# The role of coronary bypass operation on children with Kawasaki disease

Soichiro Kitamura

**Background** Kawasaki disease, initially called mucocutaneous lymph node syndrome was reported 35 years ago as a new inflammatory disease in infants and children and is characterized by a variety of symptoms and signs resulted from systemic vasculitis. Although the etiology of the disease remains unknown, its serious coronary complications have been proved to cause ischemic heart disease in children, and are now the most common cause of pediatric coronary disease in the world. The incidence of serious coronary sequelae is fortunately low (2-3% of patients with Kawasaki disease), but once myocardial infarction occurs in children, the mortality is quite high (22% at the first infarction). Development of surgical treatment for the disease was essential in preventing premature death and improving the quality of life of children.

**Methods and results** Coronary revascularization surgery was attempted following careful evaluation of characteristic patters of coronary aneurysms and obstructions secondary to Kawasaki disease, although the surgical efficacy was initially questioned because the disease is inflammatory vasculitis in origin. The operation utilizing the pedicled internal thoracic artery has been demonstrated quite successful and now established as a reliable treatment for inflammatory coronary obstructions due to Kawasaki disease (the Kitamura Operation). There is valid evidence for the internal thoracic artery graft being a viable structure, accommodating in length and diameter for the growth of children. Results of the surgery and long-term prognosis are favorable and postoperative quality of life is markedly improved.

**Conclusions** Coronary bypass operation utilizing the pedicled internal thoracic artery is a safe and reliable surgical modality for coronary artery sequelae in children due to Kawasaki disease. Long-term follow-up results up to 20-years are quite satisfactory. *Coron Artery Dis* 13:437–447 © 2002 Lippincott Williams & Wilkins.

**Coronary Artery Disease** 2002, **13**:437-447

**Keywords: Kawasaki disease, mucocutaneous lymph node syndrome, coronary aneurysm, pediatric coronary artery disease, pediatric ischemic heart disease**

Department of Cardiovascular Surgery, National Cardiovascular Center, Osaka, Japan.

Correspondence and requests for reprints to Soichiro Kitamura MD, Chairman of Cardiovascular Surgery, President of the National Cardiovascular Center, 5-7-1 Fujishirodai, Suita, Osaka 565-8565 Japan.
Tel: +81 6 6833 5012; fax: +81 6 6872 8617;
e-mail: skitamur@hsp.ncvc.go.jp

**Received** 18 June 2002 **Revised** 18 July 2002
**Accepted** 18 July 2002



## What are Kawasaki disease and its serious sequelae?

Kawasaki disease, initially called mucocutaneous lymph node syndrome (MLNS or MCLS) was reported by Kawasaki in 1967 [1] as a new pediatric disease entity [2]. It causes a variety of symptoms and signs, such as high fever, conjunctive injection, a skin rash like measles, red swollen lips, strawberry tongue, cervical lymph node swelling and desquamation of the fingertip skin, which mostly regress spontaneously within 2 weeks (but sometimes symptoms last over a month) unless rupture or obstruction of coronary aneurysms supervene at the acute phase of the illness. The current death rate at the acute phase is approximately $0.05 \sim 0.1\%$ following the induction of high-dose intravenous $\gamma$-globulin therapy [3,4]. Laboratory examinations reveal an elevation of C-reactive protein, white blood cell count, erythrocyte sedimentation rate and platelet count and a decrease in hemoglobin level and serum albumin. Recently it was found that the variety of symptoms described above are related to hypercytokinemia activated in the acute inflammatory phase of Kawasaki disease. Elevations of interleukins 1, 2, 6, 8, 10, interferon-$\gamma$ and tumour necrosis factor-$\alpha$ are noted in almost all children with this disease [5,6]. This syndrome is always preceded by symptoms like upper respiratory infection, but any causative agents such as bacteria, mycoplasma and viruses have not yet been identified. However, recently it has been reported that bacterial superantigens may be related to the etiology of systemic vasculitis of Kawasaki disease [7].

Although Kawasaki disease is currently seen worldwide, it is apparent that the disease is more predominant in Orientals than in Caucasians [8], so some genetic predispositions may be related to the etiology of vasculitis, but nothing has been confirmed at the present time. In Japan, more than 150 000 patients have been documented to date and over 8000 new patients were found in a single year (2001). The most common age for the onset of the disease is 1 year old. It usually occurs in children less than 4 years old, but sometimes it occurs in adolescents. The gender distribution is 1.5 male dominant.

Regarding the treatment for acute illness, aspirin has been used since 1977 with a resultant coronary artery aneurysm or ectasia (at 1 month after the onset) occurring in

Publisher note: This offprint incorporates the errata published in Coronary Artery Disease **14:**95.

approximately 20% of patients. Since 1982, high-dose intravenous γ-globulin administration (200–400 mg/kg for 5 days) has been introduced with a resultant occurrence of coronary artery sequela (at 1 month) being reduced to 7% of patients. However there are still many children who develop coronary aneurysms over 7–8 mm in diameter (giant aneurysms) that will frequently result in coronary artery stenosis or obstruction in 1 to 20 years.

Although the etiology of the disease remains unknown, its serious complications (coronary aneurysm formation and subsequent coronary arterial obstructive lesions) have been proved to cause ischemic heart disease in children. Although the incidence of pediatric ischemic heart disease is fortunately low (2–3% of patients with Kawasaki disease), once the serious coronary arterial lesions develop into pediatric myocardial infarction, the prognosis is more serious than previously imagined. According to the analysis by the Research Committee of the Ministry of Health and Welfare of Japan ($n = 195$) [9], the mortality rate due to pediatric myocardial infarction induced by Kawasaki disease is 22% after the first infarction and 66 and 87% after the second and third infarctions, respectively. Kawasaki disease is now the most common cause of pediatric ischemic heart disease in the world. Development of surgical treatment for this disease is essential in preventing premature death of these patients and in improving the quality of life of children [10].

## Symptoms, diagnosis and indications for surgical treatment

In most instances of inflammatory coronary artery disease as a sequela of Kawasaki disease [11], an aneurysm is formed first, which regresses spontaneously over the year [12,13]. However, a few (less than 5%) develop into obstructive lesions after 1–20 years, resulting in ischemic heart disease regardless of the administration of γ-globulin. It has been observed that frequent sites of coronary obstructive lesions are the inlet or outlet of coronary aneurysms located in the proximal part of the coronary artery [14]. In the left coronary arterial system, in particular, the lesions are concentrated in the left main coronary artery and the proximal part of the left anterior descending and circumflex branches as seen in Figure 1. In the right coronary arterial system, the proximal part is also the most common site for aneurysms, but the distribution of aneurysms is wider including the bifurcation area of the right coronary artery. The lesions are not common in the more peripheral coronary arteries. Thus, revascularization surgery is possible in almost all areas of coronary involvements, except in extremely thin vessels [15,16]. For accurate preoperative decision making, selective coronary arteriography and selective left ventriculography are mandatory even in small children.

