Mortality and Survival in Aortic Arch Surgeries with Preservation of Supra-aortic Vessels: Thirteen Years of Experience

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Abstract

Background: The aortic arch diseases exhibit high morbidity and mortality rates. Some surgical strategies recommend partial preservation of the aortic arch and the supra-aortic vessels, but the immediate and medium-term mortality rates of patients undergoing this surgical strategy is uncertain.

Objectives: To compare overall mortality and mid- term survival curve of patients undergoing surgical strategy of partial preservation of the aortic arch and supra-aortic vessels (group A) compared to conventional strategies of the aortic arch approach (group B); to assess cardiovascular mortality over time.

Methods: Descriptive and retrospective study of the medical records of patients undergoing aortic arch repair surgery between February 2000 and July 2013. We analyzed 111 patients, 29 in group A and 82 in group B. The overall survival and survival from cardiovascular events were assessed by Kaplan-Meier test.

Results: In- hospital mortality from any cause was 31% in group A and 29.3% in group B. At 1 year, 2 year, and 5 year general survival was similar between the groups. In-hospital, 2 years and 5 years mortality from cardiovascular causes was 13.8%, 14.8%, e 22.7% in group A and 26.8%, 34.6% e 50.9% in group B. The difference between the groups in 5 years showed statistical significance (p = 0.0234). Survival from cardiovascular causes in 2 years and 5 years was 85.2% and 77,3% in group A and 65.4% and 49,1% in group B. Occurrence of urgent and emergency procedures were greater in group A, but without statistical significance.

Conclusions: There was no difference in all-cause mortality over time between the groups. Group A showed lower cardiovascular mortality at 5 years than group B. (Int J Cardiovasc Sci. 2018;31(5)466-482)

Keywords: Aorta, Thoracic / physiopathology; Aorta, Thoracic / surgery; Mortality; Aortic Aneurysm / surgery; Survivorship (Public Health); Comparative Study.

Introduction

Despite considerable advances in diagnostic methods, surgical techniques (percutaneous or open surgical techniques) and postoperative care, thoracic aortic diseases, and especially aortic arch diseases are still major causes of cardiovascular mortality and challenge for physicians.[1]

The Global Burden of Disease Study 2010 showed that overall mortality rate for aortic aneurysm and aortic dissection increased from 2.49 per 100,000 population in 1990 to 2.78 per 100,000 population in 2010, with higher rates among men.[2,3]

The timing of surgical interventions in the management of thoracic aortic diseases considers the risk of rupture, possible postoperative complications and patients' life expectancy. Natural progression of thoracic aortic diseases is directly related to the aortic segment involved and the cause of the disease.[4]

Surgical management of the aortic arch is considered a complex approach, because of the high risk of brain

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injury caused by involvement of cerebral vessels. This is more evident in case of acute events, due to the need for performing the surgery in appropriate time using adequate techniques for each case.

Until the 1980's, increased mortality rates related to surgical repair of aortic arch had been mainly associated with visceral ischemia, due to diversion of blood flow to false lumen (when femoral artery perfusion was performed), neurological complications secondary to brain ischemic lesions, and hemorrhagic complications, i.e., often uncontrolled, perioperative bleeding.[5,6]

Symptomatic patients with aneurysm or dissection should be operated regardless of aneurysm size. In asymptomatic patients, aortic repair procedure is performed based on transverse diameter of the lumen, which is the main predictor of complications.[1]

Today, the most common techniques for protection of the central nervous system in aortic arch surgery are: profound hypothermia with complete circulatory arrest (18 - 20ºC),[7] profound hypothermia with retrograde cerebral perfusion (through superior vena cava)[8] and antegrade selective cerebral perfusion with moderate hypothermia (25 - 28ºC).[9] This can be performed bilaterally, or through one carotid artery, brachiocephalic trunk or subclavian artery. Antegrade selective cerebral perfusion is the most effective method for brain protection, and the technique of choice by many surgeons.[9]

Carreira et al.[5,6] described a new surgical strategy for aortic arch diseases with antegrade selective cerebral perfusion and preservation of part of patient's original vessels, which allows the aortic arch repair without interruption of cerebral blood flow, and a shorter period of unilateral antegrade cerebral perfusion. One of the main criticisms of this approach, however, is that preservation of part of patient's vascular tissue would increase the risk for recurrent aneurysmal disease or dissection.

In the present study, we compared mortality rate between patients who had undergone surgery with partial preservation of aortic arch and supra-aortic vessels (group A) and those who had undergone conventional surgical procedures of aortic arch (group B), and survival curve of these patients in a mean follow-up of 3.22 years (1,178.27 days).

The study was submitted to (Brazil online platform, May 2015) and approved by the Research Ethics Committee of *Casa de Saúde São José* (approval number 45613015300005664).

Surgical strategies

Surgical strategy of partial preservation of aortic arch and supra-aortic vessels (Group A)

Surgical strategy of partial preservation of aortic arch and supra-aortic vessels described by Carreira et al.[5,6] was the main focus of this study. The surgery involves median sternotomy to get access to the heart and great vessels, followed by dissection of aorta and supra-aortic arteries.

A curved clamp is placed on the brachiocephalic trunk and a 10 - 20 mm vascular graft anastomosis is made using a 5.0 polypropylene suture. An arterial cannula is inserted in the vascular graft next to the anastomosis. Venous cannulation depends on other associated procedures.

Nasopharyngeal temperature is decreased to 22 - 25ºC by extracorporeal circulation (ECC) and maintained during surgery of aortic valve and confection of proximal anastomosis with tubular graft. A vascular clamp is placed on ascending aorta before retroperfusion of the coronary sinus.

Then, a vascular clamp is positioned on the brachiocephalic trunk for a unilateral selective cerebral perfusion. Body perfusion is interrupted, and cerebral flow maintained at 300 - 500 mL/min through the right carotid artery for maintenance of right arterial pressure at 50 - 70 mmHg.

Blood is diverted to the brachiocephalic trunk using a roller pump or a centrifugal pump for ECC at 20ºC - 25ºC. Aorta is cut following the interruption of systemic perfusion, leaving enough aortic tissue to isolate both brachiocephalic trunk and left carotid artery.

Left subclavian artery is left close to the descending aorta. Isolation of brachiocephalic trunk and left carotid artery was achieved by closure of aortic "flap" with continuous 4.0 or 5.0 polypropylene suture.

Then, brachiocephalic trunk clamping is released, and bilateral antegrade selective cerebral perfusion is started and maintained at 500 - 1,000 mL/min and 20 - 25ºC. Distal portion of aorta is cut and prepared for placement of Dacron tubular prosthesis. Left subclavian artery is positioned next to distal anastomosis so that it can be ligated in case of significant lesion, and aortic endoprosthesis can be implanted by antegrade approach if necessary.

After completion of distal anastomosis with 4.0 polypropylene suture, an arterial cannula is inserted into aortic prosthesis and clamped for restauration of body perfusion by blood infusion at 25ºC. Rewarming (3ºC every 10 minutes) is performed during this period.

