Pathological Studies of Coronary Atherosclerosis: Especially of Sclerosis of Intramuscular Coronary Arteries

Imasato DONOMAE, M.D., Yoshihiro MATSUMOTO, M.D., Tatsuo KOKUBU, M.D., Reizo KOIDE, M.D., Rokuro KOBAYASHI, M.D., Harumichi IKEGAMI, M.D., Einosuke UEDA, M.D., Tomoo FUJISAWA, M.D., *and* Shiro FUJIMOTO, M.D.

Among the autopsied cases which had been diagnosed clinically as atherosclerotic coronary heart disease, there were some cases revealing marked myocardial fibrosis without significant atherosclerotic stenosis or occlusion of the coronary arterial stem. As a trial to find the cause of these myocardial pathology, possible meaning of the diverged branch of the coronary artery was pursued. As a result of the study the small intramuscular coronary arteries (I.M.C.A.) sized between 80μ to 500μ in diameter seemed to have an important meaning as a cause of such myocardial lesion.

These I.M.C.A. lesions were dependent of neither atherosclerosis of the coronary stem nor ante-mortem hypertension. According to authors' classification of the myocardial fibrosis, patchy natured one was most highly connected with circulatory disturbances and its direct cause seemed to be the I. M. C. A. lesions provided no significant lesions of the coronary stem existed. The comparison of these lesions in the I. M. C. A. with the ante-mortem clinical feature suggested that the lesions of I.M.C.A. may lead to the chronic cardiac failure without anginal pain.

IN contrast to a number of investigations ¹⁾⁻¹⁰⁾ on the relationship between atherosclerosis of the coronary arterial stem and myocardial changes, studies on the intramuscular coronary arteries (I.M.C.A.) in relation to the myocardium are rather rare. Among autopsied cases which had been diagnosed clinically as atherosclerotic coronary artery disease, in the authors experience, there were a few cases of significant myocardial fibrosis without any remarkable abnormality of the coronary arterial stem.

From the Third Department of Internal Medicine, Osaka University Medical School, Osaka, Japan.

This research was supported by Grant H-4402 (Cl) from the National Heart Institute, National Institute of Health, United States Public Health Service.

These myocardial fibrosis appeared to be a cause of clinical heart failure in some cases. In such cases the cause of myocardial fibrosis should be investigated as to the changes in diverged branches of the coronary artery as well as such systemic causes as anemia, intoxications, hypoxemia, and others of unknown etiology.¹¹⁾

In the studies of Fishberg,¹²⁾ Ikeda¹³⁾ and Murakami¹⁴⁾ they concluded that the changes of arterioles in the myocardium would not be important clinically. However in these studies, the observations were focused on the arterioles smaller than $50\text{--}60\mu$ in diameter as analogous to those of the kidney. As generally accepted, myocardial fibrosis is due to narrowing of the coronary arterial stem, and the myocardial fibrosis due to intramuscular arterial changes may be superimposed the by changes of the coronary stem itself. Thus the relation between the changes of I.M.C.A. and that of myocardium is not still clear.

In general, the grade of coronary atherosclerosis in Japanese is less severe than among western because of low intake of dietary fat. It might be convenient to study the hearts of Japanese in regard to myocardial fibrosis due to changes of I.M.C.A. associated with patent coronary stem.

Büchner,¹⁷⁾ Blumgart,³⁾ Miller,⁷⁾ Friedberg,⁸⁾ Master¹⁸⁾ and Horn⁹⁾ recorded cases of myocardial infarction without any occlusion in the coronary stem, which suggesting the possibility of the intramuscular coronary arteries playing part in the occurrence of myocardial infarction.

From these standpoints, the authors have attempted to clarify the role of the intramuscular coronary artery and its clinical significance.

MATERIALS AND METHODS

The hearts were obtained from the autopsied material of cases over 40 years of age, and a total of 50 hearts were studied. The causes of death and complications are listed in Table I. The cases consisted of fifth decade 5, sixth decade 12, seventh decade 18, eighth decade 11, and ninth decade 4. The cases which had shown a blood pressure above 150 mm.Hg in systole and/or 90 mm.Hg in diastole were classified as "hypertensives".

As the specimens for histopathological examinations, a piece of tissue 3 to 5 cm. long parallel with long axis of the heart was removed from a predominated part of the anterior wall including the anterior papillary muscle of the left ventricle. The sections were stained by the Haematoxylin-Eosin, Weigert, Mallory and Van Gieson techniques.

