

Indication of aortocoronary by-pass for coronary arterial obstruction due to Kawasaki disease

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Summary. Six patients with coronary arterial lesions due to Kawasaki disease underwent aortocoronary by-pass grafting at our institute. Before surgery, all of them had been closely monitored for some years by means of selective coronary arteriography, thallium myocardial imaging, electrocardiography (treadmill and/or Holter), and two-dimensional echo cardiography. Based on this experience, we propose the following guidelines as an indication for aortocoronary by-pass in such patients. First, the following three conditions should be satisfied: 1) The progress of coronary arterial lesions has been documented by serial selective coronary arteriography; 2) redistribution to the perfusion defect has been detected on the delayed image in myocardial imaging; 3) no coronary arterial lesions distal to the graft site have been detected by coronary angiography. When these three conditions are satisfied, at least one of the following conditions must apply: 1) Localized stenosis in the left main trunk has progressed to critical stenosis; 2) there is occlusion of two or more vessels; 3) collateral vessels connecting to the peripheral portion of an occluded coronary artery arise from the peripheral part of a vessel with progressive localized stenosis; 4) progressive localized stenosis or critical stenosis has developed in the left anterior descending artery, in addition to significant stenosis in the right coronary artery.

Key words: Kawasaki disease – Coronary arterial lesion – Aortocoronary by-pass.

[1–6]. However, we have previously reported that the fate of stenotic lesions of the coronary artery in Kawasaki disease is different from that in adult ischemic heart disease in several respects [9, 10]. For example, many stenotic lesions progress in Kawasaki disease and the vessel may become completely occluded without any apparent symptoms. In such cases, a marked development of the collateral vessels is usually seen and recanalization is often observed. On the other hand, sudden death occasionally occurs, even several years after the onset of Kawasaki disease. Thus, it is conceivable that the application of aortocoronary by-pass grafting in cases of Kawasaki disease should be decided after careful observation of the progress of coronary arterial lesions, in view of the long-term prognosis. In the present study, we retrospectively examined six patients with coronary arterial obstruction due to Kawasaki disease who underwent aortocoronary by-pass grafting, in order to establish a standard for indication of aortocoronary by-pass in patients with Kawasaki disease.

Follow-up cases with coronary arterial lesion

Thus far, 1000 patients with a history of Kawasaki disease have been studied using selective coronary arteriography at our institute. Of these, coronary arterial lesions were detected in 246 cases, all of which are being monitored carefully by means of serial coronary arteriography to determine their prognosis. Occlusion, segmental stenosis, and/or critical stenosis were noted in 47 cases (19%), 19 of which have a history of myocardial infarction. To date, 188 of the 246 cases have undergone a second coronary arteriogram after a 1-year interval and any changes in the arteriographic findings were evaluated. As a result, new lesions or aggravation of existing stenotic lesions were detected on the second angiogram in 25 cases (13%); moreover, the majority of these cases had exhibited no obvious symptoms. Other than this, four patients died before

To date there have been more than 30 cases reported in Japan [1–6] and two cases in America [7, 8] of aortocoronary by-pass grafting for coronary arterial lesions due to Kawasaki disease. As an indication for this procedure, the standard for application of aortocoronary by-pass grafting in adult patients with ischemic heart disease has been arbitrarily applied

