Factors influencing early surgical outcomes of patients with acute aortic dissection type A

Фактори који утичу на ране хируршке исходе болесника са акутном дисекцијом аорте тип А

1Dedinje Cardiovascular Institute, Cardiac Surgery Department, Belgrade, Serbia; 2University of Belgrade, Faculty of Medicine, Belgrade, Serbia; 3Dedinje Cardiovascular Institute, Department of Anesthesiology and Intensive Care Unit, Belgrade, Serbia; 4University Clinical Center of Serbia, Clinic of Obstetrics and Gynecology, Belgrade, Serbia; 5Dr. Dragiša Mišović – Dedinje University Clinical Hospital Center, Department of Cardiology, Belgrade, Serbia

Received: April 25, 2021
Revised: August 22, 2021
Accepted: August 23, 2021
Online First: August 31, 2021
DOI: https://doi.org/10.2298/SARH210425072N

*Accepted papers are articles in press that have gone through due peer review process and have been accepted for publication by the Editorial Board of the Serbian Archives of Medicine. They have not yet been copy-edited and/or formatted in the publication house style, and the text may be changed before the final publication.

Although accepted papers do not yet have all the accompanying bibliographic details available, they can already be cited using the year of online publication and the DOI, as follows: the author’s last name and initial of the first name, article title, journal title, online first publication month and year, and the DOI; e.g.: Petrović P, Jovanović J. The title of the article. Srp Arh Celok Lek. Online First, February 2017.

When the final article is assigned to volumes/issues of the journal, the Article in Press version will be removed and the final version will appear in the associated published volumes/issues of the journal. The date the article was made available online first will be carried over.

*Correspondence to:
Ivan NEŠIĆ
Cardiac Surgery Department, Dedinje Cardiovascular Institute, Heroja Milana Tepica 1, 11000 Belgrade, Serbia
E-mail: dr.inesic@gmail.com
Factors influencing early surgical outcomes of patients with acute aortic dissection type A

Фактори који утичу на ране хируршке исходе болесника са акутном дисекцијом аорте тип А

SUMMARY
Introduction/Objective Even with the current treatment mortality from aortic dissection remains high. The study aimed to evaluate the early postoperative outcome of patients with aortic dissection and identify which factors could have influence on it.

Methods The study included all consecutive patients who underwent surgery for acute aortic dissection type A from 2012 to 2017. We registered all parameters that could potentially impact the outcome (general data, medical history, clinical and cardioangiologic diagnostic test findings, preoperative complications, type of cannulation and the operation performed, additional surgical procedures, operation duration, etc.). Patients were surgically treated according to the current protocols. The main outcome measures were complications and mortality during a one-month postoperative period. All data collected pre-, intra-, and postoperatively were compared and statistically analyzed.

Results The study included 246 patients, of an average 57.54 +/- 12.88 years of age and mostly male sex (74%). Early postoperative mortality occurred in 17% of patients. Preoperative chronic kidney insufficiency (p = 0.005) and cerebrovascular insult (p = 0.047) and tamponade (p = 0.036) were the major risk factors for postoperative complications and mortality. Long hypothermic cardiac arrest (p = 0.001), cross clamp (p = 0.017) and cardiopulmonary bypass time (p = 0.036) increased postoperative complications. Postoperative complications started occurring after \( \geq 33.5 \) minutes hypothermic cardiac arrest and \( \geq 67.5 \) minutes cross clamp time. Having more postoperative complications (p = 0.034) increased, while performing anterograde cerebral perfusion decreased the frequency of lethal outcome (p = 0.001).

Conclusion The majority of patients surgically treated for acute aortic dissection had good postoperative outcome. However, numerous pre-, intra- and postoperative factors can impact patient survival.

Key words: acute aortic dissection type A; surgery; outcome; risk factors

САЖЕТАК
Увод/Циљ Чак и уз тренутно лечење, смртност од дисекције аорте остаје висока. Циљ студије био је да се евалуира ране постоперативне исход болесника са акутном дисекцијом аорте тип А и идентификује који фактори могу утицати на њега.

Методе Студија је обухватала све узастопне болеснике оперисане због акутне дисекције аорте типа А од 2012. до 2017. Регистровали смо све параметре који могу потенцијално утицати на исход (општи подаци, историја болести, налази клиничких и кардиолошких дијагностичких тестова, постоперативне компликације, тип хипотермиса и изведене операције, додатних хируршких поступака, трајање операције итд.). Болесници су хируршки лечени према важећим протоколима. Главне мере исхода биле су компликације и морталитет током једног месеца постоперативног периода. Сви подаци прикупљени пре, интра- и постоперативно упоређени су и статистички анализирани.

