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Factors of Prolonged Intensive Care Unit Stay After Surgery in Patients with Type A Acute Aortic Dissection

Mohammed Firoj Khan, Xian en Fa* and Hai Bin Yu

Department of Cardiovascular Surgery, 2nd Affiliated Hospital of Zhengzhou University, Zhengzhou, Henan 450014, P.R. China

***Corresponding author:** Xian en Fa, Chairman of the Hospital, 2nd Affiliated Hospital of Zhengzhou University, Jing Ba Road, Zhengzhou, Henan 450014, China, Tel: 0086-0371-63935973; E-mail: faxianen@163.com

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Abstract

Objective: To identify the risk factors of prolonged Intensive Care Unit stay after surgery in patients with the type A acute aortic dissection.

Methods: Retrospective analysis of 80 patients, 54 males (67.5%) and 26 females (32.5%) who underwent surgery for the treatment of Stanford type A acute aortic dissection in the cardiovascular department of 2nd affiliated hospital of Zhengzhou university through December 2014 to July 2016 were done. The mean age of the patients was 48.9 ± 12.5 years. The patients were divided into two groups, group A, prolonged (n=13) and group B, non-prolonged (n=67) based on the duration of ICU stay time either above or below 5 days. Univariate and multivariate analysis were done to find out the predictive risk factors.

Results: The mean length of ICU stay time was 206.9 ± 25.4 hours in group A and 63.2 ± 17.4 hours in group B respectively. Mortality rate was 15.4% in group A and 3.0% in group B while overall mortality was 5%. ICU stay time was significantly influenced by the following factors; age (P=0.013), EuroSCORE (P=0.017), preoperative D- dimer (P=0.006], Deep hypothermic circulatory arrest (P=0.026), postoperative stroke (P=0.016), CPB time (P=0.002), postoperative stroke (P=0.009), postoperative acute respiratory failure (P=0.041) and postoperative acute renal failure (P=0.002).

Conclusion: Age, Euro SCORE, preoperative D- dimer level, CPB time, Deep hypothermic circulatory arrest, postoperative stroke, postoperative acute respiratory failure and postoperative acute renal failure are independent risk factors of prolonged ICU stay in the patients after operation for Stanford type A acute aortic dissection.

Keywords: Acute aortic dissection; Intensive care unit (ICU); EuroSCORE; Predictive risk factors

List of Abbreviations:

AAD: Acute Aortic Dissection; CABG: Coronary Artery Bypass Graft; COPD: Chronic Obstructive Pulmonary Disease; CPB: Cardiopulmonary Bypass; CVA: Cerebrovascular Accident; DHCA: Deep Hypothermic Circulatory Arrest; EuroSCORE: Europian System of Cardiac Operation Risk Evaluation; ICU: Intensive Care Unit; LVEF: Left Ventricular Ejection Fraction; NYHA: New York Heart Association

Introduction

The aorta is the largest main artery in the human body originating from the left ventricle of the heart and extending down to the abdomen where it splits into two smaller arteries, the left and right common iliac arteries. It carries the oxygenated blood from the heart to the branch arteries that supply the rest of the body (including the head, arms, abdominal organs, and legs).

Aortic dissection is a catastrophic cardiovascular disease with the incidence of about 10 per 100,000 per year [1-3]. It is associated with high morbidity and mortality [4-7]. The spontaneous mortality accounts about 1%-3% per hour within the first 48 hours [4]. An acute aortic dissection (<2 weeks) is associated with high morbidity and mortality rates. Mortality is highest in the first 7 days; indeed, many patients die before presentation to the emergency department (ED) or before diagnosis is made in the ED. Patients with chronic aortic dissection (>2 weeks) have a better prognosis. The mortality associated with aortic dissection is still high despite advancements in diagnostic and therapeutic modalities [8,9].

Usual risk factors of Acute Aortic Dissection are hypertension, arteriosclerosis, connective tissue disease and iatrogenic during cardiac operation or cardiac catheterization. The most common cause of death in Acute Aortic Dissection (AAD) is cardiac tamponade [10,11]. Due to severity and extended operation, the hospital stay and ICU stay of patients with Acute Aortic Dissection are prolonged as compared to other cardiac surgery.

Various studies have found out the risk of mortality for the patients with AAD. The aim of our study is to find out various variables which can increase the time of ICU stay after surgery in patients with type A Acute Aortic Dissection. After knowing those factors which increase ICU stay time can take proper precautions and measures to decrease the risks and decrease the ICU stay time.

