Outcomes of Thoracic Aortic Surgery in Patients With Coronary Artery Disease — Based on the Japan Adult Cardiovascular Surgery Database —

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Background: Coronary artery disease (CAD) is associated with increased morbidity and mortality after open repair of thoracic aorta. Nevertheless, the efficacy of preoperative coronary angiography (CAG) and revascularization is controversial. The aim of this study was to clarify the effect of preoperative CAD on surgical outcome by reviewing the Japan Adult Cardiovascular Database.

Methods and Results: This study involved 4,596 patients who underwent open surgery for true thoracic aortic aneurysm between 2004 and 2009. After excluding patients with concomitant cardiac operation, except coronary artery bypass grafting (CABG), the remaining 1,904 patients with coronary artery stenosis included 995 cases of simultaneous CABG. The prevalence of CAD was significantly higher in patients with diabetes, renal dysfunction, hyperlipidemia, cerebrovascular disorders, peripheral artery lesions, old myocardial infarction (MI), and coronary intervention. Patients with simultaneous CABG had severe CAD compared with those without, with no other major differences in patient background noted. Thirty-day postoperative and in-hospital mortalities were higher in CAD patients. Incidence of perioperative MI was higher in patients who underwent open aortic repair with simultaneous CABG, but simultaneous CABG did not affect operative mortality.

Conclusions: In patients with surgically treated true aortic aneurysm, CAD was frequently observed, suggesting that aggressive preoperative coronary evaluation is needed.

Key Words: Coronary artery disease; Database; Thoracic aortic disease; Thoracic aortic surgery

Coronary artery disease (CAD) is currently seen in approximately 10–30% of patients with thoracic aortic disease.\(^1\)\(^-\)\(^5\) When undergoing open repair for aortic disease without coronary intervention for CAD, there are risks of developing perioperative myocardial infarction (MI), cardiac dysfunction due to insufficient intraoperative myocardial protection or myocardial ischemia, and fatal arrhythmia. Therefore, CAD is a known risk factor for early death after surgery for thoracic aortic disease.\(^6\)\(^-\)\(^8\) Especially in patients with unstable CAD, coronary revascularization before or during surgery is useful in significantly reducing the risk of cardiac complications such as perioperative MI or operative mortality.\(^1\)\(^,\)\(^2\)\(^,\)\(^4\) According to ACCF/AHA guidelines however, the benefit of coronary revascularization before or during surgery still remains a controversial subject. Furthermore, the usefulness of actively performing coronary screening and treatment, especially in patients with stable CAD, is unclear.\(^9\) A number of studies have investigated treatments for CAD and the relationship of such treatments to surgical outcome in patients with aortic disease or peripheral artery disease. Many of these studies, however, were limited by the small numbers of subjects involved; this is one of the reasons for the low evidence level in the guidelines. We therefore used the Japan Adult Cardiovascular Surgery Database (JACVSD), a national registry in Japan, to investigate the presence of CAD on preoperative coronary angiography (CAG) and its relationship to patient background and outcome of open aortic repair in patients with thoracic aortic disease.

Methods

The JACVSD is a Japanese clinical database that was introduced in 2000 as a multicenter database of cardiovascular surgery; approximately 500 institutions (99%) were enrolled in this database as of 2017.\(^10\) Investigation items were defined as being equivalent to those of the Society of Thoracic Surgeons database for comparison purposes; there are

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approximately 250 such items. Although enrollment in JACVSD is voluntary, the vast majority of institutions are currently enrolled in this database and the completeness of the data is high. Furthermore, careful checking of the consistency between registered data and clinical records by visiting randomly selected institutions regularly maintains the accuracy of data at a high level. The use of data was approved by the JACVSD Data Utilization Committee.