Резултати Студија је обухватала 246 болесника, просечне старости 57.54 +/- 12.88 година и углавном мужког пола (74%). Рани постоперативни морталитет догодио се код 17% болесника. Преоперативна хронична инсуфицијенција бубrega (p = 0.005) и цереброваскуларни инсульт (p = 0.047) и тампонада (p = 0.036) били су главни фактори ризик за постоперативне компликације и морталитет. Дуготрајање хипотермичног срчаног застоја (p = 0.001), тоталне клеме (p = 0.017) и кардиопулмоналног бајпаса (p = 0.036) повећавали су постоперативне компликације. Постоперативне компликације почеће да се јављају након \( \geq 33.5 \) минута хипотермичног срчаног застоја и \( \geq 67.5 \) минута времена тоталне клеме. Постојање више постоперативних компликација (p = 0.034) је повећавало, док је извођење антероградне церебралне перфузије емањивало учесталост смртног исхода (p = 0.001).

Закључак Већина болесника хируршки лечених због акутне дисекције аорте тип А је имала добар постоперативни исход. Међутим, бројни пре-, интра- и постоперативни фактори могу утицати на преживљавање болесника.

Кључне речи: акутна дисекција аорте тип А; операција; исход; фактори ризика

DOI: https://doi.org/10.2298/SARH210425072N
INTRODUCTION

Aortic dissection (AD) occurs as a result of direct mechanical force acting on the aortic wall (hypertension, hypervolemia, loss of laminar blood flow through the aorta) and damage to the aortic wall (connective tissue disorders, atherosclerotic changes) [1]. The worldwide incidence of acute AD ranges from 5 to 30 per million people [2, 3].

The survival and treatment outcomes of patients with acute AD type A have been continuously improving over the last decade [4]. However, even with the current treatment, due to potentially devastating complications, mortality from acute AD type A remains high. The most important and life-threatening complications of acute AD type A include lethal malperfusion syndrome, cardiac failure (myocardial infarction or cardiac tamponade) and stroke [5].

Numerous factors can impact the outcome of patients with surgically treated acute AD [1]. Some studies showed that the early survival of patients is affected by preoperative conditions like previous aortic valve replacement, migrating chest pain, limb ischemia, hypotension, shock, and cardiac tamponade. Additionally, long term survival is influenced by preoperative renal function impairment, reduced left ventricular ejection fraction and advanced age [5, 6].

The study goal was to investigate the early postoperative outcome of patients with acute AD type A, treated surgically in our referral cardio-surgery center. Moreover, we aimed to identify which factors, in terms of the patients’ preoperative characteristics, intraoperative surgical parameters, and postoperative complications could influence patient outcome.

METHODS

The study included all consecutive patients who underwent surgery for acute AD type A at the Cardiac Surgery Department, Dedine Cardiovascular Institute in Belgrade, from 01.01.2012 to 31.12.2017. We considered all parameters that could potentially impact the acute AD type A patients’ outcome. The main/primary tested effect was lethal outcome and the
secondary indicator of the patients’ condition was complications in the early postoperative period (30 days). So, we tested both which pre- and intraoperative parameters can cause postoperative complications, and how they all together impact patient survival. The study was approved by the Institutional Review Board. All patients signed informed consent for procedures and study.

Preoperatively, general data (age, sex, smoking status) and medical history were taken. We registered whether investigated patients had chronic illnesses and preoperative complications such as arterial hypertension (HTA) (pressure ≥140/90 mmHg), hyperlipoproteinemia (total cholesterol ≥4.5 mmol/L and low-density lipoprotein-cholesterol ≥2.5 mmol/L), cerebrovascular insult (CVI) previously or currently (ischemic stroke; transient ischemic attacks), periphery vascular disease (atherosclerosis except in aorta), chronic kidney insufficiency (albuminuria >30 mg/g; blood creatinine >133 μmol/L; glomerular filtration rate <60 ml/min/1.73 m²), heart tamponade, coronary illness (angina pectoris followed by acute coronary syndrome i.e. myocardial infarction and unstable angina), and other minor cardiological symptoms/complications (fatigue, shortness of breath, heart palpitations, chest pain, cold extremities) [5].

Upon admission for surgery, patients underwent a clinical and cardiology examination by transthoracic echocardiography (TTE) and multislice computed tomography (MSCT) for visualization of the dissection localization and measurement of the diameters of the ascending, descending and abdominal aorta. Only acute dissections of the type A (Stanford classification) were included in the study. Dissections were further divided into type I and II according to the DeBakey classification system. Finally, the EuroSCORE (www.euroscore.org) was determined for every patient.

The patients were surgically treated according to the current protocols for their condition (Bentall procedure; Interposition tube graft and resuspension of the aortic valve; Tirone David procedure; Hemiarch replacement and Arch replacement). The choice of operative technique for aortic reconstruction depended on the location of the primary endothelial tear [5]. In all cases, the open distal technique was performed in hypothermic cardiac arrest. Moreover, the primary entry resection was located and resected for all patients. We registered the type of cannulation and the operation performed. It was also noted if anterograde cerebral perfusion, aortocoronary bypass and intervention on the mitral valve were performed. Moreover, we
measured the deep hypothermic cardiac arrest time (DHCA) / hypothermic cardiac arrest time (HCA), cross clamp time and cardiopulmonary bypass (CPB) duration. The minimum DHCA temperature was 18°C.

Postoperatively, the patients were followed up for one month. During that period all complications were registered, such as: acute myocardial infarction, CVI, spinal cord injury, paralysis, kidney insufficiency, pneumonia, other minor complications (prolonged intensive care; the need for intubation; revision of hemostasis; uncomplicated urinary infection; uncomplicated wound infection) and/or lethal outcome.

