Original Article

Coronary Artery Bypass Surgery in Patients with Abdominal Aortic Aneurysm: Detection and Treatment of Concomitant Coronary Artery Disease

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Objectives: Complication due to coronary artery disease (CAD) is a major cause of mortality in the surgical treatment of abdominal aortic aneurysm (AAA). The purpose was to show 1) the incidence of patients who required coronary artery bypass grafting (CABG), and 2) risk factors for the necessity of CABG in patients with AAA.
Methods: Subjects were consecutive 159 patients (132 males and 27 females) undergoing elective repair of non-ruptured AAA between May 1993 and March 2002. Most patients (n=145) underwent routine preoperative coronary angiography (CAG) and received coronary revascularization when necessary. Clinical atherosclerotic risk factors were subjected to univariate and multivariate analysis to determine predictors for the necessity of CABG.
Results: Of 43 patients (27.0%) with significant coronary stenosis, 7 patients (4.4%) underwent CABG concomitantly (n=1) or prior to the AAA repair (n=6) in the same admission. Other patients received percutaneous transluminal coronary angioplasty (PTCA) (n=14) and isolated medical treatment (n=22). Overall mortality of 159 patients undergoing AAA repair was 2.5% and there were no deaths in 7 patients undergoing CABG. Univariate and multivariate analysis indicated only the history of angina as significant for the necessity of CABG in patients with AAA. Of 155 survivors, 5 patients underwent CABG later in the follow-up period.
Conclusions: The incidence of patients who required CABG in the treatment of AAA was 4.4% in our institute. It was difficult to predict the necessity of CABG without conducting CAG in patients with asymptomatic myocardial ischemia. These results may justify the routine enforcement of preoperative CAG in patients with AAA. (Ann Thorac Cardiovasc Surg 2002; 8: 213–9)

Key words: abdominal aortic aneurysm, coronary artery bypass grafting, coronary artery disease, myocardial revascularization, risk factors

Introduction

Cardiac complications constitute the principal cause of early and late morbidity and mortality after the surgical treatment of abdominal aortic aneurysm (AAA). The importance of preoperative evaluation of the coronary artery and a required myocardial revascularization has been emphasized for the improvement of early, and late survival after AAA repair.[1)] When significant coronary artery disease (CAD) is present in patients scheduled for AAA repair, treatment of CAD will be selected from percutaneous transluminal coronary angioplasty (PTCA), coronary artery bypass grafting (CABG), or medical treatment on the basis of the severity of coronary artery lesions and ischemic symptoms. There have been many reports demonstrating the incidence of CAD in AAA, and the reported incidence ranged from 40 to 60%.[2-5)] In this report, we focused on the patients who required CABG

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Table 1. Demographics and outcome of patients

Number of patients	159
Age (years)	70.6±0.6 (53-87)
Male/female	132/27
Mean size of AAA (cm)	5.3±0.1 (4.0-10.0)
Number of patients undergoing CAG	145 (91.2%)
Presence of CAD	64 (40.3%)
Presence of significant coronary stenosis	43 (27.0%)
Preoperative PTCA	14 (8.8%)
CABG performed	7 (4.4%)
Preoperative	6
Concomitant	1
Operation time (min)	200±5 (95-520)
Hospital stay (days)	42.1±2.2 (12-208)
Cardiac death	1 (0.6%)
Hospital death	4 (2.5%)

AAA: abdominal aortic aneurysm, CAG: coronary angiography, CAD: coronary artery disease, PTCA: percutaneous transluminal coronary angioplasty, CABG: coronary artery bypass grafting

due to considerable severity of CAD and reviewed preoperative coronary evaluation and the choice of treatment. We also investigated those undergoing CABG during the follow-up period after AAA repair. The main purpose of this study was to demonstrate the incidence and surgical results of these patients and to identify feasible predictors for the necessity of CABG in patients with AAA.

Patients and Methods

This is a retrospective clinical study in patients surgically treated at Aishin Memorial Hospital (Sapporo, Japan) between May 1993 and March 2002. A total of 159 consecutive patients scheduled for elective repair of atherosclerotic AAA were reviewed. Patients with a ruptured AAA or those suffering aortic dissection were excluded from the study. There were 132 males and 27 females, with a mean age of 70.6±0.6 years (range from 53 to 87 years) (Table 1). The average aneurysm diameter was 5.3±0.1 cm (range from 4.0 to 10.0 cm). In principle, the patient scheduled for elective AAA repair has routinely undergone preoperative coronary angiography since 1993 at our institute, based on the previous reports by Hertzer et al. or Roger et al.[4,5] The definition of CAD in this study was as follows: 1) A patient was diagnosed as having CAD when coronary angiography (CAG) demonstrated the stenosis equal to or exceeding 50% (≥50%) in at least one major coronary artery or in its main branch; 2) A patient was diagnosed as having "significant stenosis" when CAG demonstrated the stenosis ≥75% in at least one major coronary artery or in its main branch; 3) Stenosis of the left main trunk (LMT) ≥50% was defined as "significant stenosis". In addition to CAG, all patients underwent a standard electrocardiogram and echocardiography for the assessment of myocardial ischemia and viability. Clinical symptoms related to myocardial ischemia were also checked carefully in the patient's record and history.