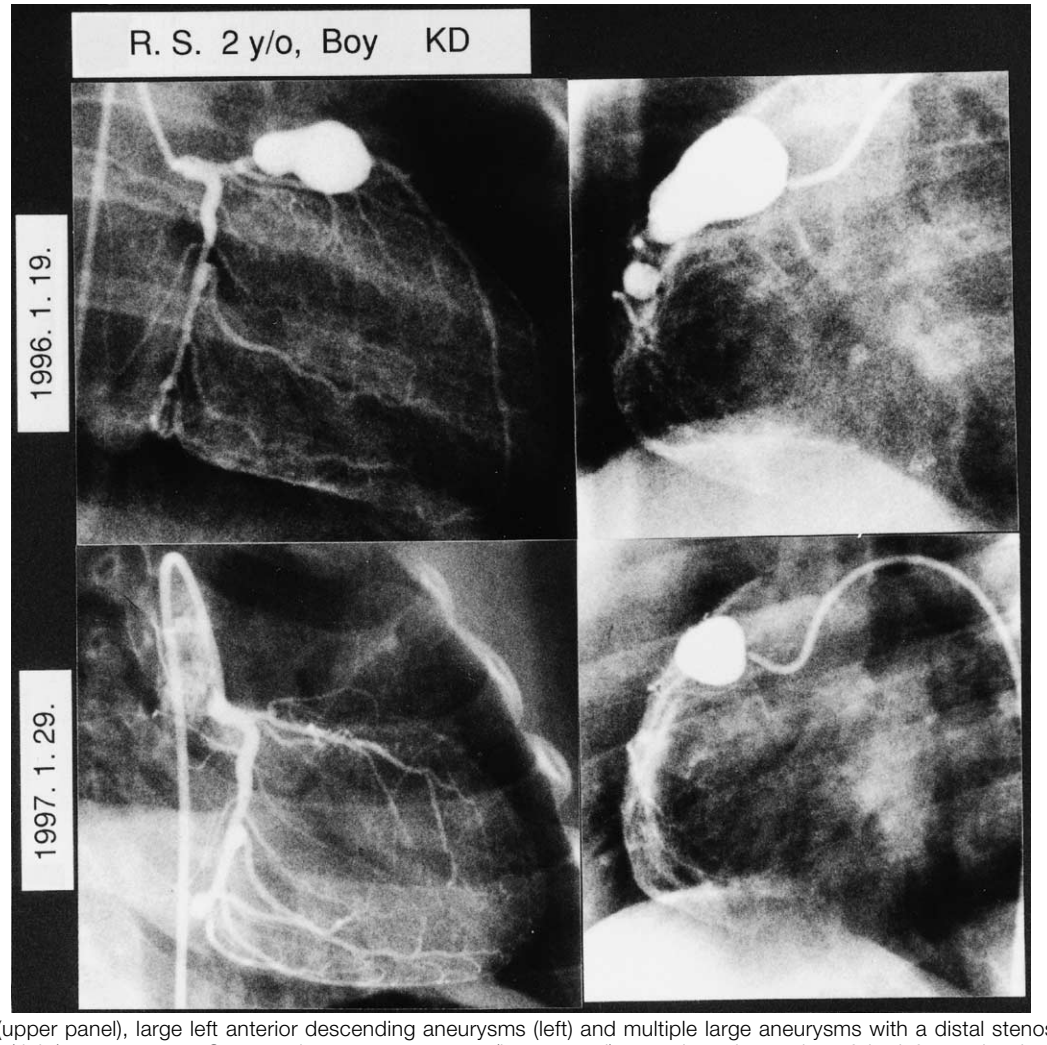
When an occlusive lesion is found in one or more of the major coronary arteries, resulting in myocardial ischemia, then there is an indication for myocardial revascularization. In this disease, the patients are usually children and despite the presence of serious coronary arterial involvement, subjective symptoms of myocardial ischemia are often poorly noted and sudden death may occur as the first presenting symptom [17,18]. Objective findings from various examinations, therefore, are important in determining the need for surgical treatment. Indications for operation should be determined with care, taking into consideration the age of the patient, the history of myocardial infarction and left ventricular function, in addition to the findings at coronary arteriography.

The standard indications for surgical treatment have been proposed by a study group of the Ministry of Health and Welfare of Japan [19]. Identification of the ischemic region and examination of the viability of myocardium should be carried out using exercise electrocardiography with a treadmill test and myocardial imaging with thallium-201 under exercise or administration of drugs such as dipyridamole. This is in addition to certain clinical findings, including a history of angina pectoris and myocardial infarction. The indications somewhat resemble those for coronary artery bypass operation in adults. In Kawasaki disease, however, several characteristics specific to children are found in the angiographic findings. First, when one of the major coronary arteries is occluded, the ability to recanalize or develop collateral vessels in children is very high. This marked ability to develop collateral circulation is considered a characteristic of children's hearts in the course of their growth, being different from atherosclerotic coronary artery disease, and is also aided by the fact that lesions within the coronary arteries in Kawasaki disease progress slowly from aneurysms to occlusive lesions. Secondly, recanalization of the coronary artery is frequently noted at the point of occlusion particularly in the right coronary artery. When lesions are limited to the right coronary artery, patients are often asymptomatic, but lesions frequently coexist in the left coronary artery system (Fig. 2). Thus, when ischemia is identified by various tests as previously described, surgery is indicated. Surgical treatment is recommended positively for the children with a previous myocardial infarct, because prognosis following recurrent myocardial infarction is unfavorable (mortality = 62.5%) [7].

## Surgical treatment

Surgical myocardial revascularization has been conducted increasingly for this disease since 1976, when we reported the first successful coronary artery bypass operation using grafts prepared from the great saphenous vein [15,20]. Since then, several questions relating to surgical treatment have been raised and thereafter resolved.

**Fig. 1**




At age 1 year (upper panel), large left anterior descending aneurysms (left) and multiple large aneurysms with a distal stenosis of the right coronary artery (right) were present. One year later, at age 2 years (lower panel), complete obstruction of the left anterior descending artery and regression of the left main coronary aneurysm (left) and recanalization of the right coronary artery with a remaining aneurysm (right) were observed. This illustrates a dramatic change of coronary artery lesions due to Kawasaki disease. This child underwent coronary bypass operation using an internal thoracic artery graft to the left anterior descending artery using the surgical microscope.