**Statistical analysis**

All data collected pre-, intra- and postoperatively were compared and statistically analyzed. The sample was portrayed by descriptive statistics (mean, standard deviation, frequency and percent). The Kruskal Wallis H test was used to assess the differences in investigated parameters regarding postoperative outcomes. Receiver operating characteristics (ROC) analysis was used to find the cut-off operative time after which postoperative complications developed more often. Finally, we applied binary logistic regression to evaluate potential predictors of postoperative outcome in patients with acute AD type A. All investigated parameters were divided in two groups (preoperative and intra/postoperative) and in that manner used as dependent variables. We used SPSS 20 statistical software and 0.05 was the significance level.

**RESULTS**

The study included 246 acute AD type A patients who were on average 57.54 +/- 12.88 years old and were more often male (p = 0.001). There were no significant differences between patients regarding their smoking status (p = 0.610). The most common operation performed in these patients was graft interposition. The longest CPB time was 3.4 hours. At least one preoperative chronic illness / complication was registered in 84.55% of patients (p = 0.001).
Postoperative complications were also rather frequent (44.7%), but this finding was not significant ($p = 0.097$). Moreover, in the overall sample the outcome was good for the majority of patients (80.9%; $p = 0.001$).

Data collected pre- and intra-operatively and the postoperative outcomes of patients are presented in Tables 1-3. Differences in general, pre- and intra-operative data regarding postoperative outcomes are presented in Tables 4 and 5.

Out of all preoperative parameters only having chronic kidney insufficiency and tamponade on admission positively correlated with both early postoperative complications and lethal outcome. In addition, having CVI on admission was associated with postoperative complications, while more preoperative complications assessed together increased mortality in early postoperative period of patients with acute AD type A.

Performing anterograde cerebral perfusion decreased the frequency of lethal outcome while performing axilar cannulation and having early postoperative complications were associated with higher mortality. If duration of deep hypothermic cardiac arrest, cross clamp time and cardiopulmonary bypass time were longer patients had more early postoperative complications.

When we applied binary regression to investigate the association of the tested pre- and intraoperative parameters with lethal outcome in patients with acute AD type A, one significant model was obtained. Early postoperative mortality could be predicted using intraoperative ($B = -1.450; \; \text{Wald} = 71.495; \; \text{OR} = 0.235; \; R^2 \; \text{Nagelkerke} = 0.191; \; p = 0.001$; classification = 80.53%), but not preoperative parameters ($p = 0.096$). Lethal outcome can be expected more often in patients with more postoperative complications and when patients spent longer time on cross clamp (Table 6).

ROC analysis showed that DHCA time adequately explained 63.5% ($p = 0.001$), CPB time 57.6% ($p = 0.052$) and cross clamp time envisaged 59.6% ($p = 0.014$) of postoperative complications development (Figure 1). The cut-off for DHCA duration was 33.5 minutes (sensitivity = 65.3; specificity = 60.2) and for cross clamp time it was 67.5 minutes (sensitivity = 60.2; specificity = 59.3).
DISCUSSION

Acute dissection of the aorta is an urgent surgical condition that with high mortality due to the disease severity and the treatment complexity. Literature data show that as many as 50% of untreated patients with acute AD will die within the first 48 hours [2, 7]. Conversely, improvements in intraoperative management such as novel surgical techniques and postsurgical critical care have recently significantly improved the outcome for acute AD patients [4]. Nevertheless, even if patients are adequately surgically treated, in cases of severe acute AD type A the mortality is around 25% [3, 8]. In our sample, early postoperative mortality was 16.9%, which is rather high, but similar to other populations from the literature. A potential cause for the high mortality could be the fact that a high percentage of patients were rather metabolically unstable preoperatively. Some data showed that higher admission creatinine value and C-reactive protein serum levels increase mortality of patients with acute AD [9].

The most common causes of death in acute AD type A (80%) are rupture of the aorta in pericardium with consequent tamponade (or tamponade without visible rupture of the aorta) and myocardial ischemia [10]. Tamponade occurs in 8-10% of cases and is one of the grarest complications and the worst prognostic signs [11, 12]. In our study, tamponade was registered in a somewhat higher percentage (16.4%), most likely due to the prolonged time from dissection onset to hospitalization. We confirmed that having tamponade on admission was associated with adverse outcome of patients with acute AD type A.

Aortic insufficiency is also one of the preoperative complications of acute AD type A correlated with worse overall outcome [13]. In the literature, the incidence of aortic valvular insufficiency ranges from 41 to 76% of cases [11]. In our sample this percentage is slightly lower (31%) as we only investigated significant aortic insufficiency which required surgical treatment. We also did not prove that having significant aortic insufficiency preoperatively could increase adverse postoperative outcomes in patients with acute AD type A.