A vascular prosthesis is then anastomosed to the (valved or not) Dacron aortic graft by continuous suture technique using 5.0 polypropylene. The cannula placed into the brachiocephalic trunk is removed, and perfusion is maintained only through the cannula placed in the aortic prosthesis. Rewarming continue until nasopharyngeal temperature of 36ºC.

Distal and proximal aortic anastomoses can be performed with separate prostheses by anastomosis of proximal to distal aortic grafts.

Conventional surgical strategies for aortic arch approach (Group B)

In severe atherosclerotic disease and brachiocephalic trunk dissection, the surgical strategy of partial preservation of aortic arch and supra-aortic vessels cannot be performed, and many other procedures can be performed as alternative. Despite the differences between them, these techniques share common features.

Group B comprised different techniques, previously described by other authors, that included moderate hypothermia combined with antegrade cerebral flow, or profound hypothermia combined with brief circulatory arrest. Complete circulatory arrest for up to 15 minutes and temperature decrease to up to 25ºC is considered safe, with no risk of neurologic sequelae. Periods from 15 to 30 minutes, and periods of up to 40 minutes or up to 60 minutes of complete circulatory arrest seem to be associated with transient neurological dysfunction in nearly 10%, 15% or even 60% of patients, respectively.

In the first technique, described by a group from Mount Sinai Hospital, NY,[10] the aortic convexity and cerebral vessels (not affected by dissection of atherosclerotic disease) are dissected en bloc and sutured to a 14 - 16 mm Dacron graft for posterior anastomosis to a second larger Dacron graft, placed between ascending and descending segment of thoracic aorta, resulting in the aortic arch reconstruction. Similarities with the technique described in Group A include prolonged periods of antegrade cerebral perfusion, and treatment of the aortic stump alone, which may include the insertion of an endoprosthesis in the descending aorta, as in type I aortic dissection.

Another technique for aortic arch disease involves the use of antegrade cerebral perfusion through catheterization of cerebral vessels, brachiocephalic trunk and left carotid artery or only profound hypothermia. In this case, cerebral vessels are also dissected en bloc (aortic convexity and brachiocephalic trunk, left carotid and left subclavian artery) and anastomosed to the interposed Dacron graft, substitute for the aortic arch.[11]

In a more recent technique, developed after the advent of branched Dacron grafts, the separated graft technique substitutes the en bloc repair technique for aortic arch reconstruction. A graft with four limbs is used, 3 of them in the arch of the graft and 1 used for reestablishment of ECC. Antegrade cerebral perfusion may also be used in this technique, as described by Kazui et al.[12] in 2000 with a catheter placed in the brachiocephalic trunk and left carotid artery.

Objectives

I. Primary objective

To evaluate medium-term (5 years) mortality and survival rates in patients undergoing the surgical technique of partial preservation of aortic arch and supra-aortic vessels in comparison with conventional strategies for aortic arch reconstruction.

II. Secondary objective

To evaluate 30-day, 1 year, 2-year, 5-year cardiovascular mortality.

Methods

Study population

In this retrospective study, we evaluated medical records of patients hospitalized for surgical resection and/or surgical treatment of aortic arch aneurysm in hospitals in Rio de Janeiro. The initial sample was composed of 150 patients, and data of 111 patients operated from February 2000 to July 2013 were analyzed.

All patients underwent surgical repair of aortic arch and ascending aorta diseases performed by the same surgical staff. Of the 111 patients included, 29 underwent the strategy with partial preservation of aortic arch and supra-aortic vessels (Group A) and 82 underwent conventional surgical techniques for aortic arch reconstruction (Group B) (Figure 1).

The search for medical records was conducted by the medical records department of each institution. A standardized form (Appendix A) was used for collection of clinical and surgical data of patients.

Figure 1 - Flowchart of database construction.
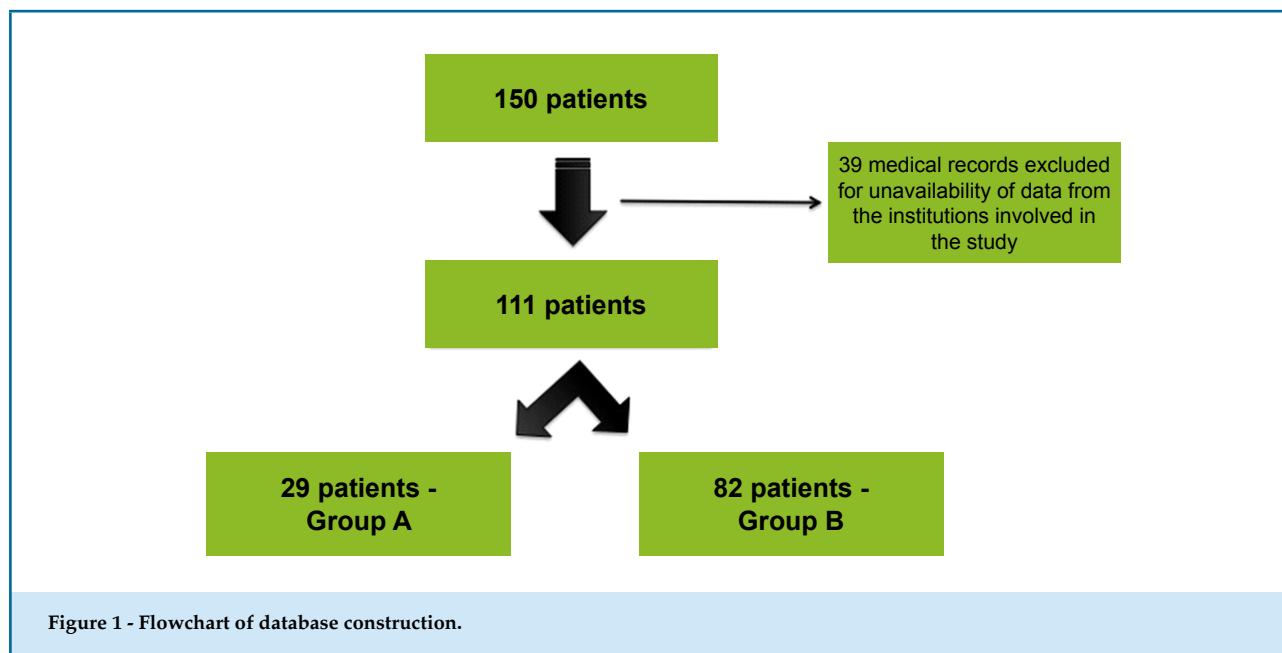
Thirty-nine patients were excluded from the initial sample (n = 350) due to missing data in the medical records and/or the medical records were not available.

As above mentioned, the strategy of partial preservation of aortic arch and supra-aortic vessels cannot be performed in severe atherosclerotic disease or brachiocephalic trunk dissection. In our study, patients with preserved brachiocephalic trunk who had not undergone this technique, this decision was left to the surgeons' discretion.