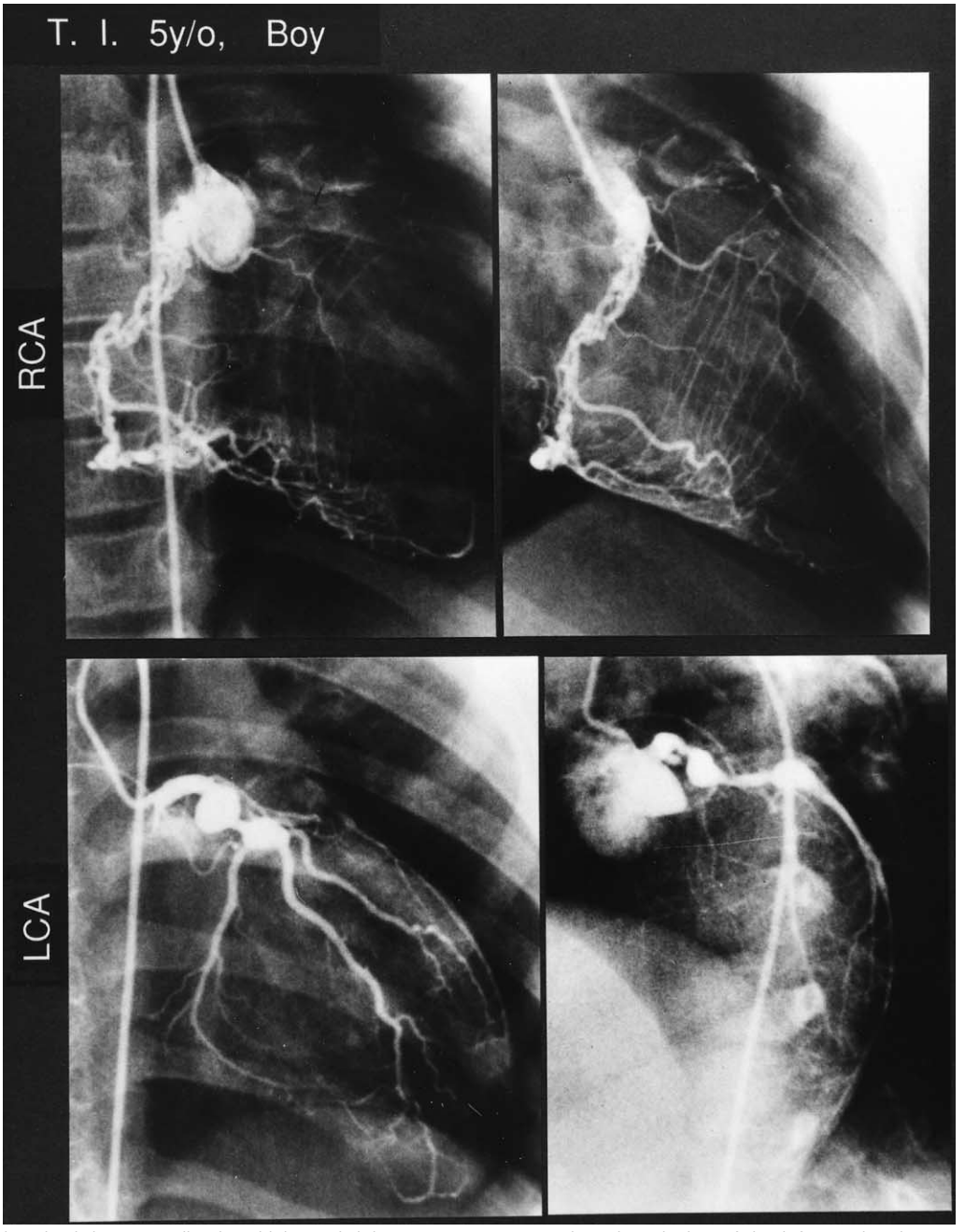
First, the main locations of coronary artery obstruction in Kawasaki disease are in the proximal portions of major coronary arteries. Thus, if the caliber of blood vessels is not particularly thin in infants, the operation can be performed anywhere in the coronary artery system. Second, coronary artery bypass operation is an effective and safe surgery in children for this peculiar inflammatory coronary artery disease secondary to Kawasaki disease (Fig. 3). Third, and this consideration is one of the most important issues in surgical treatment, long-term patency of the autologous saphenous vein graft when used in children, particularly if operated on at a young age, is unsatisfactory [14,15]. Fourth, it has been shown that the pedicled internal thoracic artery can be successfully employed [17] with favorable patency and adaptation to somatic growth of children.

## Modes of surgical treatment

### Coronary arterial bypass grafting

Since our first successful report [15] of coronary bypass surgery for a child with Kawasaki disease, operative treatment for severe Kawasaki disease has started [21–24]. Regarding the nature of the graft, autologous saphenous veins, the internal thoracic artery, the gastro-epiploic artery or a combination of these grafts have been utilized. Since our first report [16] showing favorable results for long-term patency of an internal thoracic artery graft for coronary obstructive lesions due to inflammatory Kawasaki disease, this technique (the Kitamura Operation) has been used with increasing frequency [25,26] (Fig. 4). Bilateral use of the internal thoracic artery is also recommended whenever indicated, because it does not

**Fig. 2**



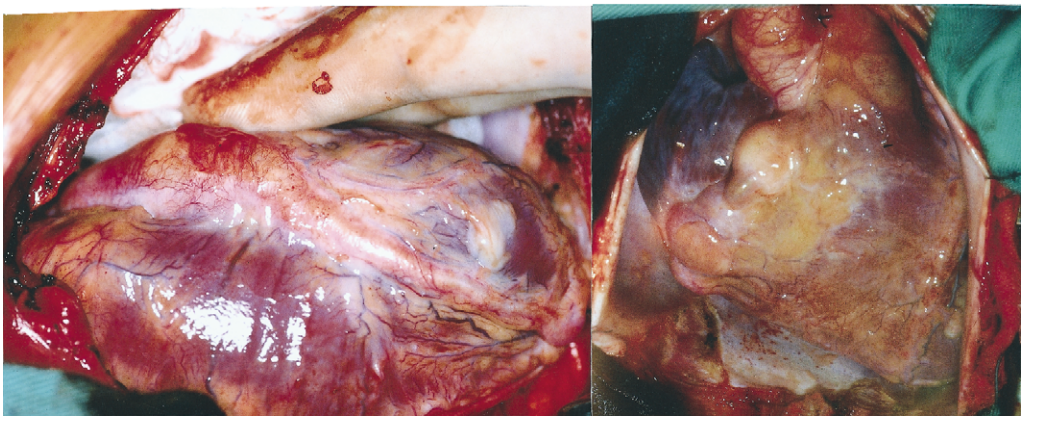

This 5-year-old boy had the recanalized multichannel right coronary artery and total occlusion of the left anterior descending artery with multiple circumflex coronary aneurysms. Surgery was indicated for the left anterior descending artery. No ishemia was found in the right coronary and circumflex areas.

adversely affect development of the chest wall in children [27] (Figs 5 and 6). The gastroepiploic artery has also been used recently with early favorable results [25,28]. All efforts to use pedicled arterial grafts are based upon the unsatisfactory long-term patency of isolated autologous saphenous veins when used in a pediatric population. As the ages of the patients are low, both the internal thoracic and the coronary arteries are thin. It is advisable, therefore, to use microsurgical techniques when anastomosing vessels of less than 1 mm diameter with the help of high-power magnifying glasses or sometimes surgical microscopes.