In some investigations nearly 80% of patients with acute AD had ischemic lesions on cerebral MSCT. If neurological disorders are found preoperatively, adverse postoperative outcomes seem to occur more often [4, 14]. Mortality of acute AD type A patients with neurological complications reaches 50% in case of further intra- and postoperative...
complications. Still, patients with neurological deficits, with a favorable early postoperative course, usually recover fully [15]. In our study, preoperative neurological complications were not very frequent (around 7%), but having CVI on admission was associated with more postoperative complications.

Pre- and postoperative renal complications are risk factors for increased mortality in patients with acute AD type A [16]. The association between renal disease and worse cardiac surgery outcomes has multiple explanations [17]. Patients with kidney disease may have more extensive coronary disease preoperatively, along with other comorbidities. Besides, impaired renal function can be a direct risk factor for intra- and postoperative complications, due to the need for greater fluid infusions or blood transfusions [16, 17, 18]. Having chronic kidney insufficiency on admission in our study was associated with both early postoperative complications and lethal outcome.

The incidence of acute AD type A correlates with age and it mostly occurs in the 6th decade of life. Men are at higher risk of developing acute AD type A than women. However, women tend to present at an older age, with more advanced dissection, and more complications, and therefore have a higher early mortality rate [1, 5, 6]. In our study majority of patients were also males around the age of 57 years, but neither sex nor age were significantly associated with early morbidity or mortality.

Hypertension is considered to be the most important risk factor for acute AD and is present in about 80% of acute AD type A patients [1, 5, 6]. Patients with hypertensive disorders lasting 5 or more years before the occurrence of acute AD type A have adverse outcomes more often than normotensive patients. Smoking is another risk factor for developing AD [12, 19]. However, we did not confirm that smoking impacted the early postoperative outcome of patients with acute AD type A.

Some investigations found that the rate of acute AD type A progressively rises along with the increase in aortic diameter. Aortic complications mostly start developing once the aortic diameter reaches 60 mm [2, 10]. In our sample the average diameter of the ascending aorta was 53.65mm, while that of the descending aorta was 32.45mm. However, the aortic diameter was not associated with postoperative outcome.
Based on our results, no other preoperative patient characteristics and comorbidities were found to affect the postoperative outcome of patients with acute AD type A. However, having more preoperative complications simultaneously did increase the rate of lethal outcome in the early postoperative period. One unexpected result was the fact that the EuroSCORE was not a significant predictor of outcome in our study. A possible explanation could be that our patients had few preoperative comorbidities that are assessed by EuroSCORE. Therefore, the average EuroSCORE was rather low in our study and consequently not sufficiently reliable for prediction. It seems that some other, not scored parameters and patient characteristic (perhaps biochemical and metabolic aspects) contributed to adverse outcome in our patients.

Treatment of acute AD type A continues to be challenging [2, 3]. Currently, different surgical techniques are being used for dissection treatment according to the indications, based on dissection type and patient condition. Adequate operative management remains the major concern for better outcome of acute AD type A patients [20, 21]. However, patients are completely different from one another, and numerous factors can impact the choice of technique and reflect surgical outcomes [22]. The results of our study show that, if appropriately chosen, the precise operation type was not a risk factor for postoperative morbidity and mortality.

Literature data show that aortic arch replacement was indicated in 12.2% of patients [12]. In our study, aortocoronary bypass, as a combined procedure with aortic reconstruction, was performed in 19.3% of patients. Studies indicate that early postoperative survival is equivalent when comparing antegrade and retrograde perfusion. Nevertheless, antegrade perfusion to the true lumen was associated with better long-term survival, while retrograde perfusion is a risk factor for late mortality [23, 24]. Our patients with antegrade perfusion also had better postoperative outcomes than those who underwent surgery without cerebral perfusion.

Currently, cannulation to establish cardiopulmonary bypass in patients with acute AD type A can be safely and efficiently performed through the femoral, subclavian, axillary artery, the ascending aorta, as well as through the left ventricular apex and the aortic valve [25, 26, 27]. Our results showed that axillar cannulation was associated with more frequent lethal outcome. A potential reason for this finding could be that patients who had axillar cannulation also had more preoperative chronic illness / complications, which might have influenced their overall outcome. Other authors also found that operative details differed significantly among
the patients with different cannulation sites [21, 23]. Other cannulation sites were found to be safe for our patients.

As expected, emergency operations were confirmed to have a significantly higher risk for both postoperative mortality and morbidity than elective acute AD surgery [2]. However, despite different novel surgical modifications, significant improvement in early mortality was not observed [9]. Moreover, no significant link between the overall early mortality and the extent of the aortic repair has been proven in literature [20]. Contrary, it was found that perioperative complications were associated with the length of cardiopulmonary bypass, which again increased complications and mortality after surgery [10, 21]. In this study, it was found for the first time that if DHCA duration was ≥33.5 minutes and cross clamp time was ≥67.5 minutes, postoperative complications were more likely.

Regression analyses performed in the literature suggest that the independent perioperative risk factors for adverse outcomes were prolonged cross clamp and cerebral perfusion time [4]. Prolonged cardiopulmonary bypass, surgery time and duration of deep hypothermia were the main intraoperative risk factors influencing surgical outcomes in patients who underwent aortic arch repair [20]. We found that performing the anterograde cerebral perfusion decreased lethal outcome. In addition, shortening the duration of DHCA, CPB and cross clamp time could reduce early postoperative complications. The obtained results should be confirmed on a larger sample in future for better reliability.

