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Original Article / *Özgün Makale*

EDITOR'S CHOICE

Results of late-onset type A aortic dissection after previous cardiac surgery: Does prior coronary artery bypass grafting affect survival?

Geçirilmiş kalp cerrahisi sonrası geç başlangıçlı tip A aort diseksiyonlarının sonuçları: Geçirilmiş koroner arter baypas greftleme sağkalımı etkiler mi?

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ABSTRACT

Background: This study aims to evaluate the results of late-onset type A aortic dissection following primary cardiac surgery and to compare the outcomes of patients with or without prior coronary artery bypass grafting.

Methods: Between January 2005 and December 2015, data of 32 patients (16 males, 16 females; mean age 58.1±10.9 years; range, 45 to 73 years) who were diagnosed with acute type A aortic dissection and underwent repair with a history of previous cardiac surgery at our institution were retrospectively analyzed. The patients were divided into two groups as those with a history of prior coronary artery bypass grafting (n=16) and the patients with a previous cardiac surgery without prior coronary artery bypass grafting (n=16).

Results: Dissection of the ascending aorta occurred in 32 patients (late acute in 22 and late chronic in 10) who underwent previous cardiac surgery (aortic valve replacement in 12, mitral valve replacement in two, aortic valve replacement + coronary artery bypass grafting in two, coronary artery bypass grafting in 10, mitral valve replacement + coronary artery bypass grafting in four, and dual valve replacement in two patients). The mean time between the first operation and dissection was 4.0±1.5 years. Dissections were treated with the Bentall procedures (n=8), ascending aorta replacement (n=14), ascending aorta replacement + hemiarch replacement (n=4), ascending aorta + aortic valve replacement (n=4) and Bentall + arch replacement (n=2). In-hospital mortality (30-day mortality) was seen in five patients, and one-year mortality rate was 21.85% (n=7). The survival rates of the all patients for primary cardiac surgery vs primary cardiac surgery + coronary artery bypass grafting were 81.25% vs 75% at one year, 75% vs 68.75% at three years,75% vs 56.25% at five years, 68.75% vs 56.25% at seven years, and 68.75% vs 56.25% at 10 years, respectively (p=0.71, CI: 95%).

Conclusion: Type-A aortic dissections may develop after cardiac operations with or without coronary artery bypass grafting at any time, and irrespective of associated histologies, they may result in high overall in-hospital mortality. With careful planning by prompt intervention, the outcomes in redo sternotomy operations with or without coronary artery bypass grafting for aortic dissections would be consistent the results of spontaneous aortic dissections.

Keywords: Aortic dissection; aortic surgery; cardiac valvular surgery.

ÖZ

Amaç: Bu çalışmada primer kalp cerrahisi sonrasında geç başlangıçlı tip A aort diseksiyonunun sonuçları değerlendirildi ve daha önce koroner arter baypas greftleme yapılan ve yapılmayan hastaların sonuçları karşılaştırıldı.

Çalışma planı: Ocak 2005 - Aralık 2015 tarihleri arasında kliniğimizde akut tip A aort diseksiyonu tanısı konan ve tamiri yapılan, daha önce kalp cerrahisi öyküsü olan 32 hastanın (16 erkek, 16 kadın; ort. yaş 58.1±10.9 yıl; dağılım 45-73 yıl) verileri retrospektif olarak incelendi. Hastalar geçirilmiş koroner arter baypas greftleme öyküsü olanlar (n=16) ve geçirilmiş koroner arter baypas greftleme öyküsü olmaksızın daha önce kalp cerrahisi yapılan hastalar (n=16) olmak üzere ikiye ayrıldı.

