ORIGINAL ARTICLE

Risk factors in the development of postoperative complications after reconstructive surgery on the thoracic aorta

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ABSTRACT

Aim To determine risk factors responsible for developing postoperative complications after the thoracic aorta reconstructive surgery.

Methods Medical records of 100 patients, who had undergone elective or emergency thoracic aorta reconstructive surgery at the Clinic for Cardiovascular Surgery, University Clinical Center Tuzla, were analysed. Intraoperative data as cross-clamp time (CCT), duration of cardiopulmonary bypass (CPBT) and hypothermic circulatory arrest time (HCAT) were evaluated. Univariate analysis was used to show risk factors for developing postoperative cardiac, respiratory, surgical and renal complications.

Results Between May 2019 and April 2021, 48 Bentall procedures (BP), 23 ascending aortic replacements (AAR), 20 BP and coronary artery bypass grafting (CABG) and 9 aortic valve replacements (AVR) with AAR were performed. Incidence of postoperative complications in the elective and emergency groups was as follows: respiratory 20% vs 38% (p=0.049), cardiac 18% vs 70% (p=0.015), renal 16% vs 48% (p=0.027) and surgical 4% vs 6% (p>0.05). Intrahospital 30 days morbidity was 44% with mortality rate of 13%. The results showed that CPBT>180 minutes was a risk factor for respiratory (p=0.034), cardiac (p=0.020) and renal (p=0.027) postoperative complications after acute type A aortic dissection surgery.

Conclusion CPBT > 180 min is a risk factor for postoperative development of respiratory, cardiac and renal complications. Postoperative cardiac and renal complications were associated with longer HCAT.

Key words: aortic aneurysm, cardiopulmonary bypass, patient outcome assessment

INTRODUCTION

Acute type A aortic dissection (AcA-AoD) is a high-risk condition that requires emergency surgical treatment. Without surgery, 50% of patients die within 24 hours of disease onset, and mortality rate is approximatley 1-2% per hour (1). Unfortunately, the early outcome of emergency surgical repair of ascending aorta has not improved over the last 20 years (2). Incidence of AcA-AoD in Europe is approximately 2-16 cases/100,000 inhabitants per year and a preoperative mortality is approximately 17.6% (3). The main risk factor for aortic aneurysm in patients with atherosclerosis is hypertension. It is present in 85% of patients with aortic aneurysm rupture and in 52% of patients with aortic aneurysm without rupture (4).

In hospital, mortality after the surgery of AcA-AoD is more than 25%. The high mortality rate is caused by various perioperative and postoperative complications (5). Preoperative risk factors affect the occurrence of postoperative complications, which prolong patients recovery period. The most common postoperative complications are cardiac, respiratory, renal, infectious and neurological. Specific complications are divided into vascular and neurological (6-9). Complications of surgical treatment occur during the surgery or immediately after the surgery.

Early treatment of urgent patients, shortening of CCT and CPBT may reduce postoperative complications and prevent fatal postoperative outcome (10).

The reason for this study was the early identification of risk factors, whose treatment leads to a reduction in morbidity and mortality of patients who underwent thoracic aorta reconstructive surgery. The aim of this study was to investigate risk factors for the development of postoperative complications in patients after the elective and emergency reconstructive surgery of the thoracic aorta.

PATIENTS AND METHODS

Patients and study design

In the two-year period retrospective-prospective study included 100 patients, 67 male and 33 female aged 19 to 78 years, who underwent reconstructive treatment of ascending aortic aneurysm.

Data were collected from May 2019 to April 2021 in the Clinic for Cardiovascular Surgery, University Clinical Center Tuzla.

According to the type of surgery based on urgency, patients were classified into two groups: elective and emergency. Elective group consisted of 50 patients of both sexes, 41 male and 9 female. Emergency group consisted of 50 patients, 26 males and 24 females, whose computed tomography angiography (CTA) confirmed ascending aortic dissection, and who underwent operative-reconstructive treatment of the ascending aorta in an emergency protocol.

The following data were obtained from patients' medical histories: age, sex, comorbidities (tobacco consumption, arterial hypertension, hyper-lipoproteinemia, obesity), previous diseases (diabetes, myocardial infarction, chronic obstructive pulmonary disease) and previous non-cardiac surgery. During surgery the following data were collected: duration of cardiopulmonary bypass (CPBT), cross-clamp time (CCT) and hypothermic circulatory arrest time (HCAT). After surgery types and occurence of postoperative complications (respiratory, cardiac, renal, surgical, and neurological), length of stay and duration of respiratory support in the Cardiovascular Intensive Care Unit (CICU) were recorded.

Methods

Operative procedures that were included in this study were: Bentall procedures (BP), ascending aortic replacement (AAR), BP with coronary artery bypass grafting (CABG) and aortic valve replacement with AAR. Computed tomography angiography (CTA) was used for the diagnosis of an ascending aortic aneurysm or AcA-AoD. All patients underwent anesthetic protocol for cardiac surgery patients, which included placing of a central venous catheter and arterial line for invasive monitoring. After surgery the patients were admitted in the CICU.