Of the patients registered in JACVSD who received elective open repair for thoracic aortic disease (ascending, arch, descending, and thoracoabdominal), 4,596 patients who underwent preoperative CAG were selected for the study. Patients who underwent emergency surgery or simultaneously received other open heart surgery, except coronary artery bypass grafting (CABG), were excluded (Figure 1). Based on the presence or absence of CAD, patients were divided into 2 groups, namely CAD (+) and CAD (−), respectively. CAD (+) patients were further divided into 2 groups based on the presence and absence of concomitant CABG, namely CABG (+) and CABG (−), respectively. Patient background (age, sex, body mass index [BMI], smoking history, hypertension, hyperlipidemia, cerebral infarction, chronic obstructive pulmonary disease [COPD], diabetes mellitus [DM], MI, renal insufficiency, dialysis, peripheral vascular disease, etiology and location of major vessel disease, presence or absence of angina, past history of coronary artery intervention, number of affected branches of coronary artery, presence or absence of left main trunk [LMT] lesion, and left ventricular function) and early post-operative outcomes of aortic surgery were retrospectively reviewed. CAD was defined as ≥50% stenosis at the LMT and ≥75% stenosis at the 3 major branches. Thirty-day mortality was defined as death in the 30 days after surgery irrespective of hospitalization; and in-hospital mortality was defined as death during hospitalization in the 30 days after surgery. Complications included new-onset cerebral infarction, transient ischemic attack, perioperative MI, cardiac arrest including fatal arrhythmia, pneumonia, gastrointestinal complications, induction of dialysis due to renal insufficiency, and infection.

Statistical Analysis
Statistical analysis was done using SPSS for Windows. Continuous variables are expressed as mean, and categorical variables are expressed as absolute number or percentage. Univariate comparisons of categorical and continuous variables were made using chi-squared test or Fisher’s exact test and Student t-test, as appropriate. All reported P-values are 2-sided, and P<0.05 was considered statistically significant. Stepwise logistic regression analysis was performed to identify independent risk factors for operative mortality. Predictors included in the multivariate analysis were as follows: age category (5-year age group), sex, BMI (≥30kg/m²), smoking, DM, COPD, renal dysfunction, dialysis, hypertension, hyperlipidemia, cerebrovascular disease, peripheral vascular disease, angina pectoris, CAD, previous MI, congestive heart failure, valvular disease, New York Heart Association (NYHA) functional class (≥3), true aneurysm, aortic lesion (ascending, arch, descending, and thoracoabdominal), rupture, and redo surgery. Moreover, multivariate analysis was performed to identify risk factors for operative mortality in the CAD (+) group. Predictors included in the subgroup analysis were as follows: age category (5-year age group), sex, renal dysfunction, dialysis, peripheral vascular disease, triple-vessel disease, congestive heart failure, NYHA functional class (≥3), true aneurysm, aortic lesion, rupture, and concomitant CABG. Results are expressed using odds ratios (OR) and 95% CI.

Results
Patient background according to the presence of CAD is given in Table 1. Overall, 58.4% of patients had a history of smoking. In addition, hypertension and hyperlipidemia were found in 81.7% and 55.8% of patients, respectively. Patients with renal dysfunction accounted for 9.8%, of whom 2.3% were receiving dialysis. A relatively small number of patients (0.8%) had ejection fraction <30%. Of 4,596 patients who underwent preoperative CAG, 1,904 (41.4%) had a significant stenosis in the coronary artery.

A history of coronary intervention was noted in 151 patients (5.6%) without CAD prior to thoracic aortic surgery. Furthermore, 995 patients with CAD received concomitant CABG; such patients were frequently observed among those who underwent open surgical repair of aortic root, ascending aorta, and aortic arch via a midsternotomy. According to the Japan System for Cardiac Operative Risk Evaluation (SCORE), a system for predicting operative risk based on JACVSD data, the CAD (+) group had a higher predicted 30-day and in-hospital mortality than the CAD (−) group, while the CABG (+) and CABG (−) groups had the same level of risk.

Of 1,904 patients with CAD, lesions were detected in single (n=856), double (n=498), and triple coronary arteries (n=436), or in the LMT alone (n=114). In addition, patients with stable angina comprised 32.9% of the CAD (+) patients (i.e., n=627), and 39 patients (2.1%) had unstable CAD (Figure 2A,B). Concomitant CABG was performed in 326 patients (38.1%) with a single coronary artery lesion, 275...
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There were 2,692 CAD (−) patients (1.2%), 13 CABG (−) patients (1.4%), and 9 CABG (+) patients (0.9%). Complications due to anticoagulant therapy were frequently observed in the CAD (+) group. Operative mortality after aortic surgery was noted in 5.3% (n=244) of all patients. Postoperative 30-day mortality was seen in 70 CAD (−) patients (2.6%), and in 99 CAD (+) patients (5.0%), showing a higher incidence in patients with CAD. In comparison, the in-hospital mortality rate was 4.3% in the CAD (−) group, and 8.0% in the CAD (+) group, showing a higher incidence in CAD (+). In-hospital mortality, however, was not significantly different between the CABG (−) and CABG (+) groups (P=0.130; Figure 3).