Bulgular: Daha önce kalp cerrahisi geçiren 32 hastada (hastaların 12'sinde aort kapak replasmanı, ikisinde mitral kapak replasmanı, ikisinde aort kapak replasmanı + koroner arter baypas greftleme, 10'unda koroner arter baypas greftleme, dördünde mitral kapak replasmanı + koroner arter baypas greftleme ve ikisinde dual kapak replasmanı) çıkan aortta diseksiyon gelişti (22'sinde geç akut ve 10'unda geç kronik). İlk ameliyat ile diseksiyon arasında geçen ortalama zaman 4.0±1.5 yıl idi. Diseksiyonlar Bentall işlemi (n=8), çıkan aort replasmanı (n=14), çıkan aort replasmanı + yarım ark replasmanı (n=4), çıkan aort + aort kapak replasmanı (n=4) ve Bentall + ark replasmanı (n=2) ile tedavi edildi. Hastane içi mortalite (30 günlük mortalite), beş hastada gözlendi ve bir yıllık mortalite oranı %21.85 (n=7) idi. Primer kalp cerrahisi + koroner arter baypas greftlemeye kıyasla primer kalp cerrahisi hastalarında sağkalım oranı sırasıyla birinci yılda %75'e kıyasla %81.25, üçüncü yılda %68.75'e kıyasla %75, beşinci yılda %56.25'e kıyasla %75, yedinci yılda %56.25'e kıyasla %68.75 ve 10. yılda %56.25'e kıyasla %68.75 idi (p=0.71, CI: %95).

Sonuç: Tip A aort diseksiyonları, koroner arter baypas greftleme ile veya olmaksızın kalp cerrahisi sonrasında herhangi bir zamanda gelişebilir ve histolojik ilişkiden bağımsız olarak genel hastane mortalitesi yüksektir. Zamanında müdahale ile dikkatli bir planlama sayesinde, aort diseksiyonlarında koroner arter baypas greftleme ile veya olmaksızın yapılan yeniden sternotomi ameliyatlarının sonuçları, spontan aort diseksiyonlarının sonuçları ile paralellik gösterecektir.

Anahtar sözcükler: Aort diseksiyonu; aort cerrahisi; kardiyak valvüler cerrahi.

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Acute type A aortic dissections (AADs) are life-threatening conditions with an overall in-hospital mortality of 15 to 32%.[1,2] This type of dissections may complicate routine cardiac surgery at any time, suddenly converting a low-risk procedure into a high-risk condition with an excessive rate of operative mortality.[3-6] Previous studies demonstrate AADs may occur in 0.6% of patients with previous aortic valve replacement (AVR) surgery.[7-9] Current guidelines do not provide additional information on the characteristic features and management requirements in this patient population.[3,7-9] Several potential sites of iatrogenic trauma during primary cardiac surgery (PCS) have been suggested as the origin for later aortic dissections.[6,10,11]

The clinical presentation and treatment strategies are critical components in the management and outcome of AADs after PCS.[12,13] The aim of this study was to evaluate the results of late-onset type A aortic dissection following PCS and to compare the outcomes of patients with or without prior coronary artery bypass grafting (CABG).

PATIENTS AND METHODS

We retrospectively reviewed the data of all adult cardiac surgical patients between January 2005 and December 2015 (n=4,873; total adult cardiac surgical procedures). A total of 32 patients (16 males, 16 females; mean age 58.1±10.9 years; range 45 to 73 years) diagnosed with AAD and previous PCS were included. The patients were divided into two groups as: *(i)* the patients who had a history of PCS without CABG (PCS) (n=16) and *(ii)* the patients who had a history of PCS with CABG (PCS + CABG) (n=16) (Table 1). The flow diagram is shown in Figure 1. The hospital records including medical notes for all hospital stays, perfusionist and anesthetist reports, surgical notes for the secondary procedure for AAD and surgical notes of PCS were reviewed. Patients with previous aortic surgery for aneurysm or dissection including connective tissue disorders, dissections occurring within one month of the initial cardiac surgery, dissections following cardiac catheter intervention and transcatheter aortic valve implantation (TAVI), traumatic ruptures, and coarctation of the aorta were excluded. A written informed consent was obtained from each patient. The study protocol was approved by the Ankara University, Faculty of Medicine, Ethics Committee. The study was conducted in accordance with the principles of the Declaration of Helsinki.