Statistical analysis

Continuous variables are presented as mean ± standard deviation (SD), while categorical variables are presented as percentages. Student t and $\chi 2$ tests were used to compare continuous and categorical variables. Statistically significant value of $p < 0.05$ was considered.

RESULTS

The average age of 41 male patients in the elective group was 60.27±16.2 years, and average age of 9 female patients was 57.7±14 years. The average age of 26 male patients in the emergency group was 56.17±14.1 years and average age of 24 female patients was 55.77±27.3 years. Males and females in the elective group (p=0.11) were older than in the emergency group (p=0.38).

The most common comorbidities in the elective and emergency group were hypertension (94% vs 90%), family history of cardiovascular diseases (84% vs 72%), smoking (78% vs 62%) and diabetes mellitus (64% vs 28%). There was a total of 15 deaths in both groups (1 in the elective and 14 in the emergency group). From the total number of deaths, 8 were females and 7 were males. A total of 60% of patients who died were current smokers. Of 15 patients who died, 86.6% were admitted to our Clinic in severe hemorrhagic shock (Table 1).

Table 1. Distribution and univariate analysis of preoperative laboratory and clinical risk factors and mortality rate in elective and emergency patients after reconstructive thoracic aorta surgery

Variable	Deaths (n=15)	Elective (n=50)	Emergency (n=50)	p
Male/Female (No)	7/8	41/9	26/24	
No (%) of patients				
Age > 65	5 (33.3)	14 (28)	9 (18)	
Hypertension	14 (93.3)	47 (94)	45 (90)	>0.05
Hyperlipoproteinemia	6 (40)	28 (56)	14 (28)	0.018
Smoking	9 (60)	39 (78)	31 (62)	>0.05
Obesity	7 (46.6)	21 (42)	17 (34)	>0.05
Family history (CVDs)	9 (60)	42 (84)	36 (72)	>0.05
Diabetes mellitus	3 (20)	32 (64)	14 (28)	0.013
COPD	2 (13.3)	7 (14)	9 (18)	>0.05
Shock	13 (86.6)	0	41 (82)	<0.05
Myocardial infarction	2 (13.3)	4 (8)	11 (22)	0.011
Renal insufficiency	1 (6.6)	3 (6)	1 (2)	>0.05
Previous non-cardiac surgical procedures	1 (6.6)	4 (8)	11 (22)	0.011
Redo	9 (60)	1 (2)	19 (38)	<0.05

CVDs, cardiovascular diseases; COPD, chronic obstructive pulmonary disease; Redo, repeated operative procedure

Univariate analysis of intraoperative variables showed prolonged operation duration in the emergency group comparing to the elective group (p=0.040). There were more patients with prolonged CPBT and CCT in the emergency (17 vs 32; p=0.029) than in the elective group (17 vs 35; p=0.024). Nineteen patients in the emergency group underwent hypothermic circulatory arrest compared to the 3 patients in the elective group (p=0.02) (Table 2).

Frequency of postoperative complications was higher in the emergency group; cardiac complica-

Table 2. Univariate analysis of intraoperative variables: duration of operation, cardiopulmonary bypass time and hypothermic circulatory arrest in elective and emergency patients after reconstructive thoracic aorta surgery

Variable	Elective (n=50)	Emergency (n=50)	p
Duration of operation (min)*			
>240	34	44	0.040
<240	16	6	0.039
Cardiopulmonary bypass time (min)*			
>180	17	32	0.029
<180	33	18	0.032
Cross-clamp time (min)*			
>120	17	35	0.024
<120	33	15	0.034
Hypothermic circulatory arrest			
Yes	3	19	0.02
No	47	28	0.016

*reference values: duration of operation < 240 minutes; cardiopulmonary bypass time < 180 minutes; cross-clamp time < 120 minutes

tions were predominant. Heart failure was highly prevalent in the emergency as compared with the elective group (20% vs 68%), as well as atrial fibrillation (28% vs 42%) and cardiogenic pulmonary edema (14% vs 24%). Renal insufficiency was the second most frequent postoperative complication in the emergency group (16% vs 48%). Of these, only 2 (4%) patients in the emergency group required a haemodialysis. Respiratory complications were the third most common and were highly prevalent in the emergency group. They included pneumonia (14% vs 30%), atelectasis (4% vs 18%), pneumothorax (2% vs 4%) and pleural effusion (2% vs 6%). Wound infection occurred in a small number of patients in both groups (4% vs 6%). There were no neurological complications in either group (Table 3).

