5-1-1936

Coronary thrombosis: a clinical and pathological study

Clinton C. Millett
University of Nebraska Medical Center

This manuscript is historical in nature and may not reflect current medical research and practice. Search PubMed for current research.

Recommended Citation

CORONARY THROMBOSIS

A CLINICAL AND PATHOLOGICAL STUDY

SENIOR THESIS

BY

CLINTON C. MILLETT

UNIVERSITY OF NEBRASKA COLLEGE OF MEDICINE

OMAHA, NEBRASKA

APRIL, 1936

CORONARY THROMBOSIS

Almost daily we learn of the sudden death of some prominent national citizen and not infrequently of a local citizen or friend. Many of these sudden deaths are attributed to coronary thrombosis and it is striking to note that the victim is usually one assumed to have been in good health. Undoubtedly this disease is on the increase but it is strange to note that even twenty five years ago this was an unknown disease to the general practitioner and many such deaths were attributed to acute indigestion.

For many years clinicians and pathologists have been observing isolated instances of rupture of the heart, aneurism of the ventricles, and occlusion of the coronary arteries but these were regarded as only interesting pathological processes and of no clinical value because they were thought to be impossible of recognition during life. (1) In fact it was not generally appreciated that occlusion of the coronary arteries was compatible with even a fair degree of health. Cases which survived what we now know to be coronary thrombosis were regarded as severe attacks of angina pectoris. Our great teachers until very recent years have confused these conditions, merely regarding the one as a more severe form of the other. This was true of Sir William Osler who divided angina pectoris into three types--mildest, mild, and severe. (1) Certainly many of his cases which he regarded as severe anginal attacks were instead cases of coronary occlusion. The same is true of Sir James Mackenzie. Even in his last work on angina pectoris published in 1924 (2) it is apparent that he had not made clinical diagnoses of coronary thrombosis. Dock (3) was one of the first to

480803

report an instance of coronary thrombosis diagnosed ante-mortem and proved at autopsy. This was in 1896 or only forty years ago. He recognized the importance of the pericardial friction rub as an aid to diagnosis, but he evidently did not recognize the other clinical features which make up the clinical picture of coronary thrombosis. "The first important and satisfactory account of the clinical features attending attacks of coronary thrombosis was published by Obratzow and Straschesko." "These Russian authors diagnosed correctly two of the three cases which they published." (1) These men evidently had a fairly good understanding of the disease. They emphasized severe, lasting retrosternal pain, dyspnoea, and orthopnoea. They also mentioned most of the features which we now recognize as important findings in coronary thrombosis. "It is surprising that after such a splendid publication appearing in the German literature, the condition was not more quickly appreciated on the continent, although in the following year a similar report of four cases, of which two were diagnosed ante-mortem, was published by Hochhaus." (1)

In 1912 Herrick (4) made the first contribution to the American literature. In this classical article he points out that sudden obstruction of the coronaries, even of the main branches does not necessarily terminate in sudden death or even in death in the immediate future. He also denies that the coronaries are strictly end-arteries, i.e. with merely capillary anastomoses, as Cohnheim and others taught. After discussion of the experimental ligation of the coronary arteries by many workers he concluded "Experimentally then, sudden death, even late death, is not a necessary consequence of obstruction of

2

even large branches, such as the descending branch of a coronary artery." He goes on to point out autopsy findings, by himself, Pagenstecher, West, Chiari, and others, which show evidences of complete obstruction of even large branches of the coronary, with fibrous scars, and areas of calcification in the myo-cardium, in patients having no referable symptoms during life, dying of some other disease. He presents several cases--diag-nosed ante-mortem and proved at autopsy. Nearly all of his cases died but he stresses the fact that death may be delayed a few days and states that "there is no intrinsic reason why some patients with obstruction of even large branches of the coronary artery may not recover." "and as already said, mild cases must occur, and one cannot pretend to say where the dividing line should be drawn between the mild obstruction of a coronary branch, whose recovery means a few fibrous patches in the myo-cardium, and the more serious one that in a few days is to lead to rupture of the heart or is to produce an extensive, weakened, fibrous area that will ultimately yield in cardiac aneurism." He also in this article emphasizes the resemblance of some of these cases to surgical accidents. By way of treatment he offers, "If these cases are recognized, the importance of absolute rest in bed for several days is clear." He suggests digitalis or strophanthus instead of nitro glycerin.

Strangely enough this classical article did not produce the desired effect for it aroused no interest. After a lapse of five or six years further papers appeared by Herrick and his associates (5), (6), and (7) in which the matter was again taken up. The same year Levine and Tranter (8) published a report of two cases one diagnosed ante-mortem. During these

3

years Libman (9) was evidently aware of this condition.

Since 1916 the literature in America has been filled with articles on coronary thrombosis. The more important of these contributions were those of Levine (10), Gorham (11), Paullin (12), Longscope (13), Thayer (14), Wearn (15), Gordinier (16), and Wolf and White (17). These various publications served to bring to the attention of the medical profession the clinical features of coronary occlusion so that it became an easily diagnosable disease. In spite of the many publications in the American literature it was not until 1925 that the subject began to be considered elsewhere.

Though a clear understanding of this disease is due to the careful observation of practicing clinicians together with their study of autopsy material, a most important advance in the clinical recognition of the disease came about with the discovery that certain electrocardiographic changes were fairly characteristic of the acute stages of this condition. This work was the development of some experimental observations on dogs by Smith who was associated with Herrick. Smith (18) (19) noted sharp inversion of the T wave of the electrocardiogram in dogs, shortly after the coronary arteries were ligated. At about this same time Herrick (7) published an account of the first case of coronary thrombosis which was proved at autopsy, with electrocardiographic tracings showing sharp inversion of the T wave in leads one and two which were not unlike those obtained by Smith in his ligation experiments. This work served as a fore-runner to the work that followed by Pardee and others. In 1929 Levine (1) published Coronary Thrombosis: It's Various Clinical Features in book form. This study was based on 145 cases seen

4

by him at Peter Bent Brigham Hospital and in private practice. Up to the present this work still remains the most complete study of this disease, though since this time the literature has been abundant. A few reports of large series of cases have been made but most of the recent literature is concerned with the electrocardiographic changes and with atypical features of the disease and their significance.

The terms coronary thrombosis, coronary occlusion, and myocardial infarction have come to be used as synonyms though some differentiation should be made. Properly I believe myocardial infarction is the end result of coronary thrombosis, coronary embolism or coronary sclerosis. The former condition being common the two latter extremely rare. Saphir (20) reported three cases of coronary embolism and stresses the rarity of its occurrence. He states that "the embolus may consist of air, fat, bacterial vegetations from heart valves, particles from atheromatous lesions, or broken up thrombi." He believes that in practically all instances the patient dies suddenly. Benson (21) in a review of coronary artery disease stresses the rarity of coronary sclerosis.

A short resume of the origin and distribution of the main coronary arteries seems appropriate. Antopol and Kugel (22) in a discussion of anamolous origin of these arteries do this well and briefly. "The average normal human heart is supplied by two coronary arteries. The left coronary artery arises from the left sinus pocket of the aorta and divides about a half centimeter from its origin into two branches, an anterior descending and a circumflex branch. The right coronary artery arises from the right sinus pocket of the aorta and emerges

5

between the roots of the pulmonary artery and aorta, pursuing its course to the right along the auriculoventricular sulcus up to and usually beyond the crux of the heart posteriorly. The terminal branches of the right coronary artery supply the posterior part of the right ventricle and part of the posterior portion of the left ventricle."

The pathology of coronary occlusion is well described by Boyd (23). He states that "sudden obstruction of a coronary artery is produced by embolism, or thrombosis, the former rare, the latter comparatively common." "Gradual obstruction is due to arteriosclerosis of the vessel wall, the occlusion often being completed by thrombosis." He further states that, "the clinical symptoms are due to the production of an infarct, an anemic necrosis of the heart muscle, caused by arteriosclerotic occlusion of one of the main branches of the coronaries, an occlusion which may or may not be completed by thrombosis. The lumen may be so narrowed that the wonder is how the heart managed to function at all. When the occlusion is gradual, auxilliary systems can develop, and maintain the nutrition of the myocardium, of these the most important are the anastomoses between the right coronary and the circumflex branch of the left posteriorly and between the right coronary and the anterior descending branch of the left anteriorly, as well as the extensive anastomoses between the coronaries and the extracardiac branches of the aorta, especially at the pericardial reflection around the mouth of the great veins. The condition of the aorta is very variable. It may show the most advanced atheroma, or may appear practically normal."

"Although coronary thrombosis and infarction of the heart

are generally spoken of in the same breath as if they were one and the same thing, ischemic necrosis may be found without any thrombosis. In such cases there is merely an extreme degree of narrowing or complete occlusion of the vessel by atheroma. In my experience this is much commoner than actual thrombosis. Occlusion of the coronary vessels may indeed, be produced in four different ways: 1. arteriosclerotic narrowing of the vessel; 2. thrombosis; 3. syphilitic aortitis at the root of the aorta, sealing the mouths of the coronaries; 4. embolism by vegetations from an acute endocarditis, a rare occurrence.