An acute ADD was defined as intraoperative, when the dissection occurred during the PCS.[14-16] Late acute dissection was defined as occurring more than 30 days after PCS with surgical repair within two weeks after the onset of specific symptoms.[13]

Surgical technique

The right subclavian artery was exposed and directly cannulated with an 18- to 22-Fr flexible arterial cannula, if applicable, followed by the cannulation of the right atrium in a standard fashion. Alternatively, cardiopulmonary bypass (CPB) was established through femoral artery cannulation and was initiated. Cooling was maintained at 28°C rectal temperature, depending on the expected time of the arch repair. The innominate and left carotid arteries were snared with silicone loops and occluded at the initiation of selective antegrade cerebral perfusion (ACP). In the patients with bilateral antegrade cerebral perfusion (BACP), the silicon loop snared around the left common carotid artery was

Table 1. Demographic and preoperative clinical characteristics of patients diagnosed with aortic dissection

Variable	All (n=32)			CABG + PCS (n=16)			PCS (n=16)			
	n	%	Mean±SD	n	%	Mean±SD	n	%	Mean±SD	*p*
Age (year)			60.1±8.9			60.6±8.6			59.6±9.4	0.77
Male	16	50		8	50		8	50		1.0
Hypertension	22	68.8		8	50		14	87.5		0.02
Creatinine level			1.8±0.7			1.6±0.6			2.09±0.7	0.09
COPD	11	34.4		5	31.2		6	37.5		0.71
Ejection fraction			44.5±6.7			42.1±6.4			47.06±6.2	0.03
Body mass index			30.9±4.4			30.5±4.3			31.3±4.7	0.61
Ascending aortic diameter (mm)			44.6±6.5			41.6±7.0			47.6±4.4	0.07
Interval to aortic dissection (year)			4.2±1.5			3.8±0.9			4.6±1.8	0.22
Typical chest pain	16	50		6	37.5		10	62.5		0.15
Stroke	4	12.5		1	6.2		3	18.8		0.6
Pericardial tamponade	4	12.5		2	12.5		2	12.5		1.0

SD: Standard deviation; COPD: Chronic obstructive pulmonary disease; CABG: Coronary artery bypass grafting; PCS: Primary cardiac surgery.

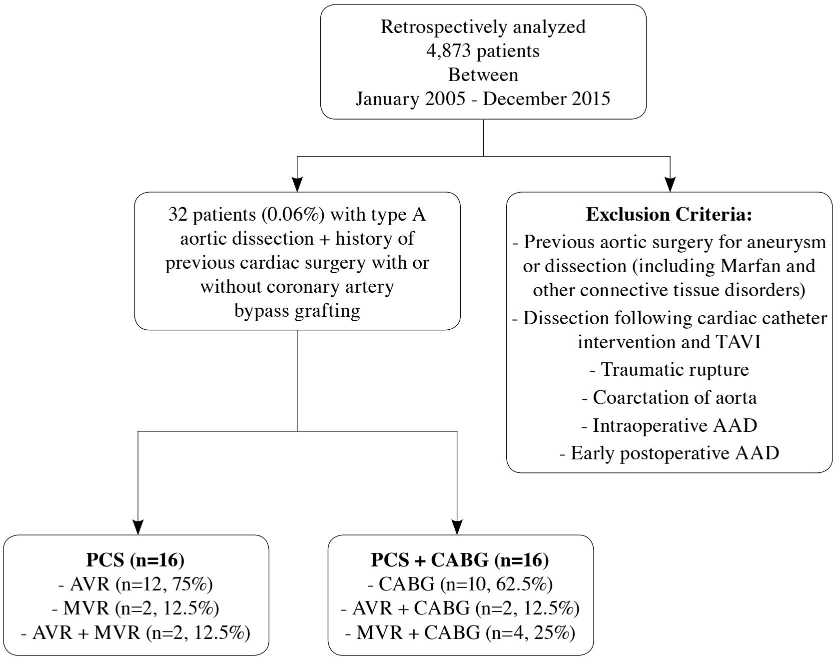

Figure 1. Treatment algorithm for type A aortic dissection repair with previous cardiac surgery.