On multivariate analysis CAD was identified as an independent risk factor for operative mortality (OR, 1.53; 95% CI: 1.138–2.062, P=0.005; Table 3). The area under the curve for the discrimination of risk model was 0.741 (95% CI: 0.708–0.774). In the CAD (+) group, on logistic regression analysis the independent risk factors for operative mortality were age, renal dysfunction, dialysis, rupture, aortic arch repair and thoracoabdominal repair, whereas concomitant CABG was not identified as a risk factor (Table 4).

### Discussion

Although there have been some studies investigating the outcomes of surgery for aortic disease in CAD patients, the

| Table 1. Preoperative Patient Characteristics |
|---------------------------------------------|
| Variables                  | CAD (−), n=2,692 | CAD (+), n=999 | P-value |
| Age (years)                | 70.3±11.0        | 72.2±7.4       | 72.4±7.4 | <0.0001 |
| Male                       | 74.4             | 83.4           | 82.9     | <0.0001 |
| BMI (kg/m²)                | 23.3±7.8         | 23.7±3.4       | 23.5±3.2 | 0.332   |
| Smoking                    | 55.9             | 65.7           | 64.8     | <0.0001 |
| Smoking in ≤1 month        | 17.3             | 15.5           | 18.8     | 0.116   |
| Hypertension               | 79.8             | 88             | 85.8     | <0.0001 |
| Hyperlipidemia             | 32.4             | 45.5           | 44.6     | <0.0001 |
| Cerebrovascular disease    | 13.9             | 19.7           | 20.7     | <0.0001 |
| COPD (≤moderate)           | 5.8              | 5.9            | 5.2      | 0.741   |
| DM                         | 14.3             | 19.8           | 20.4     | <0.0001 |
| MI                         | 2.5              | 12.1           | 11.1     | <0.0001 |
| Renal failure              | 8.5              | 13.8           | 12.7     | <0.0001 |
| Hemodialysis               | 2.1              | 3.4            | 2.5      | 0.052   |
| PAD                        | 17               | 28.9           | 28.8     | <0.0001 |
| Coronary intervention      | 5.6              | 29.6           | 12.8     | <0.0001 |
| Arrhythmia                 | 5.7              | 8.8            | 6.6      | 0.295   |
| NYHA class ≥3              | 1.2              | 1.3            | 3.8      | <0.0001 |
| LVEF<30%                   | 0.7              | 1.3            | 0.8      | 0.132   |
| Extent of graft replacement|                  |                |          |         |
| Aortic root                | 3.2              | 0.6            | 1.6      | <0.0001 |
| Ascending                  | 23.8             | 17.8           | 27.8     | <0.0001 |
| Arch                       | 49.3             | 47.4           | 66.6     | <0.0001 |
| Descending                 | 28.9             | 31.5           | 8.4      | <0.0001 |
| Thoracoabdominal           | 10.8             | 14.7           | 0.8      | <0.0001 |
| JapanSCORE                 |                  |                |          |         |
| 30-day operative mortality | 3.4±2.5          | 4.7±4.1        | 5.1±5.3  | <0.0001 |
| In-hospital mortality      | 4.9±4.3          | 6.4±5.5        | 6.6±5.9  | <0.0001 |

Data given as mean±SD or %. BMI, body mass index; CABG, coronary artery bypass grafting; CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; LVEF, left ventricular ejection fraction; MI, myocardial infarction; NYHA, New York Heart Association; PAD, peripheral artery disease; SCORE, System for Cardiac Operative Risk Evaluation.
65% of patients with CAD did not complain of symptoms of angina, suggesting difficulty in judging the presence or absence of coronary stenosis by symptoms alone. Therefore, we believe preoperative screening for CAD should be performed in patients with a true aortic aneurysm even when they are asymptomatic.

The incidence of cardiac complications directly related to CAD, incorporating perioperative MI and cardiac arrest including ventricular fibrillation, was very low and additionally, there was no significant increase in the incidence of cardiac complications in CAD patients as compared with patients without CAD. This suggests that aortic surgery is performed in association with almost no cardiac complications including perioperative MI in patients with relatively mild CAD. As described in the ACCF/AHA guidelines, limiting the group of patients who require treatment for CAD before or during aortic surgery to patients with severe CAD could reduce the incidence of perioperative cardiac complications.