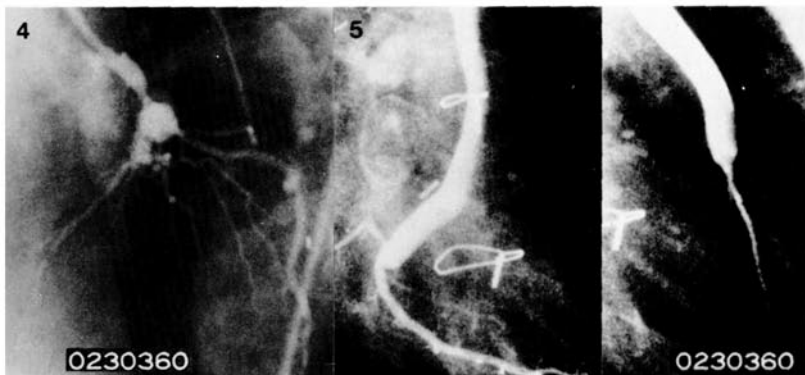
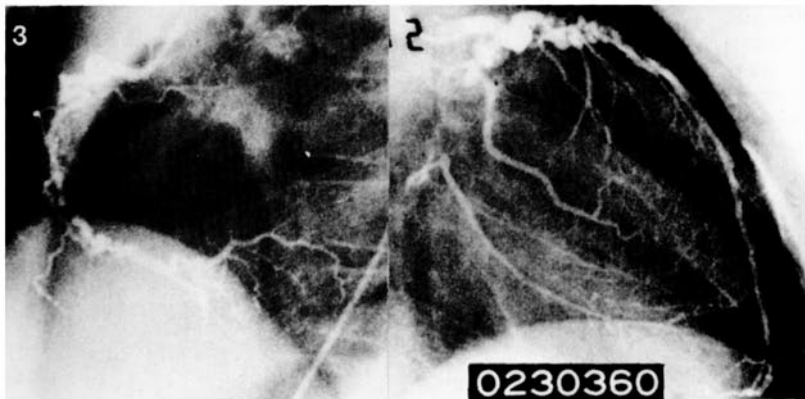
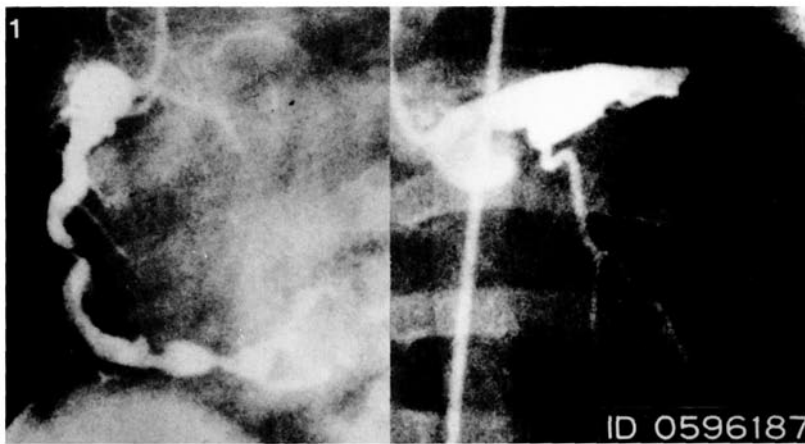


Fig. 1. Selective coronary arteriography in an 11-month-old boy 5 days before sudden death. In the right coronary artery, multiple aneurysms with irregularity of the wall and a 99% localized stenosis are evident. A large left coronary aneurysm is also present

Fig. 2. In the cross section of the heart, areas of acute myocardial infarction in the posterior part of the ventricular septum and posterior walls of both ventricles, including the left ventricular papillary muscle, are present. Old myocardial infarction is found in the posterior part of the ventricular septum

Fig. 3. Selective coronary arteriograms of case 1 at 13 years of age. Onset of disease at 1 year of age. Segmental stenosis in the right coronary artery (*left*) and in the left anterior descending artery (*right*) evident. Occlusion of the left circumflex artery (*right*) with collateral supply is present.

Fig. 4. Selective left coronary arteriogram of case 1 in the third study. The aneurysm of the left main trunk has persisted and a localized stenosis at the inlet of the aneurysm has become more severe

Fig. 5. Selective coronary arteriograms of case 1 following coronary arterial by-pass surgery. Satisfactory patency of the saphenous vein grafts to the left anterior descending and right coronary arteries is evident

undergoing the second coronary arteriogram. One of these was a male infant who suffered from Kawasaki disease at the age of 11 months. Coronary arteriography 2 months after the onset of disease revealed aneurysms and a 99% localized stenosis in the right coronary artery and a large aneurysm in the left coronary artery (Fig. 1). Five days after the angiographic study, the patient had an episode of sudden screaming followed by cardiac arrest. In a cross section of the heart, areas of acute myocardial infarction were detected in the posterior part of the ventricular septum and posterior walls of both ventricles, including the left ventricular papillary muscle. Furthermore, evidence of an old myocardial infarction approximately 7 mm in diameter was found in the posterior part of the ventricular septum (Fig. 2). Although there are many cases with occlusion of the right coronary artery, they