Materials and Methods

Grouping and clinical data

From December 2014 to July 2016, 80 patients, 54 males (67.5%) and 26 females (32.5%) were treated for Stanford type A acute aortic dissection in our department. Mean age of patients was 48.9 ± 12.5 years, range 21 to 79 years (Table 1). These patients were diagnosed type A acute aortic dissection by echocardiography as well as physical finding but were confirmed by computed tomography angiogram (CTA). Retrosternal chest pain and back pain were the most common presenting symptoms on admission. 5 patients had preoperative CVA, hypertension and COPD occurred in 51 and 5 patients respectively. Preoperative diagnosis and symptoms are shown in Table 2.

Variable	Group A	Group B
Number of patients	13	67
Age	56.6 ± 11.4	47.4 ± 12.1
Sex		
Male	9 (69.2)	45 (67.2)
Female	4 (30.8)	22 (32.8)
BMI (kg/m^2)	25.8 ± 4.2	24.1 ± 3.9

Table 1: Demographic data.

Variable	Group A (n=13)	Group B (n=67)	t/ χ^2	P
COPD	1 (7.7)	4 (6.0)	0.055	0.814
Hypertension	8 (61.5)	43 (64.2)	0.033	0.856
CVA	2 (15.4)	3 (4.5)	2.21	0.137
Diabetes	2 (15.4)	5 (7.5)	0.856	0.345
NYHA III-IV	4 (30.8)	15 (22.4)	0.422	0.516
Euro SCORE	9.2 ± 3.1	7.1 ± 2.8	2.433	0.017
D-dimer I [mg/l]	8.9 ± 2.1	7.3 ± 1.8	2.855	0.006
Creatinine [μmol/l]	98.3 ± 24.2	92.7 ± 22.5	0.812	0.420
LVEF (%)	53.6 ± 8.4	56.4 ± 8.9	1.047	0.298
Emergency operation	10 (76.9)	53 (79.1)	0.031	0.860
COPD: Chronic Obstructive Pulmonary Disease; LVEF: Left Ventricular Ejection Fraction; CVA: Cerebro Vascular Accident; EuroSCORE: Europian System of Cardiac Operation Risk Evaluation				

Table 2: Preoperative diagnosis and symptoms.

Operative techniques

Definitions

Emergency operation was defined as the surgery was performed within 24 hours after the hospital admission. ICU stay time was defined to be prolonged if the stay time is ≥ 5 days and non-prolonged if ICU stay time <5 days. Patients were divided into two groups based on ICU stay time, group A (n=13), prolonged and group B (67), non-prolonged.

All operations were performed under general anesthesia through mid-sternal incision. CPB was established by cannulating femoral artery, innominate artery and right atrium in all patients. As soon as aortic clamp was applied, we opened the aorta for cold blood cardioplagia perfusion through the left and right coronary ostia. 39 cases were performed using deep hypothermic cardio-circulatory arrest and 41 cases using hypothermic CPB. Topical ice slush was used for better myocardial protection. Further intraoperative and postoperative data are shown in Tables 3 and 4 as univariate and multivariate analysis. Cardioplagia was applied every 30 minutes in an antegrade fashion. Types of operations performed were given below in Table 5.

Variable	Group A (n=13)	Group B (n=67)	t/χ^2 value	p-value
Concurrent CABG	3 (23.1)	5 (7.5)	2.949	0.086
CPB time (min)	208.65.14	172.541.7	2.729	0.017
Aortic clamp time (min)	94.227.5	88.526.3	0.71	0.491
DHCA	10 (76.9)	29 (43.3)	4.931	0.026
DHCA time (min)	42.88.9	39.57.4	1.423	0.159
Rectal temp.	19.51.3	20.21.8	1.333	0.186
Blood transfusion (U) (24 h PO)	9.83.7	8.23.2	1.609	0.112
Positive inotropic drugs	11 (84.6)	35 (52.2)	4.67	0.031
Postoperative acute renal failure	3 (23.1)	1 (1.5)	10.679	0.031
Postoperative respiratory failure	8 (61.5)	9 (13.4)	15.056	0.000
Postoperative stroke	2 (15.4)	1 (1.5)	5.821	0.016
Re-endotracheal intubation	2 (15.4)	2 (3.0)	3.524	0.060
Re-exploration of chest	2 (15.4)	4 (6.0)	1.391	0.238
ICU stay time (h)	206.925.4	63.217.4	25.15	0.000
Hospital stay time (d)	33.211.5	24.59.6	2.895	0.005
Hospital mortality	2 (15.4)	2 (3.0)	3.524	0.060
CPB: Cardiopulmonary bypass; DHCA: Deep Hypothermic circulatory arrest; ICU: Intensive care unit				

Table 3: Uni-variate analysis of intraoperative and postoperative factors of prolonged ICU stay [e.g. (%) [$x \pm s$].