Although numerous anastomoses exist between the branches of the coronary vessels, yet the ever-acting heart demands such an enormous blood supply that from the physiological standpoint they must be regarded as end-arteries. The sudden obstruction brought about by thrombosis will, therefore, result in production of a white infarct. As the vessel most frequently affected is the descending branch of the left coronary artery, it follows that the lesions are most often found in the anterior wall of the left ventricle toward the apex and in the anterior part of the interventricular septum. When the right coronary is occluded the posterior half of the interventricular septum and the posterior part of the wall of the left ventricle are involved. The infarcted area is irregular in shape, of a whitish or yellowish color and is often surrounded by a red zone. Although usually of firm consistency, the larger areas may soften and break down into a granular material into which hemorrhage may occur, so that the affected area becomes deep red in color. This condition of softening is known as myomalacia

7

of the heart. In such cases rupture of the heart wall may occur without the previous formation of an aneurism. When the endocardial surface is involved a thrombus is deposited on the affected area from which emboli may arise. Thus a right sided lesion may be followed by pulmonary infarction, a point of diagnostic value. When the lesion extends to the external surface a varying degree of pericarditis is present. The weakening of the heart wall, especially if the patient survives for some time, may lead to a bulging and the formation of a ventricular aneurism which in time may rupture, resulting in sudden death. The larger the infarcted area the greater will be the tendency to aneurism formation.

The microscopic picture naturally varies with the duration of the lesion. If death is instantaneous there may be nothing to see in the heart. In those cases which survive for a few hours the muscle fibers show acute necrosis with swelling, granulation, loss of striation and marked shrinking of the nuclei. The necrotic tissue is soon invaded by great numbers of polymorphonuclear leucocytes, so that in some cases the appearance of an abscess may be suggested, thus accounting for the leucocytosis observed during life. If the patient survives for some time the dead muscle gradually becomes replaced, first by a loose, soft granulation tissue rich in small blood vessels and later by dense fully-formed scar tissue. The presence of scars must not, however, be regarded as indubitable evidence of previous infarction, for similar scarring may be caused either by gradual cutting off of the blood supply to an area of myocardium through narrowing of the coronaries or as the end result of inflammatory or toxic focal necrosis.

8

It is difficult to predict the effect upon the heart of this myocardial scarring. Small scars probably produce no effect. If the area is large there may be permanent myocardial insufficiency, dilitation of the heart, or the formation of a true aneurism." This seems to be the usual pathological picture, variations from this being rare. An occasional case of auricular rupture has been reported. Hirschboeck (24) reported a case of myocardial calcification subsequent to coronary occlusion, in which "the plaque-like calcification involved the area of the heart muscle supplied normally by the occluded descending branch of the left coronary artery". In this article he stresses the rarity of the condition and states that only about ten such cases have been reported.

My interest in coronary thrombosis was primarily aroused by what appeared to me to be an alarming increase in the incidence of the disease. It seems on the surface that coronary deaths are becoming as common as deaths from automobile accidents. In spite of the apparently alarming increase of the disease it seems difficult to findreliable statistics to deny or confirm this opinion. However those statistics which are available seem to confirm this view to some extent. Willius (25) in discussing this matter states "vital statistics and data from other sources call attention to the alarming increase in heart disease." "Figures of the United States Census Bureau, for example, gave the death rate from heart disease as 132 per 100,000 population in 1900, whereas deaths from heart disease attained the startling rate of 186 per 100,000 population in 1925. Thus the march of time witnesses the increasing slaughter of America's millions by heart disease, and in the vanguard of

this malicious host is coronary disease which no longer respects
certain age groups and is progressively depleting the ranks of
younger persons." He further states "It seems fitting again
to call the attention of the members of the medical profession
to the alarming increase in coronary thrombosis and to the
necessity for its prompt recognition." He bases his study on
the cases occurring at the Mayo Clinic from 1922 to 1933,
comparing the actual number of cases of coronary thrombosis
each year with the total registration of new patients." His
chart follows:

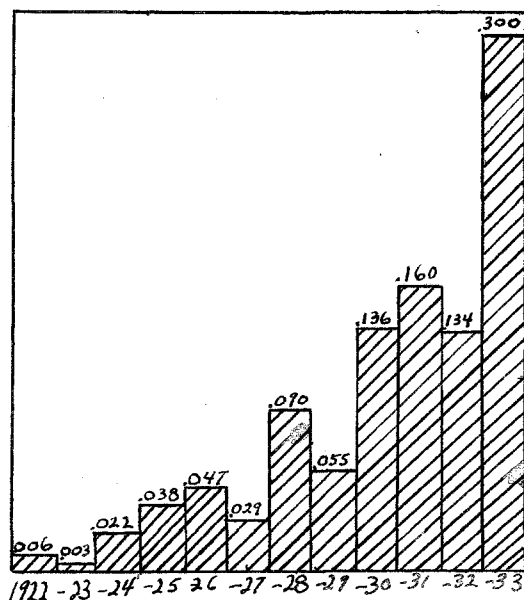Fig. 1. Increase in Incidence of Coronary
Thrombosis at the Mayo Clinic for
twelve years, per cent of first
admissions

"Fig. 1 vividly portrays the increase in the disease
from an incidence of 0.006 per cent in 1922 to an incidence
of 0.300 per cent in 1933." "The years of business adversity
must be considered in this analysis as the drop in 1923 and
the rather fixed incidence in 1930, 1931, and 1932 may have

10

been influenced by the drop in registration. However, the incidence in the three years last mentioned probably reflects a greater absolute increase in the disease than is indicated in this figure. The enormous increase during 1933 is most significant and may represent the true beginning of an alarming situation which may be the result of influences from the preceding years of adversity.

One of the disconcerting facts regarding the present situation is the increasing incidence of the disease among younger persons. It is now extremely common among persons in the fifth decade of life, it is appearing with alarming frequency among those in the fourth decade, and it occasionally is observed among those in the third."

White,(26) in commenting on the increasing incidence of coronary disease, says "My own recent experience......has made me believe that the situation is appalling and demands some action on our part. Almost certainly the most effective move that we can make is to call a halt on the world's mad rush of today."

Levy (27) in a study based on the total number of admissions to the medical service, Presbyterian Hospital, New York, 1920 to 1929 inclusive, shows an increasing incidence of coronary artery disease from 1.1 per cent in 1920 to 4.3 per cent in 1929. These figures are based on clinical diagnosis and include "arteriosclerosis of coronary artery, thrombosis of coronary artery, and infarct of heart."

From these few statistics it is difficult to arrive at a conclusion as to the present incidence of coronary thrombosis but I feel safe in saying that the disease is very definitely

11

on the increase, probably about four times as common now as it was ten years ago. However, some of this seeming increase is probably due to the more frequent diagnosis of the disease by the average physician when it does exist.

As to the etiology of coronary thrombosis there is probably no one thing which always predisposes to the disease. The common infectious diseases, and foci of infection appear to play no role whatsoever, in fact the opposite seems to be nearer the truth since the patient is usually, or at least quite commonly one apparently in the best of health.

There is obviously some relation between angina pectoris and coronary thrombosis. Levine (1) states "It is generally true that coronary thrombosis is the end result of previous angina pectoris." "Often the patient, and even the physician, is unaware of the previous existence of angina pectoris, for the complaint may have seemed trivial and of insufficient importance to call for any attention." Luten (28) in discussing the etiology of coronary thrombosis says "One relationship is at once apparent." "Most patients with coronary thrombosis have had attacks of pain conforming more or less typically to angina pectoris." He further states "The close etiological relationship between coronary occlusion and angina is further evidenced by the high incidence of occlusion in patients with angina." In my opinion the true relationship between the two diseases is probably the relationship of sclerosis of the coronary arteries to both diseases.

The role of diabetes in coronary thrombosis is much discussed and most of the work seems to indicate that diabetes does play a definite part in the etiology. Enklewitz (29) who

12

analyzed a large group of diabetic and non-diabetic patients
who came to autopsy, says in summing up his findings.

"1. Twenty six of ninety diabetic patients showed coronary
thrombosis. Twenty cases of coronary artery thrombosis occurred
in the sixth and seventh decades."

"2. Coronary thrombosis occurred more frequently in the diabetic
than in the non-diabetic female patient."

"3. In both diabetic and non-diabetic patients coronary
thrombosis occurred predominantly in the sixth and seventh
decades."

"4. Of 100 diabetic patients past the age of 40 years, 34
showed coronary thrombosis and 45 coronary sclerosis. Seventy
showed arteriosclerosis and arteriosclerosis of the kidneys.
Nineteen had gangrene of the lower extremities. Hypertension
was present in 44 cases."