In this paper, intramuscular coronary arteries were divided into the following 2 groups according to their diameter.

1) Coronary arteriolo-intramuscular coronary arterioles smaller than 80μ in diameter

Table I (a)

Case No.	Age	Intramuscular coronary artery							Coronary stem		Cause of death	Complication	
		P.I.	Intima				P.I. of media	Stenotic index	Athe-roma	Grade of stenosis			
			P.I. of intima	Fibrosis	Hyalini- zation	Fibro- elastosis							Oth- ers
1	75	58	52	16	10	36	26	40	50	+	-	Bronchitis	Asthma bronchiale
2	62	32	21	6	8	17	7	31	21	##	+	Liver cirrhosis	Hypertension
3	55	50	41	16	8	8	17	41	42	+	-	Pneumonia	Myasthenia gravis
4	56	39	29	3	16	10	10	18	29	+	-	Asphyxia	Syphilis
5	63	56	36	20	5	18	11	41	26	+	+	Cerebral hemorrhage	Hypertension
6	78	70	50	10	10	36	10	40	43	+	-	Pulm. tbc.	
7	60	87	62	50	10	48	2	50	50	+	+	Pneumonia	
8	72	56	50	26	0	48	14	50	36	+	-	Stomach cancer	Asthma bronchiale
9	49	46	37	9	9	30	12	30	35	-	-	Hepatitis	Hypertension
10	56	82	75	46	0	38	4	71	72	+	+	Cerebral hemorrhage	
11	62	70	51	21	6	34	13	58	33	+	+	Heart failure	Hypertension
12	50	90	65	41	1	38	14	80	50	+	+	Liver cirrhosis	
13	56	87	64	39	3	36	18	74	38	+	-	Stomach cancer	
14	59	91	77	50	0	61	20	85	71	+	+	Coronary heart dis.	
15	84	79	72	23	4	65	25	72	65	+	+	Myocardial infarction	
16	68	85	72	20	4	64	18	65	67	+	##	Encepholomalacia	
17	83	88	76	10	15	70	23	77	67	+	+	Myocardial infarction	Hypertension
18	62	65	57	31	12	51	6	49	53	+	-	Thyroid cancer	Hypertension
19	88	100	83	51	3	80	9	97	73	+	-	Hypertensive heart dis.	
20	65	60	33	29	3	30	1	65	33	+	-	Cerebral hemorrhage	Hypertension
21	59	43	34	22	0	30	8	43	30	+	+	Aortic insufficiency	Syphilis
22	72	76	76	33	5	58	16	66	56	+	+	Hypertensive heart dis.	
23	61	65	55	36	4	41	10	61	39	+	+	Cerebral hemorrhage	
24	67	55	33	18	4	30	6	44	24	+	-	Liver cirrhosis	
25	57	81	69	51	8	72	2	76	69	+	##	Coronary heart dis.	Myocardial infarction

P.I. : Pathologic Index.

Table I (b)

Case No.	Age	Intramuscular coronary artery										Coronary stem		Cause of death	Complication
		P.I.	Intima				P.I. of media	Stenotic index	Atheroma		Grade of stenosis				
			P.I. of intima	Fibrosis	Hyalinization	Fibro-elastosis			Others	Atheroma					
26	40	63	63	55	0	35	59	4	54	++	##	Myocardial infarction	Liver cirrhosis Hypertension		
27	61	75	60	22	20	50	65	8	55	++	##	Pneumonia			
28	47	61	57	16	9	38	42	21	51	++	++	Stomach cancer			
29	68	64	61	9	51	48	58	0	61	++	-	Uremia			
30	63	62	42	18	18	41	62	4	39	++	+	Cerebral hemorrhage			
31	73	92	89	10	12	86	88	16	86	++	##	Cancer of gallbladder	Hypertension		
32	73	100	100	64	12	72	92	12	88	##	##	Myocardial infarction			
33	67	94	94	62	6	86	84	4	86	##	##	Cerebral hemorrhage	Myocardial infarction		
34	40	38	30	22	5	21	34	3	23	-	##	Accident			
35	58	63	16	12	3	12	63	0	14	##	++	Liver cirrhosis			
36	50	70	56	40	10	43	68	4	48	##	##	Myocardial infarction	Diabetes		
37	40	51	37	21	3	21	37	6	26	-	-	Intoxication			
38	52	62	58	46	9	42	55	2	48	+	+	Accident	Hypertension		
39	70	81	79	70	4	72	73	3	79	##	##	Myocardial infarction			
40	63	51	44	37	2	39	44	2	43	++	-	Bronchitis			
41	56	50	41	35	4	39	50	0	39	++	##	Asthma bronchiale	Hypertension		
42	81	51	48	22	6	40	48	10	38	++	##	Cerebral hemorrhage			
43	68	63	63	30	3	48	51	16	51	++	-	Hepatitis			
44	57	55	43	16	10	38	43	8	32	++	++	Cerebral hemorrhage			
45	70	42	38	32	0	30	42	4	38	++	+	Chronic hepatitis			
46	61	52	45	31	1	31	42	6	42	+	-	Encephalomalacia	Hypertension		
47	73	51	49	21	4	32	38	15	43	++	+	Cerebral hemorrhage			
48	54	63	54	21	4	32	45	12	54	++	+	Cerebral hemorrhage			
49	63	92	92	78	0	88	92	8	92	++	+	Coronary heart dis.			
50	74	41	41	16	0	32	29	14	38	+	+	Pneumonia			