When the patient presented with significant CAD showing myocardial ischemia, the treatment option for the CAD was determined by the strategy resembling the Guidelines proposed by American College of Cardiology (ACC) and American Heart Association (AHA) Task Force Report in 1993 and those proposed by Japanese Circulation Society in 1999.[6,7] Briefly, PTCA was indicated for the 1- or 2-vessel CAD without involvement of the left anterior descending coronary artery (LAD), and CABG was indicated for the LMT lesion, 3-vessel CAD, and most cases of the 2-vessel CAD with involvement of LAD. Some patients with 2-vessel CAD with involvement of LAD underwent PTCA depending on the type of coronary stenosis and perfusion area. Patients with CAD of 50% stenosis received perioperative medical treatment with trinitroglycerin (TNG) and/or diltiazem (DTZ).

When CABG was indicated for a patient with significant CAD, the patient underwent either CABG as the first operation followed by AAA repair or a combined CABG and AAA repair simultaneously. Informed consent was obtained before operation after full explanation. Isolated CABG was performed with the use of standard cardiopulmonary bypass (CPB) established with moderate hypothermia and continuous retrograde blood cardioplegia. In the case of combined CABG and AAA repair, CABG

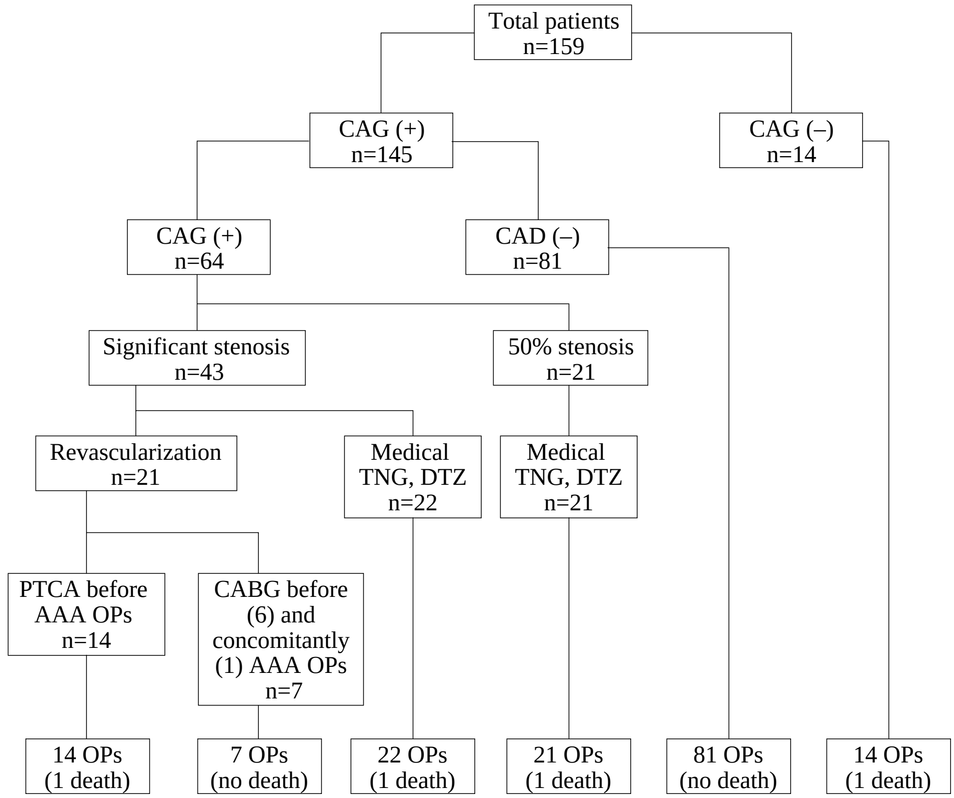

Fig. 1. Coronary evaluation and treatment tree.