The study was conducted in the following private hospitals in Rio de Janeiro - Casa de Saúde São José (30 patients), Quinta`Dor Hospital (25 patients), Copa`Dor (21 patients) and Barra`Dor (20 patients), Pró-cardíaco Hospital (5 patients), Samaritano Hospital (5 patients), Status Cor Hospital (4 patients) and Santa Maria Madalena Hospital (1 patient).

For medium-term mortality and survival rates, data were collected from death certificates issued by the Rio de Janeiro State Secretary of Health from February 2000 to December 2014.

Inclusion criteria

All patients who underwent aortic arch repair (elective or emergent, performed by the same surgical staff) for aneurysm or acute aortic dissection from February 2000 to July 2013 were included in the study.

Exclusion criteria

Patients with missing data in the medical records, or whose medical records were not made available by the institutions.

Data collection

Data were collected using a standardized form including sociodemographic and clinical data, as well as pre-, peri-, and post-operative data (Appendix A).

Preoperative data included: clinical and sociodemographic data – sex, age, systemic arterial hypertension (SAH), diabetes mellitus (DM), obesity, previous stroke (ischemic, hemorrhagic or unspecified), pre-operative serum creatinine, chronic renal failure, renal replacement therapy (hemodialysis or peritoneal dialysis), diagnosis of chronic obstructive pulmonary disease (obtained from the medical records), peripheral vascular disease, history of arrhythmia, history of acute myocardial infarction (AMI), unstable angina, heart failure and NYHA functional class, previous surgeries – myocardial revascularization surgery, heart valve replacement, partial aortic replacement, aortic dissection according to Stanford classification (type A or B), aortic arch aneurysm and/or aneurysm of ascending aorta.

The following perioperative data were evaluated: need for blood transfusion, combined procedure performed in aortic valve (valve repair or valve replacement),

endoprosthesis in descending aorta, time of ECC, aortic cross-clamping time, minimum temperature during hypothermia, nature of surgery: elective, urgent (24 - 72h of symptom onset) or emergent (within 24 hours of symptom onset), cardiorespiratory arrest during anesthetic induction, intraoperative complications, and death in the operating room.

Postoperative data evaluated were: clinical progress – low output syndrome (cardiogenic shock), cardiac tamponade, complications – ischemic, mechanical, respiratory, metabolic, neurological (ischemic or hemorrhagic event confirmed by imaging test according to medical records data), cardiologic, infectious and vascular complications, postoperative drainage volume within the first 24 hours, time of hospitalization, time of mechanical ventilation and hospitalization outcomes (death, discharge or transfer to other facilities).

Mortality and survival

Thirty-day mortality was defined as the total number of deaths that occurred in 30 days after surgery divided by the total number of surgeries performed.

Hospital mortality was defined as the total number of in-hospital deaths after surgery divided by the total number of surgeries performed.

Cardiovascular deaths were defined by the codes – I00-I99, E10-E14, R57 and J81 according to the International Statistical Classification of Diseases, tenth revision (ICD- 10).

Survival was considered as time (in years) after surgery according to data registered by the death registration service (SES-RJ/SVS/CGVS/ADVITAIS).

Patient's anonymity was protected, and patients' consent for the use of their data for research purposes was sought using a proper form at admission.

Confidentiality of the data obtained from the SES-RJ/SVS/CGVS/ADVITAIS was assured and protected by password (Appendix C and D).

Statistical analysis

The SPSS software version 21.0 for Windows was used in all analyses. Continuous variables were expressed as mean and standard deviation or median and interquartile range according to normality (or not) of data distribution, tested by the Kolmogorov-Smirnov test. Categorical variables were expressed as percentage. The unpaired Student's t-test and the Mann-Whitney test were used

for analysis of parametric and non-parametric variables, respectively. The chi-square test and Fisher's exact test were used for comparison of parametric variables.

A conventional level of significance was adopted, p < 0.05. Overall survival and cardiovascular event-free survival were assessed by Kaplan-Meier curve and the log-rank test.

Results

Data of 111 patients who had undergone surgical treatment of aortic arch dissection or aneurysm from 2000 to 2013 were evaluated.

Most patients were men (n = 73, 65.77%) with mean age of 63 ± 13 years in group A and 64 ± 15 years in group B. In the preoperative period, the most frequent risk factors were SAH (90%), DM (37.7%) and obesity (19.7%) in group B. In group A, the same risk factors were observed, with statistical significance for DM (41.7%, p = 0.036).

Median preoperative serum creatinine was 0.95 mg/dL (0.80 - 1.30 mg/dL) in group A and 1.10 mg/dL (0,90 - 1,30 mg/dL) in group B. The incidence of chronic renal failure was 7.7% in group A and 10.8% in group B; 3.9% of these patients were on hemodialysis or peritoneal dialysis. Patients with previous cardiac surgeries were found in group B (and not in group A); 3.9% (3 patients) underwent myocardial revascularization surgery, 6.5% (5 patients) valve replacement and 5.3% (4 patients) partial aortic replacement.

No patient had active endocarditis in the preoperative period. In group A, no patient had stable angina or heart failure and in group B, 2.7% of patients had unstable angina and 1.3% had heart failure in the preoperative period (Table 1).

Regarding surgical data, mean ECC time was 169 ± 42 minutes in group A and 156 ± 59 minutes in group B (p = 0.311); mean aortic cross-clamping time was 128 ± 44 minutes in group A and 116 ± 41 minutes in group B (p = 0.200).

Median minimum temperature achieved during hypothermia induced for aortic arch reconstruction was $26 \pm 4^{\circ}C$ in group A and $27 \pm 5^{\circ}C$ in group B (p = 0.169). Drainage volume within the first 24 hours of surgery was 468 mL and 375 mL in groups A and B, respectively (p = 0.469).

Blood transfusion was commonly required during the procedures (89.3% and 81.1% in groups A and B, respectively) (p = 0.321).

Table 1 - Preoperative clinical characteristics of patients who underwent partial preservation of aortic arch and supra-aortic vessels (Group A) and patients who underwent conventional surgical techniques for aortic arch reconstruction (Group B)

Variable	Group A (n = 29)		Group B (n = 82)		p
	N	n(%), median (p25 - p75) or mean ± standard deviation	N	n(%), median (p25 - p75) or mean ± standard deviation	
Age	29	63 ± 13	82	64 ± 15	0.889
Sex					
Female	10	34.5%	28	34.1%	0.974
Male	19	65.5%	54	65.9%	0.974
HAS	25	86.2%	72	90.0%	0.576
Blood pressure at admission (mmHg)					
Systolic	23	133 ± 32	67	126 ± 21	0.245
Diastolic	21	72 ± 20	67	70 ± 14	0.245
Diabetes mellitus	10	41.7%	23	37.7%	0.036
Obesity	4	14.3%	15	19.7%	0.523
BMI (kg/m²)	27	26.27 ± 3.38	77	26.85 ± 4.34	0.533
Ischemic stroke	3	10.7%	3	4.8%	0.301
Highest creatinine level (mg/dL)	22	0.95 (0.80 – 1.30)	74	1.10 (0.9 – 1.30)	0.934
CRF	2	7.7%	8	10.8%	0.648
COPD	1	3.7%	8	11.0%	0.260
PAD	1	3.6%	3	4.1%	0.911
Arrhythmia	2	7.4%	8	11.9%	0.519
AMI	3	10.3%	8	10.7%	0.962

CRF: chronic renal failure; COPD: chronic obstructive pulmonary disease; PAD: Peripheral arterial disease; AMI: acute myocardial infarction.