Operative mortality and the incidence of major complications, however, were significantly higher (approximately 2-fold increase) when aortic surgery alone was performed in patients with significant coronary stenosis. Furthermore, on multivariate analysis CAD was an independent risk factor for operative mortality. These findings raise the possibility that perioperative myocardial ischemia caused by CAD, or myocardial damage due to insufficient intra-

**Figure 2.** Clinical and angiography characteristics in patients with coronary artery disease (CAD). (A) No. diseased vessels of the coronary artery. (B) Percentage of patients with CAD and symptoms of angina pectoris. (C) Percentage of concomitant coronary artery bypass grafting (CABG) cases according to the number of diseased vessels of the coronary artery. (D) Percentage of patients with angina symptoms and concomitant CABG. LMT, left main trunk.
Table 2. Outcome of Open Aortic Surgery vs. Presence of CAD, and vs. Presence of Simultaneous CABG in CAD Patients

| Parameters                        | CAD (+), n=1,904 | CAD (-), n=2,692 | OR  | 95% CI       | P-value |
|-----------------------------------|------------------|------------------|-----|--------------|---------|
| A. CAD (+) vs. CAD (-)            |                  |                  |     |              |         |
| Reoperation for any reasons       | 6.3              | 9.9              | 1.635 | 1.318–2.029 | <0.001  |
| Re-exploration for bleeding       | 3.7              | 5.9              | 1.635 | 1.242–2.153 | <0.001  |
| Stroke                            | 5.0              | 8.0              | 1.655 | 1.303–2.101 | <0.001  |
| Continuous coma                   | 1.8              | 3.8              | 2.196 | 1.521–3.170 | <0.001  |
| Temporary CNS disorder            | 3.0              | 4.4              | 1.506 | 1.106–2.052 | 0.010   |
| Paraparesis or paraplegia         | 4.0              | 5.1              | 1.284 | 0.971–1.699 | 0.082   |
| Complete AV block                 | 0.5              | 0.6              | 1.309 | 0.606–2.818 | 0.545   |
| Cardiac arrest                    | 1.2              | 1.1              | 0.972 | 0.566–1.667 | 1.000   |
| Perioperative MI                  | 0.5              | 0.8              | 1.636 | 0.789–3.392 | 0.248   |
| Cardiac tamponade                 | 1.6              | 2.7              | 1.696 | 1.128–2.548 | 0.015   |
| Atrial fibrillation               | 13.5             | 20.0             | 1.600 | 1.367–1.873 | <0.001  |
| Pneumonia                         | 5.6              | 8.8              | 1.628 | 1.297–2.045 | <0.001  |
| Pulmonary embolism                | 0.2              | 0.3              | 1.699 | 0.550–5.248 | 0.379   |
| Prolonged ventilation >24h        | 13.6             | 20.1             | 1.600 | 1.368–1.872 | <0.001  |
| Acute renal failure requiring dialysis | 3.1            | 5.3              | 1.761 | 1.310–2.366 | <0.001  |
| Complication related to anti-coagulant Tx | 0.5           | 1.0              | 2.188 | 1.100–4.350 | 0.032   |