CAG: coronary angiography, CAD: coronary artery disease, PTCA: percutaneous transluminal coronary angioplasty, CABG: coronary artery bypass grafting, AAA: abdominal aortic aneurysm, OPs: operations, TNG: trinitroglycerin, DTZ: diltiazem

was performed first and the sternotomy incision was extended to the pubic symphysis. Abdominal aortic surgery was carried out after the patient was weaned off CPB. The procedure of AAA repair was a prosthetic aortic replacement with a bifurcated or tube graft in all patients.

This study aimed to show 1) the incidence of patients who required CABG due to an association of severe CAD, and 2) risk factors for the necessity of CABG in patients with AAA. Investigated risk factors included age, gender, presence of diabetes mellitus (DM), hypertension (HTN), hyperlipidemia (HL), history of cerebral infarction, history of symptomatic angina, and history of arteriosclerosis obliterans. These factors were compared between patients undergoing CABG and those who did not, and were subjected to univariate and multivariate analysis to determine predictors for the necessity of CABG. Follow-up of the patient after discharge has been performed periodically at the outpatient clinic in our institute. The incidence of patients who developed significant CAD and received coronary revascularization after discharge was also investigated.

Statistical analysis

All continuous variables are presented as the mean ± standard error (SEM). Univariate analysis was conducted with Student's t-test for comparisons of continuous variables, and the chi-square test for dichotomous variables. Multivariate analysis to determine predictors for the necessity of CABG was done by stepwise logistic regression analysis. All analyses were performed with SPSS software (SPSS Inc., Chicago, IL). Difference was considered significant at $p<0.05$.

Results

Overview of the clinical characteristics and overall outcomes of all patients is summarized in the Table 1. Overall mortality of 159 AAA repairs was 2.5% (4 hospital deaths including 1 cardiac death). Among 145 patients who received CAG, 64 patients (40.3%) had CAD and 43 (27.0%) had significant coronary artery stenosis. Results of coronary artery evaluation and treatment of CAD are illustrated in Fig. 1. In patients with significant coro-

Table 2. Profile of patients who received CABG concomitantly or before elective repair of AAA

	Age (yr)	Gender	CABG	Timing of CABG OPs (interval from CABG to AAA OPs)	Size of AAA (cm)	Remarks	Outcome
1	77	M	3 (SVG)	Prior to AAA OPs (8 weeks)	5.9		Alive
2	72	M	2 (SVG)	Prior to AAA OPs (10 weeks)	4.1	CABG + LV aneurysmectomy	Alive
3	71	M	1 (LITA)	Prior to AAA OPs (4 weeks)	4.0	CABG + AVR	Alive
4	79	M	3 (LITA, SVG)	Simultaneously	7.4		Alive
5	74	F	2 (LITA, SVG)	Prior to AAA OPs (5 weeks)	4.6		Alive
6	72	M	3 (LITA, SVG)	Prior to AAA OPs (8 weeks)	5.2		Alive
7	71	M	2 (LITA, SVG)	Prior to AAA OPs (3 weeks)	4.0	AAA + blt F-P bypass	Alive
Average	73.7±1.2		2.3±0.3; ITA used in 5 patients (71.4%)		5.0±0.5		

M: male, F: female, CABG: coronary artery bypass grafting, AAA: abdominal aortic aneurysm, SVG: saphenous vein graft, LITA: left internal thoracic artery, OPs: operations, LV: left ventricle, AVR: aortic valve replacement, F-P bypass: femoro-popliteal bypass, blt: bilateral

Table 3. Univariate analysis of risk factors for the necessity of CABG

Factors	Total number	Number in CABG cases (%)	Odds ratio (95% confidence interval)	p-value
Age≥70 years	96	7 (7.3)	N/A$	0.043*
Male	132	6 (4.5)	1.24 (0.14-10.72)	0.999
History				
Diabetes mellitus (DM)	15	1 (6.7)	1.64 (0.18-14.6)	0.507
Hypertension (HTN)	59	3 (5.1)	1.29 (0.28-5.95)	0.711
Hyperlipidemia (HL)	18	1 (5.6)	1.32 (0.15-11.7)	0.576
Any of DM, HTN, HL	78	3 (3.8)	1.30 (0.28-6.00)	0.999
Cerebral infarction	25	1 (4.0)	1.13 (0.13-9.77)	0.999
Angina	27	5 (18.5)	14.0 (2.56-76.7)	0.002*
ASO	18	2 (11.1)	3.40 (0.61-18.9)	0.181

CABG: coronary artery bypass grafting, ASO: arteriosclerosis obliterans
*: indicating significant difference in p-value
$: Odds ratio cannot be calculated because the data contained zero.

nary stenosis, 14 patients (8.8%) received PTCA and 7 (4.4%) underwent CABG concomitantly (n=1) or prior to the AAA repair (n=6). Other patients (n=22) underwent medical therapy with a continuous intravenous infusion of TNG and/or DTZ perioperatively. The history of angina was present in 5 of 7 patients undergoing CABG and 8 of 14 patients who required PTCA. The average operation time of AAA repair was 200±5 min.