"5. Coronary thrombosis occurred twice as frequently in diabetic
as in non-diabetic patients."

"6. The opinion is expressed that both coronary thrombosis
and diabetes in individuals over the age of 40 years are
manifestation of degenerative vascular disease."

Levine (1) in summing up his findings on 145 cases states that
"Coronary thrombosis frequently developed in long standing
mild diabetics, but because the age incidence was the same in
diabetics as in non-diabetics it would seem that the diabetes
merely indicated the type of individual who would develop
coronary disease rather than that it had any causative relation
to it." In his group of 145 cases there were 34 or 23.7
per cent in whom glycosuria was found, or where it was definitely
known that diabetes had existed previously.

13

Whether diabetes has any direct causative effect or not is difficult to say but the work of these men and others would point at least to the fact that coronary thrombosis is more common in diabetics than in non-diabetics, being particularly true of the female patients. It seems however that diabetes does not alter the age of onset of coronary thrombosis.

The role played by syphilis in the etiology of coronary thrombosis has never been clearly evaluated, and various opinions are held by clinicians as to its importance in the production of this condition. Levine (1) believes that syphilis is rarely an underlying factor in the causation of coronary thrombosis. In only three of his eighty nine cases in which a Wasserman reaction was done was there a positive reaction, and in one other case with a negative reaction, there was a definite history of a primary infection. "This would indicate that 4.5 per cent of the patients were syphilitic." "It does not follow that even in these syphilis had a direct causative influence in the coronary thrombosis." "that it was so of the patient aged 36 years who was the youngest in the series, seems likely, but it may well be true that in the others the luetic feature was incidental." However in this series the average age of the patients who had positive Wasserman reactions, was 13 years less than the general average. Warthin (30) in a report of 494 cases who came to autopsy showing microscopical evidence of active, latent syphilis arrived at the following conclusions:

"1. Active syphilitic lesions of the larger coronary branches are infrequent. They rarely produce occlusion of the vessel, or lead to thrombosis or myocardial infarction."

14

"2. Arteriosclerosis of the coronaries, coronary occlusion, coronary thrombosis, myocardial infarction and angina pectoris are more frequent in the latent syphilitic than in the non-syphilitic. Syphilis predisposes secondarily to coronary and aortic sclerosis and their resultant cardiac pathology."

"3. Sudden cardiac death was almost five times as frequent in the syphilitic as in the non-syphilitic autopsies. In the majority of cases this was due to cardiac insufficiency and dilatation, resulting from a diffuse myocarditis of slight degree, leading eventually to fibrosis."

The reports of other authors tend to point out practically the same sort of conclusions which lead me to believe that syphilis is rarely a direct etiological agent in coronary thrombosis but that syphilitic patients are more prone to develop coronary thrombosis at an early age than are the non-syphilitic.

Hypertension and arteriosclerosis are probably the most common single etiological factors in the development of coronary thrombosis. Allan (31) in a statistical study found that hypertension existed in well men at work, over 40 years of age, in 21 per cent and in sick people of all sorts about 31 per cent. His chart of the incidence of hypertension in coronary occlusion follows:

Author	No. of Cases	No. with H.B.P.	% with H.B.P.
Levine and Brown (32)	145	58	40
Conner and Holt (33)	287	97	34
Parkinson and Bedford (34)	100	49	49
White and Bland (35)	200	50	25
Riesman and Harris (36)	83	49	59
Meakins and Eakin (37)	50	24	26
Boaz and Donner (38)	171	71	42
Evans, Ambler, and Dodson (39)	72	32	44
	1108	430	39

15

This shows that in 1108 patients with coronary occlusion 430, or 39 per cent had previously existing hypertension. Since this chart represents the summary of most of the larger series of cases which have been reported, it seems reasonable to conclude that hypertension is by far the most common single etiological factor in the development of coronary thrombosis but not an absolute prerequisite. Most authors on the subject agree with this opinion.

The foregoing discussion points out that the etiology of coronary thrombosis is obscure and that specific diseases excepting diabetes and hypertension, have little to do with it. There is however, a great deal of evidence that heredity plays a quite important role in the disease. Musser and Barton (42) in a discussion of the familial tendency of coronary disease set forth the thesis that "there are two quite distinct expressions of coronary occlusion. The one in elderly individuals, possessors of a well marked sclerosis of the arterial tree as a whole and in whom the etiological factors are those of arteriosclerosis in general and represent largely the effects of senescence. The other occurs in men, as a rule, not past the sixth decade, of life, who do not have arteriosclerosis, who may have relatively slight, but never exaggerated, hypertension, who have been singularly free from past infections and who often give a history of coronary occlusion in several members of their family."

Levine (1) states that a large number of the cases in his series gave a family history indicating great susceptibility of the vascular system to degenerative diseases. Of interest is the fact that one of the youngest cases of coronary thrombosis

16

reported in the literature, that of Fernando(43) a single male age 24 years with a typical clinical syndrome of coronary thrombosis, with positive electrocardiographic findings, gave a definite history of his mother having died at an early age of what was also quite evidently coronary thrombosis. Along with this rather common finding of a hereditary history, or more likely as a part of the inherited traits, there is frequently a characteristic type of constitution that patients with coronary disease manifest. Levine (1) "The typical patient is a well set person, somewhat over weight, often of considerable physical strength who enjoyed unusual good health. Such patients often have indulged in vigorous physical effort either in the form of sports or in their ordinary work, and when they have not they were apt to feel that they had more than the average physical strength even if they were not accustomed to use it."

From the foregoing I believe that it is fair to conclude that in those patients who have not yet passed the sixth decade of life, and who do not show a general arteriosclerosis, that we are apt to find quite a definite physical type of individual. and that heredity is very often a factor in these cases.

As to the age incidence of coronary thrombosis it may be said that it is definitely a disease of the latter half of life, but that there are enough cases reported in the forties, thirties and even in the twenties, so that in all age groups the condition must be borne in mind. Allan (31) gives a very good chart of the age incidence of coronary disease. I have modified this chart to include only coronary thrombosis. It follows:

17

AGE INCIDENCE OF CORONARY THROMBOSIS

Author	Age	-30	31-40	41-50	51-60	61-70	71-80	81-100
Boaz & Donner (38)		24	215	708	869	556	253	
Conner & Holt (33)			23	72	130	55	17	
Parkinson & Bedford (34)		2	5	31	57	63	23	1
Meakins & Eakin (37)		2	5	15	16	14	10	
Evans, Ambler & Dodson (39)			3	23	62	111	72	24
Barnes & Ball (40)		1	1	6	18	17	5	1
Covey (41)					2	8	5	2
Number		29	252	857	1150	821	382	26

This chart represents practically all of the larger series
of cases which have been reported and shows that almost one
third of the cases occur in the fifth decade, about one fourth
of the cases in each, the fourth, and sixth, decades and that
less than one fifth of the cases reported are under forty or
over seventy years of age. This very definitely shows that
coronary thrombosis is a disease of the early part of the latter
half of life.

As to the sex incidence of coronary thrombosis it may be
said that it is quite definitely a disease of men but that it
does occur in women. Allan (31) gives a chart of the sex
incidence of coronary disease which I have modified to include
only coronary thrombosis. It follows:

SEX INCIDENCE OF CORONARY THROMBOSIS

Author	Male	Female
Evans, Ambler & Dodson (39)	241	64
Covey (41)	15	3
White & Bland (35)	167	33
Levine & Brown (32)	111	34
Conner & Holt (33)	243	44
Parkinson & Bedford (34)	165	18
Riesman & Harris (36)	74	14
	1016	210

This chart represents practically all of the larger series of cases which have been reported and shows an incidence of coronary thrombosis in men almost five times greater than that in women. This greater incidence of the disease in men has not as yet been explained but as possible factors causing the difference might be mentioned, greater physical effort, greater mental tension, alcohol, and tobacco.

The symptomatology of coronary thrombosis is now generally quite a well known subject so I will attempt only to give briefly a description of a typical attack and then later to describe a few of the features which are less constant though just as important.

The typical patient, a man, 50 to 60 years of age, of the type previously described, who may or may not have had previous anginal attacks, is suddenly aware that something terrible is happening. The attack comes on usually while the patient is at rest, and quite frequently during sleep in the early hours of the morning. From the moment the attack has begun, until several weeks have elapsed, death may occur at any time. If death is not instantaneous, we learn, that the patient is seized with a severe pain, generally in the chest but not infrequently in the upper abdomen. The pain may be retrosternal, substernal, or precordial. The pain is constricting, often described as "vice like", in character, and may radiate to the neck, shoulders, or down either or both arms, but more commonly the left than the right. The pain is accompanied by a feeling of extreme weakness or perhaps by complete collapse. Often with the onset of the attack or shortly thereafter there is vomitting which often leads the family and the physician to

19

to believe that the attack is one of acute indigestion.