CONCLUSION

Our study shows that early 30-day mortality after surgery for acute aortic dissection type A remains high, affecting almost 17% of patients. Preoperative chronic kidney insufficiency, cerebrovascular insult and tamponade are the major factors that could lead to more postoperative complications and potential adverse outcomes. Lethal outcome can be expected more often in patients with cumulative postoperative complications, and when patients spend a longer time on a cross clamp. Moreover, we found that after 67.5 minutes of cross-clamp and 33.5 minutes of DHCA, postoperative complications occur more frequently.

Conflict of interest: None declared.
REFERENCES

1. Nienaber CA, Clough RE, Sakalihasan N, Suzuki T, Gibbs R, Mussa F, et al. Aortic dissection. Nat Rev Dis Primers. 2016. doi: 10.1038/nrdp.2016.71. PMID: 27560366

2. Lee TC, Kon Z, Cheema FH, Grau-Sepulveda MV, Engham B, Kim S, et al. Contemporary management and outcomes of acute type A aortic dissection: An analysis of the STS adult cardiac surgery database. J Card Surg. 2018;33(1):7-18. doi: 10.1111/jocs.13511. PMID: 29314257

3. Czerny M, Schmidli J, Adler S, van den Berg JC, Bertoglio L, Carrel T, et al. Current options and recommendations for the treatment of thoracic aortic pathologies involving the aortic arch: an expert consensus document of the European Association for Cardio-Thoracic surgery (EACTS) and the European Society for Vascular Surgery (ESVS). Eur J Cardiothorac Surg. 2019;55(1):133-162. doi: 10.1093/ejcts/ezy313. PMID: 30312382

4. Schoenrath F, Laber R, Maralushaj M, Henzi D, Caliskan EI, Seifert B, et al. Survival, Neurologic Injury, and Kidney Function after Surgery for Acute Type A Aortic Dissection. Thorac Cardiovasc Surg. 2016;64(2):100-107. doi: 10.1055/s-0035-1563536. PMID: 26334243

5. Gawinecka J, Schönrath F, von Eckardstein A. Acute aortic dissection: pathogenesis, risk factors and diagnosis. Swiss Med Wkly. 2017. doi: 10.4414/swm.2017.14489. PMID: 28871571

6. Landenhed M, Engstrom G, Gottsater A, Caulfield MP, Hedblad B, Newton-Cheh C, et al. Risk profiles for aortic dissection and ruptured or surgically treated aneurysms: a prospective cohort study. J Am Heart Assoc. 2015. doi: 10.1161/JAHA.114.001513. PMID: 25609416

7. Urbanski PP, Lenos A, Irimie V, Bougioukakis P, Zacher M, Diegeler A. Acute aortic dissection involving the root: operative and long-term outcome after curative proximal repair. Interact Cardiovasc Thorac Surg. 2016;22(5):620-626. doi: 10.1093/icvts/ivw002. PMID: 26848190

8. Kouchoukos NT, Kulik A, Haynes M, Castner CF. Early Outcomes after Thoracoabdominal Aortic Aneurysm Repair with Hypothermic Circulatory Arrest. Ann Thorac Surg. 2019;108(5):1338-1343. doi: 10.1016/j.athoracsur.2019.04.014. PMID: 31085168

9. Fadahunsi O, Romeo M. Cardiac tamponade - presentation of type A aortic dissection. J Community Hosp Intern Med Perspect. 2014. doi: 10.3402/jchimp.v4.25449. PMID: 25432649

10. Tsai TT, Trimbardi S, Nienaber CA. Acute aortic dissection: perspectives from the International Registry of Acute Aortic Dissection (IRAD). Eur J Vasc Endovasc Surg. 2009;37(2):149-159. doi: 10.1016/j.ejvs.2008.11.032. PMID: 19097813

11. Chiappini B, Schepens M, Tan E, Dell’ Amore A, Morshuis W, Dossche K, et al. Early and late outcomes of acute type A aortic dissection: analysis of risk factors in 487 consecutive patient. Euro Heart J. 2014;26(2):180-186. doi: 10.1093/eurheartj/ehi024. PMID: 15618075

12. Berdajs D, Mosbah S, Ferrari E, Charbonnier D, van Segesser LK. Aortic Valve Pathology as a Predictive Factor for Acute Aortic Dissection. Ann Thorac Surg. 2017;104(4):1340-1348. doi: 10.1016/j.athoracsur.2017.02.076. PMID: 28587739

13. Niclauss L, Delay D, Ferrari E, Pretre R. Impact of preoperative central neurologic dysfunction on patients undergoing emergency surgery for type A dissection. Ann Vasc Surg. 2014;28(5):1227-1235. doi: 10.1016/j.avsg.2013.08.008. PMID: 24184458

14. Martin CE, Forteza A, Perez E, Lopez MJ, Centeno J, Blazquez JA, et al. Predictors of mortality and reoperation in Acute type A aortic dissection surgery: 18 years of experience. Rev Esp Cardiol. 2008;61(10):1050-1060. PMID: 18817681