do not usually show any symptoms except in some instances abnormal Q-waves were seen in the electrocardiogram. The 11-month-old patient can be considered a rare case in that he died from localized stenosis of the right coronary artery. Cardiac arrhythmias secondary to myocardial infarction, rather than pump failure, could have been responsible for his sudden death. We had another six patients who were considered to be at high risk of sudden death due to significant coronary arterial stenotic lesions and who underwent aortocoronary by-pass surgery. Their ages at surgery ranged from 3 to 15 years; postoperatively, they have been followed-up for 8 months to 2 years. Their pre-operative work-up included thallium myocardial imaging in addition to coronary arteriography. In all of these cases, redistribution was detected in 2-h delayed imaging. Before the operation, exercise elec-

trocardiographic studies (Master's test and the treadmill test) were performed in five cases. In the treadmill test, significant ST depression was detected in all five cases. Moreover, the performances of the right and left ventricles before the operation were all within the normal range (Tables 1, 2).

Case reports

Case 1 is a boy with a history of Kawasaki disease from the age of 1 year 9 months. During first catheterization, which was performed at the age of 13 years 9 months, a segmental stenosis was detected in the right coronary artery. The left circumflex artery showed an occlusion at the inlet of the calcified aneurysm, and a segmental stenosis was observed in the left anterior descending artery (Fig. 3). Furthermore, there was an aneurysm in the left main trunk; at its inlet, localized stenosis was also detected. This patient underwent coronary arteriographic study on three more occasions, and the serial angiograms revealed progressive aggravation of the stenosis of the left main trunk. The patient underwent aortocoronary by-pass grafting after the third arteriogram at the age of 15 years. Figure 4 shows the left main trunk on the third coronary arteriogram. Aortocoronary by-pass grafting was performed on two vessels, the left anterior descend-

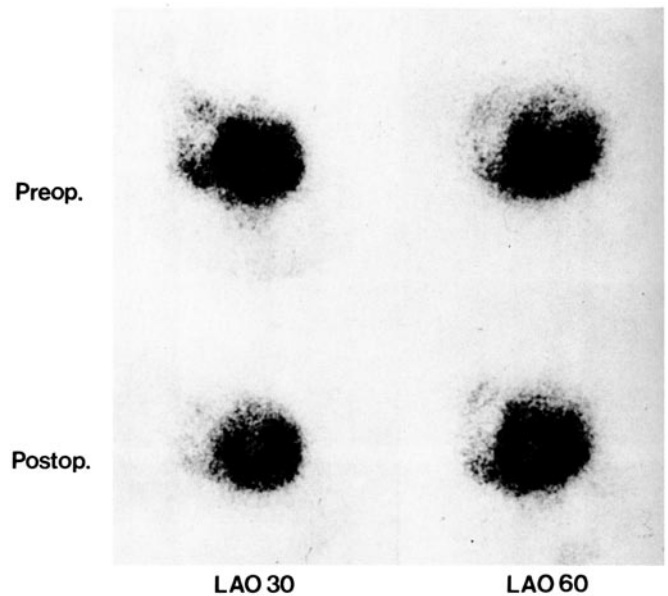


Fig. 6. Thallium myocardial imaging of case 1. There was a pre-operative perfusion defect in the posteroinferior left ventricular myocardium, which disappeared completely following by-pass surgery

Table 1. Cases with aortocoronary by-pass after Kawasaki disease

Case no.	Age at		First CAG findings				Changes in CAG findings	Date at ACB	By-pass
	onset	ACB	LMT	LAD	Cx	RCA			
1 (0230360)	1 y 9 m	15 y	LS, DiL	SS	Oc	SS	LS↑ (LMT)	8.9.82	LAD ^a Cx ^a
2 (0487216)	3 y	15 y	Dil	Oc	LC	Oc	No change	22.7.83	LAD ^a
3 (0483298)	3 y 4 m	5 y	—	An	—	An	Oc (LAD + RCA)	25.8.83	LAD ^b
4 (0496432)	5 y 3 m	7 y	—	LS, An	—	LS, An	No change	7.11.83	LAD ^b
5 (0509174)	2 y 8 m	12 y	An	LS, An	—	Oc	LS↑ (LAD)	7.2.84	LAD ^b RCA ^a
6 (0475293)	9 m	3 y	—	LS, An	—	SS	OC (LAD)	20.4.84	LAD ^b

Oc occlusion (100%), *SS* segmental stenosis, *LS* localized stenosis, *An* aneurysm, *Dil* dilation, *ACB* aortocoronary by-pass, *CAG* coronary arteriography, — not performed