P.I.: Pathologic Index.

2) Small coronary artery-intramuscular coronary arteries ranging from 80μ to 500μ in diameter

The pathological changes of the small coronary arteries were observed microscopically and classified. The "Pathologic Index" expressing the grade of pathological changes of the vessels was determined as follows:

$$\text{Pathologic Index} = \frac{\text{number of arteries with pathological changes}}{\text{total number of arteries in a specimen}} \times 100$$

The "Stenotic Index" expressing the grade of stenosis of these vessels was determined as follows:

$$\text{Stenotic Index} = \frac{\text{number of arteries with stenotic changes}}{\text{total number of arteries in a specimen}} \times 100$$

The severity of atherosclerosis of the coronary arterial stem was standardized as follows;

- : with no atheromatous lesion
- + : with slight atheromatous lesions but the most of the intima are intact macroscopically
- ++ : with moderate atheromatous lesions which invade about a half of the arterial inner surface macroscopically
- +++ : with severe atheromatous lesions involving the most of the intimal surface

The grade of stenosis of the coronary arterial stem was standardized as follows;

- : without any stenosis
- + : with stenosis of about one third of the lumen
- ++ : with stenosis of about one half of the lumen
- +++ : with stenosis of about two-third of the lumen
- ++++ : the lumen of only pin-hole size or completely occluded

RESULTS

The pathological changes of the arteriole (smaller than 80μ in diameter) were very rare and seemed to play no significant role in the cause of the myocardial fibrosis from the following basis: (A) As far as arteriolar pathology was concerned stenotic lesions which might cause circulatory disturbances were very rare. (b) The fibrotic lesions of the myocardium were not distributed in such a way as to be presumed to have originated around this sized arteriole. (c) Even the most minimum sized myocardial fibrosis lesion was too large to be considered as caused by the pathology of such a small sized arteriole. Accordingly particular attention was paid upon the small coronary arteries ranging from 80μ to 500μ in diameter.

I. The pathological changes of small coronary arteries

The pathological changes of the intima of these arteries were as follows: (a) atheroma formation (Fig. 1), (b) fibrosis (Fig. 2), (c) hyalinization (Fig. 3), (d) fibro-elastosis (Fig. 4), (e) duplication and multiplication

Fig. 1. Atheroma formation. 10× Mallory No. 18

Fig. 2. Intimal fibrosis. 100× Weigert No. 21

Fig. 3. Hyalinization of the intima. 400× Haematoxylin-Eosin No. 15

Fig. 4. Fibro-elastosis. 100× Weigert No. 20

Fig. 5. Multiplication of internal elastic lamina. 100× Weigert No. 1

Fig. 6. Focal proliferation of internal elastic lamina. 100× Weigert No. 21

of internal elastic lamina (Fig. 5), (f) focal proliferation of elastic fiber (Fig. 6). The pathological changes of the media were those of hypertrophy, atrophy and fibrosis. The incidence of these changes are shown in Table I. The sum of the percentage of the pathological changes of the intima showed a higher value than the "Pathologic Index" of the intima, because more than 2 types of lesions were found in a single vessel. Atheroma formation was a rather exceptional finding in these small arteries and only rarely found in limited cases. Changes of the elastic lamina were very common in the papillary muscle and the percentage of this change was relatively high. In the arteries of the wall, the predominant lesion was fibrosis and hyalinization of the intima. All intimal changes usually showed a stenosis of the lumen, while the changes of the media had no such stenotic tendency.