15. Fan PY, Chen CY, Lee CC, Liu KS, Wu VC, Fan PC, et al. Impact of renal dysfunction on surgical outcomes in patients with aortic dissection. Medicine. 2019. doi: 10.1097/MD.0000000000015453. PMID: 31096441

16. Akiyoshi K, Kimura N, Aizawa K, Hori D, Okamura H, Morita H, et al. Surgical outcomes of acute type A aortic dissection in dialysis patients. Gen Thorac Cardiovasc Surg. 2019;67(6):501-509. doi: 10.1007/s11748-018-1051-6. PMID: 30552649

17. Helgason D, Helgadottir S, Ahlsson A, Gunn J, Hjortdal V, Hansson EC, Jeppsson A, Menander A, Nozohoors S, Zindovic I, Olsson C, Ragnarsson SO, Sigurdsson MI, Geirsson A, Gudbjartsson T, Acute Kidney Injury After Acute Repair of Type A Aortic Dissection. Ann Thorac Surg. 2021;111(4):1292-1298. doi: 10.1016/j.athoracsur.2020.07.019. PMID: 32961133
18. Kimura N, Aizawa K, Kawahito K, Itagaki R, Yamaguchi A, Misawa Y, et al. Outcomes of Early-Onset Acute Type A Aortic Dissection - Influence of Etiologic Factors. Circ J. 2019;83(2):285-294. doi: 10.1253/circj.CJ-18-0969. PMID: 30584230
19. Zhu S, Zheng T, Qiao ZY, Chen L, Ou JF, Fang WG, et al. Acute Aortic Dissection in Young Adult Patients: Clinical Characteristics, Management, and Perioperative Outcomes. J Invest Surg. 2020;33(3):211-217. doi: 10.1080/08941939.2018.1489916. PMID: 30909770
20. Kreibich M, Chen Z, Rylski B, Bavaria JE, Brown CR, Branchetti E, et al. Outcome after aortic, axillary, or femoral cannulation for acute type A aortic dissection. J Thorac Cardiovasc Surg. 2019;158(1):27-34. doi: 10.1016/j.jtcs.2018.11.100. PMID: 31248512
21. Latt KK, Vasiliyev KN, Bayandin NL, Stupin VA. Risk factors of surgical treatment of acute aortic dissection type A. Khirurgija. 2019;3:15-20. doi: 10.17116/quirurgia201903115. PMID: 30938353
22. Etz CD, von Aspern K, da Rocha E Silva J, Girrbach FF, Leontyev S, Luehr M, et al. Impact of perfusion strategy on outcome after repair for acute type aortic dissection. Ann Thorac Surg. 2014;97(1):78-85. doi: 10.1016/j.athoracsur.2013.07.034. PMID: 24070704
23. Bekkers JA, Raap GB, Takkenberg JJ, Rogers AJ. Acute type A aortic dissection: long-term results and reoperations. Euro J Cardiothorac Surg. 2013;43(2):389-396. doi: 10.1093/ejcts/ezs342. PMID: 22677353
24. Ram E, Krupik Y, Lipey A, Shinfeld A, Peled Y, Kogan A, et al. Is Axillary Better Than Femoral Artery Cannulation in Repair of Acute Type A Aortic Dissection? Innovations. 2019;14(2):124-133. doi: 10.1177/1556984519836879. PMID: 30885088
25. Djukanovic BP, Micovic S, Peric MS, Milojivic PS, Cirkovic MV, Bortic M, et al. The role of transapical cannulation in the operative management of acute aortic dissection. Perfusion. 2018;30(4):332-336. doi: 10.1177/0267659114547380. PMID: 25122117
26. Rosinski BF, Idrees JJ, Roselli EE, Germano E, Pasadyn SR, Lowry AM, et al. Cannulation strategies in acute type A dissection repair: A systematic axillary artery approach. J Thorac Cardiovasc Surg. 2019. doi: 10.1016/j.jtcs.2018.11.137. PMID: 30770117
27. Zdravković R, Redžek A, Šušak S, Tatić M, Videnović N, Majdevac S, Vujčić V, Vučković-Karan J, Miljković T, Velicki L. In-hospital mortality predictors after surgery for Stanford type A aortic dissection – single-center five-year experience. Srp Arh Celok Lek. 2020;148(9-10):541-547. doi:10.2298/SARH191115048Z
Table 1. Descriptive data of the investigated patients with acute aortic dissection

| Parameters                                         | Minimum | Maximum | Mean  | SD  |
|----------------------------------------------------|---------|---------|-------|-----|
| Patients’ age                                      | 16      | 86      | 57.54 | 12.88 |
| Ejection fraction                                  | 25      | 65      | 54.56 | 7.87 |
| Ascending aorta diameter – millimeters             | 30      | 90      | 53.65 | 9.69 |
| Descending aorta diameter – millimeters            | 0       | 55      | 32.45 | 7.81 |
| Abdominal aorta diameter – millimeters             | 2       | 61      | 25.16 | 11.99 |
| EuroSCORE                                          | 2       | 18.45   | 7.69  | 3.75 |
| EuroSCORE 2                                        | 0.24    | 65.47   | 8.52  | 8.37 |
| EuroSCORE Log                                      | 1.2     | 38.47   | 13.65 | 8.86 |
| Deep hypothermic cardiac arrest time – minutes     | 13      | 52      | 31.56 | 11.86 |
| Cross clamp time minutes                           | 53      | 192     | 64.43 | 7.52 |
| Cardiopulmonary bypass duration – minutes          | 106     | 212     | 139.74| 69.62 |