Shortly after the attack has begun the patient presents the picture of shock. He is pale, cold, the skin is moist and clammy, and has an ashen gray pallor. The pulse is small, and rapid, the blood pressure usually falls, the respiration is rapid and labored. Examination of the heart reveals heart tones which are very distant, the first sound often being inaudible. There is often a pericardial friction rub which may be very transient. Very commonly there is a distinct gallop rhythm and an alternating pulse. During the next few days the pain gradually diminishes to become a dull ache which often persists for a considerable time. Fever of a moderate degree develops usually 100 to 101 degrees rectally. Along with the fever there is usually found a slight leucocytosis. Some patients early develop pulmonary edema and these patients usually show marked clearing of the edema during the next few days.

At this point it seems advisable to try to correlate symptoms with the pathology which produces them. Boyd (23) states, "The excruciating pain which is so characteristic a feature of sudden coronary occlusion by thrombosis is similar in origin to the pain felt when the blood supply to any muscle is suddenly cut off. It is commonly supposed that the muscle goes into a painful spasm, and this is very possible." The recent work of Lewis (44) suggests a somewhat different mechanism. He found that when the blood supply to the arm was cut off by means of a tourniquet and the hand was made to work, pain was felt in the hand in thirty seconds and became intolerable in seventy five seconds. As long as the tourniquet was kept

20

on, the pain continued even though the work was stopped.
Lewis (44) believes that the pain is chemical in origin, being
caused by products of muscular activity which accumulate in the
tissue spaces around the fibers. Katz (45) believes that the
stimulus for pain is a metabolic product or products, probably
acid in character and that "when this substance reaches a
concentration above the threshold of the pain end organs, pain
results." Boyd (23) "In coronary occlusion the ischemic muscle
is forced to continue work so that the pain is of long duration.
As already pointed out there may be dyspnoea but no pain. In
these cases old scars will usually be found in association
with the recent infarct. It would appear as if the area had
become gradually desensitized by the destruction of nerves and
muscle fibers the result of slow occlusion, so that it could
no longer react by pain to the sudden shock of thrombosis.
It is still more difficult to explain those cases in which the
only basis of a sudden heart attack is to be found in gradual,
though complete atheromatous occlusion of the artery, without
any thrombosis. It may well be that a sudden call for more
blood on the part of the heart muscle to the sclerosed coronary
which is unable to respond may have the same relative effect,
i.e., ischemia, as blockage of the artery by a thrombus.
Other observers believe that the origin of cardiac pain is
in the afferent sympathetic nerve endings in the wall of the
coronary arteries, or in the aorta in the case of angina
pectoris. They point out that it is often associated with
distended thin-walled coronaries, and this has been my own
experience. Experimental evidence suggests that vascular
distention is the usual cause of cardiac pain, rather than

21

vascular spasm. Thrombosis in the small coronary vessels causes an overfilling of the segment proximal to the infarct and therefore pain. In large infarcts there is also sudden loss of the contractile power of the myocardium, with overfilling and distention of the adventitia of the coronaries. From this discussion it is evident that the genesis of cardiac pain is still a matter of great uncertainty. Two facts must be borne in mind in considering any theory: there may be extreme occlusion and necrosis without any cardiac pain, and there may be pain without occlusion."

The leucocytosis is due to the formation of what is practically an aseptic abscess in the myocardium. The fever is of particular interest. Levine and Brown (32) have pointed out that there may be a considerable difference between mouth and rectal temperature. "Indeed, the former may be subnormal, while the latter may be as high as 103 or 104 degrees, so that the difference may amount to 4 or 5 degrees. The patient is in a state of collapse, with sweating over the head, neck and chest and corresponding loss of heat. This heat loss is not felt in the pelvis. The febrile reaction due to acute necrosis in the myocardium is, therefore, more readily observed in the rectum than in the mouth."

In a patient presenting the typical clinical picture the diagnosis of coronary thrombosis is not particularly difficult but there are many patients in whom the diagnosis is a difficult problem. This is particularly true in patients in whom cardiac infarction follows a gradual narrowing of the coronary arteries or in which thrombosis of the coronary arteries takes place slowly. In general Levine (1) states

that the acuteness of the symptoms will depend in a great measure on the rapidity of the mechanical occlusion of the coronary arteries. When coronary thrombosis develops in a patient already suffering from cardiac insufficiency, the clinical picture is not as striking or may lack many of the typical features of the usual acute attack. There are some instances in which the development of a peripheral embolus is the first thing to draw attention to the patient and lead to the thought of a left ventricular mural thrombus from which an embolus could be dislodged and thereby with the aid of an electrocardiogram lead to a proper diagnosis.

There is a small group of patients in which the diagnosis of coronary thrombosis is particularly difficult because of the similarity of their picture to that of an acute abdominal condition. A patient with coronary thrombosis may have excruciating pain in the abdomen, marked rigidity and tenderness in the upper abdomen, nausea, vomitting, fever, leucocytosis, and some may even have slight jaundice. All this in the absence of an abdominal lesion will tax the resources of any diagnostician. In such cases, the history of previous attacks of angina pectoris, or of previous abdominal complaints, the finding of muffled heart tones, pericardial friction rub, alternating pulse, gallop rythm, or any of the other things which may direct the attention to the coronary arteries may lead to electrocardiographic studies which are of the greatest value. Of great help in differentiating the two condition is the fact that dyspnoea is much more apt to be present and when present more severe in the coronary case. That coronary thrombosis may simulate many abdominal conditions, such as cholelithiasis,

23

and perforated peptic ulcer, has been pointed out time and
time again but only recently has the subject been stressed from
the opposing angle. Barker, Wilson, Coller (46) state that
"little attention has been given to the fact that in upper
abdominal disease a mistaken diagnosis of coronary disease is
sometimes made. In view of the popularity now enjoyed by the
diagnosis of coronary occlusion, and the facility with which it
is made, sometimes upon inadequate evidence, it seems desirable
to emphasize the fact that upper abdominal disease may sim-
ulate coronary disease to a striking degree." They report
four cases in which a diagnosis of coronary disease was made.
In two of these cases the symptoms were caused by gall bladder
disease, in the third by perforation of a gastric ulcer, and
in the fourth patient both cholelithiasis and coronary disease
were present. They state "Unless the symptoms and signs are
unequivocal, the diagnosis of angina pectoris or coronary
occlusion should not be made until upper abdominal disease has
been excluded."

In patients presenting an abdominal picture with even the
slightest indication of coronary disease an electrocardiogram
should be made which will usually be diagnostic. Little can
be lost by a conservative procedure in these cases because in
the coronary patient an operation besides being of no value
would usually be disastrous and in the abdominal case nothing
can be lost except for a few hours time.

The changes in blood pressure following a coronary
thrombosis are usually of great significance. Since in a large
percentage of cases a previous hypertension exists it is often
difficult to determine the actual fall in pressure. It usually

24

happens however that in the patients with a previous hyper-tension the fall in pressure is greater than in those with previous normal blood pressures. In the majority of cases the blood pressure makes a marked drop. This may occur suddenly with the onset or may gradually fall during the first 12 to 24 hours. The fall effects both the systolic and diastolic pressures. During the weeks following the attack the blood pressure generally stages a gradual increase but it rarely rises to a reading as high as before the attack. It is generally thought that in those patients showing an early fall with a persistent low pressure following the attack do better than those patients who either do not show an early fall in pressure or whose pressure returns to its previous high level after the attack. In patients having angina pectoris previous to an attack of coronary thrombosis it is frequently noted that they are no longer troubled with the angina. It has been suggested that the persistent low blood pressure following the coronary attack is the basis for the freedom from anginal attacks.

In the majority of cases of coronary thrombosis, there quickly develops a fever and leucocytosis. The fever may be noted within a few hours after the onset though as has been previously mentioned the mouth temperature may remain normal or subnormal, due to the shock and sweating, and the rectal temperature is a better guide. The usual temperature rises to about 100 degrees but often goes to 101 or 102 degrees. Foster (47) reported a case in which on the day following the attack the patient's temperature went to 103 degrees and then during the next three days gradually climbed to 107.2 degrees. This case terminated fatally. This is the only such high temperature

25

that I have found reported and must certainly represent the very unusual.

There are also rare instances reported in which no fever appears either rectally or by mouth. The fever lasts from one to several days or a week gradually returning to its previous normal level. The extent of fever and leucocytosis probably depends largely upon the size of the infarcted area. The presence of fever is often of value in distinguishing a coronary thrombosis from an anginal attack.