## Coronary aneurysmectomy

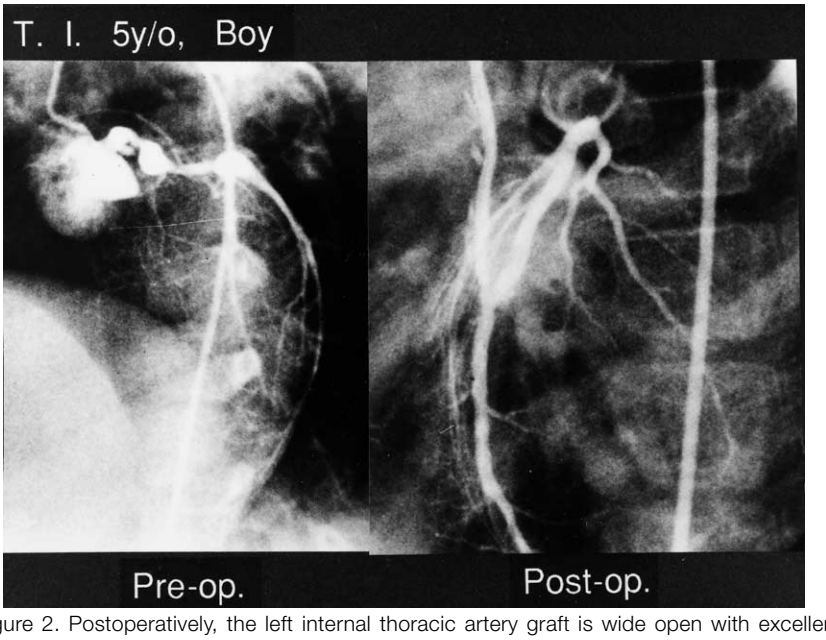
The combined use of arterial bypass grafting with resection for large coronary aneurysms has been reported [29]. Coronary aneurysms caused by this disease are not reported to rupture except at the acute febrile stage, probably

**Fig. 3**



An operative view of a child with Kawasaki disease. A large aneurysm and thickened arterial wall were obvious in the left anterior descending artery, which was obstructed at the outlet of the aneurysm (left). The right coronary artery had multiple round calcified aneurysms in a different patient (right).

**Fig. 4**



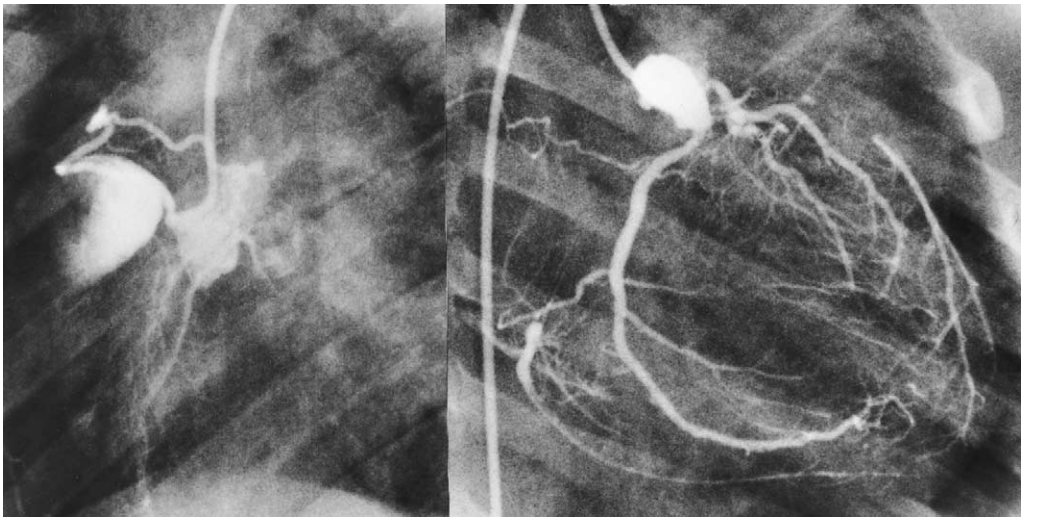

The same patient as in Figure 2. Postoperatively, the left internal thoracic artery graft is wide open with excellent flow to the obstructed anterior descending artery.

because of thick fibrosis around the aneurysm due to a healing process of severe inflammation in the wall. This is an important difference from aneurysms caused by atherosclerosis. Apparent embolization of the coronary artery distal to the aneurysm with no stenosis has also not been reported. Thus, aneurysmectomy is no longer recommended as a mode of surgical treatment because of the difficulty in restoring all coronary branches arising from the aneurysm, particularly when it exists in the left main trunk; one of the commonest sites for large aneurysm formation.

## Optimal age for operation

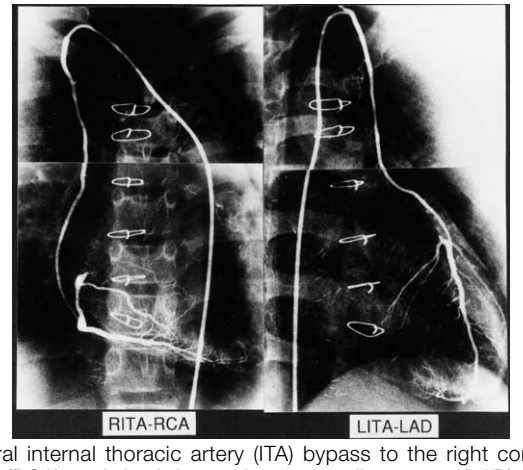
Because long-term patency of grafts prepared from saphenous veins is unsatisfactory in patients who have undergone coronary artery bypass operations at a young age [25,30], the indications for operation should be determined with care. In children of a young age (less than 2 years old), it is sometimes better to wait for them to grow older under strict medical control, achieving such monitoring with appropriately repeated coronary arteriography. In serious cases, nonetheless, surgery should be performed regardless of age. For very young children, the internal

**Fig. 5**



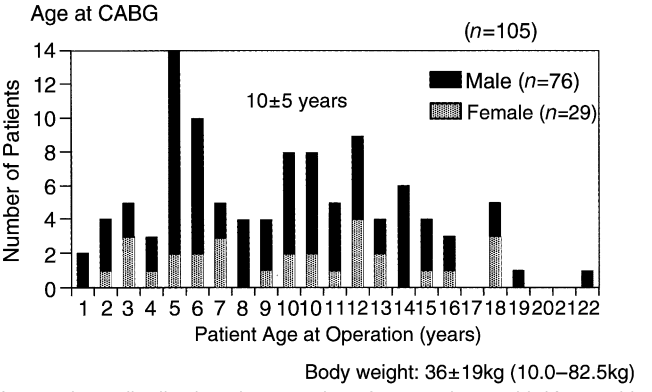
The right coronary artery was totally obstructed within a giant aneurysm with a resultant inferior wall myocardial infarct (left). The left coronary artery had an aneurysm at the main trunk and a total occlusion of the left anterior descending artery with retrograde filling to both the anterior and posterior descending arteries (right).