B. CABG (+) vs. CABG (-) in CAD patients

| Parameters                        | CABG (-), n=909 | CABG (+), n=995 | OR  | 95% CI       | P-value |
|-----------------------------------|-----------------|-----------------|-----|--------------|---------|
| Reoperation for any reason        | 8.6             | 11.1            | 1.324 | 0.977–1.795 | 0.077   |
| Re-exploration for bleeding       | 5.0             | 6.8             | 1.408 | 0.958–2.702 | 0.098   |
| Stroke                            | 7.0             | 9.0             | 1.313 | 0.941–1.831 | 0.111   |
| Continuous coma                   | 3.3             | 4.3             | 1.323 | 0.826–2.120 | 0.283   |
| Temporary CNS disorder            | 4.7             | 4.2             | 0.888 | 0.576–1.367 | 0.657   |
| Paraparesis or paraplegia         | 6.2             | 4.1             | 0.655 | 0.434–0.987 | 0.047   |
| Complete AV block                 | 0.4             | 0.8             | 1.834 | 0.585–5.741 | 0.392   |
| Cardiac arrest                    | 1.4             | 0.9             | 0.629 | 0.274–1.445 | 0.293   |
| Perioperative MI                  | 0.2             | 1.3             | 6.004 | 1.509–23.854| 0.008   |
| Cardiac tamponade                 | 2.2             | 3.1             | 1.429 | 0.814–2.509 | 0.256   |
| Atrial fibrillation               | 17.5            | 22.2            | 1.347 | 1.073–1.690 | 0.011   |
| Pneumonia                         | 9.2             | 8.5             | 0.917 | 0.670–1.257 | 0.629   |
| Pulmonary embolism                | 0.3             | 0.3             | 0.913 | 0.210–3.966 | 1.000   |
| Prolonged ventilation >24h        | 18.2            | 21.9            | 1.265 | 1.010–1.585 | 0.045   |
| Acute renal failure requiring dialysis | 4.7            | 5.9             | 1.269 | 0.850–1.896 | 0.263   |
| Complication related to anti-coagulant Tx | 1.1           | 1.0             | 0.913 | 0.388–2.147 | 1.000   |

AV, atrioventricular; CI, confidence interval; CNS, central nervous system; OR, odds ratio; Tx, therapy. Other abbreviations as in Table 1.

Figure 3. Thirty-day and in-hospital mortality after open thoracic aortic repair in (A) patients with vs. without coronary artery disease (CAD), and (B) patients with CAD with or without concomitant coronary artery bypass grafting (CABG).
Operative myocardial protection, would affect surgical outcome, although CAD was not directly related to the occurrence of perioperative MI or fatal arrhythmia. Thus, when severe coronary stenosis is detected prior to surgery, coronary revascularization, including CABG, may possibly improve outcome.

On univariate analysis the incidence of perioperative MI and prolonged ventilation was significantly higher in the CABG (+) group. According to the JACVSD definitions, regardless of electrocardiogram changes, the elevation of biochemistry cardiac markers, such as creatine kinase (CK) or CK-MB more than twice the upper limit of normal, or positive troponin test, is defined as perioperative MI. This definition may partly affect the higher incidence of perioperative MI in the CABG (+) group. It has also been reported that biochemistry cardiac markers increase after bypass surgery for coronary stenosis. Moreover, issues associated with combined procedures, such as a prolonged duration of operation and extracorporeal circulation, may negatively affect these outcomes. No significant difference in operative death, however, was observed between the CABG (−) and CABG (+) groups. Moreover, simultaneous CABG was not a risk factor for operative mortality in the CAD patients. Thus, simultaneous CABG should be considered if patients have severe CAD, such as triple-vessel disease or LMT stenosis.

**Study Limitations**

This was a retrospective study with a number of limitations. First, it was not possible to simply compare the difference in surgical outcome for thoracic aortic disease in the presence or absence of CAD because patient background differed according to the presence of CAD. Although several techniques exist, such as propensity matching, for adjusting preoperative patient background, we decided to present real-world data on the prevalence of CAD, patient background, and postoperative outcome in patients who underwent open surgery for true aneurysms of the thoracic aorta, obtained from a relatively large cohort. Second, the severity of CAD was not evaluated because detailed information regarding the severity or location of coronary stenosis was not available from the registry. Third, detailed information on the surgical procedure and the method of organ protection for each patient was unknown. The fourth limitation is that the registry data did not provide information on any relationship to postoperative cardiac complications, such as perioperative MI or cardiac arrest, and the cause of death. Although perioperative MI may be a cause of postoperative cardiac death, there were only a limited number of perioperative MI cases, irrespective of the presence of significant coronary artery stenosis, in this study. Notably, higher mortality was observed in CAD (+) patients, despite the lower number of perioperative MI cases compared with the CAD (−) patients. Therefore, we infer that the direct contribution of perioperative MI to mortality is very small.

**Conclusions**

We have investigated the current status of preoperative CAG in patients with thoracic aortic disease using the Japanese national registry database (JACVSD). Approximately 40% of patients who underwent CAG were found to have CAD. Although the incidence of cardiac complications related to CAD was very low, such as MI or ventricular fibrillation, CAD was identified as an independent risk factor for operative mortality. In patients with aortic disease having risk factors for CAD, aggressive evaluation of CAD should be carried out before surgery. Once severe CAD is detected, preoperative coronary intervention or simultaneous CABG should be considered.