^a Saphenous vein graft

^b Left internal mammary artery

Table 2. Cases with aortocoronary by-pass after Kawasaki disease

Case no.	Pre-op. symptoms	Pre-op.		Post-op.		Perfusion defect on myocardial imaging		LVEF		Evaluation by post-op. CAG
		MD	TM	MD	TM	pre-op.	post-op.	pre-op.	post-op.	
1	No	+	+	—	—	Ap, IW	Ap, IW	0.66	0.71	Good
2	Chest pain, faintness	—	+	—	—	Ap, IW, As	Ap, IW	0.60	0.58	Good
3	No	+	+	+	+	Ap, IW, As	Ap, IW, As	0.63	0.55	Fair
4	No	—	+	—	—	As	As	0.65	0.75	Good
5	Chest pain	+	+	—	—	Ap, IW, As	Ap, IW	0.68	0.73	Good
6	Chest pain	/	/	—	—	Ap, IW, As	Ap, IW, As	0.62	0.69	Good

MD ECG master double, *TM* treadmill, + ST depression, — no ST depression, / not examined, *Ap* apex, *IW* inferior wall, *As* anteroseptal, *CAG* coronary arteriography, *LVEF* left ventricular ejection fraction

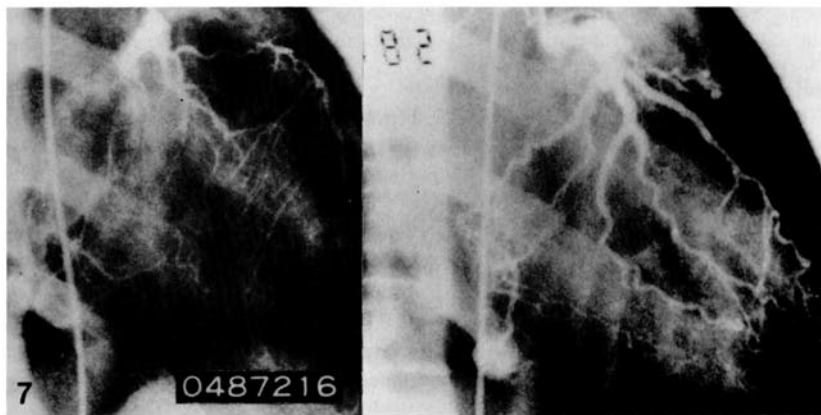


Fig. 7. Selective coronary arteriograms of case 2 at 15 years of age. Onset of disease at 3 years of age. Occlusion of the right coronary artery (*left*) in the proximal portion is evident. There are multiple small collateral vessels, including communication to the left anterior descending artery. The left main trunk is dilated and the left anterior descending artery is occluded. A localized stenosis of the left circumflex artery (*right*) can also be seen

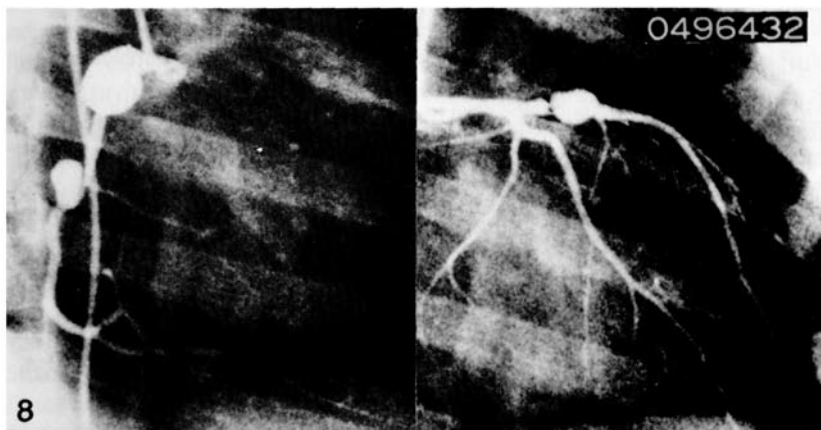


Fig. 8. First coronary arteriograms of case 4. Two aneurysms of the right coronary artery are evident and a 99% localized stenosis occurs at the inlet of the second aneurysm. An aneurysm with 99% localized stenosis at its inlet in the left anterior descending artery is also present