**Fig. 6**




Bilateral internal thoracic artery (ITA) bypass to the right coronary artery (RCA) and the left anterior descending artery (LAD) in the same boy (8 years old) as in Figure 5.

**Fig. 7**




Age and sex distributions in my series of 105 patients with Kawasaki disease who underwent surgical revascularization of the heart.

thoracic artery should be used as the graft of choice, anticipating long-term patency and adaptation for rapid somatic growth (the Kitamura Operation). A surgical microscope will be useful in such cases. Whenever necessary and feasible, I recommend the use of bilateral internal thoracic artery grafts [27] (Figs 5 and 6). Serious obstructive lesions and symptoms however, are rarely found in very young children and occlusive lesions frequently develop several years after the onset of Kawasaki disease. In children above the age of 5 years, less difficulty is expected in surgical procedures. Accordingly, it may be desirable to manage the patients by means of meticulous observation and medical treatment until that time, if this proves possible. The youngest patient in my own series is a child of 1 year and the oldest is an adult of 23 years, the mean age being $10 \pm 5$ years ($n = 105$). Most of our patients were aged 5–6 years [25,30]. The sex distribution is 2.5:1 male dominant and the body weight at the time of operation ranged from 10.0 to 82.5 kg as shown in Figure 7.

## Operative results

The results of coronary artery bypass grafting in children with Kawasaki disease are now very stable and good. According to investigations conducted by the Multicenter Cooperative Group [25] only two of 170 patients

undergoing surgery for Kawasaki disease died in hospital. Eight patients (4.7%) died suddenly or due to myocardial infarction in the 90-month period of follow-up after surgery. As to the causes of death, left ventricular dysfunction, arrhythmia and late occlusion of the graft prepared from the saphenous veins are all reported. Interestingly, the lack of an internal thoracic artery graft is a strong predictor of late postoperative death [25]. In my own series [30] of over 100 patients undergoing surgery using the pedicled internal thoracic artery for this disease only two late deaths occurred during a follow-up period of nearly 20 years (Fig. 8).

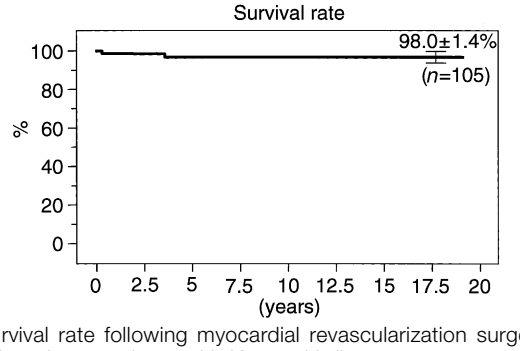
## Surgical effects and postoperative cardiac events

Coronary bypass surgery for patients with Kawasaki disease is useful for improving myocardial ischemia. This is demonstrated by exercise electrocardiography and myocardial perfusion imaging, both of which show evidence of increased myocardial perfusion after surgery [14,20]. Postoperative improvement in blood flow measured as coronary sinus blood flow and in left ventricular function under exercise loading have also been noted [31].

Postoperative clinical status was analysed in 105 patients in my series [30], including two dying in the intermediate term. The event-free rate was 77.6 ± 4.4% at 10 and nearly 20 years (Fig. 9). Considerable myocardial ischemia recurred postoperatively in 15 (Fig. 10) because of either obstruction of the bypass grafts or progression of other coronary arterial lesions. Of these patients, the symptoms spontaneously regressed without interventional procedures in four, reoperation was indicated for repeated coronary artery bypass grafting in four and catheter intervention was efficiently carried out in the remaining seven. Percutaneous transluminal coronary angioplasty (PTCA) was carried out for the site of anastomosis between the coronary artery and the internal thoracic artery graft in four patients. PTCA with stenting was needed for vein grafts in one patient. PTCA and percutaneous transluminal coronary rotational ablation were carried out repeatedly for progressive lesions at the native circumflex artery in two. These catheter interventions were successful and no further progression of obstructive lesions was noted at the coronary arteries or the bypass grafts. All these patients are currently doing well 2–8 years after catheter intervention.

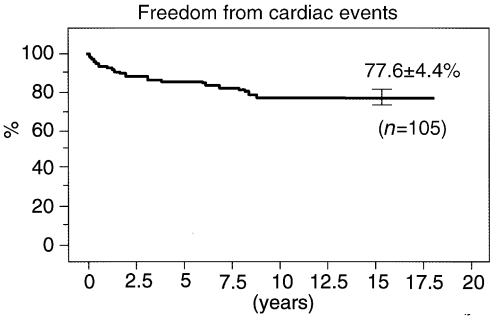
Another two patients had episodes of ventricular tachyarrhythmia; one of them had severe left ventricular dysfunction and was subsequently admitted for cardiac transplantation. In the other patient, the administration of mexiretine was effective in suppressing such critical arrhythmia. Of the survivors, 81 patients are currently school or college students and 22 are in employment. Three women could have their babies by normal delivery. Physical exercise is strictly limited in five patients. Strenuous exercise is prohibited in 11. The remaining 87 patients, in contrast, are doing well with no obvious

**Fig. 8**



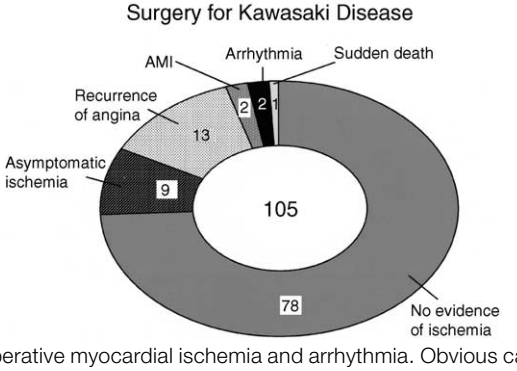

The survival rate following myocardial revascularization surgery in my series of 105 patients with Kawasaki disease.

**Fig. 9**




Freedom from cardiac events after coronary bypass operation in children with Kawasaki disease. The cardiac event-free rate was 77.6 ± 4.4% at more than 15 years.

**Fig. 10**




Postoperative myocardial ischemia and arrhythmia. Obvious cardiac events were noted in 18 patients. In another nine, mild myocardial ischemia was demonstrated, although it was asymptomatic, by single photon emission computed tomography. AMI, acute myocardial infarction.

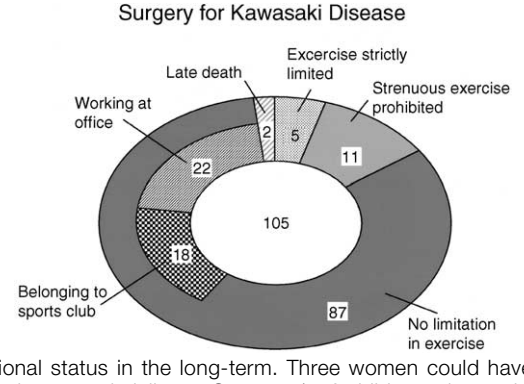
restriction, 18 of these belonging to sports clubs (Fig. 11). Before surgery, most children were totally restricted from the physical exercise programme at school, but after surgery, the rate of return to normal school athletics was as high as 85%. Bypass surgery with pedicled internal thoracic artery initiated by the author is effective in improving the quality of life of children with severe coronary sequelae of inflammatory Kawasaki disease.