Four hospital deaths occurred in a patient who underwent PTCA prior to AAA repair (drug allergy during the cardiac catheterization before discharge), a patient with significant CAD who received medical treatment (cardiac death), a patient with CAD of 50% stenosis (multiple organ failure (MOF) resulting from ischemic colitis and infection), and a patient who did not undergo CAG (MOF resulting from postoperative bleeding). There was no significant difference of mortality between these groups of different therapy. The average period of hospital stay in all patients was 42.1±2.2 days.

Table 2 summarizes the profile of 7 patients undergoing CABG. Staged operation was selected in 6 of 7 patients except for a patient (No. 4) with 3-vessel CAD and large AAA (7.4 cm in diameter). The average age is 73.7±1.2 years and the number of grafts in most cases was 2 or 3, except for a patient (No. 3) undergoing concomitant aortic valve replacement and CABG. In the case of a staged operation, the average interval between the two operations (CABG and AAA repair) was 6.3±1.1 weeks (range from 3 to 10 weeks). There were no patients who suffered an urgent expanding AAA and required emergency repair of AAA during the intervals.

Results of univariate analysis of clinical risk factors are demonstrated in Table 3. Univariate analysis showed two factors, age (≥70) (p=0.043) and history of angina

Table 4. Profile of patients who received CABG during the follow-up period after AAA repair

	Age	Gender	CAG findings at AAA repair	Treatment of CAD at AAA repair	Graft of CABG	Intervals from discharge to CABG (months)	Remarks	Outcome
1	73	M	1-vessel disease	Medical (TNG, DTZ)	3 (LITA, SVG)	33	History of PTCA after AAA OPs	Alive
2	65	M	2-vessel disease	Medical (TNG, DTZ)	4 (LITA, SVG)	27		Alive
3	64	M	2-vessel disease	PTCA	2 (SVG: emergency)	54	History of re-PTCA after AAA OPs	Alive
4	61	M	1-vessel disease	PTCA	1 (LITA)	3	History of PTCA after AAA OPs	Alive
5	82	M	2-vessel disease	PTCA	2 (SVG)	4	History of re-PTCA after AAA OPs	Alive

Age: age at AAA repair, M: male, CAG: coronary angiography, CAD: coronary artery disease, CABG: coronary artery bypass grafting, AAA: abdominal aortic aneurysm, TNG: trinitroglycerin, DTZ: diltiazem, SVG: saphenous vein graft, LITA: left internal thoracic artery, OPs: operations, PTCA: percutaneous transluminal coronary angioplasty

($p=0.002$), significant for patients undergoing CABG in the same admission. In multivariate analysis to which these factors were subjected to determine predictors for the necessity of CABG, stepwise regression analysis demonstrated the history of angina as the only significant predictor ($R=0.345$, $R^2=0.119$, standard regression coefficient=0.279, $t=3.575$, $p=0.005$ by multiple logistic regression analysis) for the necessity of CABG.

Patients who survived the AAA repair were followed up for an average of 31.5±2.4 months (range from 2 to 117 months). During this period, 5 patients underwent CABG for the treatment of CAD later and their profile is shown in Table 4. All 5 patients presented with significant 1- or 2-vessel CAD at the time of AAA repair and received either PTCA prior to AAA repair (n=3) or perioperative medical treatment (n=2). Most patients (n=4) also had undergone PTCA once or more prior to CABG. The average intervals between discharge and CABG were approximately 2 years (24.2±9.5 months). There were no deaths in these 5 patients undergoing CABG later.

Discussion

The leading cause of perioperative mortality in AAA repair is myocardial infarction and reduction of cardiac mortality associated with AAA repair has been an important goal to improve surgical result of AAA repair.[3] Preoperative screening to detect CAD and its treatment has been essential for successful outcome after AAA repair. The prevalence of CAD in our series was 40.3% by conducting preoperative CAG in almost all patients, which was similar to that reported previously ranging from 40 to 60%.[2-5] The incidence of patients undergoing CABG, investigated in this study, may be assumed the prevalence of those with a highly severe CAD. Previous reports have shown that the incidence of these patients with AAA ranged from 4.4 to 22.4%,[1,4,8] the lower incidence of which is similar to that in our series (4.4%).