II. Sclerosis of the small coronary artery and age

In Fig. 7, the incidence of these pathological changes was plotted

Fig. 7. Pathologic index of intramuscular coronary artery and age.

Fig. 8. Age and stenotic index of intramuscular coronary artery.

against the age. The "Pathologic Index" of I.M.C.A. showed no tendency to increase with age, and was already high even in ages as early as before

the fifth or sixth decade. However, the "Stenotic Index" of I.M.C.A. showed some tendency to increase with age (Fig. 8). The correlation between these could be expressed by the following formula,

$$Y=0.62X+8.7 \text{ (Y: Stenotic Index, X: Age).}$$

Fig. 9. Pathologic index of intramuscular coronary artery and severity of atherosclerosis of coronary arterial stem. C.A.S.: Coronary arterial stem.

Fig. 10. Stenotic index of intramuscular coronary artery and severity of atherosclerosis of coronary arterial stem. C.A.S.: Coronary arterial stem.

III. Sclerosis of the small coronary artery and athero sclerosis of the coronary arterial stem

As a means to consider the pathogenesis of small arterial sclerosis, the "Pathologic Index" of I.M.C.A. was compared with the degree of atherosclerosis of the coronary stem (Fig. 9 and 10).

As seen in Fig. 9, there were a number of cases with a high "Pathologic Index" of I.M.C.A. even in cases with slight (+) atheromatous

Fig. 11. Pathologic index of intramuscular coronary artery and grade of stenosis of coronary arterial stem.

Fig. 12. Stenotic index of intramuscular coronary artery and the grade of stenosis of coronary arterial stem.

changes of the coronary stem, while a low "Pathologic Index" of I.M.C.A., such as 32%, in cases with severe (++) atheromatous change of the coronary stem, thus meaning no clear correlation between atheroma and small arterial sclerosis. Further, there was no clear parallel correlation between the "Stenotic Index" of I.M.C.A. and severity of atherosclerosis of the coronary stem as shown in Fig. 10.

The grade of stenosis of the coronary stem was not parallel with the "Pathologic Index" and "Stenotic Index" of I.M.C.A. (Fig. 11 and 12). The changes of the intramuscular coronary arteries seemed to occur independently of the atherosclerosis of the coronary stem.

IV. Sclerosis of the small coronary artery and hypertension

In order to clarify the etiological meaning of hypertension for small coronary arteriosclerosis, the "Pathologic Index" and "Stenotic Index" of I.M.C.A. of 23 hypertensives were compared with those of normotensives. As seen in Fig. 13, the "Pathologic Indexes" of I.M.C.A. of hypertensives

Fig. 13. Pathologic index and stenotic index of intra-muscular coronary artery and blood pressure.

were distributed between 32% and 100%, 68% in average, while those of normotensives were distributed between 39% and 91%, 64% in average; showing no obvious difference between them. The average value of the "Stenotic Index" of I.M.C.A. of hypertensives was 51% and that of normotensives 46%, no significant difference being detected here also. It seemed

likely that small coronary arteriosclerosis would not be caused or accelerated by hypertension.

V. Sclerosis of the small coronary artery and myocardial fibrosis

From the possible relation to vascular disease, myocardial fibrosis was divided into the following 3 types according to the distribution, size or relation to the small vessels.

(1) Infarct type (Fig. 14): Large or small single localized fibrotic lesion, or sharply defined multiple patchy fibrosis which were considered as healed myocardial infarction. This type was expected to have to have a high causal relation to circulatory disturbances. (2) Perivascular type (Fig. 15): Dominantly perivascular fibrotic lesions, of which some could be possibly caused by circulatory disturbances and some by inflammation or systemic factors. (3) Diffuse type (Fig. 16): Diffusely scattered fibrosis in the myocardium which were considered mostly to be caused by systemic factors such as malnutrition, anemia or intoxication. These 3 types of myocardial fibrosis could not always be clearly defined; cases with mixed type or coexistence of 2 types were found. The predominant type of fibrosis was represented for the case.

