards the time of pulse examination and the methodology of examination, it has been described that the pulse should be examined in the morning hours of the day by giving and releasing the pressure over it. And it should not be examined just after the bath, in hungry or thirsty states or during sleep and just after awakening and after anointing with the oil. These all have been mentioned in the later works. Also, there is mentioning that to acquire perfection in the skill of pulse examination to diagnose diseases, constant practicing of examination of normal pulse must be continued. Including Sharngadhara and onward all have described the forms of pulses by giving simile of movements of various birds and amphibians etc. Only Bhavaprakasha has not followed this pattern, and he has simplified and has given the more practical form of pulse movement to make it conceivable and to be stick to the memory.

The Ayurvedic pulse lore has not been described distinctly in terms of its rate, rhythm, volume, character, force, tension and the condition of arterial wall. These problems have been solved in two ways : (1) by describing various movements of pulses correlating these with those of birds, amphibians and

reptiles etc. and (2) there is an abundance of terminological words in the literature of pulse lore. These words can be coined to explain satisfactorily the rate, rhythm, volume and character etc.

(1) Correlation of Movements of Animals and Pulses :

If one hand the simile of movements signifies character of pulse, on the other hand, it also indicates the rate and volume of pulses. For example, the movement of Vatika pulse resembling to that of leech and the snake signifies that the rate of the pulse should be fast, the volume should be smallest and the character should be curvilinear. Similarly, if Paittika pulse jumps like the frog, it indicates that the character of the pulse is of bounding nature and relatively the rate would be slower than Vatika pulse and the volume of the pulse would be quite high. If Kaphaja pulse moves like goose, it indicates that the pulse rate would be slowest and amplitude of pulse would occupy the intermediate position between Vatika and Paittika types of pulses. Likewise, Sannipatika pulse, if moves like the act of woodpecker (Kashthakutta), it indicates that the character of volume of the pulse would be insignificant, while the rate would be too rapid. It would not be out of place to mention here that Ravana and Yogaratnakara have also mentioned about the rate of pulse in number by using the word "Trinshadvaram" while they have described the condition to assess the prognosis of the patient.

(2) Explanation of Modern Terminology in Ayurvedic Terms :

As regards explanation of rate, rhythm etc. of modern terminology is concerned, sufficient synonyms and explanation can be given from available literature of Ayurveda.

Rate : For tachycardia, the words used are (a) Druta (b) Twarita (c) Tivra (d) Shighra (e) Vyakul and (f) Vikal. Similarly for bradycardia the words used are (a) Manda (b) Manthara. The word "Madhyagati" has also been used to signify that the pulse rate occupies the intermediate position between "Mandagati" and "Drutagati". It usually indicates the rate of Paittika pulse.

Rhythm : To explain regular rhythm the words like 'Sarala' (not crooked) and 'Samya' (regular) have been used. And for irregular pulse 'Trutita', 'Vakra' and 'Kautilya' can safely be used.

Volume : The word 'Atyuchchaka' can be used for high volume pulse. The words used to explain low volume also justify to denote the low tension of the pulse. For example, the words Sukshma (fine, thin), Atisukshma (very thin), Shithil (weak, feeble) if explain that the pulse is of low volume, they also signify that the pulse is of low tension. But the word 'Pushtihina' can be coined as a single word for low tension.

Force : For forceful pulse the words 'Vegavati', 'Vegadhara', 'Balawati', 'Prabal' and 'Uttanabhedin' can be used. And these words also tell about high tension of the pulse.

Character : In the charactar, the pulse wave refers to the manner of its ascent, summit and descent. Various types of pulses can satisfactorily be explained in relation to these events. For example, 'Atikshina', 'Sukshma', 'Atisukshma', and 'Tantusama' types of pulses indicate that the ascent is very rapid without any appreciation of sustaining nature of the summit with rapid fall. Such type of pulses denote excess vitiation of Vata and may also be taken as Sannipatika pulse.

When the pulse is 'Balawati' (vehement), 'Daruna' (violent), 'Vegawati' (vehement), and 'Atyuchchaka' (jumping), the rise would be more steep with transient sustaining of the summit and moderately rapid fall. Such types of pulses resemble the bounding pulse where there is marked undulations over the dicrotic wave. And this condition happens to occur when there is predominance of Pitta. Therefore, these types of pulses can be counted as to be Paittika pulses.

The pulse 'Sthira' (steady) indicates that percussion wave would be rising fairly constant having sustained summit and gradual fall. Similarly in 'Gurvi' (heavy), 'Gariyasi' (extremely heavy), 'Gambhira' (heavy) and 'Dirgha' (long) pulses the rise of percussion waves would be slowest with an appreciable sustaining summit and the more gradual fall. These pulses indicate vitiation of Kapha.

Condition of Arterial Wall : Ayurvedic pulse lore is also furnished with good number of words to indicate the condition of arterial wall. As for example 'Karkasha', 'Khara' and 'Kathina' (hard) denote the hardening of arterial wall.

Temperature of Skin Over the Pulse : Old treatises available on sphygmology also describe pulse in relation to its temperature. It indicates the temperature of skin over the pulse. The

words 'Koshna' and 'Soshma' have been used for hot skin over the pulse and 'Shita' indicates the coldness of skin over the pulse.

Haemodynamic Interpretation :

Because stroke volume and heart rate play a major role in determining the contour of the pulse, therefore, probable haemodynamic interpretations may be given for Vatika, Paittika and Kaphaja pulses.

Vatika pulses can be explained haemodynamically on the ground that the stroke volume is reduced and sometime to that extent that even minute output falls for below the normal. This condition occurs only where there is excessively increase in the rate of heart beating. In this condition the heart beats rapidly and the force of contraction is also reduced. As a result of reduction in force of contraction and stroke volume, the percussion wave becomes smallest of all and its ascent is most rapid. The summit of the percussion-wave is not prominent. And the fall is also rapid. As a result the pulse becomes smallest of all, and dicrotic notch becomes sometimes rudimentary and sometimes disappears. Because the column of blood which regurgitates back in the aorta against the closing semilunar valve during diastole period of ventricle is small. And the impact given to this column of blood at the time of closure of semilunar valve is small producing rudimentary dicrotic notch or its complete absence in some cases.

The Paittika pulses which become 'Soshma' and 'Vegawati' to touch can be best correlated with the hyperkinetic or high cardiac output states. As the name itself suggests, the resting cardiac output is increased beyond the normal range. The main state of the body which can give rise to hyperkinetic state is the hypoxia in which there is increased secretion of adrenaline. There is peripheral vasodilatation in this condition which increase the venous return and thereby there is increase in cardiac output. In the condition of peripheral vasodilatation the arteries too full in systole and too empty in diastole. Variations in body temperature, effect of hormones and other chemical substances play an important role in causing the increase of cardiac output. The decrease peripheral vascular resistance is associated with a warm flushed skin.

Above facts are quite sufficient in proving that the high cardiac output states coincide completely with 'Paittika' stage of the body. Sometimes, high cardiac output state is also found in the condition of infective hepatitis which is well known Paittika disease. The apical impulse becomes forceful and the heart beats strongly. And the pulse becomes 'bounding' or 'water-hammer' type. This type of pulse can be truly correlated with the movement of frog which signifies the Paittika nature of the pulse from Ayurvedic point of view. In such type of pulse the ascent becomes fairly rapid and steep, giving rise to a quite long percussion wave with a bit appreciable sustaintion of the top of the wave, and moderately rapid fall with marked dicrotism or undulations.

As regards Kaphaja pulse, a moderately large percussion wave with a sustained summit and gradual fall determine the character of it. Such type of contour can be achieved only in regular and slow pulse, when the cardiac output is constant. In this condition with a constant force the contraction of the heart remains fairly constant. Thus a slow resting cardiac output determines the contour of Kaphaja pulse. This condition can be found in 'Sthira' type of pulse. In 'Gambhira' and 'Gariyasi' types of pulses when the Kapha is more predominent, the contour of the pulse will be slightly altered. Because in these conditions there is damping of the pulse wave and there is marked delay in its rise time, because a longer time is required to force blood. The ejection period is prolonged i. e. 'Dirgha'. The summit will be well marked and the fall will be gradual.

From the above discussion of haemodynamic interpretations of Vatika, Paittika and Kaphaja pulses, we can safely conclude that the pulse pressure would be highest in 'Paittika' type of pulses. Because, the percussion wave after achieving the maximum peak point after systolic ejection, comes down rapidly to the diastolic level creating a wider range between systolic and diastolic pressure. In Vatika type of pulses, because systolic ejection is smallest, in the same ratio the dicrotic wave is also small. Therefore, the range between two pressure is also reduced proportionately. Pulse pressure in Kaphaja type of pulses occupies the intermediate position between Paittika and Vatika varieties of pulses.

Clinical Study

The total number of cases studied were 160. Out of these

total number 40 were normal volunteers, and among which on the basis of their pulse examination, 9 were of Vatika group, 20 were of Paittika group and remaining 11 were of Kaphaja group.

In remaining 120 diseased cases, 50 were of cardiac valvular lesions and out of which 14 were of Vatika group, 22 were of Paittika group and the remaining 14 were of Kaphaja group.

In total 30 cases of hypertension, 6 were of Vatika group, 12 were of Paittika group and the remaining 12 were of Kaphaja group.

Out of 20 cases of jaundice, 11 were of Paittika group and 9 were of Kaphaja group. All 20 cases of thyrotoxicosis belonged to Paittika group.

Normal Group :

Total cases studied in this group were 40. Out of this total number, 9 were of Vatika group, 20 were of Paittika group and 11 were of Kaphaja group.

In Vatika pulses due to increased heart rate the pulse was found to be rapid. To explain increased heart rate in such type of pulse, it may be said that in addition to chief role of parasympathetic activity there is also slight overtone of sympathetic nerves. The rhythm was regular. The impact of pulse felt under the finger was short and was of smaller duration. That is why the rise of percussion wave was of shorter duration, giving rise its length of small nature. The Pulse felt under the finger was of short duration.

In Paittika type of pulses the rate was found to be slower than Vatika pulses. The rhythm was regular. And the amplitude was maximum appreciable under the finger. This indicates moderately rapid and steep rise of percussion wave. The pulse was relatively of a bit more sustaining nature than the Vatika variety. This indicates the moderately rapid fall of the pulse.