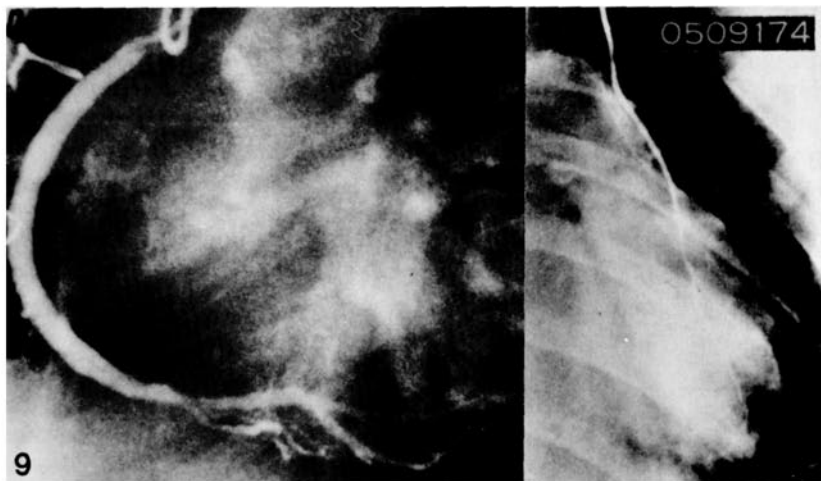


Fig. 9. Coronary arteriograms of case 5 after bypass surgery. The right coronary artery was bypassed using the patient's own saphenous vein, and the left internal mammary artery was anastomosed to the left anterior descending artery

ing artery and the left circumflex artery, using the patient's own saphenous vein as a graft. Figure 5 shows an arteriogram of the bypass, obtained 1 month after the operation. Two years later, patency of the grafts was observed with computed tomography. A comparison of the myocardial imaging during exercise with a bicycle ergometer before and after the operation (Fig. 6) revealed that the perfusion defect detected at the posteroinferior ventricular wall before the operation had disappeared after the operation.

Case 2 is a boy who has had a history of Kawasaki disease from the age of 3 years. The first coronary arteriogram, taken when the patient was 14 years 2 months revealed an occlusion at the proximal portion of the right coronary artery, dilatation of the left main trunk, occlusion of the left anterior descending artery, and localized stenosis at the proximal left circumflex artery. Although no progression of the stenotic lesions was evident on a second arteriogram (Fig. 7) taken 1

year later, a fall in blood pressure was observed in addition to frequent chest pain and ST depression induced by the treadmill exercise. Therefore, this patient was considered to be a candidate for aortocoronary by-pass grafting. Patency of the graft has been confirmed twice by angiographic study 1 month and 1 year after the operation. Chest pain and ST depression during exercise disappeared after the operation.

Case 3 is a boy with a history of Kawasaki disease from the age of 3 years. Coronary arteriography performed at the age of 4 years detected large aneurysms in the right coronary and left anterior descending arteries. On an arteriogram taken 1 year later, occlusions were detected at the inlets of the aneurysms in both the right and left coronary arteries. This patient showed no symptoms or electrocardiographic changes during the observation period, but perfusion defects on myocardial imaging were detected during the second

examination, and significant ST depression due to exercise appeared. The left internal mammary artery was anastomosed to the left anterior descending artery when the patient was aged 5 years. A follow-up angiogram performed 1 month after the operation demonstrated the patency of the by-pass.

Case 4 was a girl with a history of Kawasaki disease from the age of 5 years 3 months. The first arteriogram, taken at the age of 6 years, revealed two aneurysms in the right coronary artery (Fig. 8). At the inlet of the second aneurysm, a 99% localized stenosis was detected in the left anterior descending artery. On the second arteriogram, taken 1 year later, although no apparent changes were detected, the stenosis in the left anterior descending artery was considered to be critical, possibly fatal. Furthermore, a perfusion defect at the anterosseptal portion was clearly detected by myocardial imaging in the second study. The left internal mammary artery was anastomosed to the left anterior descending artery. The patency of the vessel was confirmed 2 months after the operation by angiographic study and 1 year after operation by computed tomography.