The frequencies of combined surgeries were 58.6% in group A and 72.7% in group B. In addition, in group A, 24.1% of patients underwent elective surgery, 58.6% urgent surgery and 17.2% emergent surgery, whereas in group B these frequencies were 45.7%, 44.4% and 9.9%, respectively.

Intraoperative complications – blood dyscrasia, hypotension secondary to the use of amine, etc. – occurred in 24.1% of patients in group A and no deaths were reported. In group B, intraoperative complications occurred in 22.5% of patients, with death in 1.3% (Table 2).

The most frequent postoperative complications were – blood transfusion (48.3%), drainage volume within the first 24 hours of surgery greater than 600 mL (41.4%), mechanical ventilation time longer than 24 hours (37.9%) and acute renal failure (32.1%). In group B, complications were – arrhythmia (34.2%), mechanical ventilation time longer than 24 hours (33.8%) and blood transfusion (32.5%) (Table 2).

One hemorrhagic event was reported in each group confirmed by clinical and imaging data obtained from the medical records.

Reoperated patients were found only in 2 patients in group B (2.43%), during different hospital admissions.

Also, 60.7% and 43.0% of patients in groups A and B, respectively had aortic dissection (Graph 1).

Table 2 - Surgical data of patients who underwent partial preservation of aortic arch and supra-aortic vessels (Group A) and patients who underwent conventional surgical techniques for aortic arch reconstruction (Group B)

Variable	Group A (n = 29)		Group B (n = 82)		p
	N	n(%), median (p25 - p75) or mean ± standard deviation	N	n(%), median (p25 - p75) or mean ± standard deviation	
Time of ECC (min)	26	169 ± 42	79	156 ± 59	0.311
Aortic cross-clamping time (min)	26	128 ± 44	79	116 ± 41	0.200
Hypothermia (ºC)	26	26 ± 4	79	27 ± 5	0.169
Drainage within the first 24 hours (mL)	27	468 (250 – 850)	72	375 (225 – 750)	0.469
Blood transfusion	25	89.3%	60	81.1%	0.321
Aortic valve repair	9	34.6%	20	27.0%	0.463
Descending aortic prosthesis	9	36.0%	16	21.9%	0.163
Coronary reimplantation	4	17.4%	20	27.8%	0.318
Combined surgery	17	58.6%	56	72.7%	0.162
Elective surgery	7	24.1%	37	45.7%	0.042
Urgent surgery	17	58.6%	36	44.4%	0.190
Emergent surgery	5	17.2%	8	9.9%	0.292
Intraoperative complications	7	24.1%	18	22.5%	0.857

ECC: extracorporeal circulation.
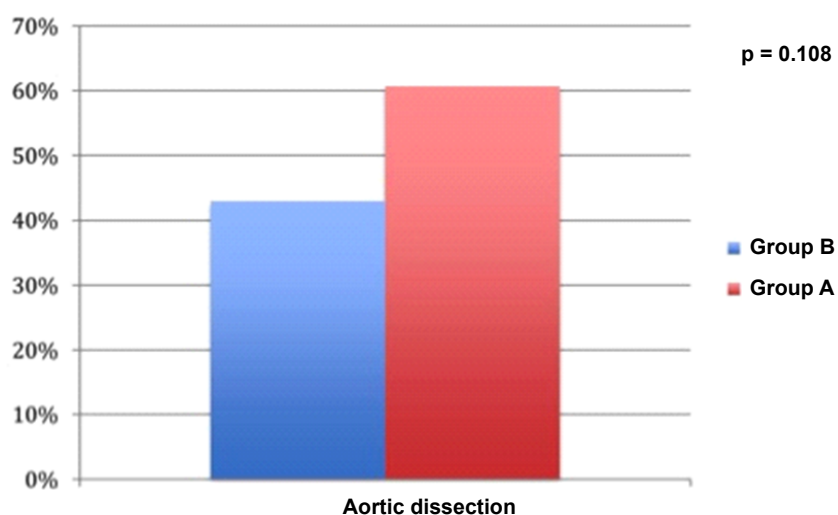
Graph 1 - Aortic dissection according to technique.

Thirty-day mortality and in-hospital mortality was found in 24.1% (7 patients) and 31% (9 patients), respectively, in group A and in 26.8% (22 patients) and 29.3% (24 patients) in group B, with no statistically significant differences between the groups (Table 3).

Overall survival was 1,178.27 days (mean) and 843.00 days (median). In group A, mean survival was 1,182.83 days and in group B, 1,176.66 (OR = 268.114 days – 95% CI [-527.705-515.367]).

Regarding all-cause mortality, a two-year survival rate of 59.3% and 59% were observed in groups A and B, respectively, and a 5-year survival rate of 45.5% and 35.8% were observed in groups A and B, respectively, with no statistically significant difference between the groups (Graph 2).

Survival curve was also analyzed by the causes of death registered in death certificates and classified into cardiovascular and non-cardiovascular death.

Group A showed a thirty-day cardiovascular mortality of 10.3%, an in-hospital cardiovascular mortality of 13.8%, and a 2-year and 5-year mortality for cardiovascular diseases of 14.8% and 22.7%, respectively. In group B,

Table 3 - Overall mortality by techniques for aortic arch reconstruction (partial preservation of aortic arch and supra-aortic vessels, Group A or conventional surgeries, Group B)

Outcome	Group A		Group B		p
	N	n(%)	N	n(%)	
30-day mortality	7	24.1%	22	26.8%	0.777
In-hospital mortality	9	31.0%	24	29.3%	0.858
1 year- mortality	10	34.5%	28	34.1%	0.974
2-year mortality	11	40.7%	32	41.0%	0.979
5-year mortality	12	54.4%	34	64.2%	0.437