In Kaphaja type of pulses, the rate was found slowest. Here it may be said that parasympathetic overtone dominates in such varieties of pulses. The rhythm was regular due to regular beat of the heart. The percussion wave felt under the finger was of longer duration and of sustaining nature because of a relative increase in maximum ejection period. In the just beginning the fall of the wave was also appreciated under the fingers for a short while. That is why the pulse as a whole felt under the fingers was of longer duration.

Diseased Group :

Total cases studied in this group were 120 and the diseases taken under study, were cardiac valvular lesions, hypertension, jaundice and thyrotoxicosis.

Cardiac Valvular Lesions : Total cases studied in this group ware 50 out of which 14 were having Vatika nature of pulses, 22 were having of Paittika nature of pulses and the rest 14 were having of Kaphaja nature of pulses.

Vatika pulses were found 14 cases. These cases were having mitral stenosis with congestive heart failure. In this condition due to compensatory mechanism caused by increased reflex activity the pulse was quite rapid. Here increased reflex activity may be correlated to predominance of Vata. In this group the pulse was found to be small and of shortest duration. The percussion wave was found to be maximally of small size without any appreciable note of sustaintion of the summit. The fall was quite rapid without any undulation or insignificant undulation over it. And such type of pulse resembles the movement of leech or snake.

These all happened due to increased pulse rate; because due to rapidity of the pulse, the force of contraction was reduced. As a result the less blood was ejected into the aorta with reduced force of impact over the wall of it. Therefore, during examination also, the force and volume of the pulse were also proportionately reduced.

Also due to increased heart rate, time taken for each pulse was reduced. Similarly length of percussion wave, length between two top points, time of percussion wave and distance of dicrotic notch were also reduced to an appreciable extent.

Paittika pulses were found in 22 cases suffering from aortic incompetence. In this condition due to aortic regurgitation, the length of the muscle fibres of left ventricle is increased, and hence the force of contraction is also increased. Due to greater load of the work, the metabolic activity of cardiac muscle fibres also increases proportionately.

On examination the pulse was found to be of high amplitude, because of the greater force of contraction and thereby greater impact over the walls of the aorta. The pulse disappeared suddenly beneath fingers. Such type of pulse can be said of 'Utplutya-gati' which is criteria of the movement of the frog.

From Ayurvedic point of view such type of pulse can be said to be of Paittika nature and from modern point of view, it is termed as 'water-hammer' type of pulse.

In this pulse, the percussion wave was found to be rising steeply. The rise of percussion wave was moderately rapid and the fall was also quite rapid with marked undulations over it. The pulse pressure was found to be high because there was wide gap between the systolic and diastolic pressure.

Kaphaja pulses were found in 14 cases. The cases were suffering from aortic stenosis. In this disease due to prolonged ejection period, the impact felt under the fingers was neither great nor too small. But occupied the middle position. Therefore, the percussion wave was found to be rising slowly and of sustaining nature. The fall was also gradual. Such type of pulse can be correlated with the movement of 'Hans' indicating Kaphaja type of pulse.

In this group, the length of the percussion wave occupies the middle position in between the Vatika and the Paittika pulse. Because the impact on the wall of aorta in this case is neither too great nor too low as in the case of Paittika and Vatika pulses respectively. Due to slow heart rate the distance between the onset points of two percussion wave was also more.

Hypertension :

Total cases taken under this group were 30 out of which 6 belonged to Vatika group, 12 Paittika group and the rest 12 belonged to the Kaphaja group.

Vatika pulse : In Vatika type of hypertension, the pulse rate was found to be quite significantly increased. And this played its dominating role in determining the contour of the pulse. Because due to significantly increased heart rate the stroke-volume was reduced. As a result the impact of blood on the wall of the aorta was also reduced. Therefore, whatever the pressure pulses were generated, they were rapidly formed with the production of smallest percussion wave. Since the column of blood falling back over the semilunar valves during the end of their closure was small. Therefore, the dicrotic notch found over the dicrotic wave, was also quite small. The arterial wall was found to be hard.

Paittika Pulse : On examination, it was found that in Paittika type of hypertension, the wall of the artery was not so

hard, as in case of Kaphaja type of hypertension. The wall was also found to be less tortuous. These findings indicate that arteriosclerosis was not so much as it was in Kaphaja type of pulses. The second point is that the pulse rate was also found increased, causing relatively a bit higher cardiac output. And third, the pulse pressure was also higher. Due to these findings i. e. less development of arteriosclerosis and thereby relatively more preservation of elasticity of the walls of the artery, a bit increase in cardiac output and the great pulse pressure, whatever amount of blood was pumped into the aorta that gave the greater impact on the wall of aorta. And this resulted into giving rise the long percussion wave with marked dicrotism.

Kaphaja Pulse : As it is proved fact that impaired elasticity of vessels causes a small percussion wave so it was the case in Kaphaja pulse too. Second due to bradycardia, relatively than Paittika type of hypertension, the stroke volume output naturally remained a bit smaller. Therefore, due to additive effect of above two factors, the percussion wave was found to be of smaller size with relatively longer pause. The impact felt under the finger was lesser than Paittika pulses. But the tension was found a bit more in Kaphaja variety of pulse. The wall of the artery was found to be more tortuous and harder.

Jaundice :

This group consisted of total number of 30 cases. Out of which 11 cases belonged to Paittika group and the rest 9 cases belonged to Kaphaja group.

Paittika Pulse : Paittika pulses in jaundice denote the hyperkinetic circulatory condition of the heart. Due to the condition, the heart and thereby the pulse was found to be relatively increased than Kaphaja type of pulse in jaundice. Because of moderate increase in heart rate, the cardiac output was also increased, giving the greater impact on the lateral wall of the aorta. Hence, the percussion wave was found to be relatively larger and steeply rising than the Kaphaja type of pulse. The pulse was found to be of jumping nature.

Kaphaja Pulse : The Kaphaja type of pulse in jaundice was found only because due to not increase in the heart rate, and therefore, cardiac output was not affected, and remained about normal. As a rule, within the limited range of increment in heart rate, the cardiac output is also increased giving greater

impact on the lateral wall of the aorta, causing larger percussion wave and moderately rapid fall of dicrotic wave with marked dicrotism. Because, due to lack of increased cardiac output, these findings were not present in Kaphaja type of pulse in jaundice, therefore, percussion wave was found to be of smaller size with steady fall of dicrotic wave and increased distance between the two onset points of percussion wave.

Thyrotoxicosis :

In all 20 cases of thyrotoxicosis the pulses were of Paittika nature. The pulses were of Paittika nature because of hyperkinetic or high cardiac output states. In this condition, the resting cardiac output is increased beyond the normal range. In this condition due to increase venous return there is increase in cardiac output. Variation in body temperature, harmones and other chemical substances also play an important role in causing the increase of cardiac output. From practical point of view, body temperature, harmones and other chemical substances may be included in Paittika gorup. The skin in thyrotoxicosis becomes warm and flushed due to decrease peripheral vascular resistance.

Regarding character of the pulse, it was found that the percussion wave was rising fairly steeply, giving rise to a quite long percussion wave without an appreciable sustaintion of the top of the wave. The fall was rapid with marked undulations or dicrotism. Such type of character of the pulse coincides completely with the movement of the frog indicating the Paittika nature of the pulse. From modern point of view, such type of pulse is called 'bounding' or 'water-hammer' type. The rate of the pulse was increased due to high cardiac output. The amplitude of the pulse was high and under the fingers the pulse was striking forcefully.

Experimental Study

The same number of cases of clinical group i. e. 160 have been studied in this group also. Out of the total number 40 were normal volunteers, and among these on the basis of their pulse examination, 9 were of Vatika group, 20 were of Paittika group and the rest 11 were of Kaphaja group.

In remaining 120 diseased cases, 50 were of cardiac valvular lesions out of which 14 were of Vatika group, 22 were of Paittika group and the rest were of Kaphaja group.

In total 30 cases of hypertension, 6 were of Vatika group, 12 were of Paittika group and the rest 12 were of Kaphaja group.

Out of 20 cases of jaundice, 11 were of Paittika group and 9 were of Kaphaja group. All 20 cases suffering from thyrotoxicosis were of only Paittika nature.

As the experimental study has been conducted under qualitative and quantitative heads, therefore, interpretation is being given in the same light. For qualitative study, the parameters taken were various movements of birds, reptiles and amphibians. For example, Vatika pulse moves like leech and snake; Paittika pulses correspond to the movement of frog, and Kaphaja pulses resemble the movement of goose.

Qualitative Interpretation : It has been observed, when both leech and snakes move, they move very fast and assume the curvilinear motion. But actually their movements do not possess the amplitude. It means that Vatika type of pulses should only possess the rate and as regards amplitude, it would be quite small. That is why in tracings we find that the percussion wave is quite small, the fall is quite rapid and small, with a little significant or without dicrotic notch over the dicrotic wave. Due to small amplitude, dicrotic wave after short fall also assumes the horizontal character. And due to rapid rate after very short interval the next percussion wave is generated.

Regarding Paittika pulses and their resemblance to the movement of frogs, it can be said that the movement of the frog mainly contains the amplitude of high range. But as regards rate it is certainly appreciably less than those of leech and the snake. That is why Paittika varieties of pulses acquire the highest range of amplitude than the Vatika varieties. This achievement is also found in pulse tracings. And we find that the percussion wave rises quite steeply with the moderate fall. Since Pitta has the jumping character, therefore, we find marked undulations with marked dicrotic notch and sometimes tidal wave too. And also due to rapid fall, the dicrotic wave forms an appreciable acute angle with percussion wave giving a quite conical shape to the summit of the pulse. Some time exacerbation of Pitta is also responsible for causing dicrotic notch to be situated relatively at lower level in some tracings.

As regards Kaphaja varieties of pulses and their coincidence to the movement of goose, it can be said that the goose neither

possesses the rapid movement like leech and snake nor it possesses so much range of amplitude like that of frog. Instead the goose has steady and slow movement with the amplitude neither so much high as that of frog nor too much low as that of leech. Therefore, it can be said that Kaphaja pulses occupy the intermediate position in between Vatika and Kaphaja varieties as regards rate and amplitude. That is why in pulse tracings, we find that the percussion wave occupies the length in between the Vatika and the Paittika varieties with well marked rounded summit and the gardual and steady fall of dicrotic wave. The dicrotic notch is also not so much marked as found in Paittika pulses, nor so much small as found in Vatika varieties. And due to slow movement the distance between two percussion waves are also found greatest of all.