Fig. 14. Infarct type of myocardial fibrosis. 40× Mallory No. 47

Fig. 15. Perivascular type of myocardial fibrosis. 40× Mallory No. 1

Fig. 16. Diffuse type of myocardial fibrosis. 40× Mallory No. 4

Table II. Severity of Atherosclerosis of Coronary Arterial Stem and Type of Myocardial Fibrosis

Type \ Severity	—	+	++	+++	Total
Infarct type	0	7	9	5	21
Perivascular type	0	5	5	0	10
Diffuse type	4	7	6	1	18
Total	4	19	20	6	49

Table III. Grade of Stenosis of Coronary Arterial Stem and Type of Myocardial Fibrosis

Type \ Grade	—	+	++	+++	####	Total
Infarct type	5	5	3	4	4	12
Perivascular type	5	2	2	1	0	10
Diffuse type	8	6	3	1	0	18
Total	18	13	8	6	4	44

In Table II and III, the severity of atherosclerosis and the grade of stenosis of the coronary arterial stem were compared with each type of myocardial fibrosis. As shown in Table IV, the type of myocardial fibrosis showed some correlation to the severity of atherosclerosis in the coronary arterial stem; a high incidence of the infarct type was seen in the group with moderate (++) and severe (+++) sclerosis of the coronary arterial stem. As shown in Table III, the diffuse type and perivascular type were not seen in the group with severe stenosis (++) and occlusion (####) of the coronary arterial stem, and the infarct type showed no tendency of predomination in any grade. There were 7 cases of the infarct type in the group with slight (+) atherosclerosis (Table II), which showed these myocardial fibrosis were not due to atherosclerosis of the coronary arterial stem. In Table IV and V, the "Pathologic and Stenotic Index" were compared with

Table IV. Pathologic Index of I.M.C.A. and Type of Myocardial Fibrosis

Type \ Index	0-40%	41-60%	61-80%	80-100%	Total
Infarct type	0	2	9	10	21
Perivascular type	0	6	1	3	10
Diffuse type	3	9	5	1	18
Total	3	17	15	14	49

Table V. Stenotic Index of I.M.C.A.
and Type of Myocardial Fibrosis

Type \ Index	0-40%	41-60%	61-80%	81-100%	Total
Infarct type	3	7	6	5	21
Perivascular type	4	5	1	0	10
Diffuse type	14	4	0	0	18
Total	21	16	7	5	49

I.M.C.A. : Intramuscular coronary artery

each type of myocardial fibrosis: most of the infarct type lesions showed a high "Pathologic and Stenotic Index." The average of both indexes are shown in Table VI; they were highest in the infarct type (77% and 62%

Table VI. Pathologic Index and Stenotic Index of
I.M.C.A. and Type of Myocardial Fibrosis

Type \ I.M.C.A.	Pathologic index	Stenotic index
Infarct type	74%	62%
Perivascular type	64%	45%
Diffuse type	53%	36%

I.M.C.A. : Intramuscular coronary artery.

respectively) and lowest in the diffuse type (53% and 36% respectively). Fig. 17 shows the interrelationship between atherosclerosis of the coronary arterial stem or small coronary arteriosclerosis and myocardial fibrosis. The cases with the infarct type of myocardial fibrosis (black point) were more frequent in the cases with higher grade of small coronary stenosis ("Stenotic Index" 51% or more) or in the cases with severe (++) atherosclerosis in the coronary stem.

Actually, 16 cases out of 20 with a "Stenotic Index" of 51% or more showed the infarct type of fibrosis, and even as many as 13 cases out of these 16 showed only a moderate (++) or slight (+) degree of atherosclerosis of the coronary stem, which would obviously suggest the definite etiological importance of the small coronary stenosis for the myocardial lesions. As for the perivascular and the diffuse type of fibrosis, most of these cases were plotted below the 51% line of the "Stenotic Index." This seemed to show the fact that only the infarct type of myocardial fibrosis could be pathognomonic for the vascular pathology.