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**Disclosures**

The authors declare no conflicts of interest.

**References**

1. Girardi LN, Rabotnikov Y, Avgermos DV. Preoperative percutaneous coronary intervention in patients undergoing open thoracoabdominal and descending thoracic aneurysm repair. *J Thorac Cardiovasc Surg* 2014; 147: 163–168.

2. Nakai M, Shimamoto M, Yamasaki F, Fujita S, Masumoto H, Yamada T, et al. Surgical treatment of thoracic aortic aneurysm in patients with concomitant coronary artery disease. *Jpn J Thorac Cardiovasc Surg* 2005; 53: 84–87.
3. Gertz ZM, Levitt SA, Epps KC, Bavaria JE, Moser GW, Kolansky DM. Cardiac catheterization in patients with ascending aortic aneurysm: Safety, success, and prevalence of coronary artery disease. J Invasive Cardiol 2014; 26: 241–244.

4. Ueda T, Shimizu H, Shin H, Kashima I, Tsutsumi K, Iino Y, et al. Detection and management of concomitant coronary artery disease in patients undergoing thoracic aortic surgery. Jpn J Thorac Cardiovasc Surg 2001; 49: 424–430.

5. Iba Y, Minatoya K, Matsuda H, Sasaki H, Tanaka H, Kobayashi J, et al. Contemporary open aortic arch repair with selective cerebral perfusion in the era of endovascular aortic repair. J Thorac Cardiovasc Surg 2013; 145: S72–S77.

6. Svensson LG, Crawford ES, Hess KR, Coselli JS, Raskin S, Shenaq SA, et al. Deep hypothermia with circulatory arrest. Determinants of stroke and early mortality in 656 patients. J Thorac Cardiovasc Surg 1993; 106: 19–28.

7. Svensson LG, Crawford ES, Hess KR, Coselli JS, Safi HJ. Experience with 1509 patients undergoing thoracoabdominal aortic operations. J Vasc Surg 1993; 17: 357–368.

8. Kouchoukos NT, Dougenis D. Surgery of the thoracic aorta. N Engl J Med 1997; 336: 1876–1889.

9. Hiratzka LF, Bakris GL, Beckman JA, Bersin RM, Carr VF, Casey DE Jr, et al. 2010 ACCF/AHA/AATS/ACR/ASA/SCA/SCAI/SIR/STS/SVM Guidelines for the diagnosis and management of patients with thoracic aortic disease. A Report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines, American Association for Thoracic Surgery, American College of Radiology, American Stroke Association, Society of Cardiovascular Anesthesiologists, Society for Cardiovascular Angiography and Interventions, Society of Interventional Radiology, Society of Thoracic Surgeons, and Society for Vascular Medicine. J Am Coll Cardiol 2010; 55: e27–e129.

10. Japan Adult Cardiovascular Surgery Database (JACVSD). http://www.jacvsd.umin.jp (accessed February 25, 2019).

11. Santilli SM. The Coronary Artery Revascularization Prophylaxis (CARP) Trial: Results and remaining controversies. Perspect Vasc Surg Endovasc Ther 2006; 18: 282–285.

12. Busch T, Sirbu H, Aleksic I, Friedrich M, Dalichau H. Development of cardiovascular procedures before abdominal aortic aneurysm repair over 16 years. Ann Thorac Cardiovasc Surg 1999; 5: 326–330.

13. Takahashi J, Okude J, Gohda T, Murakami T, Hatakeyama M, Sasaki S, et al. Coronary artery bypass surgery in patients with abdominal aortic aneurysm: Detection and treatment of concomitant coronary artery disease. Ann Thorac Cardiovasc Surg 2002; 8: 213–219.

14. Fusari M, Parolari A, Agostinelli A, Spirito R, Rubini P, Esposito G, et al. Coronary and major vascular disease: Aggressive screening and priority-based therapy. Cardiovasc Surg 2000; 8: 22–30.

15. Onorati F, Renzulli A, De Feo M, Santarpino G, Gregorio R, Biondi A, et al. Does antegrade blood cardioplegia alone provide adequate myocardial protection in patients with left main stem disease? J Thorac Cardiovasc Surg 2003; 126: 1345–1351.