Quantitative Interpretation : Quantitatively pulses of both normal and diseased groups have been studied in two ways as have been mentioned already. Firstly, they have been studied in relation to the measurements of time of each pulse wave, length of percussion wave, length between two top points, time of each percussion wave, angle of deviation of percussion wave and the distance of dicrotic notch from the base. Secondly both groups of pulses have been studied in relation to their pulse rate and pulse pressure with their statistical studies. Therefore, it is imperative here to discuss about pulses in the light of these studies conducted separately.

After calculating the time taken by each pulse wave, it has been found that time taken is minimum, medium and maximum by Vatika, Paittika and Kaphaja pulses respectively. These findings depend on the rate of contraction of the heart. In predominance of Vata, the rate of contraction is more, and in predominance of Pitta it is relatively less, whilst in case of Kapha it is still less even than Pitta.

After measurement the length of percussion wave, it has been found minimum, medium and maximum in Vatika, Paittika and Kaphaja pulses respectively. These findings depend on force of contraction of left ventricle and to some extent elasticity of arterial wall. In vitiation of Pitta, the increased cardiac output as a result of peripheral vasodilatation and release of chemical substance, the force of contraction of left ventricle is increased. Therefore, relatively more blood is forced against

the wall of aorta giving rise the maximum length of percussion wave in this case.

In case of predominance of Kapha, there is no such condition as peripheral vasodilatation and thereby increase in cardiac output. Therefore, the force of contraction remains to be of medium nature or may be less than it. That is why the force of contraction is not so vigorous as in case of Pitta. Therefore, the length of percussion wave assumes the height in the same ratio and acquires the medium position.

Since in vitiation of Vata the force of contraction reduces maximum. Therefore, the amount of blood propelled into the aorta and the impact given to its wall is maximally reduced. Therefore, the length of percussion wave assumes its minimum height. The distance between two top points of successive percussion wave depends on the rate. As the rate is maximum the distance would be minimum as in Vatika pulses. Similarly if the rate of heart is slow the distance between two points would be maximum as in case of Kaphaja pulse. Here the Paittika pulses occupy the intermediate position.

Regarding time of percussion wave taken from its point of start to the point of its top, it has also been found in minimum, medium and maximum ratios. The minimum value has been found in Vatika pulses, whereas maximum value has been found in Paittika pulses. The Kaphaja pulses occupy the intermediate position. These findings are also in accordance with the force of contraction and thereby the length of percussion waves of Vatika, Paittika and Kaphaja pulses. Greater is the length, maximum would be time taken as in Paittika pulses. Similarly in Vatika and Kaphaja pulses the time would be minimum and medium respectively.

As regards angle of deviation from the point of start of percussion wave towards the base line, it has been found maximum in case of Vata, medium in case of Kapha and medium in case of Pitta. Because due to jumping tendency of Paittika pulses its rise would be more straight. Therefore, the percussion wave would be more nearer to the perpendicular drawn upwards from the point of start of percussion wave. That is why deviation of percussion wave in case of Paittika pulses towards the base would be much more lesser in relation to Vatika and Kaphaja varieties. In case of Vatika pulses, maximum deviation

towards the base is due to short contraction of the heart causing quite rapid fall of dicrotic wave towards the base. In case of Kaphaja pulses due to heavy nature of Kapha, really the rise of percussion wave takes a little more time than Vatika pulses and relatively it is straighter. Therefore, the bent towards the base is not so much as in the case of Vatika pulses. But certainly the bent would be more in relation to Paittika pulses. Therefore, the angle of deviation of percussion wave would naturally occupies the intermediate position.

As regards the distance of dicrotic notch from the base, here there is found also three categories of minimum, medium and maximum distance. In case of Vatika pulses, it is minimum because of least distance of dicrotic wave from the base. And the distance is medium and maximum respectively in Kaphaja and Paittika pulses because of their relative distances of dicrotic waves from the base.

Regarding second type of quantitative study done in relation to pulse rate and pulse pressure, the pulse rate has been found maximum and the pulse pressure has been found minimum in Vatika pulses in comparison to Paittika and Kaphaja pulses. Such findings of pulse pressure in Vatika variety of pulse can be explained on the ground that during systole and diastole neither there is maximum filling nor there is maximum emptying of arteries respectively. That is why in case of Vatika pulses the pulse pressure is much more reduced.

In case of *Paittika* pulses, pulse rate has been found to occupy intermediate position in between Vatika and Kaphaja varieties. That is more than Kaphaja pulses and lesser than the Vatika pulses. But *pulse pressure* has been found acquiring maximum position than the rest two varieties. In this, the pulse pressure has been found maximum because during systole and during diastole the filling and emptying of arteries is much more in relation to condition of vitiation of Vata and Kapha. Therefore, the pulse pressure is found to be maximum in Paittika varieties of pulses. The maximum filling and emptying is due to hyperkinetic circulatory condition of the heart and peripheral vasodilatation.

In *Kaphaja* varieties of pulse, neither there is so small filling and emptying of arteries nor so much filling and emptying of

them. Therefore, the pulse pressure occupies the intermediate position. The pulse rate is lowest of all varieties. The pulse rate in Kaphaja pulses is slow probably because the parasympathetic overtone is more rather than the sympathetic.

When summarising the whole discussion related to qualitative and quantitative experimental studies, following results can be drawn for Vatika, Paittika and Kaphaja pulses.

Qualitatively, Vatika pulses should possess smallest percussion wave, slightly conical summit, insignificant or absence of dicrotic notch and small dicrotic wave assuming horizontal position quite immediately just after the dicrotic notch. And on looking the whole pulse tracings at glance it gives the appearance of curvilinear motion resembling to the movements of leech and snake.

As regards Paittika pulses, they should have straight and longest percussion wave, maximum conical summit, exaggerated dicrotic notch and rapid fall having proportionately the same height as the percussion wave. And on looking the pulse tracings as a whole, it gives the jumping appearance as if these were produced by movements of some frog.

As regards Kaphaja pulses they should possess medium height of percussion wave, flattened summit of sustaining nature, small dicrotic notch and steady and gradual fall of dicrotic wave.

As regards *quantitative* study, Vatika pulses should take minimum time in passing from one wave to the next and should have smallest length of percussion wave, least period of time of percussion wave from the point of start to its top, maximum deviation of angle in bending towards the base, minimum distance of dicrotic notch from the base, high pulse rate and minimum pulse pressure in relation to Paittika and Kaphaja pulses.

Paittika pulses should take medium period of time in passing from one wave to the next and should have highest length of percussion wave, maximum period of time of percussion wave from the point of its start to its top, least deviation of angle from normal line in bending towards the base, maximum distance of dicrotic notch from the base, medium pulse rate and maximum pulse pressure.

Kaphaja pulses should take maximum period of time in passing from one wave to the next and should have medium height of percussion wave, medium period of time of percussion wave from the point of start to its top, medium deviation of angle in bending towards the base from normal line, medium distance of dicrotic notch from the base line, slow pulse rate and medium pulse pressure. Here it should be taken into account that these values are both for normal as well as diseased cases with the difference that some of these values are exaggerated and some are reduced in cases of diseased group. But so far as maintenance of relative values in each group is concerned, they follow the same order.

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Part Six

Conclusions

Conclusions

The pulse is a pressure wave that travels along the vessels wall. The factors responsible for generation of pulse are three in numbers namely, (1) the intermittent flow of blood from the heart i. e. stroke volume output, (2) the resistance to outflow of blood from the arteries into the capillaries and (3) the elasticity of arterial walls. The contour of a radial pulse possesses percussion, tidal and dicrotic waves and a dicrotic notch found just before the beginning of dicrotic wave. Latest research shows that this terminology should be replaced either entirely in relation to timing or entirely in relation to mechanism. In relation to former one may substitute "early systolic", "late systolic", and "diastolic" for "percussion", "tidal", and "dicrotic", and in relation to later "percussion", "tidal" and "dicrotic" waves may be replaced by "impact", "cephalic reflected" and "caudal reflected".

In Ayurveda Vatika, Paittika and Kaphaja pulses have not been described distinctly in terms of rate, rhythm, volume and character etc. Instead they have been described vividly in terms of movements of various birds, reptiles and amphibians. Really speaking plenty of words are there in existing literature of Ayurvedic pulse lore, which may be coined to explain satisfactorily the rate, rhythm, volume and character etc. For example, Druta, Twarita, Tivra and Shighra words signify the rapid movement of pulse i. e. tachycardia. And this condition is always found when there is vitiation of Vata. Similarly Manda and Manthara indicate the slow movement of the pulse i. e. bradycardia. And this condition is always found in predominance of Kapha. The word Madhyagati i. e. the pulse rate between the two extremes of tachycardia and bradycardia has also been used which may be taken to interpret the rate of Paittika pulse which occupies the intermediate position in between Vatika and Kaphaja pulses.

For regular rhythm the word **Samya (regular) and Sarala** (not crooked) can safely be used, whilst for irregular pulse the words Trutit (irregular) can be used.

The word Atyuchchaka indicates high volume pulse. And the word Sukshma indicates the low volume. The later also

indicates the low tension of the pulse. The word Pushtihina (light and thin) can be coined as a single word for low tension of the pulse.

For forceful pulse the words Vegawati, Vegadhara, Balawati and Prabala can be used. These words also indicate the high tension of the pulse.

As regards character, Druta and Sukshma type of pulses indicate that the rise of percussion wave would be quite rapid. Therefore, the pulse would be appreciated for a short while under the fingers. This condition happens to occur in Vatika pulses.

When the pulse is Balawati and Atyuchchaka (jumping), it indicates that naturally the rise of percussion wave would be moderately rapid giving greater impact beneath the fingers. This condition happens to occur in Paittika type of pulses.

The Kaphaja pulses like Sthira, Gariyasi and Gurvi indicate that the rise of percussion wave would be slow for a bit longer period. And therefore, the rise of percussion wave would be appreciated for a bit longer period with sustained summit i. e. the pulse fet under the fingers remains appreciable for a longer period than Vatika and Paittika pulses.

As regards condition of arterial wall, Karkasha, Khara and Kathina words are used. These words indicate the hardening of arterial wall.

As mentioned in previous chapters that Vatika, Paittika and Kaphaja pulses have been studied for their qualitative and quantitative standardization. And the study has also been conducted in the direction to see any correlation among symptoms, pulse examination and pulse tracings. The whole study has been completed in clinical as well as experimental forms.

To conduct above studies, 160 cases were chosen including both normal and diseased groups. Out of total cases, 40 were normal volunteers and the remaining 120 cases belonged to diseased group. Normal volunteers were again classified on the basis of their pulse examination in Vatika, Paittika and Kaphaja groups. Radial pulse in this group were also studied in the morning and the evening in 20 cases and in rest 20 cases study was performed before and after meal. Volunteers belonging to Vatika, Paittika and Kaphaja groups were 9, 20 and 11 in numbers respectively. Their range of age was varying from 17–40 years.