TAVI: Transcatheter aortic valve implantation; AAD: A aortic dissection; PCS: Primary cardiac surgery; MVR: Mitral valve replacement ; AVR: Aortic valve replacement; CABG: Coronary artery bypass grafting.

temporarily loosened at this point, and a Y-shaped arterial line connected to the arterial CPB cannula was placed inside the vessel for additional perfusion of the left hemisphere. Unilateral antegrade cerebral perfusion (UACP) was the method of choice to avoid the potential risk of creating cerebral embolism, while manipulating the arch vessels during the insertion of the second arterial inflow cannula. Selective ACP was conducted with a perfusate temperature of 28 to 30°C. The perfusion pressure was controlled on the pump unit and kept at 75 mmHg, allowing for a UACP flow of 1 l/min and respective BACP flow of 1.2 l/min. At that point, the arch replacement was performed, including a reimplantation of the arch vessels *en bloc*, if necessary, followed by the reconstitution of full body perfusion through the right axillary artery, once the arch replacement was completed. Neurovascular monitoring varied throughout the study period and consisted of cerebral saturation assessment using near-infrared spectroscopy (NIRS) (Covidien, Dublin, Ireland) since 2012. A sudden decrease in cerebral oxygenation, indicating cerebral malperfusion, was treated by immediate circulatory arrest and opening of the aortic arch with direct cannulation of the brachiocephalic trunk and the left common carotid artery. During the rewarming phase, the temperature gradient between the oxygenated blood (arterial line) and the patient's core temperature was set at a maximum of 10°C with a peak temperature of blood leaving the oxygenator of 38.5°C. Concerning the level of systemic cooling, we adjusted it to the anticipated extent of arch repair, approximately 30°C for 15 min, 28-30°C for 30 min and 28°C for >45 min.

In patients with an isolated tear of the aortic root, repair or replacement of the aortic root was combined with replacement of the proximal ascending aorta without aortic arch surgery. Total arch replacement was reserved for those patients with a primary entry or secondary re-entry tear in the aortic arch, while partial arch replacement was performed in the rest. Proximal aortic root repair or replacement was performed during the rewarming phase in patients requiring aortic arch surgery. In hemodinamically stable (no malperfusion, no cardiac tamponade, no severe aortic valve insufficiency) PCS patients, our management algorithm is evolved to diminish the bleeding risk and delineate coronary anatomy. For patients on oral anticoagulation, partial or complete reversal of coagulopathy with maximal delay to surgery of 24 hours is performed. In patients with previous CABG, coronary imaging using CT angiography, or in selected patients with suspected progressive

Table 2. Operative data

Variable	All (n=32)			CABG + PCS (n=16)			PCS (n=16)			
	n	%	Mean±SD	n	%	Mean±SD	n	%	Mean±SD	*p*
AA replacement	14	43.8		10	62.5		4	25		0.03
AA + hemiarch replacement	4	12.5		2	12.5		2	12.5		1.0
AVR + AA replacement	4	12.5		2	12.5		2	12.5		1.0
Bentall	8	25		2	12.5		6	37.5		0.22
Bentall + arch replacement	2	6.2		0	0.0		2	12.5		0.48
Cardiopulmonary bypass (min)			191±46.8			180.2±43.3			201.9±49	0.12
Cross clamp (min)			78.9±24.5			73±16.5			84.8±29.9	0.42
Deep hypothermic cardiac arrest (min)	12		42±15.6	4		31.5±13.8	8		47.2±14.5	0.73
Antegrade cerebral perfusion time (min)			37.6±4.0			28.6±2.5			43.1±3.7	0.10
Intensive care unit stay (hour)			94±74.5			82.8±71			105.3±78.5	0.23
Support of ventilation (day)			8.3±3.6			6.7±2.4			9.9±4.0	0.003
Right blood cell transfusion (unit)			3.3±3.9			3.7±4.7			2.9±2.9	0.89
Fresh frozen plasma transfusion (unit)			4.3±3.8			5.3±4.9			3.4±2.1	0.53
Platelets transfusion (unit)			6.4±9.2			10.7±10.8			2.1±4.4	0.001