Table 3. Prevalence and univariate analysis of postoperative respiratory, cardiac, surgical and renal complications in elective and emergency patients after reconstructive thoracic aorta surgery

Complication	No (%) of patients		
	Elective (n=50)	Emergency (n=50)	p
Respiratory			
Pneumonia	7 (14)	15 (30)	> 0.05
Atelectasis	2 (4)	9 (18)	> 0.05
Pneumothorax	1 (2)	2 (4)	> 0.05
Pleural effusion	1 (2)	3 (6)	> 0.05
Cardiac			
Heart failure (ICU)	10 (20)	34 (68)	0.028
Cardiogenic pulmonary oedema	7 (14)	12 (24)	> 0.05
Atrial fibrillation	14 (28)	21 (42)	> 0.05
Surgical			
Surgical wound infection	2 (4)	3 (6)	> 0.05
Renal			
Renal insufficiency	8 (16)	24 (48)	0.027
Haemodialysis	0	2 (4)	
Neurological			
Stroke	0	0	
Paresis/paralysis	0	0	

ICU, intensive care unit

A longer duration of CPB (>180 minutes) was associated with higher prevalence of postoperative complications. There was a direct relation between longer duration of CPB and prevalence of respiratory (p=0.034), cardiac (p=0.020) and renal complications (p=0.027) after the surgical treatment of the thoracic aorta. There was no statistically significant difference in the prevalence of surgical wound infection in relation to CPB duration (Table 4).

Table 4. Univariate analysis results of postoperative complications regarding cardiopulmonary bypass time (CPBT) in elective and emergency patients after reconstructive thoracic aorta surgery

CPBT (min)	No of patients				
	Respiratory	Cardiac	Renal	Neurological	Surgical
> 180	21	33	24	0	3
< 180	8	11	8	0	2
Total	29	44	32	0	5
p	0.034	0.020	0.027		>0.05

Patients who were longer than 30 minutes in hypothermic circulatory arrest during the surgical treatment of the thoracic aorta had significantly higher prevalence of cardiac (p=0.046) and renal (p=0.029) postoperative complications. There was no statistically significant difference in the incidence of respiratory complications in relation to hypothermic circulatory arrest duration (Table 5).

Table 5. Univariate analysis results of postoperative complications regarding hypothermic circulatory arrest time (HCAT) in elective and emergency patients after reconstructive thoracic aorta surgery

HCAT (min.)	No of patients	Respiratory	Cardiac	Renal	Neurological
>30	9	5	10	9	0
<30	13	3	4	3	0
Total	22	8	14	12	0
p		0.072	>0.05	0.046	0.029

The length of respiratory support in the elective group (115.25±42.03 minutes) was significantly reduced compared to the emergency group (317.22±126.07 minutes) (p=0.003). The length of CICU stay in the elective group (3.43±0.46 days) was significantly shorter compared to the emergency group (7.8±15.3 days) (p=0.007).

DISCUSSION

Several studies have reported a correlation between mean cardiopulmonary time and cross-clamp time as risk factors for postoperative complications. Shultz et al. found that the mean cross-clamp time was 364±45 minutes, and the total cardiopulmonary bypass time was 421±70 minutes; additionally, they found significant early mortality and morbidity in cardiac procedures requiring long ischemic time (300 minutes) (11). In our study the cross-clamp time and the duration of cardiopulmonary bypass was shorter compared to Shultz et al. study, but it is statistically significant for the occurrence of early postoperative complications. In a retrospective study by Salsano et al. the prolonged CPBT was a predictor for severe complications (12). Nadeem et al. study followed the effect of cardiopulmonary bypass time on the duration of postoperative ventilatory support and found that prolonged mechanical ventilation strongly correlated with prolonged CPBT (13). A study by Xu et al. found that mean CPBT was 211± 56 minutes confirming that a prolonged CPBT is independently associated with an increased risk of postoperative acute kidney injury in patients who underwent thoracic aortic surgery (14). Similar results were found in a study by Lannemyr et al. that elevated markers of renal injury in serum were correlated with prolonged CPBT (15).

A total of five patients in our study had postoperative sternal wound infection, with no statistically significant difference between the groups. Jamil at al. found that CPBT was directly related to the occurrence of surgical site infection (16) with prevalence of 4.5%, which is consistent with the results of our study (4% in the elective group and 6% in the emergency group.

In a study conducted by Naveed et al. which included 517 patients, the prevalence of postoperative pulmonary complications was 6.2% (17). Similarly, Ji et al. study including 1043 patients found 6.96% prevalence of postoperative pulmonary complications (18). Our study showed a higher prevalence of respiratory complications compared to Ji et al. study (in the elective group it was 20% and in the emergency group 38%). Certainly, studies with a larger number of patients are more reliable.

In a study conducted by Raffa et al. prevalence of the neurological complications after cardiac surgery was 1.7%, and incidence of stroke ranged from 1 - 2% (19). In a study conducted by Yong et al. the incidence of overt stroke ranged from 1.2 - 6%. (20). Our study showed no neurological complications in either group.

In conclusion, our study has shown that CPBT > 180 minutes and HCAT > 30 minutes are the risk factors for respiratory, cardiac and renal

complications after the reconstructive surgery on the thoracic aorta, which is consistent with the results of similar studies conducted in Europe and in other parts of the world. Prevalence of postoperative complications was higher in patients undergoing reconstructive surgery on the thoracic aorta in an emergency protocol. Early treatment of emergency patients reducing cardiopulmonary bypass time and hypothermic circulatory arrest time may reduce postoperative complications and prevent fatal postoperative outcome. Therefore, poor outcomes after emergency surgery on the thoracic aorta require further research so the treatment of these patients can be improved and in-hospital mortality rate can be reduced.

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TRANSPARENCY DECLARATION

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