VI. Sclerosis of the small coronary artery and some clinical signs

As has been mentioned above, the infarct type of myocardial fibrosis

Fig. 17. Stenotic index of intramuscular coronary artery, severity of atherosclerosis of coronary arterial stem and the type of myocardial fibrosis.

can arise without severe atherosclerosis of the coronary stem. From the clinical standpoint, it is of great interest to determine whether the infarct type of fibrosis without atherosclerosis in the coronary stem could cause any clinical symptom or sign. To clarify this problem, the cases with the infarct type were divided into 2 groups according to their clinical symptoms, namely, (a) with angina (Table VII a) and (b) without angina (Table VII b). As seen in Table VII a and VII b, in the cases with angina the average "Pathologic Index" was 74% and the "Stenotic Index" was 63%, and in the cases without angina the average values were 74% and 60% respectively; there were no difference between the former and the latter. But in respect to the severity of atherosclerosis of the coronary arterial stem, there was a significant difference between (a) and (b); in the cases with angina, severe atherosclerosis and stenosis of the coronary arterial stem were apparently more frequent than in the cases without it. In other words, angina pectoris seems to be based on atherosclerosis of the coronary stem, while the lesions in the small coronary artery may develop without this clinical syndrome.

Table VII (a) Analysis of Myocardial Scars; with Anginal Signs.

Case No.	Age (yrs.)	I.M.C.A.		C.A.S.	
		P.I.%	S.I.%	Atheroma	Stenosis
2	62	32	21	##	++
23	59	43	27	+	-
27	67	81	69	++	-
35	73	100	88	##	##
36	67	94	86	##	##
40	50	70	46	##	##
43	70	81	79	##	##
53	63	92	92	++	+
Average	64	74%	63%		

I.M.C.A.: Intramuscular coronary artery

C.A.S.: Coronary arterial stem

P.I.: Pathologic Index

S.I.: Stenotic Index

Table VII (b) Analysis of Myocardial Scars; without Anginal Signs

Case No.	Age (yrs.)	I.M.C.A.		C.A.S.	
		P.I.%	S.I.%	Atheroma	Stenosis
3	55	50	42	+	-
12	56	82	72	+	+
16	59	91	71	++	##
17	84	79	65	++	+
19	83	88	67	++	+
21	88	100	73	+	-
32	68	64	61	+	-
33	63	62	39	+	+
51	73	51	43	+	+
47	68	63	51	+	-
52	54	63	54	++	+
34	73	92	86	++	##
Average	68	74%	60%		

DISCUSSION

There are few investigations concerning the pathology of I.M.C.A. in relation to resultant myocardial changes and its clinical significance.

Gross²⁰ studied the changes in arteries of intramyocardium with age. He observed a high incidence of the proliferation of elastic fiber of the media in the posterior papillary muscle of the left ventricle even in the

newborn, and suspected that this change was to be the preface of the elastic-hyperplastic changes of the vessels frequently seen at the beginning of third decade and increasing with age. He was especially interested in the fact that these changes were highest in frequency and severity in an area where myocardial infarction was most frequent. However, he considered that myocardial infarction was not the result of sclerosis of these small coronary arteries but caused by the occlusion of a larger coronary artery, though the former might contribute to the myocardial disease through the diminished collateral circulation. Saphir²¹⁾ examined 100 cases of autopsy and found that 82 showed changes remnant of inflammation, which he assumed to be an important cause of this type of lesions of I.M.C.A., however, he did not mention the influence of these small arterial changes in the myocardium. Blumenthal²²⁾ also observed the same change of I.M.C.A. and found that the cell-proliferative type was especially frequent in diabetes mellitus, but he too did not recognize any clinical significance of such changes of the vessels.

In the present study, atheroma formation was observed only in few cases and only in the vessels of 400μ in diameter at the smallest, which seemed to be the limit of the size for atheromatosis. The predominant changes of the small coronary arteries were fibrosis and fibro-elastosis of the intima and fibrosis of the media, similar to Gross' findings. Though the accurate incidence of these changes in relation to the age is not known, if the changes develop in the early period of life as Gross stated, it is reasonable that the authors found a high incidence of these changes in the early period of fifth decade. Shozawa²³⁾ also found a high frequency of the lesions in the small artery.

As for the pathogenesis of these changes of I.M.C.A., Gross considered it as a result of aging process and Saphir as the remnant of inflammatory changes. Shozawa stated that the cause might be due to circulatory disturbance of the small arterial wall which was caused by contraction of hypertrophied media of the extramyocardial coronary artery because of the intimate correlation between the grade of medial hypertrophy and the frequency of the small coronary arterial changes.