Diseases selected for the study were of cardiac valvular lesions, hypertension, jaundice and thyrotoxicosis. And the total cases belonging to this group were 120. Out of the total number, 50 cases were in valvular lesions group of average age of 27; 30 cases were in hypertension group of average age of 50; 20 cases were in jaundice group of average age of 42; and 20 cases were belonging to thyrotoxicosis of average age of 27 years.

Clinical Study

Before putting under this study normal volunteers as well as diseased cases were thoroughly interrogated to detect any abnormality in volunteers and to decide the severity and characters of diseases in diseased group. After interrogation in both groups normal as well as diseased, laboratory and radiological investigations were performed. In cases of cardiac valvular lesions, E. C. G. was also performed. Regarding laboratory investigations, these were conducted under two heads namely (1) routine laboratory investigations and (2) specific investigations as for example estimation of S. G. O. T., S. G. P. T., Vandenbergh reaction and the other liver function tests etc. in cases of jaundice, and radioactive iodine study in cases of thyrotoxicosis. In cases of hypertension, the serum cholesterol level and blood sugar level was estimated.

In 9 normal Vatika cases during pulse examination the rate was found to be highest in this group. The rhythm was found to be regular i. e. at every time beats were equidistant. The impact of pulse felt under the fingers was of shorter duration indicating shorter duration of time taken by percussion wave. The sustaintion of the pulse under the fingers was also of short duration. Force was also relatively on lower side than Paittika and Kaphaja pulses.

In 20 normal Paittika cases the pulse occupied the Madhyagati i. e. the rate was slower than Vatika pulses and increased than Kaphaja pulses. The rhythm was regular.

As regards volume the impact felt under the finger was appreciated nicely indicating relatively longer duration taken by percussion wave than in the case of Vatika pulses. The summit was also a bit relatively of more sustaining nature than Vatika pulse. The force was found to be more in cases of Paittika pulse.

In 11 normal Kaphaja cases the pulse rate was slow. Successive beats were coming after good period of intervals. The rhythm was regular. And the pulse felt under the fingers were appreciated for a longer period, and the summit was of sustaining nature. This indicates the greater time taken by the rise of percussion wave. The force was appreciable but was a bit on lower side than Paittika pulses.

The above findings were also obtained in Vatika, Paittika and Kaphaja types of pulses examined in the morning, in the evening and before and after taking meal.

Clinical examination was also conducted in diseased group. In this group, out of 50 cases of cardiac valvular lesions, 14 cases were having Vatika type of pulses and remaining 22 cases and 14 cases were having Paittika and Kaphaja types of pulses respectively.

Out of 30 cases of hypertension, 6 were having Vatika type of pulse and remaining 12 cases and the other 12 cases were having Paittika and Kaphaja varieties of pulses respectively.

In total 20 cases of jaundice, 11 cases were possessing Paittika type of pulses and the rest 9 cases were having Kaphaja variety of pulses. All 20 cases of thyrotoxicosis were having only Paittika nature of pulses.

In diseased group too, Vatika, Paittika and Kaphaja pulses bore the same relations among rate, rhythm, volume, character and force etc. as the normal Vatika, Paittika and Kaphaja pulses could have. Only the difference was found with the exaggeration or reduction of some values or the others.

Cardiac Valvular Lesions :

In cardiac valvular lesions, 14 were belonging to Vatika group and these were the cases of decompensated heart of congestive heart failure. In this group the heart rate was found to be much more increased than Vatika pulses of normal group. In cases rhythm was found to be irregular at certain moment. Volume was also found to be on lower side in relation to normal Vatika pulses. And the time taken by each pulse felt under the finger was also quite small. Relatively the tension and force were also found to be on lower side than normal Vatika pulses.

In this group of disease, 22 cases were having Paittika type of pulses. The rate in this type of pulse was found to be relatively slower than Vatika pulse. But the amplitude was found to

be highest in this group, because these cases were found to have water-hammer type of pulse. The impact given by rise of percussion wave was maximum in this group. Therefore, the force of impact was maximum in this group.

In Kaphaja pulses of this group, the period of rise of pulse wave felt under the fingers was maximum. These cases belonged to aortic stenosis. The amplitude and force were not so much as in the case of Paittika variety of pulse.

Hypertension :

In hypertension group, 6 cases were having Vatika character of pulse. In relation to Paittika and Kaphaja pulses, rate was found to be maximum in this case. There was relative reduction also in volume, force and tension in the pulses of this group.

In all 12 Paittika cases of this group, the force was found to be maximum and the arterial wall was not so hard as was in Kaphaja variety. The tension was also found to be a bit on lower side than Kaphaja variety.

In the rest 12 cases having Kaphaja character of pulse, the pulse was beating slowly. And the impact felt under the finger was of longer duration. The arterial wall was found to be more harder than Paittika pulses. And the tension was found to be relatively a bit more.

Jaundice :

In jaundice group, 11 cases were having Paittika nature of of pulses. The impact felt under the finger was quite appreciable. In remaining 9 cases, the pulse was found to be of Kaphaja character. In this case, the rise of wave was found to be appreciably slow and the summit was found to be of sustaining nature.

Thyrotoxicosis :

All 20 cases of thyrotoxicosis the character of the pulse resembled to that of Paittika pulses i. e. the impact felt under the fingers was quite appreciable and the summit was of short duration. The pulses felt were a little forceful.

Experimental Study

In normal as well as diseased group, this study was conducted under two heads namely (1) Sphygmographic tracings of

pulse wave and (2) Quantitative studies of pulse tracings. The later study was further conducted under two heads (a) numerical estimation of time taken by each pulse wave, length of percussion wave, length between two top points, time of each percussion wave, angle of deviation of percussion wave and the distance of dicrotic notch from the base, (b) statistical analysis of pulse rate and pulse pressure in Vatika, Paittika and Kaphaja pulses.

As regards qualitative and quantitative studies of Vatika, Paittika and Kaphaja pulses are concerned, following conclusions may be drawn.

Vatika Pulse :

Qualitatively it possesses smallest percussion wave, slight conical summit, insignificant or absence of dicrotic notch and small dicrotic wave assuming horizontal position quite immediately just after the generation of dicrotic notch. On looking as a whole the appearance of tracings seems to be resembling to the movements of leech and snake.

Quantitative studies show that Vatika pulse takes minimum time in passing from one wave to the next and has smallest length of percussion wave, least period of time taken by percussion wave from the point of start to its top, maximum deviation of angle in bending towards the base line, minimum distance of dicrotic notch from the base line, high pulse rate and minimum pulse pressure when compared to the values of Paittika and Kaphaja pulses.

Paittika Pulse :

Qualitative study shows that Paittika pulse possesses longest percussion wave, maximum conical summit, exaggerated dicrotic notch and rapid fall. The look of tracings as a whole gives the appearance of jumping character as if it were the movement of frog.

Quantitative study in this variety of pulse shows that Paittika pulses must take medium period of time in passing from one wave to the next and should have highest length of percussion wave, maximum period of time of percussion wave in passing from the point of start to the point of its top, least deviation of angle in bending towards the base line, maximum distance of dicrotic notch from the base line, medium pulse

rate and maximum pulse pressure as compared to Vatika and Kaphaja pulses.

Kaphaja Pulse :

Qualitative study shows that the pulse of this nature should have medium height of percussion wave, flattened summit looking to be of sustaining nature, small dicrotic notch steady and gradual fall of dicrotic wave.

Quantitative study shows that a Kaphaja pulse should take maximum period of time in passing from one wave to the next and should have medium length of percussion wave, medium period of time of percussion wave from the point of start to its top, medium deviation of angle in bending towards the base line, slow pulse rate and medium pulse pressure as compared to Vatika and Paittika pulses.

Numerical Correlation :

Ultimately as regards the study of pulse in relation to its examination and its correlation with symptoms and pulse tracings, mathematical data have been provided in the section of observations. Study of correlation of above three has been further conducted under the heads complete, partial and negative. In this connection. it should be noted here that in all diseased cases of valvular lesions, hypertension, jaundice and thyrotoxicosis as far as correlation between pulse examination and pulse tracing in different groups of Vatika Paittika and Kaphaja cases is concerned, it was found to be hundred percent (100%). It means that correlation between pulse examination and pulse tracing was hundred percent in all groups of cases and in this, no one was found to be related to partial or negative groups. It also indicates on the other hand that complete and partial correlation had their limited scope only with the symptoms and pulse examination, and symptoms and pulse tracings.

In 50 cases of cardiac valvular lesions out of 14. Vatika pulses maximum correlation was found (64.26%) in complete group as far as correlation between symptoms and pulse examination, and symptoms and pulse tracings was concerned. In relation to above study respective percentage was 35.74% and 35.74% in partial group.

In this disease out of 22 Paittika pulses no correlation was found at all as far as correlation between symptoms and pulse examination, and symptoms and pulse tracing was concerned.

In this disease out of 14 Kaphaja pulses there was no correlation found in complete group. In partial group, the percentage of correlation between symptoms and pulse examination, and symptoms and pulse tracing was 57.14% and 57.14% respectively. 42.86% and 42.86% cases were found to be non-correlated respectively.

In 30 cases of hypertension, 6 were having Vatika pulses. And the percentage in complete group regarding symptoms and pulse examination and symptoms and pulse tracings was 50% and 50% respectively. Regarding partial group the percentage was 33.3% and 50% respectively. One case (16.7%) was found having no correlation between symptoms and pulse examination.

In this disease out of 30 cases, 12 cases were having Paittika pulses. The percentage in complete group regarding symptoms and pulse examination, and symptoms and pulse tracings was 41.5% and 41.5% respectively. In partial group percentage was 16.6% and 16.6% respectively. In both studies no correlation was found in 41.5% and 41.5% cases.

In 30 cases of hypertension, 12 cases were having Kaphaja pulses. Regarding symptoms and pulse examination, and symptoms and pulse tracing, no correlation was found in complete group. 41.5% and 41.5% cases were found in partial correlation group respetively. And 58.5% and 58.5% cases were found to have no correlation.

Out of 20 cases of jaundice, 11 were having Paittika pulses. Regarding symptoms and pulse examination, and symptoms and pulse tracing the percentage of correlation in complete group was 27% and 27% respectively. And in partial correlation group percentage was 9% and 9% respectively. 64% and 64% cases were found to be non-correlated.