Log rank - p = 0.989

Group A
Group B

Graph 2 - Overall survival curve in patients who underwent partial preservation of aortic arch and supra-aortic vessels (Group A, n = 29) and patients who underwent conventional surgical techniques for aortic arch reconstruction (Group B, n = 82).
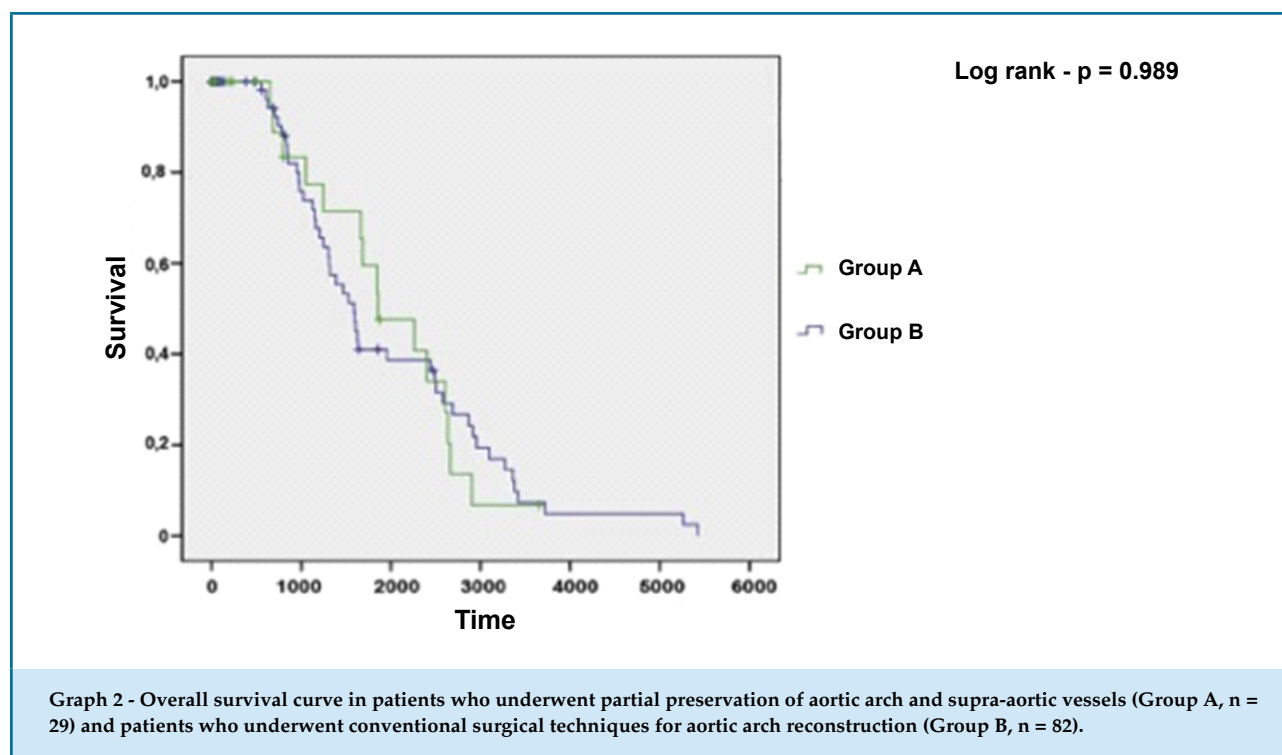
these percentages were 25.6%, 26.8%, 34.6% and 50.9%, respectively. Five-year mortality was significantly different between the groups (Table 4).

Overall cardiovascular mortality was 20.7% in group A and 32.9% in group B, with no statistic difference between the groups (Graph 3).

Discussion

Antegrade cerebral perfusion is recognized as the best method to protect the brain against ischemic injuries, regardless of the surgical technique or strategy adopted for the aortic arch approach. Also, moderate hypothermia (approximately 25°C) is not associated with neurologic sequalae.

Total aortic arch replacement, as in group A, was performed under selective cerebral perfusion and moderate hypothermia since, as reported by Kazui et al.,[9] selective cerebral perfusion is a reliable technique for brain protection and facilitates time-consuming total arch replacement.

In group B, many conventional techniques for aortic arch reconstruction were performed, with a wide theoretical base and practical applicability. Brain

Table 4 - Cardiovascular mortality by techniques for aortic arch reconstruction (partial preservation of aortic arch and supra-aortic vessels, Group A or conventional surgeries, Group B)

Outcome	Group A		Group B		p
	N	n(%)	N	n(%)	
30-day mortality	3	10.3%	21	25.6%	0.086
In-hospital mortality	4	13.8%	22	26.8%	0.154
2-year mortality	4	14.8%	27	34.6%	0.052
5-year mortality	5	22.7%	27	50.9%	0.024
Global mortality	6	20.7%	27	32.9%	0.215
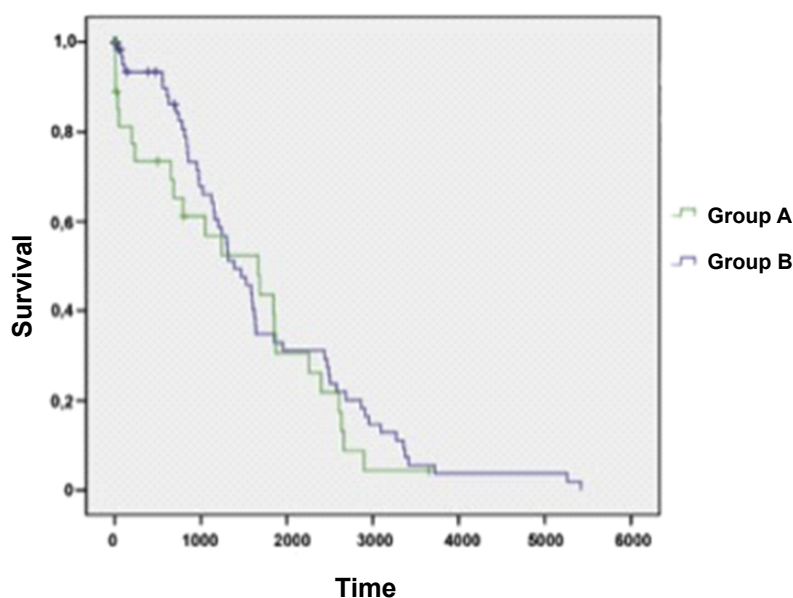
Graph 3 - Cardiovascular survival curve in patients who underwent partial preservation of aortic arch and supra-aortic vessels (Group A, n = 29) and patients who underwent conventional surgical techniques for aortic arch reconstruction (Group B, n = 82).

475

Oliveira et al.
Mortality and survival in aortic arch surgeries

Int J Cardiovasc Sci. 2018;31(5)466-482
Original Article

protection was also established by selective cerebral perfusion. In the study by Tang et al.,[13] a review of the contemporary practice in total arch replacement by using the trifurcated graft technique was performed. The authors concluded that unilateral and bilateral antegrade cerebral perfusion and profound hypothermia can be performed without adding significant complexity to the procedure while conferring maximal cerebral protection.

Surgical strategy for aortic arch reconstruction described in group A includes axillary artery cannulation. Although femoral arterial cannulation is considered a routine procedure, Benedetto et al.[14] reported that there is a growing perception that this technique, by reversing the flow in the thoracoabdominal aorta, may increase the risk of retrograde brain embolization, dissection and organ malperfusion in type A aortic dissection. Axillary artery cannulation shows better surgery outcomes by allowing antegrade outflow. In this meta-analysis, acute aortic dissection was demonstrated to be superior to femoral artery cannulation in reducing in-hospital mortality and the incidence of permanent neurological deficit in patients operated for type A acute aortic dissection.

Characteristics of the study population are similar to those of other groups[15] studied for operative outcomes of surgical approaches of aortic arch diseases, including the high prevalence of the most common risk factors. In group A, there were patients with history of neurologic events (ischemic or hemorrhagic), representing 10.7% and 7.4% of total study population, respectively.