From the comparison of the clinical description and the incidence of these small arterial lesions, hypertension seemed to have no causal relation to these lesions as Shozawa and Saphir recognized before. The lesion also develops quite independently of atheromatosis in the coronary stem, which seems to deny a common etiology for these 2 types of arterial pathology. Shozawa, too, stated the same idea and deemed it to have a different pathological entity from atherosclerosis.

As for the causal relationship of these small arterial lesions to the myocardial pathology, most of the authors except Gross had paid little

attention. As a practical mean to pursue this problem, it is very difficult to study the correspondence between a single arterial lesion and myocardial lesion, because in such small sized arteries (40μ to 200μ) collateral circulation may easily develop as Schlesinger stated. From these standpoints, a certain number of arterial lesions should contribute to cause a single or several myocardial lesions and no clear single relation between these is to be expected. This was the reason why the authors used the incidence of the arterial lesions ("Pathologic and Stenotic Index") in this study. So, in comparison of the small arterial and myocardial lesions, the possible causal influence of lesions of the coronary stem on the myocardium should always be kept in mind. Among our cases some with a marked myocardial fibrosis of the infarct type, which is most highly suggestive of circulatory disturbances, had marked small arterial lesions and no remarkable narrowing of the coronary stem. Of course, there are many factors other than vascular which produce myocardial fibrosis. However, according to the authors' study all the cases with the infarct type of fibrosis showed a "Stenotic Index" of I.M.C.A. over 51% whereas the cases with other types of fibrosis showed a lower percentage of the Index. This shows that if more than half of the small arteries be stenotic then ischemic myocardial lesion may result.

As for the relation of vascular lesions to ante-mortem clinical features, 7 cases out of 8 with definite angina pectoris showed a moderate or severe grade of atherosclerosis in the coronary stem, while all the cases without angina showed no severe atherosclerosis even though some of them had marked myocardial fibrosis with small arterial lesions (Table VII a and VII b). This indicates that angina pectoris is highly related with atherosclerotic narrowing of the coronary stem, and the coronary arteriolar lesions with the silent cardiac failure. The cases with high "Stenotic Index" of I.M.C.A., above 51%, and without severe atherosclerosis of the coronary stem are selected in Table VIII. In these cases, 5 out of 7 had the clinical course of chronic heart failure which might be caused by patchy fibrosis of the myocardium. Laurie and Wood²⁵⁾ stated a similar idea from their comparison of coronary heart disease in the Bantu and European; the characteristics of ischemic heart disease in the Bantu is patchy fibrosis of the myocardium in the early stage which is considered as minute infarction progressing without pain.

As generally believed, atherosclerosis is closely related to the dietary fat intake,²⁶⁾ but among Japanese, a people of low fat diet, acute coronary heart disease such as angina pectoris or infarction are not so frequent and most of the coronary cases are of the silent type with cardiac decompensation. The fact seems to support the idea that besides atherosclerosis, coronary arteriolar sclerosis could also be an important cause for the

Table VIII. Myocardial Fibrosis Considered Due to the Changes of I.M.C.A.

Case No.	Age	C.A.S.		I.M.C.A.		Clinical course
		Atheroma	Stenosis	P.I.	S.I.	
10	56	+	+	82	72	Cerebral hemorrhage
21	88	+	—	83	73	Chronic heart failure
24	72	+	+	76	56	Chronic heart failure, X-ray, ECG abnormal
32	68	+	—	64	61	Chronic heart failure, stomach cancer
47	68	+	—	63	51	Chronic heart failure, ECG abnormal
52	54	++	—	63	54	Chronic heart failure, hemiplegia
53	63	++	+	92	92	Chronic heart failure

coronary heart disease, especially of the silent type, which is so common in this country.

SUMMARY

(1) Intramuscular coronary arterial (I.M.C.A.) (80–500 μ) sclerosis as a cause of myocardial disease was studied pathologically.

(2) I.M.C.A. sclerosis was found in high incidence in the cases over 40 years of age, and the tendency of stenosis of the vessels with the lesions increased with age.

(3) The lesions was independent of atherosclerosis of the coronary arterial stem or ante-mortem hypertension.

(4) Severe lesions of this type was considered to be a cause of definite myocardial lesions without atherosclerosis in the coronary arterial stem, and its clinical feature seemed to be a cardiac decompensation without anginal pain.

(5) In addition to atherosclerosis of the coronary arterial stem, I.M.C.A. sclerosis could be an important cause of coronary heart disease, especially in people with a low grade of atherosclerosis such as the Japanese.

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