In 9 Kaphaja pulses of this disease regarding symptoms and pulse examination, and symptoms and pulse tracing the percentage in complete group was 66.6% and 66.6% respectively. In partial correlation group the percentage was 33.3% and 22.2%. One case (11.1%) was having no correlation between symptoms and pulse tracing.

In all 20 cases of thyrotoxicosis the pulse was found to be of Paittika nature, and regarding correlation between symptoms and pulse examination, and symptoms and pulse tracing the

percentage in complete correlation group was hundred percent in both types of observations.

The above study in all groups of diseases irrespective of their Vatika, Paittika and Kaphaja groups shows the hundred percent result as far as complete correlation between pulse examination and pulse tracing is concerned. But in rest other types of studies belonging to correlation between symptoms and pulse examination, and symptoms and pulse tracing, maximum result was obtained in complete correlation group of Vatika group of cardiac valvular lesions and hypertension, and Kaphaja group of jaundice, In Kaphaja group of valvular lesions, maximum correlation between symptoms and pulse examination, and symptoms and pulse tracing was found in partial correlation group. And in negative group, maximum percentage was obtaind in Kaphaja group of hypertension and Paittika group of jaundice.

Now from the above studies it can be concluded that (1) Vatika, Paittika and Kaphaja pulses can be well explained in their rate, rhythm, volume, character, force, tension and condition of the arterial wall. (2) The new advent of pulse tracing to diagnose diseases in their Vatika, Paittika and Kaphaja character is more scientific and reliable. Because, if on one hand different contours obtained after tracing standardize the character of Vatika, Paittika and Kaphaja pulses, on the other hand they also predict about important roles of different Doshas affecting the haemodynamics of the body. And thus the contours help in bringing into the light of more subtle process of Doshas going on in the body. (3) Not only this much, but one can very easily assess the relative values of Doshas from the contour of any specific pulse. For example, Vatika pulse not only denotes the predominance of Vata but side by side it also tells about the condition of Pitta and Kapha too in the same patient at the same time. For example, the shortness of percussion and dicrotic wave occupying immediately horizontal position just after the formation of very small dicrotic notch or without its presence not only indicate the vitiation of Vata but also suggest that if there would have been a little increase in amount of Pitta, the percussion wave would have occupied a bit more straight position with relatively marked undulation over dicrotic wave. And if in relation to Pitta, Kapha would have been there, the summit of the wave would have become

rounded with a bit gradual fall of dicrotic wave. Similar explanations can also be given to Paittika and Kaphaja pulses. In case of Paittika pulse, the 'Ushma' character of Pitta becomes responsible for greater uplift and moderately rapid and straight rise of percussion wave. If there would have been a good proportion of Kapha in this case, the uplift of percussion wave would have not been possible to that extent and the fall of dicrotic wave would have become a bit more gradual and steady without so much marked dicrotic notch. The gradual and steady fall with rounded summit of Kaphaja pulse indicates that the Pitta is less dominating. (4) Further the knowledge of pulse tracing can be utilized in detecting even the finest shades of Vata, Pitta and Kapha in each tracing with the help of frequency analysis as described in the terminal portion of modern review.

Thus, it is quite evident that the present work conducted in the direction of evaluation of *Vatika, Paittika and Kaphaja* pulses has certainly lead the way in the great service of Ayurvedic pulse lore and has laid down the foundation stone for further study.

Part Seven

Summary

Summary

Historical Review :

From time immemorial different civilizations of the world have been aware of the importance of pulse, either in the form of simple means just to know only the condition of the heart or to diagnose different diseases and to assess the expectancy of life of the patient. Controversies exist among the scholars of Ayurveda as to how and from where Ayurvedic pulse lore took, its origin. In this regard giving the concluding remark a synthetic view has been hypothesized that the theoretical knowledge of Indian pulse lore has been derived from pre-existing pulse lore of Tantrik literature of India, whereas the practical knowledge of Indian pulse lore ows its indebtedness to the Greeko-Arabic system of medicine who practised in India. The knowledge of pulse examination handed down, from civilization to civilization is explained here in following passages.

1. Egyptian Pulse Lore : Two authoritative Egyptian papyruses, the surgical papyrus of Edwin Smith and Eber's papyrus refer to pulse examination. Both limit their knowledge to the pulse only to know the condition of the heart. The papyrus of Ebers also mention about the various sites as for example head, the back of the head, hands, stomach, arms and feet to see the pulsation. Beyond the imperfect reference to the pulse vis a vis the heart, in both papyruses there is no information available about the procedure of examining the pulse and the pulse signs with reference to diagnosis and prognosis.

2. **Greek Pulse Lore :** In this system of medicine Galen is seen to have written several treatises on the pulse according to their length, breadth and depth and has described over 27 varieties of them. And also on account of his experience he has mentioned to 'slow' and 'fast', 'regular' and 'irregular', 'strong' and 'feeble', 'wave like', 'ant-like', 'caprezens', 'dicrotic' and vibratory pulses. The usual site for pulse examination he has described to be the radial artery. Pulse has been described only in its qualitative form and there is no where reference to its counting.

3. Chinese Pulse Lore : I-Tsing's claim that "his country was never superseded by any other country in the skill of the

feeling of the pulse" is probably not an exaggeration. Chinese have wealth of treatises on the pulse and they are considered to be utterly disproportionate to other branches of medicine.

Chinese physicians assert that entire superstructure of medical practice is built upon the theory of the pulse. The nature, location, course and treatment of diseases depend upon this alone. Besides diagnosing diseases, pulse has also been used to assess the expectancy of life of the patient.

The pulse has been advised to examine on both wrist putting the fingers at three places Inch, Bar and Cubit correlating again these three to external and internal organs. Thus twelve pulses have been described.

Pulses have also been described as a superficial and deep and Yang and Yin belongs to female principle. Describing quantitative form of the pulse it has been mentioned that one inspiration and one expiration constitute one cycle of respiration, and the normal ratio to pulse beat is four beats to one respiration.

Chinese physician has also observed the pulse variations under the influence of seasons, age, constitution, temperament and the sex of the subject. According to most historians of Chinese medicine, the pulse should be examined at Sunrise.

4. Arabic Pulse Lore : The Arabic medicine is founded mostly on the physiology, concept and principles of Greek medicine particularly Galen's medicine inheriting the humoral doctorine of the Greek medicine. But the four humors of Arabic medicine i. e. Khoon, Balagam, Sofra and Sauda have neither been to the pulse signs and symptoms nor is the interpretation of the pulse signs and symptoms made in terms of impairment of the one or the other or all of the four humors, so far as prognosis and diagnosis are concerned. Instead, the temperament or Mizaz and the vital force or Roop, among others are seen to form the basis of the study of pulse examination in ease and diseases.

The description of pulse lore in Arabic medicine is qualitative and the pulse has been described in the form of its (i) length (ii) breadth (iii) height (iv) needs of the body (v) hard (vi) soft (vii) irregular and (viii) strength.

The description of main features of the pulse which Avicenna in the later period has described are of outstanding importance. And he has advised to examine the pulse in its (i) size

(ii) strength (iii) velocity (iv) quality (v) temperature (vi) rate (vii) consistancy (viii) regularity and (ix) rhythm.

5. Tantrik Pulse Lore : There have been many Siddhacharya belonging to the school of Shaiva-Agama Tantrism who along with the development of alchemy (Rasavada), iatrochemistry (Rasatantra/Rasashastra) also developed medicine (Ayurveda, Vaidyam) including pulse lore. Thus the pulse lore is seen to be an outcome of Yoga which deals among other things with the pulse (Nadi) and the control of breath. The number of Siddhacharyas grew to eighty-four between the eight and tenth centuries. In the opinion of Ghosh, "It is specially to be noted that although the general 'Nadi-Chakra' system has no real bearing on the pulse examination, yet the consideration of the same in works on sphygmology has been considered imperative by most of the authors".

6. Ayurvedic Pulse Lore : In the classics and after works of Arurveda till the period of Sharngadhara the word 'Nadi' has been used in various denotations but the pulse. Though the theoretical knowledge has been derived from Tantrik literature and the practical one from Greeko-Arabic system of medicine, yet Sharngadhara has been the first authoritative Ayurvedic physician who has implanted the knowledge of pulse examination in third chapter of his work—Sharngadhara-Samhita. And there we see the dawn of life of pulse examination as a means of diagnosis. From that onward the knowledge has constantly been gaining momentum till the period of Yogaratnakara.

(i) Sharngadhara-Samhita : Sharngadhara's description to pulse examination is completed only in eight verses. The knowledge of pulse examination in the work is quite elementary. The important thing is that simile of various birds, reptiles and amphibian has been given to correlate the character of the pulse.

(ii) Bhavaprakash : Bhavamishra in his work Bhavaprakash has added the knowledge after Sharngadhara in describing (a) the use of three fingers index, middle and ring for Vata, Pitta and Kapha respectively (b) inspite of giving the simile of movements of birds etc. he has directly described the character of Vatika, Paittika and and Kaphaja pulses. And thus he has made the subject more practicable.

(iii) Yogaratnakara : The knowledge after Bhavaprakasha

has been furthered in this work. The work mentions about (a) detailed anatomical position of the forearm including wrist during pulse examination (b) there is indication of fixed time to examine the pulse (c) there is description of quantitative form of the pulse as thirty time. Here the pulse has been described to indicate good prognosis of the patient (d) there is enumeration of greater number of pulses indicating bad prognosis and death.

(iv) **Kanada's Nadivijnana :** This is independent book of sphygmology written by Tantrik Kanada. In this work Tantrik idea has been furnished about the source of origin of Nadi. The work mentions about (a) the great number of diseases to be diagnosed by means of pulse examination (b) in the same there is also enumeration of good number of pulses indicating bad prognosis (c) there is also enumeration of pulses indicating good prognosis and (d) above all character of pulse has been described after taking various foods.

(v) **Ravana's Nadipariksha :** This is also an independent work of sphygmology finding its source of origin from Tantrism. Ravana has followed Kanada in describing diseases to be diagnosed and the prognosis to be assessed by means of pulse examination.

7. Modern Concept : The pulse is a pressure wave that travels along the vessel wall. Three factors i. e. (1) stroke volume output (2) resistance to outflow of blood from the arteries into the capillaries and (3) elasticity of arterial walls, are responsible for its generation.