The leucocyte count usually runs hand in hand with the fever. The usual leucocyte count is between 12 and 15,000 but frequently goes to 20 or 25,000. Hines (48) reported one case in which following a typical attack of coronary occlusion the patient showed a leucocyte count over 100,000 and as high as 140,000 for twelve days following the attack. The patient died and at autopsy there was no evidence of leukemia found in the blood or blood forming organs though the diagnosis of coronary thrombosis was confirmed. This must certainly be a rare finding since I have found no other case reported with a leucocytosis exceeding 35,000. The leucocytosis usually lasts about as long as the fever but not infrequently persists for a few days longer. Levine(1) states that a "leucocytosis is one of the most constant findings in coronary thrombosis." Besides it's value from the standpoint of diagnosis it probably serves as an excellent guide as to the progress of healing in the in-farcted area.

Some recent work by Rabinowitz and Shookhoff (49) has pointed out that the red cell sedimentation time was definitely shortened following attacks of coronary thrombosis. They

26

reported ten cases diagnosed clinically, two of which were proven at autopsy in which it was observed that the red cell sedimentation time was definitely shortened, that this change appeared later in the disease than did the fever and leucocytosis, and persisted for some time after the temperature and blood count had returned to normal. They state in their summary that "This persistence of the rapid sedimentation time beyond the temperature and leucocytosis made it for us, a better index of the progress of healing of an acute myomalacia due to coronary occlusion than the temperature and leucocytosis."

An acute pericarditis not infrequently develops following an attack of coronary thrombosis. The only clinical evidence of this is the presence of a pericardial friction rub. This does not occur in the majority of patients. Levine (1) reported about 14 per cent in his series of 145 cases. The mechanism of this type of pericarditis is due to the area of infarction in the heart muscle being so situated or so extensive that it extends to the surface to involve the visceral pericardium where a local inflammation results. If the infarction involves the posterior or diaphragmatic portion of the heart or the interventricular septum, no friction rub will be heard although there may develop a pericarditis. The pericardial rub is a variable sign, but when present is a very helpful aid to diagnosis. When the friction rub is present it usually occurs during the first 24 to 48 hours after the attack but may be present within a few hours.

Urinary findings following attacks of coronary thrombosis are not at all constant and are probably not of great significance. Quite a number of patients show a mild transitory

glycosuria during the first few days following the attack
while others may show albumin, casts, and even blood. These
all however clear up within a few days and the urine again
becomes normal. Not infrequently the urine is scanty during
the first few days following an attack and rarely may be completely
suppressed. This probably results from the state of shock and
the markedly diminished blood pressure.

Although the rhythm of the heart is usually normal before
attacks of coronary thrombosis following the attack almost any
form of cardiac irregularity may be found. Many of these
irregularities are very transient and may last only a few hours.
Many of them are also difficult to detect and are discovered
only with the electrocardiogram.

Premature beats and extra systoles are very common but of
little significance. The most important irregularity is the
development of heart block. This block may be anything from
an occassional dropped beat to a 2 to 1 block or even complete
block. The latter however is fortunately quite rare. Auricular
fibrillation and ventricular tachycardia are both rather
common but are usually only transient and disappear without
treatment. If however they persist they deserve treatment
with digitalis or quinidine as will be pointed out later. The
disturbance in rhythm most frequently met with is the gallop
rhythm. During the first few days following an attack it
usually develops. "Here there is no change in the rythmicity
of the heart or in the conduction of impulses, but there is a
definite change in the quality of the heart sounds." (1) The
detection of a gallop rhythm may in many cases be of aid in
diagnosis though it is frequently encountered in conditions

other than coronary thrombosis.

Following an attack of coronary thrombosis death may be instantaneous, occur at any time during the first few weeks or the patient may recover. In those patients who die suddenly or during the first few hours following the attack the death is usually attributed to sudden fibrillation of the ventricles or to shock. In those patients who do not die of shock but die during the first few weeks the death may be due to rupture of the heart, sudden ventricular fibrillation, heart block, general circulatory failure, or from the lodgement of emboli, from the ventricular mural thrombus, in the brain, limbs, or other important organs.

There is another group of patients who recover from the immediate effects of coronary thrombosis, then to develop a progressive failure of the circulation of the congestive type and in spite of treatment die in one to three months of general circulatory insufficiency.

The group of patients offering the most valuable picture from the clinical standpoint are those patients who are considered as having recovered from an attack of coronary thrombosis. These recovery patients are of several types. The most favorable type of recovery is that in which a patient suffering from angina pectoris has an attack of coronary thrombosis following which becomes ambulatory and the angina pectoris does not return. Many of these patients are quite well and active three to five years after the attack.

The next most favorable group of patients are those in which angina symptoms are present after the attack whether or not they were present previous to the attack. In such cases

either the fall of blood pressure did not occur, was slight, or if it did fall rose again to a high level after the attack. These patients offer the ordinary problem of angina pectoris which limits their activities to a considerable extent.

The greatest group of patients represent the lease favorable type of recovery. These patients develop evidence of general circulatory insufficiency. They may have no evidence of circulatory failure during the early weeks following the attack then to gradually develop edema, dyspnoea on the slightest exertion, and any of the other signs of circulatory failure. In this group the symptoms must be treated as they arise. The patient may go along for a long time but they are not well and their activity is very limited.

Besides these three main groups there are many patients who present individual problems. There are a large number of cases who after apparently complete recovery develop a second and even a third attack of coronary thrombosis.

A statistical study of recovered cases over a great many years is not as yet available but will gradually be built up and only then will it be possible to even approximate a forecast for the patient's future.

Typical cases of coronary thrombosis can and should be diagnosed from clinical findings. Of great importance however are the electrocardiographic changes which occur in this condition. Coronary thrombosis is undoubtedly the one disease in which the electrocardiogram is of greatest value. Not only is it an invalubale aid in the diagnosis of many cases but it is also of great value in following the course of healing in the area of infarction and in giving a prognosis. There is practically

no other condition in which the form of the electrocardiogram changes from day to day, or at least goes through such significant changes so quickly as occurs in coronary thrombosis.

The form of the electrocardiographic record may show changes within a few hours following the attack which are diagnostic of coronary thrombosis and then as healing occurs in the infarcted area return to normal within six months or a year.

It is a little difficult to analyze the literature on this subject since during the past ten years contributions have been so abundant. It seems however that there is agreement by most authors on the following points.

"The most important type of change in the electrocardiogram is the one discovered by Pardee (50) (51). He noted that during the early days following an attack of coronary thrombosis the form of the complex between the downstroke of the R wave and the end of the T wave changes. This change consists of the disappearance of the brief iso-electric interval that normally exists between the Q-R-S complex, or initial ventricular deflection, and the T wave or terminal ventricular deflection. Furthermore the T wave begins on the downstroke of the R wave before it has reached the base line and has a peculiar rounded hump." (1)

Wiggers (52) states "The changes observed in most severe cases of infarction, and hence having a more unfavorable prognosis consist in a merging of the T wave with the R deflection. This may produce a curve which resembles a monophasic deflection with a broad declining plateau or a curve in which the descending limb of R is extended by a large rounded hump. If death does

31

not occur the curve gradually changes and the T wave gradually
assumes a lower position but still branches directly from the
descending limb of R."

"The next stages are more commonly met with in patients
who recover, i.e., when the collateral circulation set up in
infarcted areas causes a restoration of function to some degree.
The T wave assumes a lower position on the descending limb of
R until finally it becomes inverted," developing an incisive
character. "The descent in a convex curve to an acute apex,
the sharp return to the base line and the deep character of the
depression are of considerable value in differentiating the
condition from others accompanied by a negative T wave. The
characteristic changes are not usually observed in all three
leads but affect predominantly either lead I or III, but lead
II is commonly involved as well."

" In favorable cases the T wave gradually becomes less
negative and may eventually revert to a positive form. The
characteristic changes noted as typical of left coronary thrombosis
are not seen when the right coronary artery is involved.
Obstruction of the right coronary artery generally produces
infarction of the posterior wall of the left ventricle or of the
interventricular septum, infarction of the right ventricle
being rare. These however exert no characteristic influence
on the electrocardiogram." He further states that the frequency
with which diagnosis of coronary thrombosis can be made with
the electrocardiogram is due to the frequency of involvement
of the left coronary artery.

Master (53) in a recent publication stressed the importance
of the changes in the form of the P wave. He states "In 40 cases

32

of coronary thrombosis definite changes in the P waves occured in 80 per cent. These changes consisted for the most part in increase in amplitude of the P wave and occassionally in notching or widening of the auricular complex. The change occured more frequently in leads I and II rather than in II and III, but always in lead II. There is evidence that the larger P wave early in acute coronary artery disease is indicative of a dilated auricle, and it is suggested that this chamber takes over a portion of the work of the injured ventricle. The increase in size or the change in shape of the P wave is one of the electrocardiographic signs of acute coronary artery occlusion."

Katz and Kissen (54) are the chief advocates of the use of lead IV in diagnosis of coronary thrombosis. They state "Three types of changes occurring in lead IV are "specific" for recent coronary occlusion. (a) A positive "humped" S-T segment with a negative coronary T wave. (b) A negative "humped" S-T segment with a positive coronary T wave. (c) A diphasic coronary T wave which is transient. The progression of changes in lead IV in a series of records is not always parallel to that in the ordinary leads. Often the changes progress most rapidly in lead IV.