In both groups, there were patients who were submitted to surgical procedure despite suffering a stroke in the preoperative period, which until a few years ago, would be considered contraindication to surgery. However, this fact started to change by the study by Most et al.[16] The authors retrospectively studied 53 patients with recent neurological deficit (which were considered a contraindication for surgery due to poor prognosis) who received surgical repair for acute aortic dissection type A between 2005 and 2012. They showed that more than half of them recovered from surgery without neurological sequelae and concluded that patients with acute type A aortic dissection and neurological deficit before surgery should not be excluded from emergency surgery.

In group A, 24.1% of patients underwent elective surgery, 58.6% urgent and 17.2% emergent surgery. Aortic dissection was the predominant procedure among these patients, similar to the study by Martín et al.[15] However, in this study, 93% of patients underwent emergent surgery and 7% urgent surgery, and positive outcomes were observed even in patients in coma.[16] Early diagnosis and therapy for acute aortic dissection is crucial for postoperative outcome. While less significant improvements were associated with surgical interventions performed more than 9 hours of symptom onset, patients who underwent surgery less than 5 hours of symptom onset showed more favorable outcomes.

It is of note that postoperative drainage volume within the first 24 hours was associated with possible postoperative bleeding. Mean drainage volume was 468 mL and 375 mL in groups A and B, respectively (no statistical significance). In Miana et al.,[17] mean 24-hour bleeding volume was 610 ± 500 mL in a group of 411 patients undergoing surgery for acquired heart diseases. In the subgroup of patients who underwent aortic surgery, mean bleeding volume was 765 ± 770 mL among those at higher risk of bleeding and 604 ± 479 mL among those at lower bleeding risk.

Although surgical strategy performed in group A proposes a more careful approach of hemostasis, a greater bleeding volume was observed in these patients. This may be explained by the longer ECC time and higher rates of emergent surgeries, which are independent risk factors for bleeding.[17] Also, in this group, most patients underwent surgical repair of acute aortic dissection.

Among postoperative neurological complications, hemorrhagic stroke occurred in 1 patient (3.4%) in group A and 1 patient (1.3%) in group B. In a group of 98 patients undergoing surgery for type A aortic dissection, the incidence of permanent stroke was 9%.[15] In a recent meta-analysis, 7.3% of patients undergoing antegrade cerebral perfusion and moderate hypothermia had permanent neurological dysfunction.[18] In the study by Kazui et al.[9] the incidence of temporary and permanent neurological dysfunction was 4.2% and 2.4%, respectively.

Hagl et al.[19] examined 717 patients who survived aortic arch and ascending aorta operations through median sternotomy for risk factors for stroke. When all patients with total cerebral protection time between 40 and 80 minutes were examined, the method of cerebral protection did not influence the occurrence of stroke; however, antegrade cerebral perfusion resulted in a significant reduction in the incidence of temporary neurological dysfunction (p = 0.05; OR 0.3).

Postoperative AMI was present in 10.3% of patients in group A and in 1.3% of patients in group B (p = 0.025).

However, this result should be interpreted with caution, as these frequencies corresponded to 3 patients in group A and only 1 patient in group B in absolute number due to the small sample size, and maybe these frequencies would not be repeated in larger populations.

Diagnosis of AMI was established very subjectively, only by medical records data, without considering electrocardiographic or clinical (cardiac enzymes) criteria. It is also worth pointing out that the lack of difference in the frequency of cardiogenic shock between the groups and the use of BIA reinforce the hypothesis that the frequency of AMI in the postoperative period was not relevant or, if present, not clinically significant.

Early mortality in patients with type A aortic dissection varies between 15 and 35% in the literature, with an estimated 5-year survival between 65% and 75%.[20] In our study, 30-day mortality (24.1% in group A and 26.8% in group B) and in-hospital mortality (31.0% in group A and 29.3% in group B) were similar between the groups, with no statistically significant difference. Overall 30-day mortality in a group of 518 patients undergoing type A aortic dissection repair was 20.2%.[21]

Martín et al.[15] reported an in-hospital mortality rate of 15% in patients undergoing aortic dissection surgery. In another study comparing partial aortic arch repair with total aortic arch repair, in-hospital mortality rate was 6.7% and 6.9%, respectively.[22]

In the study by Dossche et al.,[23] including 163 patients, 55% of them with degenerative aneurysm and 28% with acute type A dissection, in-hospital mortality or perioperative neurological complications did not significantly affect the duration of selective antegrade cerebral perfusion. In univariate analysis, some factors had a significant influence on overall mortality – acute type A dissection (p = 0.003), central neurological damage less than 24 h before the surgery (p < 0.001), preoperative hemodynamic instability (p = 0.034), and thoracotomy for any cause (p = 0.036).

Patel and Deeb[24] also reported that morbidity increases with the necessity of (total or partial) aortic arch resection, with an increased risk from 5% to 7%. Early mortality in type A aortic dissection is greater than 20%. In addition, repair of thoracoabdominal aortic aneurysm is still recognized as a high-risk procedure, with mortality and paraplegia rates higher than 20%, according Acher & Wynn.[25]

Kazui et al.[9] evaluated 330 patients who underwent aortic arch surgery using selective cerebral perfusion.

Surgeries were performed with hypothermia, ECC, selective cerebral perfusion and systemic circulatory arrest. Total aortic arch replacement with a branched graft was performed in 288 patients (94%). In-hospital mortality rate was 11.2%.

Short- and long-term survival in patients with acute type A aortic dissection varies from 52 - 94% (1 year) and 45 - 88% (5 years). Ten-year survival rate of patients with acute dissection after initial hospitalization was reported to be between 30% and 60% in many studies. In the study by Shiono et al.,[22] a 55% and a 30% survival rate within 10 years and 20 years, respectively were reported.

In our study, survival rates were 65.5% and 65,9% within 1 year, 59.3% and 59.0% within 2 years, and 45.5% and 35.8% within 5 years in groups A and B, respectively. These results are in accordance with the review by Braverman,[20] in which a 5-year survival rate of 45 - 88% was described.

Our results do not corroborate the hypothesis that a partial aortic arch repair with preservation of part of affected tissue could worsen mortality and morbidity by increasing the risk for recurrent dissection or aneurysm expansion of remaining tissue. Five-year mortality rate was similar between the groups (45.5% vs. 35.8%). In the meta-analysis by Li et al.,[18] comparing partial and total aortic arch repair, 5-year survival rate was also similar between the groups (77.4% vs. 80.8%). In addition, the authors point out that, although the literature does not support superiority of total aortic replacement over partial replacement, a more extensive resection may be necessary in case of extensive lesions, or those located in the aorta. The choice for this method should be individually considered according to clinical and anatomic conditions, as well as pathologic features of the dissection.

Considering only deaths for cardiovascular causes, group A was superior than group B, with a 5-year cardiovascular mortality of 22.7% and 50.9%, respectively. These rates demonstrate both safety and efficacy of surgical strategy used in group A for aortic aneurysm and dissection (whenever possible).