SD: Standard deviation; CABG: Coronary artery bypass grafting; PCS: Primary cardiac surgery; AA: Ascending aorta; AVR: Aortic valve replacement.

coronary artery disease cardiac catheterization is obtained. Techniques for surgical repair are shown in Table 2. Operations were performed without delay as emergencies in 22 patients, whereas 10 patients with chronic AAD were classified as elective procedures. Ten patients received one or more new CABG, and 12 had their proximal anastomoses reimplanted into the prosthetic aortic graft with a button of the native aorta (n=22), arterial cannulation via the right subclavian or axillary artery in 25 patients (78.1%), and the remaining patients had femoral arterial cannulation (21.8%; n=7). Venous drainage was established via the right atrium (53%; n=17), the femoral vein (40%; n=13) or by bicaval cannulations (6%; n=2).

Surveillance data were obtained by contacting the patients and their family members or by the Social Security Death Index. Complete follow-up was available in 32 hospital survivors (100%). The median follow-up was 4.3 (range 2.4 to 11) years.

Statistical analysis

Statistical analysis was performed using the PASW version 17.0 software (SPSS Inc., Chicago, IL, USA). Continuous variables were expressed in mean and standard deviation (SD) or in median for non-normally distributed variables. Categorical variables were expressed in number and percentage. For the univariate analysis, we used chi-square or Fischer's exact test for variables with an expected cell count less than five patients for categorical variables, and the Mann-Whitney U test or Kruskal-Wallis test in case of more than two groups for continuous variables.

Table 3. Perioperative complication

Variable	All (n=32)		CABG + PCS (n=16)		PCS (n=16)		
	n	%	n	%	n	%	*p*
Postoperative stroke	9	28.1	3	18.8	6	37.5	0.43
Postoperative sepsis	4	12.5	2	12.5	2	12.5	1.0
Postoperative ARF	12	37.5	7	43.8	5	31.2	0.46
Continuous renal replacement	10	31.2	7	43.8	3	18.8	0.12
Perioperative MI	5	15.6	4	25	1	6.2	0.33
Reoperation for bleeding	11	34.4	6	37.5	5	31.2	0.71
GIS complications	6	18.8	4	25	2	12.5	0.65
Low cardiac output	11	34.4	6	37.5	5	31.2	0.71
In-hospital mortality	5	15.6	3	18.8	2	12.5	1.0

SD: Standard deviation; CABG: Coronary artery bypass grafting; PCS: Primary cardiac surgery; ARF: Acute renal failure; MI: Myocardial infarction; GIS: Gastrointestinal system.