What we feel as a radial pulse is one of peripheral pulses. And it is nothing but a more continuation of central and intermediate pulses generated in the aorta and its other intermediate branches respectively. With the help of reflected waves generated at the origin of branches, the central and intermediate pulses constitute the radial pulse. Taking the help of frequency analysis, it can be analysed further that the radial pulse is made up of many such small waves having different troughs and crests at different phases and amplitudes.

Clinical and Experimental Studies :

The aim behind to conduct study on pulse examination is its traditional use as an important means of diagnosis. Because in the field of Ayurveda, this is the first work of its own kind,

therefore, we limited our study only to normal volunteers and selected groups of diseases namely, (1) cardiac valvular lesions (2) hypertension (3) jaundice and (4) thyrotoxicosis.

The studies have been conducted in the direction to standardize Vatika, Paittika and Kaphaja pulses qualitatively and quantitatively in 40 normal volunteers as well as in 120 cases of selected diseases as mentioned above. And also the effort has been made in diseased group in the direction of correlation of the triad, i. e. symptoms depending on predominance of Doshas, pulse examination and the pulse tracings performed with the help of Dudgeon's sphygmograph.

Before conducting the clinical study in normal as well as diseased groups, case taking, pulse examination and grouping it into Vatika, Paittika and Kaphaja character, thorough general and systemic examinations, routine and specific laboratory investigations and MMR etc. were performed.

As regards experimental study in normal as well as diseased groups, it has been completed in two groups namely, (1) qualitative study in graphic forms i. e. sphygmographic tracing of pulse waves and (2) quantitative study of pulse tracings which has been completed further in two subheads (a) numerical estimation of time taken by each pulse wave, length of percussion wave, length between two top points, time of each percussion wave, angle of deviation of percussion wave and the distance of dicrotic notch from the base and (b) statistical analysis of pulse rate and pulse pressure in Vatika, Paittika and Kaphaja pulses.

1. Normal Group : Out of total 40 cases of this group, 9 were having Vatika pulses and the remaining 20 and 11 cases were having Paittika and Kaphaja type of pulses.

(a) Vatika Pulse : Clinically, all 6 Vatika pulses were found to have (i) high pulse rate (ii) regular rhythm (iii) small pulse i. e. the rise of pulse felt under the fingers was of short duration (iv) after rising, the sustaintion of pulse under the fingers was also of short duration (v) force was relatively on lower side than Paittika and Kaphaja pulses. On experimental study, Vatika pulses were found to have the following characteristics (i) smallest percussion wave (ii) slight conical summit (iii) insignificant or absent dicrotic notch (iv) small dicrotic wave (v) minimum time in passing from one wave to the next

(vi) minimum period of time taken by percussion wave from the point of start to its top (vii) maximum deviation of angle in bending towards the base line (viii) minimum distance of dicrotic notch from the base line (ix) high pulse rate and minimum pulse pressure when compared to the values of Paittika and Kaphaja pulses.

(b) Paittika Pulse : On clinical examination, 20 volunteers of normal group were found to have Paittika character of pulses, which were distinguished by their following qualities : (i) medium pulse rate occupying intermediate position in between the rate of Vatika and Kaphaja pulse (ii) regular rhythm (iii) relatively high volume than Vatika and Kaphaja pulses. The rise of wave felt under the fingers was of relatively more duration than Vatika pulses (iv) the summit was also a bit relatively of more sustaining nature than Vatika pulses (v) the force was also found to be more in case of Vatika pulse.

On experimental study Paittika pulses were found to have (i) longest percussion wave (ii) maximum conical summit (iii) exaggerated dicrotic notch and moderately rapid fall of dicrotic wave. The look of the tracing as a whole gives the appearance of jumping character (iv) medium period of time taken in passing from one wave to the next (v) maximum period of time of percussion wave in passing from the point of start to its top (vi) least deviation of angle in bending towards the base line (vii) maximum distance of dicrotic notch from the base line (viii) high pulse pressure.

(c) Kaphaja Pulse : On clinical examination 11 normal Kaphaja pulses were found to have (i) slowest pulse rate (ii) regular rhythm. The pulse felt under the fingers were appreciated for a longer period, and the summits were also of maximum sustaining nature (iii) the force was appreciable but was a bit on lower side than Paittika pulses.

On experimental study Kaphaja pulses were found to have (i) medium height of percussion wave occupying intermediate position in between Vatika and Paittika pulses (ii) small dicrotic notch (iii) rounded summit indicating its sustaining nature (iv) steady and gradual fall of dicrotic wave (v) maximum period of time in passing from one wave to the next (vi) medium period of time of percussion wave from the point of start to its top (vii) medium deviation of angle in bending towards the base line (viii) medium pulse pressure.

The same findings were also obtained in Vatika, Paittika and Kaphaja pulses examined in the morning, in the evening and before and after meal.

2. **Diseased Group :** In this group study was carried out in 120 cases. Out of the total number, 50 were belonging to cardiac valvular lesions, 30 cases to the hypertension, 20 cases to the jaundice and the remaining 20 cases were studied in thyrotoxicosis group. Regarding qualitative interpretation of contour of different pulses in diseased group, it should be noted down here that cases of this group also have the same configuration in general as normal Vatika, Paittika and Kaphaja pulses have but with the difference of dominance or diminution of one or the other factors.

(a) Cardiac Valvular Lesions : Out of 50 cases studied in this group, 14 were having Vatika pulses, 22 were having Paittika pulses and remaining 14 were having Kaphaja pulses.

(i) Vatika Pulse : It was found to have (i) high pulse rate (ii) rhythm was irregular at certain moment (iii) volume was quite low (iv) small pulse wave felt under the fingers (v) least sustaining summit (vi) low tension and force (vii) smallest percussion wave (viii) slight conical summit (ix) insignificant or absent dicrotic notch and small dicrotic wave assuming horizontal position quite immediately just after the generation of rudimentary dicrotic notch (x) taking minimum time than Paittika and Kaphaja pulses in passing from one wave to the next (xi) least period of time taken by percussion wave from the point of start to its top (xii) maximum deviation of angle (xiii) minimum distance of dicrotic notch (xiv) minimum pulse pressure.

(ii) Paittika Pulse : It was found to have (i) slower rate than Vatika pulse (ii) regular rhythm (iii) highest amplitude of maximum appreciation when felt under the fingers (iv) good force with low tension (v) longest percussion wave (vi) maximum conical summit (vii) highly exaggerated dicrotic notch with moderately rapid fall of dicrotic wave (viii) taking medium period of time in passing from one wave to the next (ix) highest length of percussion wave (x) maximum period of time of percussion wave from the point of start to its top (xi) least deviation of angle (xii) maximum distance of dicrotic notch and (xiii) maximum pulse pressure.

(iii) Kaphaja Pulse : It was found to have (i) slowest pulse rate (ii) regular rhythm (iii) medium amplitude occupying intermediate position in between Vatika and Paittika pulses, but appreciated for maximum period under the finger during rise of wave (iv) moderate force and tension (v) medium percussion wave (vi) rounded summit (vii) small dicrotic notch (viii) steady and gradual fall of dicrotic wave (ix) maximum period of time in passing from one wave to the next (x) medium deviation of angle (xi) medium period of time of percussion wave (xii) medium pulse pressure as compared to Vatika and Paittika pulses.

(b) Hypertension : Out of 30 cases of hypertension, 6 were having Vatika type of pulse and remaining 12 cases and the other 12 cases ware having Paittika and Kaphaja varieties of pulses respectively.

(i) Vatika Pulse : It was found to have (i) high pulse rate (ii) regular rhythm (iii) low volume (iv) force and tension was appreciable but was on lower side relatively than Paittika and Kaphaja pulses (v) the artery was found to be slightly hard (vi) quite small percussion wave (vii) slightly angular summit suddenly converting into dicrotic wave which occupies immediately the horizontal position (viii) insignificant or absent dicrotic notch (ix) minimum time taken by precussion wave from the point of start to its top (x) maximum deviation of angle towards the base line and (xi) minimum pulse pressure.

(ii) Paittika Pulse : It was found to have (i) medium pulse rate in between Vatika and Kaphaja pulses (ii) regular rhythm (iii) more amplitude than Vatika pulse (iv) more tension and force than Vatika pulse (v) less hard arterial wall than Kaphaja pulse of hypertension (vi) longest percussion wave (vii) conical summit (viii) exaggerated dicrotic notch (ix) medium period of time in passing from one wave to the next (x) maximum period of time of percussion wave in passing from the point of start to its top (xi) least deviation of angle of percussion wave and (xii) maximum pulse pressure.

(iii) Kaphaja Pulse : It was found to have (i) slow pulse rate (ii) regular rhythm (iii) medium amplitude in between Vatika and Paittika pulses (iv) slow rising of wave felt under the finger for good period of time in relation to Vatika and Paittika pulses (v) more tension than Paittika pulse (vi) medium

height of percussion wave in between Vatika and Paittika pulses (vii) maximum period of time in between the two pulse waves (viii) medium period of time of percussion wave from the point of start to its top (ix) medium pulse pressure.

(c) Jaundice : Out of 20 cases of jaundice, 11 were having Paittika pulses and 9 were of Kaphaja group.

(i) Paittika Pulse : It was found to have (i) moderate pulse rate (ii) regular rhythm (iii) good amplitude (iv) slightly forceful (v) longer percussion wave than Kaphaja pulses (vi) maximum conical summit (vii) exaggerated dicrotic notch and moderately rapid fall of dicrotic wave (viii) medium period of time in between two percussion waves (ix) maximum period of time of percussion wave in passing from the point of start to its top (x) least deviation of angle of percussion wave (xi) maximum distance of dicrotic notch (xii) more pulse pressure than Kaphaja group.

(il) Kaphaja Pulse : It was found to have (i) slow pulse rate than Paittika pulse (ii) regular rhythm (iii) medium amplitude. The pulse felt under the finger was of relatively longer duration than Paittika pulse (iv) smaller percussion wave than Paittika pulse (v) rounded summit (vi) gradual and steady fall of dicrotic wave (vii) small dicrotic notch (viii) more period of time in between two percussion waves (ix) medium deviation of angle of percussion wave (x) lesser pulse pressure than Paittika group.

(d) Thyrotoxicosis : All 20 cases of thyrotoxicosis were found to have the complete findings of Paittika pulses found in other groups.

3. Numerical Correlation : This study has been conducted to show the correlation in the followings (1) symptoms and pulse examination (Sy. ex.) (2) symptoms and pulse tracings (Sy. Tr.) and (3) pulse examination and pulse tracings (Pe. Tr.). Each correlation group has been further studied in three subgroups namely, (a) complete correlation (C. C.) (b) partial correlation (P. C.) and (c) no correlation (N. C.) i. e. negative group.