Conclusions

This study showed that cardiovascular mortality was significantly different between the groups after a 5-year follow-up. The group in which a partial preservation of aortic arch and supra-aortic vessels was performed

showed a lower 5-year cardiovascular mortality than the group in which conventional strategies for aortic arch repair were used. No statistically significant differences were found in other time intervals.

Thirty-day and 5-year overall mortality after surgery were not statistically different between the groups.

Limitations

Due to its retrospective and descriptive nature, this study has some inherent limitations, such as – data collected from medical records, which involves incomplete data or data of difficult interpretation, lack of test results at hospital admission or in postoperative follow-up, in addition to unavailability of medical records from some institutions.

Although the study was conducted in different hospitals, all procedures analyzed in the study were performed by the same surgical staff and, for this reason, both performance and learning curve of the techniques are linear.

The study groups are very heterogeneous, which make some comparisons and analysis impossible. Also, sample size is considered small for the establishment of definitions.

Finally, it is worth mentioning that the study was not designed to evaluate the best surgical strategy for aortic arch repair. This retrospective analysis of patients that had undergone aortic arch repair may add information about 30-day mortality and in-hospital mortality. In this 5-year multicentric analysis, no difference was observed regarding 30-day mortality, in-hospital mortality or survival rates between the two techniques

Author contributions

Conception and design of the research: Oliveira PF, Sá MPL, Almeida Junior GLG, Carreira VJ. Acquisition of data: Oliveira PF, Almeida Junior GLG, Carreira VJ, Rangel BSS, Silva SP. Analysis and interpretation of the data: Oliveira PF, Sá MPL, Almeida Junior GLG, Silva FB. Statistical analysis: Oliveira PF, Almeida Junior GLG, Silva FB. Obtaining financing: Oliveira PF. Writing of the manuscript: Oliveira PF, Sá MPL, Almeida Junior GLG, Silva FB. Critical revision of the manuscript for intellectual content: Oliveira PF, Sá MPL, Almeida Junior GLG, Silva FB, Carreira VJ. Supervision / as the major investigador: Oliveira PF, Sá MPL, Almeida Junior GLG. Providing the database: Carreira VJ.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Study Association

This article is part of the thesis of master submitted by Paula Ferraz de Oliveira, from Universidade Federal do Rio de Janeiro.

Ethics approval and consent to participate

This article does not contain any studies with human participants or animals performed by any of the authors.

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Appendix

Appendix A - Standardized data collection form

DATA COLLECTION FORM

FILE _____

1. Demographic data

Hospital: _____

Medical record (number): _____   Date of admission: _____/_____/_____

Name of patient: _____

Date of birth: _____/_____/_____   Age (years) _____

Sex: (   ) female   (   ) male   (   ) NI

Skin color: (   ) white   (   ) pardo   (   ) yellow   (   ) black   (   ) other _____   (   ) NI

2. Clinical data

a. Risk factors (at admission)

Family history   CAD: (   ) yes   (   ) no   (   ) NI

                   Sudden death: (   ) yes   (   ) no   (   ) NI

Diabetes mellitus: (   ) yes   (   ) no   (   ) NI   Glycemia: _____

          Use of medication: (   ) yes   (   ) no   (   ) NI   Time of disease _____(years) (   ) NI

SAH   (   ) yes   (   ) no   (   ) NI   Sys: _____ Day: _____

          Use of medication: (   ) yes   (   ) no   (   ) NI   Time of disease _____(years) (   ) NI

Dyslipidemia: (   ) yes   (   ) no   (   ) NI   Total Chol _____ LDL _____ HDL _____ TG _____

          Use of medication: (   ) yes   (   ) no   (   ) NI

Obesity: (   ) yes   (   ) no   (   ) NI   BMI _____ weight _____ (kg) Height _____ (cm) (   ) NI

Smoking: (   ) current smoker   (   ) ex-smoker   (   ) never smoker   (   ) NI

          Current – time of smoking _____ (years)(   ) NI   Cigarettes per day _____ (   ) NI

          Ex-smoker – time since quitting _____ (years)   (   ) NI

                   Time of smoking _____ (years)   (   ) NI   Cigarettes per day _____ (   ) NI

Sedentary lifestyle: (   ) yes   (   ) no   (   ) NI

Marfan syndrome: (   ) yes   (   ) no   (   ) NI

Rheumatic fever: (   ) yes   (   ) no   (   ) NI

Collagenosis: (   ) yes   (   ) no   (   ) NI

b. Comorbidities (past events)

Ischemic stroke: (   ) yes   (   ) no   (   ) NI   Recent: (   ) yes   (   ) no   (   ) NI

Hemorrhagic stroke: (   ) yes   (   ) no   (   ) NI   Recent: (   ) yes   (   ) no   (   ) NI

Unspecified stroke: (   ) yes   (   ) no   (   ) NI   Recent: (   ) yes   (   ) no   (   ) NI

Motor incapacity caused by musculoskeletal or neurological dysfunction: (   ) yes   (   ) no   (   ) NI

Higher creatinine before the procedure: _____   Date: _____/_____/_____

Chronic kidney failure: (   ) yes   (   ) no   (   ) NI

Hemodialysis or peritoneal dialysis: (   ) yes   (   ) no   (   ) NI

COPD: (   ) yes   (   ) no   (   ) NI

Peripheral vascular disease: (   ) yes   (   ) no   (   ) NI

Previous arrhythmia: ( ) yes   ( ) no   ( ) NI

      Specified: ( ) yes   ( ) no   ( ) NI

      ECG in the records: ( ) yes   ( ) no   ( ) Which one _____

      PM: ( ) yes   ( ) no   ( ) temporary   ( ) permanent

Previous AMI: ( ) yes   ( ) no   ( ) NI

      How long ago _____   ( ) NI   (days/weeks/years/NI)

Unstable angina: ( ) yes   ( ) no   ( ) NI

Heart failure: ( ) yes   ( ) no   ( ) NI   NYHA HF: ( ) I ( ) II ( ) III ( ) IV ( ) NI

Mod/Severe valve failure: 1. Mitral: ( ) yes   ( ) no   ( ) NI

                        2. Aortic: ( ) yes   ( ) no   ( ) NI

                        3. Tricuspid : ( ) yes   ( ) no   ( ) NI

Mod/Severe valve stenosis: 1. Mitral: ( ) yes   ( ) no   ( ) NI

                        2. Aortic: ( ) yes   ( ) no   ( ) NI

                        3. Tricuspid : ( ) yes   ( ) no   ( ) NI

Extracardiac vascular disease

      Claudication: ( ) yes   ( ) no   ( ) NI

      Carotid artery occlusion or stenosis > 50%:   ( ) yes   ( ) no   ( ) NI

      Amputation for vascular disease: ( ) yes   ( ) no   ( ) NI

      Abdominal aortic, iliac or carotid arterial intervention: ( ) yes   ( ) no   ( ) NI