Variable	partial regression	SE coefficient	Ward	RR	95% CI	p
Age	0.037	0.03	1.57	1.04	0.979 ~ 1.101	0.211
EuroSCORE	0.196	0.217	0.81	1.22	0.794 ~ 1.861	0.368
Preoperative D-dimer	0.24	0.16	2.25	1.27	0.929 ~ 1.739	0.134
CPB time	0.038	0.012	9.73	1.04	1.014 ~ 1.064	0.002
DHCA time	0.974	0.593	2.7	2.65	0.829 ~ 8.465	0.100
Positive inotropic agent	1.03	0.775	1.76	2.8	0.613 ~ 12.801	0.184
Postoperative Respiratory Failure	1.653	0.81	4.16	5.23	1.067 ~ 25.576	0.041
post-operative Renal Failure	1.806	0.592	9.32	6.08	1.908 ~ 19.396	0.002
Brain stroke	2.291	0.873	6.9	9.89	1.778 ~ 54.698	0.009

Table 4: Multivariate analysis of intraoperative and postoperative factors of extended ICU stay.

Procedure	No.
Ascending aorta repair+coronary angioplasty	2
Ascending aorta repair+Descending aorta stenting	2
Bentall+hemiarch replacement	2
Bentall+Descending aorta stenting	2
Bentall+total arch replacement+Descending aorta stenting	3
Ascending aorta replacement+CABG	3
Ascending aorta replacement+hemi arch replacement	3
David	4
Bentall+CABG	5
Ascending aorta replacement+Whole arch replacement	5
Ascending aorta replacement+Descending aorta stenting	5
Bentall	14
Ascending aorta replacement	23
Total	80

Table 5: Operating procedures.

Statistical Analysis

Data were collected using MS Excel for windows and statistical analysis was done using SPSS 16.0 software. Measurement data for the normal distribution were expressed in mean ± standard deviation [$x \pm s$]. The groups were compared using t test and χ^2, P<0.05 is considered statistically significant.

Results

Age (P=0.013), preoperative D-dimer (P=0.006), Europian score (P=0.017), showed statistically significant difference in terms of surgery as shown in Table 3. In group A, mean ICU stay time and mean hospital stay time were (206.9 ± 25.4) hours and (33.2 ± 11.5) days respectively, 2 patients (15.4%) died in hospital. In group B, mean ICU stay time and mean hospital stay time were (63.2 ± 17.4) hours and (24.5 ± 9.6) days, 2 patients (3%) died in hospital. Overall mortality was 5%. The ICU stay time and hospital stay time between group A and B was statistically significant (P<0.0000) and (P=0.005) respectively. In univariate analysis, Deep Hypothermic Circulatory Arrest (P=0.026), positive inotropic drugs (P=0.031), postoperative stroke (P=0.016), postoperative acute renal failure (P=0.031), postoperative respiratory failure (P=0.000), showed significant univariate influence (Table 3).

Multivariate analysis results showed a significant difference between the two groups in the following variables, CPB time (P=0.002), postoperative stroke (P=0.009), postoperative respiratory failure (P=0.041), and postoperative renal failure (P=0.002), which justifies that these variables are independent risk factors for prolonged ICU length of stay (Table 4).

Discussion

In recent years, the number of cardiac surgery rises very rapidly however; mortality rate after heart surgery has decreased significantly due to improvement in intensive critical care, perioperative and postoperative managements. Even though mortality has been decreasing, postoperative complications and ICU stay time and care have been raising due to growing number of elderly and critically ill patients undergoing cardiac surgery. Prolonged hospitalization in ICU increased costs of treatment significantly and consumed a lot of medical resources and equipments which can lead to the lack of bed for new patients to be admitted in the ICU after cardiac surgery. So sometimes it can lead to postpone some operations [12]. In addition, patients with prolonged ICU stay after heart surgery can lead to develop poor quality of life after discharge from hospital [13]. In some study, it was found that prolonged ICU stay can increase the mortality rate, 1-year mortality as high as 34% and 3 year mortality of about 60% [14,15]. Therefore, the analysis of risk factors for prolonged ICU can reduce postoperative complications; reasonable arrangement for short supply of ICU resources, medical expenses and saving clinical work is of great significance.

Research on risk factors associated with postoperative mortality about Stanford Type A acute aortic dissection is numerous. Many

studies have pointed out that the elderly, renal failure, preoperative hemodynamic instability, cardiopulmonary resuscitation, cardiac tamponade, prolonged deep hypothermic cardio-circulatory arrest (DHCA), damaged nervous system(CVA), respiratory insufficiency are important factors of postoperative death [16-19]. Postoperative ICU stay time affects on recovery of Stanford acute type A aortic dissection. Studies have shown that routine postoperative ICU monitoring and the time of stay depends on factors such as re-exploration or re-operation, emergency surgery, age, increased pre-operative creatinine levels, left ventricular dysfunction, duration of cardiopulmonary bypass, and blood transfusion etc. [20-24].