DOI: https://doi.org/10.2298/SARH210425072N
Table 2. General and preoperative acute aortic dissection patient data

| Parameters                                         | Frequency | %  |
|----------------------------------------------------|-----------|----|
| Patients’ sex                                      |           |    |
| male                                               | 182       | 74 |
| female                                             | 64        | 26 |
| Smoking status                                     |           |    |
| not smokers                                        | 127       | 51.6 |
| smokers                                            | 119       | 48.4 |
| Dissection type                                    |           |    |
| one                                                | 213       | 86.6 |
| two                                                | 33        | 13.4 |
| Marfan syndrome                                    |           |    |
| no                                                 | 227       | 92.3 |
| yes                                                | 19        | 7.7 |
| Hypertension                                       |           |    |
| no                                                 | 75        | 30.5 |
| yes                                                | 171       | 69.5 |
| Hyperlipoproteinemia                                |           |    |
| no                                                 | 205       | 83.3 |
| yes                                                | 41        | 16.7 |
| Cerebrovascular insult before operation            |           |    |
| no                                                 | 229       | 93.1 |
| yes                                                | 17        | 6.9 |
| Periphery vascular disease                         |           |    |
| no                                                 | 226       | 91.9 |
| yes                                                | 20        | 8.1 |
| Chronic kidney insufficiency                        |           |    |
| no                                                 | 237       | 96.3 |
| yes                                                | 9         | 3.7 |
| Coronary illness before operation                   |           |    |
| no                                                 | 213       | 86.6 |
| yes                                                | 33        | 13.4 |
| Tamponade on admission                              |           |    |
| no                                                 | 183       | 74.4 |
| yes                                                | 63        | 25.6 |
| Cerebrovascular insult on admission                 |           |    |
| no                                                 | 226       | 91.9 |
| yes                                                | 20        | 8.1 |
| Type 1/2 aortic regurgitation                       |           |    |
| no                                                 | 124       | 50.4 |
| yes                                                | 122       | 49.6 |
| Type 3/4 aortic regurgitation                       |           |    |
| no                                                 | 175       | 71.1 |
| yes                                                | 71        | 28.9 |
| Other symptoms and complications                    |           |    |
| no                                                 | 213       | 86.6 |
| yes                                                | 33        | 13.4 |
| Had some preoperative complications                 |           |    |
| no                                                 | 38        | 15.4 |
| yes                                                | 208       | 84.6 |
Table 3. Intraoperative parameters and postoperative complications

| Parameters                              | Frequency | %    |
|-----------------------------------------|-----------|------|
| Cannulation type                        |           |      |
| apical                                  | 129       | 52.4 |
| femoral                                 | 41        | 16.7 |
| axillar                                 | 76        | 30.9 |
| Cerebral perfusion                      |           |      |
| no                                      | 124       | 50.4 |
| antegrade                               | 122       | 49.6 |
| Operation type                          |           |      |
| graft interposition                     | 132       | 53.7 |
| Bentall                                 | 55        | 22.4 |
| David                                   | 4         | 1.6  |
| hemiarch                                | 4         | 1.6  |
| graft + hemiarch                        | 38        | 15.4 |
| Bentall + hemiarch                      | 13        | 5.3  |
| Intervention on mitral valve            |           |      |
| no                                      | 231       | 93.9 |
| yes                                     | 15        | 6.1  |
| Aortocoronary bypass                    |           |      |
| no                                      | 204       | 82.9 |
| yes                                     | 42        | 17.1 |
| Postoperative myocardial infarction     |           |      |
| no                                      | 241       | 98   |
| yes                                     | 5         | 2    |
| Cerebrovascular insult postoperatively  |           |      |
| no                                      | 214       | 87   |
| yes                                     | 32        | 13   |
| Postoperative paralysis                 |           |      |
| no                                      | 243       | 98.8 |
| yes                                     | 3         | 1.2  |
| Postoperative kidney insufficiency      |           |      |
| no                                      | 217       | 88.2 |
| yes                                     | 29        | 11.8 |
| Other postoperative complications       |           |      |
| no                                      | 162       | 65.9 |
| yes                                     | 84        | 34.1 |
| Had early postoperative complications   |           |      |
| no                                      | 136       | 55.3 |
| yes                                     | 110       | 44.7 |
| Lethal outcome (30-day mortality)       |           |      |
| no                                      | 199       | 80.9 |
| yes                                     | 47        | 19.1 |
Table 4. Differences in preoperative parameters regarding postoperative outcomes