The incidence of patients undergoing CABG simultaneously or prior to AAA repair may be influenced by many factors including diagnostic procedure of preoperative evaluation of CAD, and indication of PTCA and CABG for significant CAD in each institute. The feasibility to detect significant CAD may differ with whether preoperative CAG is performed only for selected patients or all patients with AAA. On the other hand, some patients may develop complications due to CAG, risk of which is increased when CAG is performed routinely. In addition, indication of PTCA for CAD has a wide range depending on the country, especially in Japan where PTCA predominates in the treatment of CAD.[7] Recently, Japanese Circulation Society proposed guidelines for the indication of interventional therapy in coronary artery disease on assessment of diagnostic and therapeutic cardiovascular disease.[7] If the bias of therapeutic strategy for CAD is corrected, such comparisons of incidence as performed in this study will have more significance.

Regarding the timing and method of CABG in patients with AAA, there may be two therapeutic strategies. One is simultaneous operation for CABG and AAA repair, and the other is a staged operation. When a staged repair was planned, most patients with CAD and AAA had undergone CABG first, followed by elective AAA repair within 2 to 3 or 6 months.[1,4,9] Recent reports favored simultaneous operation,[10-12] but we have employed a staged operation for most cases and performed a combined operation only for the case of unstable CAD and a large AAA with increasing risk of rupture.[8,13] One reason is that the aged patients were more common in our institute. The average age of patients with AAA who underwent CABG is 73.7±1.2 years in our series, which is relatively higher than that in previous series (65-67 years).[10,12] A combined approach causes longer operating and anesthesia time requirements, which may increase the risk of overlapping complications. In the aged patients with AAA, it would be important to prevent not only myocardial ischemia but pneumonia and other pulmonary complications.[14,15] The adequate control of postoperative wound pain is mandatory for the drainage of sputum, which would reduce the risk of pulmonary complications. We have employed an epidural spinal anesthesia for its purpose, which can be used in a staged operation but cannot be used in a combined operation due to the need of a large amount of heparin. The prevalence of pulmonary complications may also increase when greater systemic inflammatory responses related to the use of CPB develop.[16] Of course, a combined approach has a great advantage of removing the risk of rupture during the intervals between CABG and AAA repair. Recently, Ascione et al. reported the surgical results of the combined approach to compare patients with or without the use of CPB.[10] They concluded off-pump CABG (OPCAB) decreased postoperative complications in high-risk patients undergoing simultaneous CABG and AAA repair compared with the conventional one-stage procedure using CPB. OPCAB can avoid exposure to detrimental effects of CPB and eliminate the amount of heparin used in the operation. Currently we think the therapeutic strategy of patients who require both CABG and AAA repair can be determined according to the severity of CAD and size of AAA especially in the aged patients,[13] but simultaneous OPCAB and AAA repair will be an excellent method of treatment for these patients. Further evaluation of a prospective study with larger number is needed.

In the statistical analysis of clinical risk factors, reported atherosclerotic factors such as DM, HTN, or HL were not identified as significant predictors for the necessity of a CABG in patients with AAA. This was a rather unexpected result, but patients with AAA have been reported to present with fewer atherosclerotic risk factors than do patients with ordinary arterial occlusive disease in some reports.[17] The only predictor for the necessity of CABG was a history of angina in our series, which is similar to results described in previous reports.[2,4] This result may not be of great clinical significance, because most patients with a history of angina will undergo preoperative CAG prior to AAA repair currently. However, some patients with significant CAD without symptomatic angina will not be detected if preoperative CAG is carried out only for selected patients with angina. In our series, 5 of 7 patients undergoing CABG and AAA repair had a history of angina but 2 patients did not have the history. Moreover, 6 of 14 patients who required PTCA were asymptomatic. Significant CAD in these patients could not be detected without routine preoperative CAG. In addition, some patients with significant CAD who undergo preoperative PTCA may require CABG later during the follow-up period, which was seen in 5 patients in our series. These results may also emphasize the value of preoperative CAG. Recent progress in catheterization technology and development of the transradial approach have reduced the invasiveness of CAG.[18,19] From these viewpoints, we believe that the merits of routine CAG may exceed its demerits for the detection of patients with AAA who require CABG.

In conclusion, the incidence of patients who required CABG in the treatment of AAA during the same admission was 4.4% in our institute. It was difficult to predict the necessity of CABG without conducting CAG in patients with asymptomatic myocardial ischemia. These results may support the routine enforcement of preoperative CAG in patients with AAA. Further studies will be required to show the superiority of simultaneous or a staged operation to another operation for patients who require both CABG and AAA repair.

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