Case 5 was a boy with a history of Kawasaki disease from the age of 2 years 8 months. The patient developed recurrent chest pain at the age of 11 years, and the first coronary arteriogram, taken at that time, revealed an occlusion at the right coronary artery and an aneurysm with localized stenosis at its inlet in the left anterior descending artery. The second angiogram, performed 1 year later, demonstrated significant progression of the localized stenosis in the left anterior descending artery; the patient was then considered to require an aortocoronary by-pass graft. The right coronary artery was by-passed, using the patient's saphenous vein as a graft, and the left internal mammary artery was anastomosed to the left anterior descending artery. An angiographic study 2 months after the operation confirmed good blood flow in the graft (Fig. 9). Figure 10 depicts treadmill exercise electrocardiographic findings before the oper-

ation. The ST depression observed before the operation disappeared postoperatively, as did chest pain and the perfusion defect in the anterosseptal portion.

Case 6 was a girl with a history of Kawasaki disease from the age of 9 months. Her first coronary arteriogram, taken at the age of 10 months, revealed an aneurysm and localized stenosis in the left anterior descending artery as well as segmental stenosis in the right coronary artery. The second arteriogram was taken when the patient was 1 year 10 months old; no significant changes from the previous findings were detected. However, the third arteriogram, taken at the age of 3 years 8 months showed complete occlusion of the left anterior descending artery, which was previously stenotic. The third myocardial imaging revealed a perfusion defect at the anterosseptal portion for the first time, in addition to the perfusion defects in the apex and inferior wall portions which had been persistent since the first examination. The left internal mammary artery was anastomosed to the left anterior descending artery at the age of 3 years 10 months. One month after the operation, the graft was angiographically shown to be patent.

Discussion

Aortocoronary by-pass for coronary arterial obstruction due to Kawasaki disease is occasionally indicated, especially in young children; however multiple problems are involved. First of all, anastomosis of the graft to a very small coronary artery requires a very high level of surgical skill. Moreover, growth of the graft used in the by-pass is desirable. Because the long-term patency rate is considered to be lower than in adult patients [1, 2, 4–6] and because the mechanism of the coronary arterial lesion in Kawasaki disease is based on inflammatory changes, the long-term outcome is not yet completely clear. In determining the applicability of by-pass grafting, the possibility of compromised cardiac performance, secondary both to myocardial ischemia and myocarditic changes due to Kawasaki disease, should be taken into consideration [12, 13]. In addition to these factors, the majority of cases with occluded coronary arteries show no symptoms or evidence of heart failure whichever coronary artery is occluded, and remarkable development of collaterals is frequently seen. On the other hand, the mechanism of sudden death due to Kawasaki's disease has not yet been clarified. As we mentioned above, sudden death due to arrhythmia appears to be a likely possibility. Thus, at present, aortocoronary by-pass grafting is not necessarily to be widely recommended as a therapeutic method for coronary arterial obstruction due to Kawasaki disease. Accordingly, application of aortocoronary by-pass grafts in patients with coronary stenotic lesions of Kawasaki disease should be limited to patients with definite indications. At present, the standard for indication of aortocoronary by-pass in the case of coronary arterial obstruction due to Kawasaki disease has not been established, the operative indication being based on the aortocoronary by-pass standard for arteriosclerotic coronary arterial obstruction in adult patients [1–6]. As we reported previously [9, 10, 14], the fate of coronary arterial

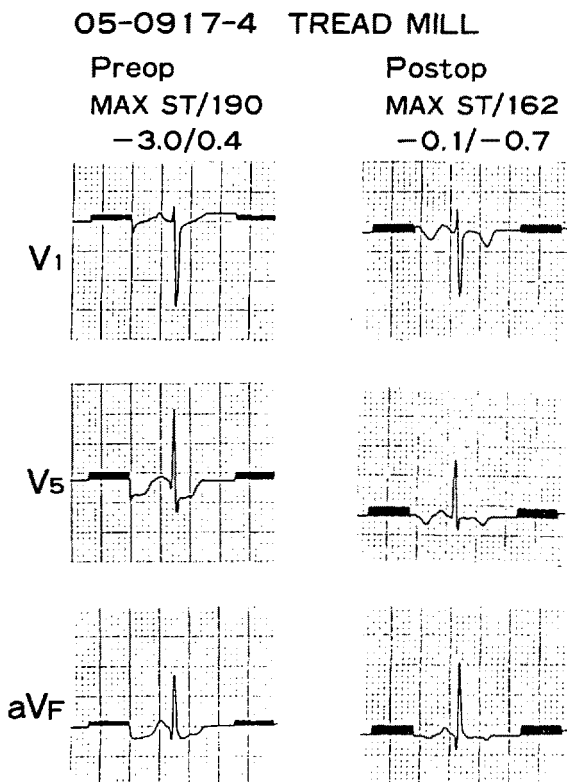


Fig. 10. Findings in the treadmill test in case 5. Significant ST depression was observed preoperatively, but no more ST changes were noted after surgery