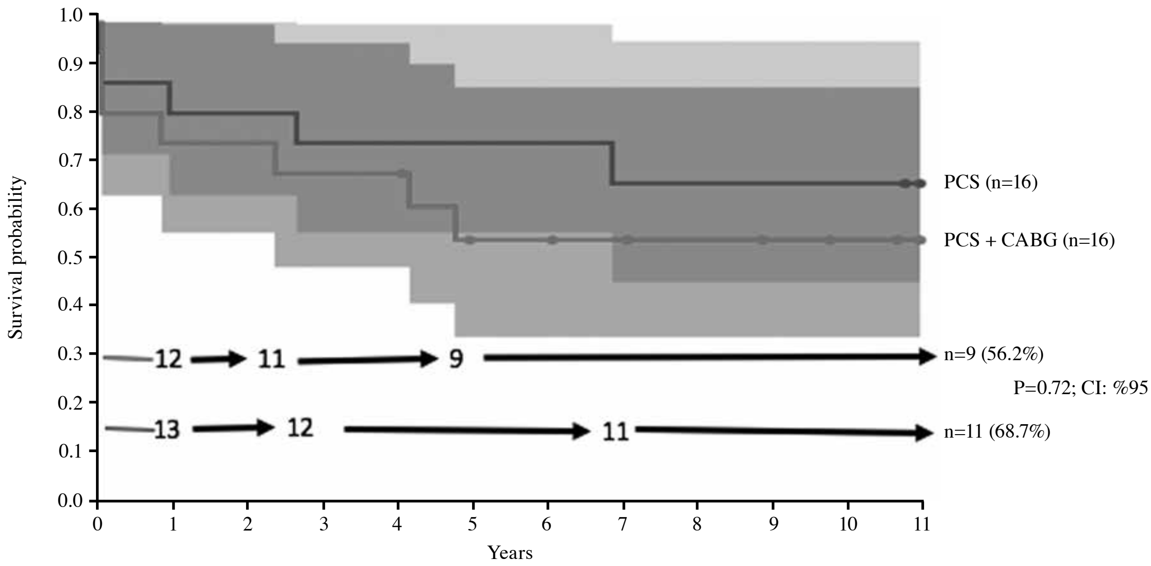

Figure 2. Survival probability for type A aortic dissection repair after previous cardiac surgery with or without coronary artery bypass grafting.

The Kaplan-Meier estimates were used to calculate cumulative probabilities of overall survival rates. A two-sided *p* value less than 0.05 was considered statistically significant with 95% confidence interval (CI).

RESULTS

Demographic characteristics of the study population are shown in Table 1. The majority of the patients were hypertensive (n=22; 68.75%). All parameters were analyzed as non-significant, except for left ventricular ejection fraction (LVEF) (PCS: EF 47.1±6.2%, PCS + CABG: 42.1±6.4; p=0.03), and hypertension (PCS n=14 (87.5%), PCS + CABG n=8 (50%); p=0.02) (Table 1). Nearly all (81%; n=26) of the aorta which was later dissected were reported as enlarged at the primary operation with a diameter ≥40 mm (mean 44±3 mm; range 40 to 54 mm). The mean interval between PCS and reoperation was 4.3±1.5 years.

Typical presentation with sudden-onset of pain in the chest was noted in 50% of cases (n=16). There was only one case of late acute AAD with rupture and severe tamponade (Table 1).

The proximal graft anastomosis and aortotomy sites were identified as entries in approximately half of the patients with prior isolated AVR (18%; n=6) and CABG (34.3%; n=11). Other dissection entry locations were sites of cannulation (18%; n=6), cross-clamping, and side-biting clamping (12%; n=4), and cardioplegia (6%; n=2). The entry was not identified in three patients.

Of these 32 patients, five underwent ≥2 PCS, while 27 underwent one PCS. Types of previous surgeries were as follows: CABG (n=10; 31.25%), AVR (n=12; 37.5%), CABG + AVR (n=2; 6.25%), mitral valve replacement (MVR): (n=2; 6.25%), MVR + CABG (n=4; 12.5%), and AVR + MVR (n=2; 6.25%).

Twenty-seven patients recovered without major complications and the mean length of intensive care unit stay was 94±74.5 hours (PCS: 105.3±78.5 vs PCS + CABG: 82.8±71; p=0.23).