(a) Cardiac Valvular Lesions : Out of total 50 cases in 14 *Vatika pulses* (i) Sy. ex.; C. C. 64.26%, P. C. 35.74%, N. C. 0% (ii) Sy. Tr.; C. C. 64.26%, P. C. 35.74%, N. C. 0% (iii) Pe. Tr.; C. C. 100%, N. C. 0%. In 22 *Paittika Pulses* (i) Sy.

ex.; C. C. 0%, P. C. 0%, N. C. 0% (ii) Sy. Tr.; C. C. 0%, P. C. 0%, N. C. 0% (iii) Pe. Tr.; C. C. 100%, P. C. 0%, N. C. 0%. In 14 *Kaphaja pulses* (i) Sy. ex.; C. C. 0%, P. C. 57.14%, N. C. 42.86% (ii) Sy. Tr.; C. C. 0%, P. C. 57.14%, N. C. 42.86%, (iii) Pe. Tr.; C. C. 100%, P. C. 0%, N. C. 0%.

(b) Hypertension : Out of total 30 cases in 6 *Vatika pulses* (i) Sy. ex.; C. C. 50%, P. C. 33.3%, N. C. 16.7% (ii) Sy. Tr.; C. C. 50%, P. C. 50%, N. C. 0% (iii) Pe. Tr.; C. C. 100%, P. C. 0%, N. C. 0%. In 12 *Paittika pulses* (i) Sy. ex.; C. C. 41.5%, P. C. 16.6%, N. C. 41.5% (ii) Sy. Tr.; C. C. 41.5%, P. C. 16.6%, N. C. 41.5% (iii) Pe.Tr.; C. C. 100%, P. C. 0%, N. C. 0%. In 12 *Kaphaja pulses* (i) Sy. ex.; C. C. 0%, P. C. 41.5%, N. C. 58.5% (ii) Sy. Tr.; C. C. 0%, P. C. 41.5%, N. C. 58.5%, (iii) Pe. Tr.; C. C. 100%, P. C. 0%, N. C. 0%.

(c) Jaundice : Out of 20 total cases of jaundice in 11 *Paittika pulses* (i) Sy. ex.; C. C. 27%, P. C. 9%, N. C. 64% (ii) Sy. Tr.; C. C. 27%, P. C. 9%, N. C. 64%, (iii) Pe. Tr.; C. C. 100%, P. C. 0%, N. C. 0%. In 9 *Kaphaja pulses* (i) Sy. ex.; C. C. 66.6%, P. C. 33.3%, N. C. 0% (ii) Sy. Tr.; C. C. 66.6%, P. C. 22.2%, N. C. 11.1% (iii) Pe. Tr.; C. C. 100%, P. C. 0%, N. C. 0%.

(d) Thyrotoxicosis : In all 20 Paittika pulses (i) Sy. ex.; C. C. 100%, P. C. 0%, N. C. 0%, (ii) Sy. Tr.; C. C. 100%, P. C. 0%, N. C. 0% (iii) Pe. Tr,; C. C. 100%, P. C. 0%, N. C. 0%.

The present scientific sudies on Nadi-Pariksha has certainly given a new light of hope in the direction of abvancement of Ayurvedic pulse lore and has proved to be a good asset to this science. Particularly the sphygmographic tracings have given a new practical form of standard Vatika, Paittika and Kaphaja pulses and has made the pulse examination more easy and practicable for an accurate diagnosis.

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आयुर्वेद-सन्दर्भाः

शार्ङ्गधरसंहिता

करस्याङ्गुष्ठमूले या धमनी जीवसाक्षिणी ।
तच्चेष्टया सुखं दुःखं ज्ञेयं कायस्य पण्डितैः ।। ३-१ ।
नाडी धत्ते मरुत्कोपे जलौकासर्पयोर्गतिम् ।
कलिङ्गकाकमण्डूकगतिं पित्तस्य कोपतः ।। ३-२।
हंसपारावतगतिं धत्ते श्लेष्मप्रकोपतः ।
लावतित्तिरवर्तीनां गमनं सन्निपाततः ।। ३-३।
कदाचिन्मन्दगमना कदाचिद् वेगवाहिनी ।
द्विदोषकोपतो ज्ञेया हन्ति च स्थानविच्युता ।। ३-४।
स्थित्वा स्थित्वा चलति या सा स्मृता प्राणनाशिनी ।
अतिक्षीणा च शीता च जीवितं हन्त्यसंशयम् ।। ३-५।
ज्वरकोपे तु धमनी सोष्णा वेगवती भवेत् ।
कामक्रोधाद् वेगवहा क्षीणा चिन्ताभयप्लुता ।। ३-६।
मन्दाग्नेः क्षीणधातोश्च नाडी मन्दतरा भवेत् ।
असृक्पूर्णा भवेत्कोष्णा गुर्वी सामा गरीयसी ।। ३-७।
लघ्वी वहति दीप्ताग्नेस्तथा वेगवती मता ।
सुखितस्य स्थिरा ज्ञेया तथा बलवती स्मृता ।।
चपला क्षुधितस्यापि तृप्तस्य वहति स्थिरा ।। ३-८।

भावप्रकाशः

पुंसो दक्षिणहस्तस्य स्त्रियो वामकरस्य तु ।
अङ्गुष्ठमूलगां नाडीं परीक्षेत भिषग्वरः ।। ७-११।
अङ्गुलीभिस्तु तिसृभिर्नाडीमवहितः स्पृशेत् ।
तच्चेष्टया सुखं दुःखं जानीयात् कुशलोऽखिलम् ।। ७-१२।
सद्यःस्नातस्य सुप्तस्य क्षुत्तृष्णाऽऽतपशीलिनः ।
व्यायामश्रान्तदेहस्य सम्यङ् नाडी न बुध्यते ।। ७-१३।
वातेऽधिके भवेन्नाडी प्रव्यक्ता तर्जनीतले ।
पित्ते व्यक्ता मध्यमायां तृतीयाङ्गुलिगा कफे ।। ७-१४।
तर्जनीमध्यमामध्ये वातपित्ताधिके स्फुटा ।
अनामिकायां तर्जन्यां व्यक्ता वातकफे भवेत् ।। ७-१५।

मध्यमाऽनामिकामध्ये स्फुटा पित्तकफेऽधिके ।
अङ्गुलित्रितयेऽपि स्यात् प्रव्यक्ता सन्निपाततः ।। ७-१६।
वाताद् वक्रगतिं धत्ते पित्तादुत्प्लुत्य गामिनी ।
कफान्मन्दगतिर्ज्ञेया सन्निपातादतिद्रुता ।। ७-१७।
वक्रमुत्प्लुत्य चलति धमनी वातपित्ततः ।
वहेद् वक्रञ्च मन्दञ्च वातश्लेष्माधिकात्त्वतः ।। ७-१८।
उत्प्लुत्य मन्दं चलति नाडी पित्तकफेऽधिके ।
कामात् क्रोधाद् वेगवहा क्षीणा चिन्ताभयप्लुता ।। ७-१९।
स्थित्वा स्थित्वा चलेद् या सा हन्ति स्थानच्युता तथा ।
अतिक्षीणा च शीता च प्राणान् हन्ति न संशयः ।। ७-२०।
ज्वरकोपेन धमनी सोष्णा वेगवती भवेत् ।
मन्दाग्नेः क्षीणधातोश्च सैव मन्दतरा मता ।। ७-२१।
चपला क्षुधितस्य स्यात् तृप्तस्य भवति स्थिरा ।
सुखिनोऽपि स्थिरा ज्ञेया तथा बलवती मता ।। ७-२२।

योगरत्नाकरः

रोगाक्रान्तशरीरस्य स्थानान्यष्टौ निरीक्षयेत् ।
नाडीं मूत्रं मलं जिह्वां शब्दं स्पर्शं दृगाकृतीः ।। १-१।
दोषकोपे घनेऽल्पे च पूर्वं नाडीं परीक्ष्य च ।
अन्ते चाऽऽदौ स्थितिस्तस्या विज्ञेया भिषजा स्फुटम् ।। १-२।
यथा वीणागता तन्त्री सर्वान्रागान्प्रभाषते ।
तथा हस्तगता नाडी सर्वान् रागान् प्रकाशयेत् ।। १-३।
आदौ सर्वेषु रोगेषु नाडीजिह्वाक्षिमूत्रतः । १-५।
जाड्यान्मूत्रस्य जिह्वाया लक्षणं यो न विन्दति ।
मारयत्याशु वै जन्तुं स वैद्यो न यशो भजेत् ।। १-६।
नाडीमङ्गुष्ठमूलाद् यः स्पृशेद् दक्षिणगे करे ।
ज्ञानार्थं रोगिणो वैद्यो निजदक्षिणपाणिना ।। १-९।
स्थिरचित्तः प्रशान्तात्मा मनसा च विशारदः ।
स्पृशेदङ्गुलिभिर्नाडीं जानीयाद् दक्षिणे करे ।। १-१०।
प्रायः स्फुटा भवति वामकरे वधूनां
पुंसां च दक्षिणकरे तदियं परीक्षा ।
ईषद्विनामितकरं विततांगुलीकं
बाहुं प्रसार्य रहितं परिपीडनेन ।। १-११।

ईषद्विनम्रकृतकूर्परवामभागे हस्ते प्रसारितसदङ्गुलिसन्धिके च ।
अङ्गुष्ठमूलपरिपश्चिमभागमध्ये नाडीं प्रभातसमये प्रहरं परीक्ष्य ॥ १-१२।

वारत्रयं परीक्षेत धृत्वा धृत्वा विमोचयेत् ।
विमृश्य बहुधा बुद्धया रोगव्यक्तिं विनिर्दिशेत् ॥ १-१३।

अङ्गुलित्रितये स्पृष्ट्वा क्रमाद् दोषत्रयोद्भवाम् ।
मन्दां मध्यगतिं तीक्ष्णां त्रिभिर्दोषैस्तु लक्षयेत् ॥ १-१४।

वातं पित्तं कफं द्वन्द्वं त्रितयं सान्निपातिकम् ।
साध्यासाध्यविवेकं च सर्वं नाडी प्रकाशयेत् ॥ १-१५।

स्नायुर्नाडी ततो हंसी धमनी धरणी धरा ।
तन्तुकी जीवनज्ञाना शब्दाः पर्यायवाचकाः ॥ १-१६।