Active endocarditis: ( ) yes   ( ) no   ( ) NI

Previous surgeries

      Myocardial revascularization: ( ) yes   ( ) no   ( ) NI

      Valve replacement: ( ) yes   ( ) no   ( ) NI

      Partial aortic arch replacement: ( ) yes   ( ) no   ( ) NI

      Structural repair/tumor resection: ( ) yes   ( ) no   ( ) NI

Aortic dissection (Stanford classification)

      Type A: ( ) yes   ( ) no   ( ) NI

      Type B: ( ) yes   ( ) no   ( ) NI

Aortic arch aneurysm: ( ) yes   ( ) no   ( ) NI

Ascending aortic aneurysm: ( ) yes   ( ) no   ( ) NI

3. Echocardiographic data

Echocardiography test: ( ) yes   ( ) no   ( ) NI   Date: _____/_____/_____

Ejection fraction   _____   ( ) NI   LVd: _____   ( ) NI

SIV: _____   ( ) NI   VDs: _____   ( ) NI

PP: _____   ( ) NI   LVH: _____   ( ) NI

LA: _____   ( ) NI   PASP: _____   ( ) NI

Functional subjective assessment

      LV systolic function: ( ) normal   ( ) mild disf.   ( ) Mod disf.   ( ) Severe disf.   ( ) NI

      LV diastolic function: ( ) normal   ( ) mild disf.   ( ) Mod disf.   ( ) Severe disf.   ( ) NI

      RV: ( ) normal   ( ) mild disf.   ( ) Mod disf.   ( ) Severe disf.   ( ) NI

Pericardial effusion: ( ) yes   ( ) no   ( ) NI

Mod/Severe valve insufficiency	1. Mitral:	( ) yes	( ) no	( ) NI
	2. Aortic:	( ) yes	( ) no	( ) NI
	3. Tricuspid:	( ) yes	( ) no	( ) NI
Severe/Mod valve stenosis	1. Mitral:	( ) yes	( ) no	( ) NI
	2. Aortic:	( ) yes	( ) no	( ) NI
	3. Tricuspid:	( ) yes	( ) no	( ) NI

4. Surgery data

Blood transfusion:	( ) yes	( ) no	( ) NI	
Aortic valvuloplasty:	( ) yes	( ) no	( ) NI	
Descending aortic endoprosthesis:	( ) yes	( ) no	( ) NI	
Coronary reimplantation:	( ) yes	( ) no	( ) NI	

Prosthesis

Biologic:	( ) yes	( ) no	( ) NI	Number _____
Mechanical:	( ) yes	( ) no	( ) NI	Number _____
Combined surgery:	( ) yes	( ) no	( ) NI	

Which one? _____

ECC time	_____ (minutes)
Clamping time	_____ (minutes)
Hypothermia	_____ (ºC)

Elective surgery:	( ) yes	( ) no	( ) NI
Urgent surgery:	( ) yes	( ) no	( ) NI
Emergency surgery:	( ) yes	( ) no	( ) NI
Resuscitation (pre anesthetic CRA):	( ) yes	( ) no	( ) NI
Intraoperative complication:	( ) yes	( ) no	( ) NI

Which one? _____

| Death in the operating room: | ( ) yes | ( ) no | ( ) NI |
| Reoperation: | ( ) yes | ( ) no | ( ) NI |

5. Postoperative data

Course:	Low cardiac output syndrome (cardiogenic shock):	( ) yes	( ) no	( ) NI
	Bleeding:	( ) yes	( ) no	( ) NI
	Cardiac tamponade:	( ) yes	( ) no	( ) NI
	Intra-aortic balloon:	( ) yes	( ) no	( ) NI
	Another ventilatory assistance device:	( ) yes	( ) no	( ) NI
Ischemia	Infarction:	( ) yes	( ) no	( ) NI
	Angina:	( ) yes	( ) no	( ) NI
	CRA:	( ) yes	( ) no	( ) NI
Mechanical	Acute MI:	( ) yes	( ) no	( ) NI
	IVC:	( ) yes	( ) no	( ) NI
	Free-wall rupture:	( ) yes	( ) no	( ) NI
Respiratory:	Mechanical ventilation >24 h:	( ) yes	( ) no	( ) NI

| | Pneumonia: | ( ) yes | ( ) no | ( ) NI |

Pneumonia: ( ) yes   ( ) no   ( ) NI

SARS: ( ) yes   ( ) no   ( ) NI

Uni/bilateral pleural effusion: ( ) yes   ( ) no   ( ) NI

Metabolic: Post-operative acute renal failure (ARF):   ( ) yes   ( ) no   ( ) NI

Dialysis: ( ) yes   ( ) no   ( ) NI

If ARF o dialysis: Highest serum Cr _____   Highest glycemia _____

Insulin: ( ) yes   ( ) no   ( ) NI

Hyperkalemia: ( ) yes   ( ) no   ( ) NI

Neurologic: stroke   ( ) Embolic ischemic   ( ) Thrombotic ischemic   ( ) Unspecified ischemic

( )Hemorrhagic   ( ) Unspecified   ( ) No   ( ) NI

Confirmation of stroke: CT: ( ) yes   ( ) no   ( ) NI

MRI: ( ) yes   ( ) no   ( ) NI

Without tests: ( ) yes   ( ) no   ( ) NI

Coma: ( ) yes   ( ) no   ( ) NI

Convulsive episode: ( ) yes   ( ) no   ( ) NI

Psychiatric disorder (delirium):   ( ) yes   ( ) no   ( ) NI

Paraplegia: ( ) yes   ( ) no   ( ) NI

Cardiologic HF: ( ) yes   ( ) no   ( ) NI

PTE: ( ) yes   ( ) no   ( ) NI

Arrhythmia: ( ) yes   ( ) no   ( ) NI

Which one? _____

Infection Superficial: ( ) yes   ( ) no   ( ) NI

Soft tissues: ( ) yes   ( ) no   ( ) NI

Mediastinum: ( ) yes   ( ) no   ( ) NI

Sepsis: ( ) yes   ( ) no   ( ) NI

Septic shock: ( ) yes   ( ) no   ( ) NI

Amines: ( ) yes   ( ) no   ( ) NI

Other sites: _____   ( ) NI

Peripheral vascular DVT: ( ) yes   ( ) no   ( ) NI

Other complications: MSOF   ( ) yes   ( ) no   ( ) NI

Bleeding   ( ) Yes, without transfusion   ( ) Yes, with transfusion   ( ) no   ( ) NI

( ) Yes, without reoperation   ( ) Yes, with reoperation   ( ) no   ( ) NI

Drain output (first 24 hours) _____ (mL)   ( ) NI

6. In-hospital course

Time of hospitalization _____   ( ) NI   Number of days

Time of ICU _____   ( ) NI   Number of days

Time of MV _____   ( ) NI   Number of days

Hospital course   ( ) Death   ( ) Discharge   ( ) Transfer   ( ) NI

Date _____/_____/_____

Cause of death _____

IDC _____   ( ) NI

Place of death   ( ) Ward/room Surgical   ( ) Operating room   ( ) ICU

( ) Semi-intensive care unit   ( ) NI   ( ) Survivor