## Patency of grafts

The efficacy of coronary artery bypass surgery depends on the long-term patency of the graft. The patency of the autologous isolated saphenous vein graft, which has been previously used frequently, is not satisfactory. The venous graft used in children, particularly at a young age, has been found to have a high occlusion rate [25,30]. When the patency rate of venous grafts is compared between older children and those aged 9 years or younger, the patency rate over 10 years is 48.8 ± 17.9% in those aged 10 years or older and only 16.7 ± 13.6% in those aged 9 years or younger. In addition, occlusion was noted more frequently after 1 month and up to 2 years (13% closure rate within 1 month, 56% within 1 year and 31% later than 1 year). This fact shows that vein graft closure is not related to technical factors alone. The rate of degeneration of isolated venous grafts is, thus, very high. In childhood, metabolism related to growth differs from that in adults. For instance, the xenograft valve implanted in childhood becomes readily calcified and fails to function in a few years. It is also doubtful whether the saphenous vein, when used as a free isolated graft, has the potential to grow in a fashion corresponding to the somatic growth of the patient [32,33]. When providing myocardial revascularization for Kawasaki disease, the saphenous vein is not a suitable graft, particularly in small children. The use of the internal thoracic artery is anticipated to overcome the disadvantages of the venous graft [32]. The arterial graft has been shown to have excellent long-term patency in adults, but its use in children seemed at first difficult because of the small caliber of the blood vessels. After our initial successful report [16] using an arterial graft in Kawasaki disease, however, more operations have been performed using this technique [25,27,34].

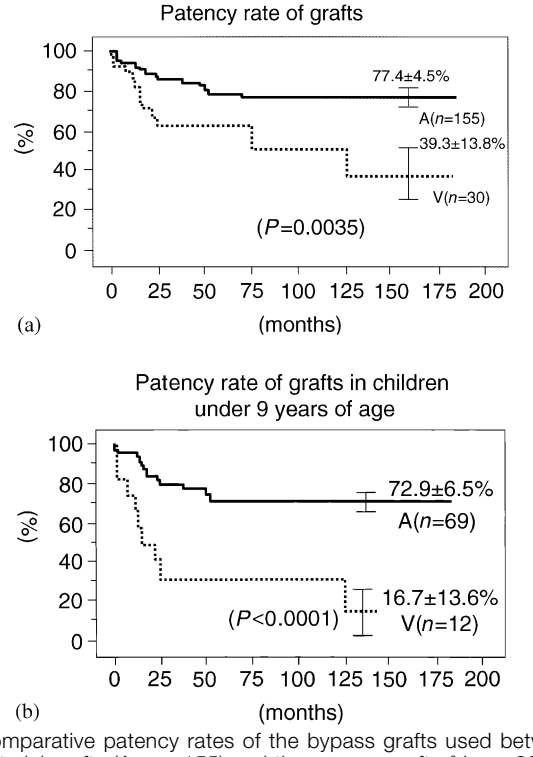
Postoperative examination by coronary arteriography demonstrated that the patency rates of the arterial grafts were 94.3 ± 1.9, 82.5 ± 4.0 and 77.4 ± 4.5% at 1, 5 and 10–15 years, respectively (Fig. 12a), while those of saphenous vein grafts were 85.3 ± 7.4, 62.6 ± 9.4 and 39.3 ± 13.8%, respectively. When 12 venous grafts and 69 arterial grafts were compared in patients under 9 years of age undergoing operation, the patency was markedly poor for vein grafts (16.7 ± 13.6% compared with 72.9 ± 6.5% at 10–15 years (Fig. 12b)). The use of vein grafts in patients younger than 5 years old was almost hopeless. Complete occlusion of the graft was the rule, occurring most frequently within the first and second postoperative years. The patency rate was greater when used in those over 10 years of age (48.8 ± 17.9% at 10–15 years). However, the arterial grafts provided a greater patency rate (86.9 ± 6.0% at 10–15 years), which is significantly better. Although the numbers

**Fig. 11**




Functional status in the long-term. Three women could have their babies by normal delivery. Over 85% of children who underwent surgery are now performing unrestricted physical exercise, although all of them were prohibited from exercise before operation.

**Fig. 12**




(a) Comparative patency rates of the bypass grafts used between the arterial grafts (A, $n = 155$) and the venous grafts (V, $n = 30$). (b) Comparative patency rates of the arterial grafts (A, $n = 69$) and the venous grafts (V, $n = 12$) in children under 9 years of age at the time of operation.

involved are small, the patency of the pedicled gastroepiploic artery also seemed to be promising in our experience, as well as in that of others [28].

## Do arterial grafts grow with the children?

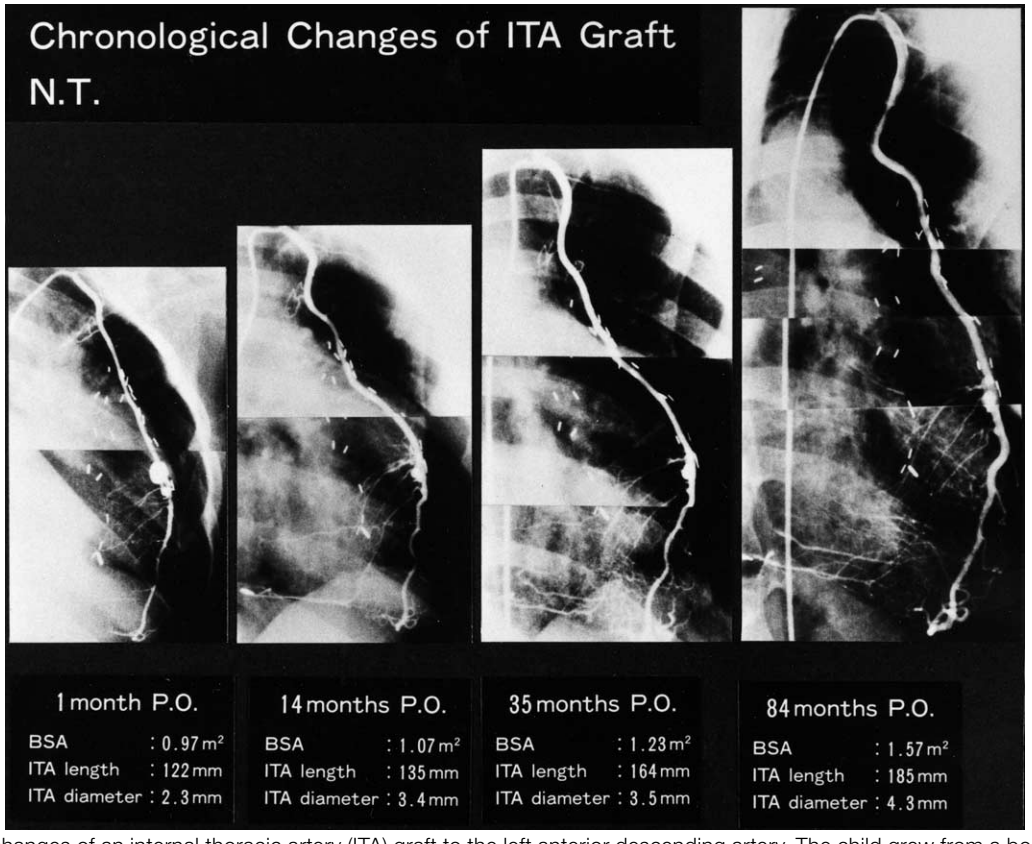
When the length of internal thoracic arterial grafts was compared between the early period within one month after surgery and the late period of about one year, it was confirmed that they grow in keeping with the growth of the child [32,33] (Figs 13 and 14). The methods of measurement of graft length and diameter located in the thorax in a three-dimensional fashion have been reported elsewhere [32]. This is valid evidence for the internal thoracic artery graft being a viable structure, accommodating in length and diameter for the growth of the child and the requirements for transport of blood. On the other hand, the isolated vein graft does not have the capability of growing in length in accordance with the somatic growth of the child. A close correlation was found between the length of the arterial graft and the increase in body surface area of the patient [32,33] (Fig. 15). Thus, the internal thoracic artery is a very suitable graft for growing children with Kawasaki disease who require coronary artery bypass surgery.