सद्यः स्नातस्य भुक्तस्य तथा स्नेहावगाहिनः ।
क्षुत्तृषार्तस्य सुप्तस्य नाडी सम्यङ् न बुध्यते ॥ १-१७।

अङ्गुष्ठमूलभागे या धमनी जीवसाक्षिणी ।
तच्चेष्टया सुखं दुःखं ज्ञेयं कायस्य पण्डितैः ॥ १-१८।

स्त्रीणां भिषग्वामहस्ते पादे वामे च यत्नतः ।
शास्त्रेण सम्प्रदायेन तथा स्वानुभवेन वै ॥ १-१९।

परीक्षा रत्नवच्चास्यास्त्वभ्यासादेव जायते ।
वातनाडी भवेद् ब्रह्मा पित्तनाडी च शङ्करः ॥
श्लेष्मनाडी भवेद् विष्णुस्त्रिदेवा नाडिसंस्थिताः ॥ १-२०।

अग्रे वातवहा नाडी मध्ये वहति पित्तला ।
अन्ते श्लेष्मविकारेण नाडी ज्ञेया बुधैः सदा ॥ १-२१।

सर्पजलौकादिगतिं वदन्ति विबुधाः प्रभञ्जने नाडीम् ।
पित्तेन काकलावकमण्डूकादेस्तथा चपलाम् ॥ १-२२।

राजहंसमयूराणां पारावतकपोतयोः ।
कुक्कुटस्य गतिं धत्ते धमनी कफसङ्ज्ञिनी ॥ १-२३।

मुहुः सर्पगतिं नाडीं मुहुर्भेकगतिं तथा ।
वातपित्तसमुद्भूतां तां वदन्ति विचक्षणाः ॥ १-२४।

सर्पहंसगतिं तद्वत् वातश्लेष्मवतीं वदेत् ।
हरिहंसगतिं धत्ते पित्तश्लेष्मान्विताधरा ॥ १-२५।

काष्ठकुट्टो यथा काष्ठं कुट्टते चातिवेगतः ।
स्थित्वा स्थित्वा तथा नाडी सन्निपाते भवेद् ध्रुवम् ॥ १-२६।

स्पन्दते चैकमानेन त्रिंशद् वारं यदा धरा ।
स्वस्थानेन तदा नूनं रोगी जीवति नान्यथा ॥
स्थित्वा स्थित्वा वहति या सा ज्ञेया प्राणघातिनी ॥ १-२७।

मन्दं मन्दं शिथिलशिथिलं व्याकुलं व्याकुलं वा,
स्थित्वा स्थित्वा वहति धमनी याति सूक्ष्मा च सूक्ष्मा ।
नित्यं स्कन्धे स्फुरति पुनरप्यङ्गुलीः संस्पृशेद् वा,
भावैरेवं बहुविधधरैः सन्निपातादसाध्या ॥ १-२८।

तस्य मृत्युं विजानीयाद् यस्येदं नाडिलक्षणम् ॥ १-२९।

पूर्वं पित्तगतिं प्रभञ्जनगतिं श्लेष्माणमाबिभ्रती-
मत्यन्तं भ्रमणं मुहुर्विदधतीं चक्रादिरूढामिव ।
भीष्मत्वं दधतीं कलासु पतितां सूक्ष्मत्वमातन्वतीं
नो साध्यां धमनीं वदन्ति मुनयो नाडीगतिज्ञानिनः ॥ १-३० ।

गम्भीरा या भवेन्नाडी सा भवेन्मांसवाहिनी ।
ज्वरवेगेन धमनी सोष्णा वेगवती भवेत् ॥ १-३१।

कामक्रोधाद् वेगवहा क्षीणा चिन्ताभयप्लुता ।
मन्दाग्नेः क्षीणधातोश्च नाडी मन्दतरा भवेत् ॥ १-३२।

असृक्पूर्णा भवेत् सोष्णा गुर्वी सामा गरीयसी ।
लघ्वी वहति दीप्ताग्निस्तथा वेगवती मता ॥ १-३३।

चपला क्षुधितस्यापि तृप्तस्य वहति स्थिरा ।
मृत्युर्डमरुकस्येव भवेदेकदिनेन च ॥ १-३४।

कम्पते स्पन्दतेऽत्यन्तं पुनः स्पृशति चाङ्गुलीः ।
तामसाध्यां विजानीयान्नाडीं दूरेण वर्जयेत् ॥ १-३५।

स्थिरा नाडी भवेद् यस्य विद्युद् द्युतिरिवेक्ष्यते ।
दिनैकं जीवितं तस्य द्वितीये मृत्युरेव च ॥ १-३६।

शीघ्रा नाडी मलोपेता शीतला वाऽथ दृश्यते ।
द्वितीये दिवसे मृत्युर्नाडी ज्ञेया विचक्षणैः ॥ १-३७।

मुखे नाडी वहेत् तीव्रा कदाचिच्छीतला वहेत् ।
आयाति पिच्छिलः स्वेदः सप्तरात्रं न जीवति ॥ १-३८।

देहे शैत्यं मुखे श्वासो नाडी तीव्रा विदाहवत् ।
मासार्धं जीवितं तस्य नाडीविज्ञानभाषितम् ॥ १-३९।

मुखे नाडी यदा नास्ति मध्ये शैत्यं बहिः क्लमः ।
यदा मन्दा भवेन्नाडी त्रिरात्रं नैव जीवति ॥ १-४०।

अतिसूक्ष्माऽतिवेगा च शीतला च भवेद् यदि ।
तदा वैद्यो विजानीयाद् रोगिणं च गतायुषम् ॥ १-४१।

विद्युद्वन्नमिता नाडी दृश्यते न च दृश्यते ।
अकालविद्युत्पातेव स गच्छेद् यमशासनम् ।। १-४२।
तिर्यगुष्णा च या नाडी सर्पगा वेगवत्तरा ।
कफपूरितकण्ठस्य जीवितं तस्य दुर्लभम् ।। १-४३।
चैलाञ्चलितवेगा च नासिकाधारसंयुता ।
शीतला दृश्यते या च याममध्ये च मृत्युदा ।। १-४४।
दृश्यते चरणे नाडी करे नैवाभिदृश्यते ।
मुखं विकसितं यस्य तं दूरं परिवर्जयेत् ।। १-४५।
वातपित्तकफाश्चापि त्रयो यस्यां समाहिताः ।
कृच्छ्रसाध्यामसाध्यां वा प्राहुर्वैद्यविशारदाः ।। १-४६।
वक्रा च चपला शीतस्पर्शा वातज्वरे भवेत् ।
द्रुता च सरला दीर्घा शीतपित्तज्वरे भजेत् ।। १-४७।
मन्दा च सुस्थिरा शीता पिच्छिला श्लेष्मतो भवेत् ।
वक्रा च ईषच्चपला कठिना वातपित्तजा ।। १-४८।
ईषच्च दृश्यते स्पृष्टा मन्दा स्याच्छ्लेष्मवातजा ।
सूक्ष्मा शीता स्थिरा नाडी पित्तश्लेष्मसमुद्भवा ।। १-४९।
हंसगा चैव या नाडी तथैव गजगामिनी ।
मुखं प्रशस्तं च भवेत् तस्याऽऽरोग्यं भवेत्सदा ।। १-५०।
यो रोगिणः करं स्पृष्ट्वा स्वकरं क्षालयेद् यदि ।
रोगास्तस्य विनश्यन्ति पङ्कः प्रक्षालनाद् यथा ।। १-५१।

कणादकृतं नाडीविज्ञानम्

सार्द्धत्रिकोट्यो नाड्यो हि स्थूलाः सूक्ष्माश्च देहिनाम् ।
नाभिकन्दनिबद्धास्तास्तिर्यगूर्ध्वमधः स्थिताः ।। ३।
द्वासप्ततिसहस्रन्तु तासां स्थूलाः प्रकीर्त्तिताः ।
देहे धमन्यो धन्यास्ताः पञ्चेन्द्रियगुणावहाः ।। ४।
शतसप्तानां मध्ये चतुरधिका विंशतिः स्फुटास्तासाम् ।
एका परीक्षणीया या दक्षिणकरचरणविन्यस्ता ।। ७।
तिर्यक्कूर्मो देहिनां नाभिदेशे वामे वक्त्रं तस्य पुच्छं च याम्ये ।
ऊर्ध्वे भागे हस्तपादौ च वामौ तस्याधस्तात् संस्थितौ दक्षिणौ तौ ।। ८।
सूक्ष्मा शीता स्थिरा नाडी पित्तश्लेष्मसमुद्भवा ।
कफवातोद्भवा नाडी सर्पहंसगतिर्भवेत् ।। २७।
अत्युच्चका स्थिराऽत्यन्तं या चेयं मांसवाहिनी ।
या च सूक्ष्मा च वक्रा च तामसाध्यां विनिर्दिशेत् ।। ३१।

कषाये कठिना म्लाना लवणे सरला द्रुता ।
एवं द्वित्रिचतुर्योगे नानाधर्मवती धरा ।। ६५।
सौम्या सूक्ष्मा स्थिरा मन्दा नाडी सहजवातजा ।
स्थूला च कठिना शीघ्रा स्पन्दते तीव्रमारुते ।। ८५।
चञ्चला तरला स्थूला कठिना वातपित्तजा ।। ८८

रावणकृता नाडीपरीक्षा

क्वचिन्मन्दां क्वचित्तीव्रां त्रुटितां वहते क्वचित् ।
क्वचित्सूक्ष्मां क्वचित्स्थूलां नाडचसाध्यगदे गतिम् ।। २०।
गुर्वी सोष्णा च रक्तेन पूर्णा नाडी प्रजायते ।
सामा गुर्वी भवेन्नाडी मन्दाऽसृक्पूर्णितापि च ।। २६।
गम्भीरा या भवेन्नाडी सा भवेन्मांसवाहिनी ।
दीर्घा कृशा वातगतिर्विषमा वेपते धरा ।। ३६।
सौम्या सूक्ष्मा स्थिरा मन्दा नाडी सहजवातजा ।
ईषच्चपलवक्रा च कठिना वातपित्तजा ।। ४२।
समा सूक्ष्मा ह्यणुस्पन्दा मलाजीर्णे प्रकीर्त्तिता ।
विषमा कठिना स्थूला मलशेषात् प्रकीर्त्तिता ।। ४८।
वक्रा च चपला शीतस्पर्शा वातज्वरे भवेत् ।
द्रुता च सरला दीर्घा शीघ्रा पित्तज्वरे भवेत् ।। ५३।