| Parameters                                      | Early postoperative lethal outcome (yes/no) | Early postoperative complications (yes/no) |
|------------------------------------------------|---------------------------------------------|-------------------------------------------|
|                                                 | KW χ²  | p       | KW χ²  | p       |
| Dissection type                                 | 0.648  | 0.421   | 1.071  | 0.301   |
| Marfan syndrome                                | 0.146  | 0.702   | 1.441  | 0.230   |
| Hypertension                                   | 0.882  | 0.348   | 0.927  | 0.336   |
| Hyperlipoproteinaemia                           | 1.514  | 0.219   | 2.214  | 0.137   |
| Cerebrovascular insult before                   | 1.250  | 0.264   | 0.498  | 0.480   |
| Periphery vascular disease                      | 0.236  | 0.627   | 0.928  | 0.335   |
| Chronic kidney insufficiency                    | 7.998  | 0.005   | 4.114  | 0.043   |
| Coronary illness before operation               | 0.021  | 0.885   | 0.008  | 0.927   |
| Ejection fraction                               | 1.783  | 0.182   | 0.301  | 0.583   |
| Ascending aorta diameter mm                     | 0.019  | 0.892   | 0.453  | 0.501   |
| Descending aorta diameter mm                    | 0.965  | 0.326   | 0.409  | 0.522   |
| Abdominal aorta diameter mm                     | 0.002  | 0.963   | 0.321  | 0.571   |
| Tamponade on admission                          | 4.487  | 0.036   | 2.921  | 0.087   |
| Cerebrovascular insult on admission             | 0.487  | 0.485   | 3.906  | 0.047   |
| Type 1/2 aortic regurgitation                   | 1.428  | 0.232   | 0.827  | 0.363   |
| Type 3/4 aortic regurgitation                   | 0.041  | 0.840   | 0.045  | 0.833   |
| Other preoperative complications/symptoms       | 1.198  | 0.274   | 0.218  | 0.640   |
| Had some preoperative complications             | 4.607  | 0.034   | 0.123  | 0.725   |
| EuroSCORE                                      | 0.824  | 0.364   | 3.143  | 0.076   |
| EuroSCORE 2                                    | 0.156  | 0.693   | 0.842  | 0.359   |
| EuroSCORE Log                                  | 0.053  | 0.818   | 0.515  | 0.473   |
Table 5. Differences in general and intraoperative data regarding postoperative outcomes

| Parameters                              | Early postoperative lethal outcome (yes/no) | Early postoperative complications (yes/no) |
|-----------------------------------------|---------------------------------------------|-------------------------------------------|
|                                         | KW $\chi^2$  | p   | KW $\chi^2$  | p   |
| Patients’ age                           | 1.248         | 0.264 | 0.001         | 0.971 |
| Patients’ sex                           | 2.432         | 0.119 | 0.223         | 0.637 |
| Smoking status                          | 3.451         | 0.063 | 2.530         | 0.112 |
| Cannulation type                        | 12.981        | 0.001 | 1.714         | 0.190 |
| Anterograde cerebral perfusion          | 11.977        | 0.001 | 0.392         | 0.531 |
| Operation type                          | 0.316         | 0.574 | 0.882         | 0.348 |
| Intervention on mitral valve            | 0.588         | 0.443 | 0.143         | 0.705 |
| Aortocoronary bypass                    | 0.001         | 0.992 | 0.570         | 0.450 |
| Deep hypothermic cardiac arrest time (minutes) | 0.002         | 0.964 | 11.815        | 0.001 |
| Cross clamp time (minutes)              | 0.131         | 0.717 | 5.690         | 0.017 |
| Cardiopulmonary bypass duration (minutes) | 0.956         | 0.328 | 4.439         | 0.036 |
| Had early postoperative complications   | 8.552         | 0.003 | /             | /     |
**Table 6.** Significant model for prediction of acute aortic dissection operative outcome

| Parameters                          | B     | Standard error | Wald  | p     | OR   |
|------------------------------------|-------|----------------|-------|-------|------|
| Cannulation type                   | -0.014| 0.007          | 3.823 | 0.051 | 0.986|
| Arrest Time                        | -0.007| 0.009          | 0.608 | 0.435 | 0.993|
| Anterograde perfusion              | 0.675 | 0.447          | 2.277 | 0.131 | 1.964|
| CPB duration                       | 0.005 | 0.003          | 2.599 | 0.107 | 1.005|
| **Cross clamp time**               | 0.541 | 0.239          | 5.111 | **0.024** | 1.718|
| Operation type                     | 0.095 | 0.107          | 0.799 | 0.371 | 1.100|
| Aortocoronary bypass               | 0.060 | 0.531          | 0.013 | 0.910 | 1.062|
| Intervention on MV                 | 0.892 | 0.765          | 1.359 | 0.244 | 2.439|
| **Postop complications**           | 1.469 | 0.417          | 12.428 | **0.001** | 4.343|
| Constant                           | -3.373| 0.708          | 22.668| 0.001 | 0.034|
**Figure 1.** Receiver operating characteristics curve for postoperative complications based on operative times;

CPB – cardiopulmonary bypass; DHCA – deep hypothermic cardiac arrest time