While lead IV may show no abnormalities, or only non-specific types of abnormalities in recent coronary occlusion, there are a significant number of cases in which the specific changes occurred only in lead IV. Therefore lead IV should be taken routinely in all cases of suspected recent coronary occlusion."

I believe that the majority of men now use lead IV routinely but that most of them feel that if there are significant findings

33

in lead IV that they will also be present in the other leads.

Barnes (55) has probably been the leader in recent work
on electrocardiographic changes following coronary thrombosis.
In this article he states "The electrocardiogram of patients
in whom acute coronary occlusion is complicated by pericarditis
differ from the type of RS-T changes associated with uncom-
plicated acute coronary occlusion. The typical feature of the
electrocardiogram seen in coronary occlusion associated with
pericarditis in its early stages consists of elevation or
upward rounding of the RS-T segment in all leads. This may
be followed by inversion of the T wave in all leads. In some
instances it is followed by the development of a T pattern
that can be classified definitely as a late relic of acute
coronary occlusion. In the stage when the RS-T segment is
elevated in all leads, the Q pattern may be typically developed,
not only indicating infarction, but also pointing to the situation
of the infarct in the left ventricle."

Another feature of the electrocardiogram is the presence
or development of prominent Q waves in lead III. The exact
significance of this seems obscure but it is reported with great
enough frequency so that it seems unlikely that such a change
is accidental.

There are many other electrocardiographic abnormalities
that occur in this disease but they are not constant and are
no different from those observed in other patients with de-
generative myocardial disease who have not had coronary thrombosis.
Such changes are bundle branch block, or evidence of intra-
ventricular defective conduction as indicated by lengthening of
the duration of the Q-R-S complex.

In patients presenting the typical clinical picture of coronary thrombosis there is little difficulty in making the diagnosis but needless to say, many patients do not present a typical picture. Since many patients with coronary thrombosis have a preceding angina pectoris this condition becomes the chief obstacle in differential diagnosis. The following chart by Parkinson and Bedford (34) sets forth the main points which distinguish angina pectoris from coronary thrombosis.

	Angina Pectoris	Cardiac Infarction
Onset	During exercise.	Often during rest or sleep.
Site of pain	Sternum, often mid-sternum.	Sternum, often lower third.
Attitude	Immobile	Restive, often walk about.
Duration	Minutes	Hours or days.
Shock	Absent	Present
Dyspnoea	Absent	Present
Vomitting	Rare	Common
Pulse	Unchanged	Small, often rapid.
Temperature	No fever	Fever follows
Blood pressure	Normal or rise	Fall
Heart sounds	Normal	Distant, sometimes gallop, or peri-cardial rub.
Congestive failure	Absent	Commonly follows
Electrocardiogram	Often abnormal	Usually diagnostic

I would add to this chart the facts that in angina pectoris the pain is relieved by nitrites, and that in coronary thrombosis embolic phenomena often occur and that there are often gastric symptoms present. If all of these features are kept in mind there should be few cases in which the diagnosis can not be made, especially if the electrocardiogram is resorted to.

There are several other conditions that may be confused with coronary thrombosis and reuqire special mention. Of particular importance are those patients presenting a picture simulating an acute surgical abdominal condition. This type of

patient was discussed before but is again worthy of emphasis. In any patient, especially past the age of 40, presenting a picture of acute pain in the upper abdomen, coronary thrombosis must be excluded.

Other conditions that may simulate or be confused with coronary thrombosis are diabetic acidosis, pneumonia, and rarely pneumothorax. Diabetic acidosis is strongly suggested in those patients with sugar in the urine, depressed CO_2 combining power of the blood, shock and stupor. In these cases further study usually easily leads to the correct diagnosis.

Pneumonia will sometimes give a picture which is quite typical of coronary thrombosis. Pain in the chest, dyspnoea, cough, rales at one or both bases of the lungs, fever, and leucocytosis are characteristic of both conditions. The location, type and severity of the pain is usually quite different and changes in the mechanism of the heart are quite rare in pneumonia. Other evidence pointing to arterial disease such as history, hypertension and angina pectoris are usually significant and in most all cases the electrocardiogram is diagnostic.

There are some atypical cases which will tax the ability of any diagnostician and a proper diagnosis will be made only after complete study with all features well in mind. Some of these atypical cases are those attacks of dyspnoea without pain, sudden nocturnal dyspnoea, and those patients in which the occlusion occurs so gradually that no acute episode is ever noted, or where attention is first called to the patient by the occurrence of embolic phenomena.

The diagnosis of coronary thrombosis having been made, the first essential in treatment is the relief of pain. This should

be immediate and thorough. If the pain is terrific a half
grain of morphine is usually advised, if however the pain is
less severe a quarter grain can be given, and repeated in half
an hour if the patient is still in distress. The morphine should
be given hypodermically and in any case the dose should be
repeated until relief is obtained. In some cases it is even
necessary to give a light anesthetic to relieve the pain until
the morphine has begun to be effective. At any rate the pain
must be relieved effectively since there is nothing to gain by
withholding morphine and the patient must have rest. During
the first day or so the pain may recur, and any such recurrence
is an indication for a further injection of morphine. It is
generally agreed that the vaso-dilators are of no value in
relieving the pain and that such drugs may even be dangerous.

The second essential in treatment is rest to the damaged
heart muscle and in view of the necrosis and softening of the
muscle it is imperative that rest be as complete as possible
during the time when the infarcted area is being repaired.
During the first two weeks **any** slight strain on the damaged
myocardium may lead to rupture of the ventricle so that this
is the true danger period during which rest is most essential.
Most authors now agree that a month is the minimum for absolute
bed rest and that six weeks to two months is far better.
During this period in bed, particularly during the first two
weeks, sedatives should be used to insure rest, and good nursing
care is essential in order to eliminate even the slightest effort
upon the patient's part.

"An outstanding feature of the onset is collapse." Hay (56)
"The patient is shocked, ashen grey, cold and bedewed with

37

sweat. The pulse may be rapid, small in volume, easily compressible, almost imperceptible, and there is usually a dramatic drop in blood pressure. The condition of shock may be so profound that life is endangered, and some form of cardiac stimulation is indicated: this is justifiable during the first forty-eight hours, more especially if the blood pressure has touched dangerous limits--that is, a level so low that the circulation in essential organs is jeopardized. This limit will depend on the condition of the blood pressure before the occlusion, but as a rough guide anything below 100 mm. Hg. systolic may be looked upon as dangerous. After the first forty-eight hours, and for the first three weeks at least, there should not be any attempt at vigorous stimulation of the heart. The object of treatment is to maintain the circulation at the lowest level compatible with life during the period in which the lesion in the myocardium is being repaired. During the stage of shock and collapse hot bottles, hot fomentations to the chest, warm blankets, hot drinks, and hot coffee should all be imployed. The head should be kept low, and caffeine should be given intravenously, or 5 minims of adrenaline hydrochloride (1:1000) should be injected intramuscularly."

Hick (57) suggests as an emergency measure the application of tourniquets to all four extremities. These to be left on until effective durgs can be administered or until the blood pressure raises above the dangerous level.

A great deal has recently been written on the use of oxygen in the treatment of coronary thrombosis. Barach and Levy (58) are the chief advocates of this form of treatment. They state in a summary "Employment of oxygen therapy may aid in maintaining an adequate circulation until the heart has had an opportunity

38

to recover from its acute functional disturbance. Obviously, the cardiac injury may be so severe that recovery is impossible but in certain instances, effective use of oxygen may be responsible for the saving of life." These men employ 50 per cent oxygen, preferably in a tent, but occasionally by means of a nasal catheter. If the cyanosis is not relieved by 50 per cent they sometimes increase the oxygen to 60 and 70 per cent. Niehaus (59) in a discussion of cardiac therapy says of oxygen therapy--"relieves the pain of coronary thrombosis and may perhaps decrease the extent of necrosis in infarction." Hick (57) states "the relief of dyspnoea, cyanosis and restlessness in two cases of coronary occlusion is attributed to the use of oxygen. The oxygen is beneficial in supplying all the myocardium to which circulation is maintained with arterial blood bearing oxygen under an increased diffusion pressure. Hence any collateral circulation and the thebesian vessels function more effectively in minimizing the size of the infarct." From the foregoing it seems reasonable to think that in many cases oxygen therapy is well worth trying in that it appears to have a definite value in relieving the pain, cyanosis, dyspnoea, and restlessness. If the pain is on a basis of anoxemia, and most evidence seems to bear this out, then oxygen should certainly be of value in relieving it.

As to the use of digitalis in the treatment of coronary thrombosis it is generally agreed that it should not be used unless there is specific indication for it such as auricular fibrillation, flutter, or congestive failure. In the absence of these indications it is contraindicated because of the danger of stimulating the damaged myocardium to more forceful

39

contractions and hence increasing the danger of ventricular
rupture.