Postoperative complications were as follows: stroke, sepsis, acute renal failure, myocardial infarction (MI), reoperation for bleeding, severe respiratory complications, gastrointestinal complications, low cardiac output, and in-hospital mortality (30-day mortality) (Table 3). One-year mortality was 21.8% (n=7). Among them, five patients died within 30 days (Figure 2).

Long-term survival was evaluated for 25 patients who were still alive one year after the operation. The survival rates of all patients for PCS vs PCS + CABG were 81.25% vs 75% at one year, 75% vs 68.75% at three year, 75% vs 56.25% at five year, 68.75% vs 56.25% at seven year, and 68.75% vs 56.25% at 10 year (p=0.71, CI: 95%), respectively (Figure 2).

DISCUSSION

Aortic dissection occurring in the setting of PCS may have a different natural history. As there are main discrepancies in clinical presentation, surgical management and prognosis, we believe that AADs after PCS must be distinguished from acute AAD cases, and the presence of prior CABG during PCS may affect the long-term outcomes of AAD. Several studies have shown that patients with PCS have higher in-hospital mortality rates after aortic repair.[3,8] In the present study, we hypothesized that PCS might increase the risk of morbidity and mortality in patients with AAD dissection, and previous CABG might worsen the postoperative results.

Besides a mandatory high index of suspicion, timely diagnosis critically depends on imaging, regardless of the clinical presentation.[3,9,16] In addition, the explanation for absence of pain in AAD is a matter of controversy. Previous mechanical traumas, inflammation, and consecutive scarring have also the potential to damage the innervation of the vessel wall, resulting in silence pain.[15,16] Our study supports the protective effects of PCS on rupture and tamponade, given that these patients had a lower rate of pericardial effusion and hypotension. Medically treated PCS patients had an in-hospital mortality rate of 43%, compared to 30% in the surgically treated group.[9,17] Medically treated patients who survived until hospital discharge had significantly worse intermediate mortality than those patients who had operative dissection repair. In our series, we also obtained similar results during the follow-up period.

In this study, we observed that AADs occurred mainly in the patients with pre-existing aortic wall pathologies and hypertension at sites of iatrogenic mechanical trauma. The aortic wall was defined at the initial surgery as fragile or thin in nearly all cases. Furthermore, the mean aortic diameter was 44.6±6.5 mm in all available imaging (CT) reports (PCS: 41.6±7.0 vs PCS + CABG: 47.6±4.4; p=0.07). This is consistent with the Estrera et al.'s study[8] who found an aortic diameter of 43±10 mm in their series.

Arterial hypertension is a key element in the etiology of AAD. Luk et al.[11] analyzed the aortic histology in a series of patients with late AAD after PCS. In our study, the aortotomy and the proximal graft anastomoses sites were identified as entry tear locations in half of cases with AVR and CABG, respectively. Dissections in the remaining patients originated from the sites of clamping, cardioplegia, or cannulation.

Operative mortality at one year in our cohort was 21.8%, in consistent with the other reports. Of these, five patients were defined as in-hospital mortality. Overall survival at one year was 78.15%.

The limitations of the present study are its single center and retrospective design with small sample size.

In conclusion, open heart surgery is associated with a low, but significant incidence of acute type-A aortic dissections. Pre-existing aortic wall pathology and hypertension is associated with acute type-A aortic dissections occurring at the sites of iatrogenic surgical trauma. The operative mortality of AAD repair in this group of patients is high and dependent on the primary procedure, the time interval between the initial cardiac surgery and acute type-A aortic dissections and surgical management. The patients with PCS are frequently in stable condition should undergo preoperative native coronary and graft status assessment and appropriate operative planning and aggressive revascularization. With the increasing number of patients undergoing cardiac surgery and as PCS has been increasingly recognized as an additional risk factor for aortic dissection, the incidence of post-cardiotomy aortic dissection is expected to increase. With careful planning by prompt intervention, the outcomes in redo sternotomy operations for aortic dissections would be consistent with the results of spontaneous aortic dissections.

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