## Conclusion

Coronary revascularization surgery for the sequelae of Kawasaki disease is effective in improving cardiac function during exercise and probably in preventing sudden deaths and myocardial infarction in children. This operation utilizing pedicled arterial grafts is now established as a reliable treatment for severe inflammatory coronary obstructive disease due to Kawasaki disease (the Kitamura Operation). Results of the surgery and long-term prognosis are favorable and the postoperative quality of life is markedly improved.

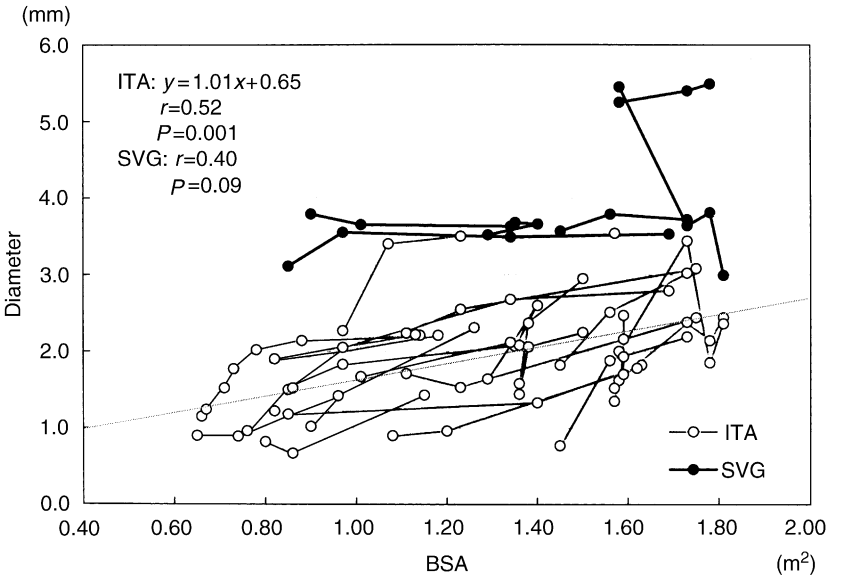
The internal thoracic artery graft is not only excellent in its long-term patency but is also capable of growing with the child and meeting the perfusion demand of the myocardium. Thus, it is an ideal material for coronary artery reconstruction in children. Use of the bilateral internal thoracic artery is also safe. Moreover, right gastroepiploic artery grafts are useful in patients with distal coronary artery lesions. The merits of surgical treatment for severe coronary artery lesions due to Kawasaki disease have now been recognized not only in Japan but all over the world.

**Fig. 13**



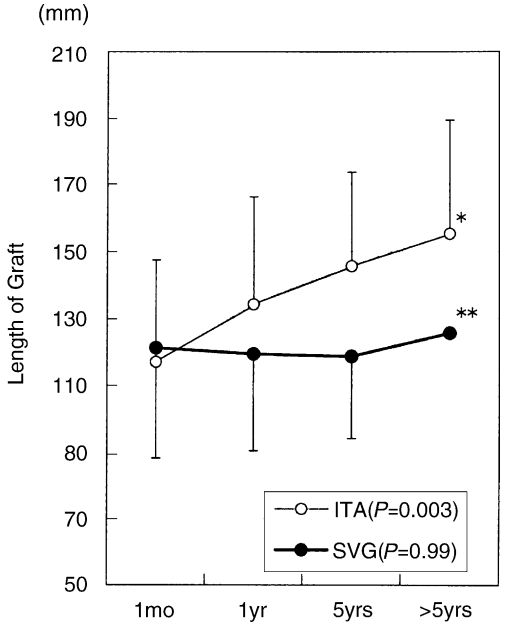

Chronological changes of an internal thoracic artery (ITA) graft to the left anterior descending artery. The child grew from a body surface area of 0.97 $m^2$ to 1.57 $m^2$. During this period of time, the graft grew from 122 mm to 185 mm in length and from 2.3 mm to 4.3 mm in diameter. The measurement method is described elsewhere [32].

**Fig. 14**




The length of internal thoracic artery (ITA) grafts increases in accordance with the size of the body and the length of isolated venous grafts (SVG) does not. BSA, body surface area.

**Fig. 15**




The lengths of pedicled internal thoracic (ITA) grafts and isolated saphenous vein grafts (SVG) according to postoperative years elapsed are shown. The ITA grows and the SVG does not.

## Appreciation

I would like to thank all the colleagues of Departments of Cardiovascular Surgery at Nara Medical University (Nara) and National Cardiovascular Center (Osaka), Japan.

## References

1 Kawasaki T. Acute febrile mucocutaneous syndrome with lymphoid involvement with specific desquamation of the fingers and toes in children [in Japanese]. *Jpn J Allergy* 1967; **16**:178–222.

2 Kawasaki T, Kosaki I, Okawa S, Shigematsu I, Yanagawa H. A new infantile acute febrile mucocutaneous lymph node syndrome (MLNS) prevailing in Japan. *Pediatrics* 1974; **54**:271–276.

3 Newburger JW, Takahashi M, Burns JC. The treatment of Kawasaki syndrome with intravenous gamma-globulin. *N Engl J Med* 1986; **315**:341–347.

4 Furusho K, Kamiya T, Nakano H. High-dose intravenous gamma-globulin for Kawasaki disease. *Lancet* 1984; **2**:1055–1058.