During the first week a common difficulty is abdominal dis-
tention.(56) "This is apt to prove a troublesome handicap,
because emphysema is a relatively frequent finding in this type
of patient, and any limitation of the free movement of the
diaphragm is therefore dangerous. Restriction of diet, simple
enemata, and laxatives may be sufficient to give relief. If
they fail a rectal tube should be passed, and may be left in
position for an hour or more. In any case food should be re-
stricted to a minimum for the first few days, and the desires
of the patient met with, weak tea, coffee, and lemonade or
orangeade, fortified with glucose or honey. Thirst is a common
complaint during the first week and fluids should not be
restricted."

Constipation is a common complaint during the first few
weeks, due to the action of morphine, along with confinement ot
bed and restriction of diet. This condition should be relieved
by use of enemata or some of the milder laxatives.

The two commonest complications of coronary thrombosis are
auricular fibrillation and ventricular tachycardia. The latter
should be suspected when the rate goes toward 200 per minute
and the action is regular. Auricular fibrillation is usually
transient but if it persists digitalis should be used. Ven-
tricular tachycardia requires full dosages of quinidine sulphate.

Another complication is that of heart block. "Partial
block is not uncommon but requires an electrocardiogram for
recognition and in any case does not call for treatment." (56)
Complete block is fortunately rare but when it does occur

40

ephedrine hydorchloride by mouth or adrenaline chloride intra-
muscularly are recommended.

After six weeks to two months of absolute bed rest the
patient should then be allowed to begin a gradual approach to
normal life. At this time the patient should be well informed
as to the status of his heart so that full cooperation can
be obtained from him. If his occupation is such that it
requires any great deal of physical effort he should consider
retirement or in any event his work should be modified so that
he can lead a fairly leisurely life. His full and intelligent
cooperation is imperative. He must recognize his limitations
and live within them. The earliest manifestations of cardiac
inadequacy, such as shortness of breath or pain, must be con-
sidered as indications that, for the time being at least, too
much is being required of the damaged myocardium.

In speaking of the prognosis of coronary thrombosis
Levine (1) states "there are few diseases in which the prognosis
in any individual case is more difficult to predict than in
coronary thrombosis." I believe that most clinicians are in
great agreement with this statement. There is no specific
criteria that is indicative of recovery or of the reverse.
One patient with an apparently mild attack may appear to be
recovering without difficulty then to suddenly die: while
another patient with an apparently terrific attack may recover
rather uneventfully. It is however possible to arrive at some
general conclusions, as to prognosis, from the data afforded by
the several large series of cases which have been reported.

Of the 143 cases reported by Levine (1) in which the
outcome was known, the immediate mortality was 53 per cent.

76 died and 67 recovered. After recovery, the average duration
of life in this series was 24 months but this included 42
individuals still living at the time. He predicts that when
the final outcome of the series is known, the average length of
life will be about three years, with variation from a few months
to ten years or more.

Conner and Holt (33) in an analysis of 287 cases found
that the immediate mortality in the first attack was 16.2 per
cent. Of the 117 patients who recovered satisfactorily from
the first attack; 75 per cent were in good health at the end
of one year: 56 per cent at the end of two years; 21 per cent
at five years, and 3.4 per cent at ten years. One patient
remained in good health for 17 years and died in a second
attack eighteen years after the first.

A single attack only of thrombosis was recorded in 67
per cent; three or more attacks in 9 per cent. Of the patients
having a single attack one half were living at the time of the
report and one third were in good health. "although the im-
mediate mortality in attacks of coronary thrombosis is higher
when the initial symptoms are severe than when they are mild,
yet almost one third of the patients who recovered from the
attack had symptoms of very severe character." (33)

White and Bland (35) in an analysis of 200 cases found
that "the average duration of life after the first attack of
coronary thrombosis for the 101 patients who died was 1.5 years-
ranging from a few hours to eleven years. If we exclude the
21 patients who did not survive the acute attack by one month,
the average duration of life of the remaining 80 patients was
1.9 years. The average duration of life after the attack of

42

coronary thrombosis in the 94 patients known to be still alive
is 3.2 years, giving an average of 2.4 years for the entire,
but uncompleted, series of 200 cases."

Cooksey (60) in an analysis of 53 cases of acute coronary
occlusion reported an immediate mortality of 39.6 per cent.
Of the living patients one was alive 13 years after the initial
attack, and ten, 6 years after the initial attack. This series
of cases is hardly large enough to be of great significance
but it is a much more optimistic report than are most of the
series of cases.

Parkinson and Bedford (34) on the basis of 100 cases
investigated, states that a patient seen alive with coronary
thrombosis was more likely to survive the attack than to
succumb to it. Of their 100 patients 31 had died at the time
of reporting, 23 within six months, and another 7 within two
years of the attack. This gives an immediate mortality of 23
per cent within 6 months.

Bedford (61) says "the diagnosis of coronary thrombosis
having been made, the prognostic problem is twofold: 1. What
is the patients chance of surviving the attack? e.g. the im-
mediate prognosis. 2. If the patient survives the attack, what
degree of activity will be possible, and what is his expec-
tation of life?" "If all cases in which the diagnosis can be
established with reasonable certainty are included, whether the
symptoms are mild or severe, then the immediate mortality-i.e.
during the first 6-8 weeks from the onset is probably not more
than 25 per cent. These figures relate only to cases diagnosed
clinically, excluding sudden deaths at the onset, and do not,
of course, indicate the true mortality of coronary thrombosis."

Regarding the ultimate prognosis he states, "no opinion can be formed as to what degree of exertion is permissible until the patient is ambulant and the heart's capacity can be tested. Once the acute attack is over, the presence of congestive failure, of gross enlargement of the heart, or of a very low blood pressure are indications that little activity can be hoped for."

From the foregoing I believe that the prognosis in coronary thrombosis may in general be summed up as follows: In any given case of coronary thrombosis the chances for recovery are about one to one. In a case of coronary thrombosis seen alive and diagnosed clinically the chances for recovery are about three to one. Of those patients who recover from the acute attack, the life expectancy is from one to three years with a possibility of surviving five years and a still more remote possibility of surviving ten years or longer.

There is no specific criteria upon which to base prognosis but we may expect more from the younger patients, and from the patients with less severe symptoms. We can expect less from the older patients, from those patients with more severe symptoms, and especially from those patients who after recovery show signs of congestive failure, of gross enlargement of the heart, or of a very low blood pressure.

Of great importance in giving a prognosis in coronary thrombosis is a consideration of the early management of the patient-i.e. during the first month or two following the acute occlusion. Finally any prognosis must be very guarded in spite of the age of the patient, the severity of the symptoms, or the subsequent management.

Summary

1. Coronary thrombosis is an obstruction, usually acute, of a branch of one of the coronary arteries resulting in infarction of the heart muscle in the area supplied by the occluded vessel.

2. Coronary thrombosis is often preceeded by angina pectoris; frequently develops in long standing mild diabetics; syphilis and the other infectious diseases are rarely a cause. A previous hypertension is present in the majority of patients. Heredity is a factor of considerable importance as indicating a familial tendency to chronic vascular disease.

3. About one third of the cases occur in the fifth decade; about one fourth of the cases in each, the fourth and sixth decades; less than one fifth of the cases occur before 40 or after 70 years of age. The relation of males to females is about 5 to 1.

4. Characteristic symptoms are severe, lasting retrosternal pain, dyspnoea, shock, collapse and gastric symptoms.

5. Characteristic findings are fever, leucocytosis, distant heart sounds, gallop rhythm and pericardial friction rub.

6. The electrocardiogram is usually diagnostic.

7. The important conditions considered in differential diagnosis are angina pectoris, acute abdominal conditions, pneumonia, diabetic acidosis and chronic myocarditis.

8. The essentials of treatment are relief of pain and rest to the damaged myocardium. The vaso-dilators and digitalis should not be used unless specifically indicated. Subsequent management of the patient is of the greatest importance.