This research displayed prolonged cardiopulmonary bypass time, perioperative brain stroke (CVA), postoperative acute respiratory failure, postoperative acute renal failure are the independent risk factors for prolonged ICU stay time in patients undergoing surgery for treatment of standford type A acute aortic dissection. Many studies showed that, prolonged extracorporeal circulation, extended mechanical ventilation time after cardiac surgery, postoperative renal failure, gastrointestinal complications, and prolonged ICU stay time are the responsible risk factors for death after cardiac surgery [25,26].

This study also confirmed that the prolonged cardiopulmonary bypass during surgery for Stanford type A acute aortic dissection is a leading independent risk factor for the extended duration of postoperative ICU stay time. CPB during heart surgery can trigger various inflammatory reactions releasing increased amount of oxidation product leading to damage vascular endothelial cell by increasing adherence of blood cell. This leads to decrease function of various important organs such as heart, brain, lung, liver, and kidney. All these factors lead to prolonged mechanical ventilation time and hence ICU stay time [26]. Duration of CPB, complexity of disease, surgical operative techniques and proficiency of operation have certain relationship in the prolongation of ICU stay time. We should try to shorten the time of cardiopulmonary bypass which can reduce multiple organ damage and as a result can reduce postoperative ICU monitoring and stay time. Damage in the brain is one of the serious complications after cardiac surgery leading to increased incidence of postoperative mortality in hospital. In particular, brain stroke (CVA) is a catastrophic complication after vascular surgery and its high fatality and disability rate seriously affects the prognosis and quality of life.

The results of this study confirm postoperative brain stroke in Stanford type A acute aortic dissection is an independent risk factor of prolonged postoperative ICU stay time. Perioperative use of effective protective measures can reduce the incidence of postoperative cerebral stroke which is one of the important measures to shorten the time of ICU care. Deep hypothermic circulatory arrest and selected antegrade cerebral perfusion in aortic artery surgery is more effective methods for brain protection [27]. The use of effective monitoring techniques during operation such as, near infrared spectrum technology (NIRS) in deep hypothermic circulatory arrest and continue monitoring degree of brain oxygen saturation. This can timely find out serious brain hypoxia during operation and prevent cerebro-vascular accident and can provide effective processes to prevent further cerebral complications [28].

This study also shows that respiratory failure after surgery for Stanford type A acute aortic dissection is an independent risk factor for longer ICU stay time. Many studies have found regular prolonged ICU stay time after heart surgery due to respiratory failure [29,30]. Respiratory failure is one of serious complications after the surgery in the Stanford type A acute aortic dissection. Studies have shown that the incidence of around 13% cannot wean ventilator due to respiratory failure [31] leading to longer postoperative tracheal intubation, or tracheostomy and hence longer ICU monitoring time. Perioperative effective measures for lungs protection should be taken. Timely effective prevention and treatment of postoperative respiratory failure can reduce postoperative ICU monitoring time in patients undergoing surgery for Stanford type A acute aortic dissection. Studies have shown that postoperative respiratory failure in patients with prone position ventilation can significantly shorten the time of mechanical ventilation and ICU care [31].

Acute renal failure is a common complication after heart surgery at the rate of 1% ~ 31% [26] which is a risk factor for increased mortality in patients after cardiac surgery [30]. The results of this study also showed that acute renal failure in Stanford type A acute aortic dissection is an independent risk factors for prolonged postoperative ICU monitoring. Many studies have confirmed that duration of CPB have close relationship with postoperative acute renal failure. Therefore, to minimize the time of CPB can also reduce the incidence of postoperative acute renal failure thereby reducing postoperative ICU monitoring time. Timely or continuous renal protective measures of patients with acute renal failure can reduce ICU monitoring time and improve the prognosis of patients [32].

Conclusion

Out of various preoperative, intraoperative and postoperative variables, duration of CPB, postoperative stroke, postoperative respiratory failure, and postoperative renal failure are independent risk factors for prolonged ICU length of stay. To protect the function of brain, kidney and lung during perioperative period, timely correction of respiratory failure after surgery, to improve postoperative heart functions to ensure renal blood supply, avoiding the use of nephrotoxic drugs, timely renal replacement therapy and effective operation time with minimized CPB time can be effective in reducing postoperative complications and shorten the time of ICU care.

Limitations

A small sample size is a considerable limitation of this study. The retrospective study with such a small sample population must be improved.

Conflict of Interest

Mohammed Firoj Khan (M.S), Xian en Fa (Ph.D), Hai Bin Yu (M.D). There is no any conflict of interest among these 3 authors.

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