5 Nash MC, Shah V, Dillon MJ. Soluble cell adhesion molecules and von Willebrand factor in children with Kawasaki disease. *Clin Exp Immunol* 1995; **101**:13–17.

6 Kim DS, Lee KY. Serum soluble E-selection levels in Kawasaki disease. *Scand J Rheumatol* 1994; **23**:283–286.

7 Abe J, Onimaru M, Matsumoto S, Noma S, Baba K, Ita Y, *et al.* Clinical role for a superantigen in Yersinia pseudotuberculosis infection. *J Clin Invest* 1997; **99**:1823–1830.

8 Beiser AS, Takehashi M, Baker AL, Sundel RP, Newburger JW (US Multicenter Kawasaki Disease Study Group). A predictive instrument for coronary artery aneurysms in Kawasaki disease. *Am J Cardiol* 1998; **81**:1116–1120.

9 Kato H, Ichinose E, Kawasaki T. Myocardial infarction in Kawasaki disease, clinical analysis in 195 cases. *J Pediatr* 1986; **108**:923–927.

10 Kitamura S. Surgery for coronary artery disease and pediatric ischemic heart disease due to Kawasaki disease. *Asian Med J* 1993; **36**:333–340.

11 Naoe S, Shibuya K, Takahashi K, Wakayama M, Masuda H, Tanaka M, *et al.* Pathological observation concerning the cardiovascular lesions in Kawasaki disease. *Cardiol Young* 1991; **1**:212–220.

12 Kato H, Ichinose E, Yoshioka F, Takechi T, Matsunaga S, Suzuki K, *et al.* Fate of coronary aneurysms in Kawasaki disease: serial coronary angiography and long term follow up study. *Am J Cardiol* 1982; **49**:1758–1766.

13 Takahashi M, Mason W, Lewis AB. Regression of coronary aneurysms in patients with Kawasaki syndrome. *Circulation* 1987; **75**:387–394.

14 Kitamura S. Surgical management for cardiovascular lesions in Kawasaki disease. *Cardiol Young* 1991; **1**:240–253.

15 Kitamura S, Kawashima Y, Fujita T, Mori T, Oyama C. Aortocoronary bypass grafting in a child with coronary artery obstruction due to mucocutaneous lymph node syndrome: report of a case. *Circulation* 1976; **53**:1035–1040.

16 Kitamura S, Kawachi K, Oyama CM, Miyagi Y, Morita R, Koh Y, *et al.* Severe Kawasaki heart disease treated with an internal mammary artery graft in pediatric patients. A first successful report. *J Thorac Cardiovasc Surg* 1985; **89**:860–866.

17 Chow LT, Chow W, Tse CC, Wong EH, Wong K, Yip DC. Kawasaki disease—sudden death as the first presenting symptom. *Cardiol Young* 1992; **2**:73–77.

18 Gersony WM. Kawasaki disease, clinical overview. *Cardiol Young* 1991; **1**:192–195.

19 Kato H, Kitamura S, Kawasaki T. Guidelines for treatment and management of cardiovascular sequelae in Kawasaki disease. *Heart Vessels* 1987; **3**:50–54.

20 Kitamura S, Kawachi K, Harima R, Sakakibara T, Hirose H, Kawashima Y. Surgery for coronary heart disease due to mucocutaneous lymph node syndrome (Kawasaki disease). *Am J Cardiol* 1983; **51**:444–448.

21 Sandiford FM, Vargo TA, Shin JY, Pelargonio S, McNamara DG. Successful triple coronary artery bypass in a child with multiple coronary aneurysms due to Kawasaki's disease. *J Thorac Cardiovasc Surg* 1980; **79**:283–287.

22 Mains C, Wiggins J, Groves B, Glarke D. Surgical therapy for a complication of Kawasaki's disease. *Ann Thorac Surg* 1983; **35**: 197–200.

23 Myers JL, Gleason MM, Cyran SE, Baylen BG. Surgical management of coronary insufficiency in a child with Kawasaki's disease: use of bilateral internal mammary arteries. *Ann Thorac Surg* 1988; **46**: 459–461.

24 D'Amico TA, Sabiston DC Jr. Kawasaki's disease. In: Sabiston DC Jr, Spencer FC, editors: *Surgery of the chest.* Philadelphia: Saunders; 1990. pp. 1759–1766.

25 Kitamura S, Kameda Y, Seki T, Kawachi K, Endo M, Takeuchi Y, *et al.* Long-term outcome of myocardial revascularization in patients with Kawasaki coronary artery disease. *J Thorac Cardiovasc Surg* 1994; **107**:663–674.

26 Mavroudis C, Backer CL, Muster AJ, Pahl E, Sanders JH, Zales VR, *et al.* Expanding indications for pediatric coronary artery bypass. *J Thorac Cardiovasc Surg* 1996; **111**:181–189.

27 Kitamura S, Kawachi K, Seki T, Morita R, Nishii T, Mizuguchi K, *et al.* Bilateral internal mammary artery grafts for coronary bypass operations in children. *J Thorac Cardiovasc Surg* 1990; **99**:708–715.

28 Takeuchi Y, Gomi A, Okamura Y, Mori H, Nagashima M. Coronary revascularization in a child with Kawasaki disease: use of right gastroepiploic artery. *Ann Thorac Surg* 1990; **50**:294–296.

29 Suma K, Takeuchi Y, Shiroma K, Tsuji T, Inoue K, Yoshikawa T, *et al.* Early and late post-operative studies in coronary arterial lesions resulting from Kawasaki's disease in children. *J Thorac Cardiovasc Surg* 1982; **84**:224–229.

30 Yoshikawa Y, Yagihara T, Kameda Y, Taniguchi S, Tsuda E, Kawahira Y, *et al.* Results of surgical treatments in patients with coronary-arterial obstructive disease after Kawasaki disease. *Eur J Cardio-thorac Surg* 2000; **17**:515–519.

31 Kawachi K, Kitamura S, Seki T, Morita R, Kawata T, Hasegawa J, *et al.* Hemodynamics and coronary blood flow during exercise after coronary artery bypass grafting with internal mammary arteries in children with Kawasaki disease. *Circulation* 1991; **84**:618–624.

32 Kitamura S, Seki T, Kawachi K, Morita R, Kawata T, Mizuguchi S, *et al.* Excellent patency and growth potential of internal mammary artery grafts in pediatric coronary bypass surgery. New evidence for a 'live' conduit. *Circulation* 1989; **78**(suppl I):129–139.

33 Kameda Y, Kitamura S, Taniguchi S, Kawata T, Mizuguchi K, Nishioka H, *et al.* Differences in adaptation to growth of children between internal thoracic artery and saphenous vein coronary bypass grafts. *J Cardiovasc Surg* 2000; **41**:1–8.

34 Isomura T, Hisatomi K, Hirano A, Ohishi K, Inoue O, Kato H. The internal thoracic artery and its branches after coronary artery anastomoses in pediatric patients. *J Cardiovasc Surg* 1992; **7**:225–230.