9. There is no specific criteria upon which to base prognosis.

45

Bibliography of References

1. Levine, S. A., Coronary Thrombosis: It's Various Clinical
   Features, Medicine Monographs 1929

2. Mackenzie, J., Angina Pectoris, Oxford Medical Publications
   1923

3. Dock, G., Some Notes on the Coronary Arteries, Med. and Surg.
   Reporter LXXV, 1, 1896. Quoted from Levine (1)

4. Herrick, J. B., Clinical Features of Sudden Obstruction of
   Coronary Arteries, J.A.M.A. 59: 2015-2020, Dec. 7, 1912

5. Herrick, J. B. Thrombosis of the Coronary Artery. Trans.
   Assoc. of Am. Phys., May 1918. Quoted from Levine (1)

6. Herrick, J. B. and Nuzum, F. R., Angina Pectoris: Clinical
   Experience with Two Hundred Cases, J.A.M.A., LXX, 67, 1918

7. Herrick, J. B., Thrombosis of the Coronary Arteries, J.A.M.A.
   LXXII, 387, 1919

8. Levine, S. A. and Tranter, C. L., Infarction of the Heart
   Simulating Acute Surgical Abdominal Condition, Am. Jour.
   Med. Sc., CLV, 57, 1918

9. Libman, E. Trans. Assn. Am. Phys., 1919, XXXIV, 138. Quoted
   from Levine(1)

10. Levine, S. A. Angina Pectoris: Some Clinical Considerations,
    J.A.M.A., LXXIX, 928, 1922

11. Gorham, L. W., The Significance of Transient Localized Peri-
    cardial Friction in Coronary Thrombosis, Albany Medical
    Assn., XLI, 109, 1920

12. Paullin, J. E., Thrombosis of the Coronary Arteries: A
    Clinical and Pathological Study, South Med. Jour., XIV, 16, 1921

13. Longscope, W. T., The Effect of Occlusion of the Coronary
    Arteries in the Heart's Action and It's Relationship to
    Angina Pectoris, Ill. Med. Jour., XLI, 186, 1922

14. Thayer, W. S., Reflections on Angina Pectoris, International
    Clinics, Vol. I, XXXIII, 23, 1923

15. Wearn, J. T., Thrombosis of the Coronary Arteries with
    Infarction of the Heart, Am. Jour. Med. Sc., CLXV, 250, 1923

16. Gardinier, H. C. Coronary Arterial Occlusion: A Perfectly
    Definite Symptom Complex, Am. Jour. Med. Sc. CLXVIII, 181, 1924

17. Wolff, L and White, P. D., Acute Coronary Occlusion, Boston
    Med. and Surg. Jour., CXCV, 13, 1926

18. Smith, F. M., The Ligation of the Coronary Arteries with
    Electrocardiographic Study, Arch. Int. Med., XXII, 8, 1918.
    Quoted from Levine (1)

19. Smith, F. M., Further Observations on the T Wave of the
    Electrocardiograph of the Dog Following the Ligation of the
    Coronary Arteries, Arch. Int. Med., XXV, 673, 1920
    Quoted from Levine (1)

20. Saphir, Otto, Coronary Embolism, Am. Heart Jour. 8: 312-321,
    March, 1933

21. Benson, R. L., The Present Status of Coronary Arterial
    Disease, Arch. Path. 2: 876, 1926

22. Antopol, Wm. and Kugel, M. A., Anomalous Origin of the Left
    Circomflex Coronary Artery, Am. Heart Jour: 8: 802-806,
    July, 1933

23. Boyd, Wm., Pathology of Internal Disease, Second Edition,
    65-75, 1935

24. Hirschbock, F. J., Calcification of the Myocardium Following
    Coronary Occlusion, Am. Heart Jour. 10: 264-267, Dec., 1934

25. Willius, F. A., The Increasing Incidence of Coronary Thrombosis, Minnesota Medicine. 17: 355, June, 1934

26. White, P. D., Heart Disease, The MacMillan Co., New York, 609, 1931

27. Levy, Robert, L., Some Clinical Features of Coronary Artery Disease, Am. Heart Jour. 7: 431-441, April, 1932

28. Luten, Drew, Contributory Factors in Coronary Occlusion, Am. Heart Jour. 7: 36-43, October, 1931

29. Enklewitz, Morris, Diabetes and Coronary Thrombosis, Am. Heart Jour. 9: 386-395, Febr., 1934

30. Warthin, Aldred Scott, The Role of Syphilis in the Etiology of Angina Pectoris, Coronary Arteriosclerosis and Thrombosis, and of Sudden Cardiac Death, Am. Heart Jour. 6: 163-170, Dec., 1930

31. Allan, Wm., The Relation of Arterial Hypertension to Angina Pectoris and Coronary Occlusion, Southern Medicine & Surgery. 96: No. 8, 377-379, August, 1934

32. Levine, S. A. and Brown, C. L., Coronary Thrombosis: Its Various Clinical Features, Medicine. 8: 245, Sept., 1929

33. Conner, Lewis, O. and Holt, Evelyn, The Subsequent Course and Prognosis in Coronary Thrombosis, Am. Heart Jour. 5: 705-719, August, 1930

34. Parkinson, John and Bedford, D. E., Cardiac Infarction and Coronary Thrombosis, Lancet. 1: 4-10, Jan. 11, 1928

35. White, P. D. and Bland, E. F., A Further Report on the Prognosis of Angina Pectoris and of Coronary Thrombosis. A Study of Five Hundred Cases of the Former Condition and of Two Hundred Cases of the Latter, Am. Heart Jour. 7: 1-14, October, 1931

36. Riesman, D. and Harris, S. E., Diseases of the Coronary
    Arteries With a Consideration of Data on the Increasing
    Mortality of Heart Disease, Am. Journ. Med. Sc. 187: 1, Jan.,
    1934

37. Meekins, J. C., and Eakin, W. W., Coronary Thrombosis; A
    Clinical and Pathological Study, Canadian M. A. Journ. 26:
    18, Jan., 1932

38. Boaz, E. D. and Donner, S, Coronary Artery Disease in the
    Working Classes, J.A.M.A., 98: 2186, June, 1918

39. Evans, N., Ambler, A. C., and Dodson, W., Coronary Disease;
    Its Pathogenesis, Cal. & West. Med. 38: 98, Febr., 1933

40. Barnes, A. R., & Ball, R. G., The Incidence and Situation of
    Myocardial Infarction in One Thousand Consecutive Post
    Mortem Examinations, Am. Journ. Med. Sc. 183: 215, Febr., 1932

41. Covey, G. W., Coronary Thrombosis--A Review of Autopsy
    Findings, Nebr. State Med. Journ. 15: 466, Dec. 1930

42. Musser, J. H. and Barton, J. C., Familial Tendency of Coronary
    Disease, Am. Heart Jour. 7: 45-51, October, 1931

43. Fernando, P. B., Coronary Occlusion in a Patient Aged 24
    Years, Brit. Med. Journ., 976, May 11, 1935

44. Lewis, Sir Thomas, Cardiac Pain, Arch. Int. Med.49: 713,
    1932 Quoted from Boyd (23)

45. Katz, Louis, N., Mechanism of Pain Production in Angina
    Pectoris, Am. Heart Jour. 10: 322-327, Feb., 1935

46. Barker, Paul S., Wilson, Frank N., and Coller, Frederick, A.,
    Abdominal Disease Simulating Coronary Occlusion,Am. Journ.
    Med. Sciences 188: 219-224, August 1934

47. Foster, J. H., Coronary Thrombosis with Hyperpyrexia,
    J. A. M. A. 100: 1027-1029, April, 1, 1933

48. Hines, D. C., Occlusion With Hyperleukocytosis, Cal. and
    West. Med. 38: 372-373, May, 1933

49. Rabinowitz, Meyer A., and Shookhoff, C., The Red Cell
    Sedimentation Time in Coronary Occlusion, Am. Heart Jour.
    7: 52-65, Oct. 1931

50. Pardee, H. E. B., An Electrocardiographic Sign of Coronary
    Occlusion, Arch. Int. Med. XXVI, 244, 1920 Quoted from Levine

51. Pardee, H. E. B., Clinical Aspects of the Electrocardiogram,
    Paul B. Hoeber Inc. New York, 1924

52. Wiggers, Carl J., Principles and Practice of Electrocardio-
    graphy, C. V. Mosby Co. 1929

53. Master, A. M., P Wave Changes in Acute Coronary Artery
    Obstruction, Am. Heart Jour. 8: 462-470, April, 1933

54. Katz, L. N. and Kissin, M., A Study of Lead IV Am. Heart
    Jour. 8: 595-607, May, 1933

55. Barnes, Arlie R., Electrocardiographic Pattern Observed
    Following Acute Coronary Occlusion Complicated by Pericarditis
    Am. Heart Jour. 9: 734-741, 1934

56. Hay, John, Coronary Thrombosis British Med. Journ. 1:
    936-937, May, 4, 1935

57. Hick, Ford K., Oxygen in Acute Coronary Occlusion, Medical
    Clinics of North America 17: 1657-1664, May, 1934

58. Barach, A. L. and Levy, R. L., Oxygen in Treatment of
    Acute Occlusion J. A. M. A. 103: 1690-1693, Dec., 1, 1934

59. Niehaus, J. W., Cardiac Therapy, Nebr. Med. Jour. 19: 168-
    172, May, 1934

60. Cooksey, W. B., Coronary Thrombosis: Follow up Studies

With Especial Reference To Prognosis, J. A. M. A. 104: 2063-2065, June, 8, 1935

61. Bedford, D. E., Prognosis in Coronary Thrombosis, Lancet, 1: 223-224, Jan., 26, 1935