lesions due to Kawasaki disease is quite different from that of adult arteriosclerotic lesions, in that they have very different sequelae. First, the majority of the aneurysms tend to become smaller within a relatively short time (several months to 1 year), whereas some stenotic lesions appear and progress continuously over a long time. Aneurysms in the right coronary artery are more susceptible to occlusion and recanalization (segmental stenosis). Segmental stenosis shows no further stenotic aggravation, but there is gradual improvement in the degree of stenosis. Localized stenosis in the left coronary artery exhibits a significantly higher frequency of aggravation than in the right coronary artery. The localized stenosis is usually found at the inlet and/or outlet of an aneurysm. The aggravation of stenotic lesions is generally unaccompanied by apparent symptoms. Even in the presence of serious stenotic lesions in multiple vessels, cardiac performance at rest remains within the normal range in the majority of cases. The development of multiple collateral vessels is very remarkable. In a pathological study remarkable proliferative intima of coronary arteries were diffusely observed from proximal to distal branches [13].

Based on these observations, we consider the conditions listed below as indicating the need for aortocoronary by-pass graft in cases of Kawasaki disease. These criteria seem to be more limited than the indication for aortocoronary by-pass surgery in adult patients. One reason for this is that the first three conditions need to be satisfied even though the coronary arterial stenosis may be severe. First, it should be clear that the stenotic lesion is definitely progressive, as documented by coronary arteriography, and that its prognosis is considered poor. Second, in order to be sure that an aortocoronary by-pass graft will be effective, one should be certain that the myocardium to be perfused through the graft is still viable. This can be ascertained at a late phase of myocardial imaging. This second condition is considered to be useful to rule out both complete necrosis due to myocardial infarction and hypoperfusion due to myocarditis. Third, no appreciable coronary lesions should be present in the coronary artery peripheral to the graft site. If there is a stenotic lesion, it may aggravate gradually and aneurysm may result in new stenotic lesions even several years after the onset. When these three conditions are satisfied an aortocoronary by-pass graft may be considered for those cases indicated in which more than one of the following four coronary arteriographical findings are observed: 1) The localized stenosis in the left coronary main trunk has progressed to a critical stenosis; 2) occlusions are detected in two or more vessels; 3) collateral vessels to the peripheral portion of an occluded coronary artery arise from the peripheral portion of a vessel with progressive localized stenosis; 4) in addition to the occlusion, segmental stenosis or critical localized stenosis is present in the right coronary artery, progressive localized stenosis is

detected in the left anterior descending artery. The indication for arteriographical findings in children is similar to that in adults, because the location of the fatal lesion seems to be the same in both. However, in Kawasaki disease, an isolated stenotic lesion in the proximal left anterior descending artery does not represent an indication for aortocoronary by-pass because of the marked development of collateral vessels.

At present, we do not consider isolate right coronary arterial stenosis to be an indication for aortocoronary by-pass grafting. However, the outcome and prognosis of right coronary arterial obstruction in children needs to be elucidated further. Isolated segmental stenosis is also not an indication for by-pass grafting because it shows improvement for several years. Subjective symptoms and ischemic findings in electrocardiography, which are considered to be significant findings to justify aortocoronary by-pass surgery in adults, are totally unreliable in children with Kawasaki disease. Therefore, the decision with respect to aortocoronary by-pass surgery should not be based on symptomatology or electrocardiographic findings alone but on an overall comprehensive study considering the course of each individual patient.

As stated above, the aortocoronary by-pass grafting cannot be considered an established therapeutic measure for cases of Kawasaki disease at present. Nevertheless, it is also true that we occasionally come across cases where the lives of the patients depend on such grafts. The indication for aortocoronary by-pass grafting should not be established without considering the special nature of Kawasaki disease. At the same time, however, the grafting should be performed without delay in a patient with definite indications.

Thus, a standard of indication for aortocoronary by-pass grafting based on the natural history of coronary arterial obstructions due to Kawasaki disease is urgently needed. In the present study, we have proposed approximate guidelines for the indication of aortocoronary by-pass grafting in Kawasaki disease. In future, if the long-term results improve, the indication may be extended.

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