

A Case of Successful Treatment of Left Ventricular Rupture after Transcatheter Aortic Valve Implantation

Rustem Tuleutayev

Department of Cardiac Surgery, Research Institute of Cardiology and Internal Diseases, Almaty, Republic of Kazakhstan

Kuat Abzaliyev

Consultative and Diagnostic Center, Research Institute of Cardiology and Internal Diseases, Almaty, Republic of Kazakhstan
Department of Clinical Specialties, Al-Farabi Kazakh National University, Almaty, Republic of Kazakhstan

Alexey Kolesnikov

Department of X-ray Endovascular Surgery, Scientific Research Institute of Cardiology and Internal Diseases, Almaty, Republic of Kazakhstan

Igor Kim

Intensive Care Unit, Research Institute of Cardiology and Internal Diseases, Almaty, Republic of Kazakhstan

Symbat Abzaliyeva*

Higher School of Medicine, Faculty of Medicine and Healthcare, Al-Farabi Kazakh National University, Almaty, Republic of Kazakhstan
ORCID ID <https://orcid.org/0009-0004-9802-0129>

Abstract. Background: The article talks about a patient who had nonrheumatic disease of the aortic valve and had a left ventricular rupture during a transcatheter aortic valve implantation (TAVI) procedure. **Methods:** The discrepancy between the size of the prosthesis and the size of the native aortic valve (mismatch) led to the need to deploy a second prosthesis, which was dislocated into the left ventricular cavity and led to myocardial damage and the development of tamponade. **Results:** As a result of timely cardiac surgery and effective measures of the emergency support service, both prostheses were removed from the left ventricular cavity, the aortic valve was replaced with a “Medtronic Hancock No. 25” biological prosthesis, and the left ventricular myocardial rupture was sutured. **Conclusions:** In case of the development of such complications during the transcatheter aortic valve implantation (TAVI) procedure with asystole and cardiac tamponade, it was suggested to conduct cardioplegia (instead of chest compressions).

Keywords: TAVI, transcatheter aortic valve implantation, aortic valve, prosthesis dislocation, left ventricular rupture

Sėkmingas kairiojo skilvelio plyšimo po transkateterinės aortos vožtuvo implantacijos gydymo atvejis

Santrauka. Įvadas: Straipsnyje rašoma apie pacientą, kuris sirgo nereumatine aortos vožtuvo liga ir kuriam transkateterinės aortos vožtuvo implantacijos (TAVI) procedūros metu plyšo kairysis skilvelis.

* Corresponding author: Symbat Abzaliyeva, Higher School of Medicine, Faculty of Medicine and Healthcare, Al-Farabi Kazakh National University, Almaty, Republic of Kazakhstan. E-mail: phd.abzaliyeva@yahoo.com

Received: 25/04/2024. Revised: 17/06/2024. Accepted: 18/06/2024

Copyright © 2024 Rustem Tuleutayev, Kuat Abzaliyev, Alexey Kolesnikov, Igor Kim, Symbat Abzaliyeva. Published by Vilnius University Press. This is an Open Access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Metodai: Dėl protezo dydžio ir aortos vožtuvo dydžio neatitikimo reikėjo įdėti antrą protezą, jis buvo dislokuotas į kairiojo skilvelio ertmę ir sukėlė miokardo pažeidimą bei tamponados išsivystymą.

Rezultatai: Dėl laiku atliktos kardiochirurginės operacijos ir veiksmingų skubios pagalbos tarnybos priemonių abu protezai buvo pašalinti iš kairiojo skilvelio ertmės, aortos vožtuvas pakeistas „Medtronic Hancock No. 25“ biologiniu protezu, o kairiojo skilvelio miokardo plyšimas susiūtas.

Išvados: Pasireiškus tokioms komplikacijoms transkateterinės aortos vožtuvo implantacijos (TAVI) procedūros metu su asistolija ir širdies tamponada, pasiūlyta atlikti kardioplegiją (vietoj krūtinės ląstos paspaudimų).

Raktažodžiai: TAVI, transkateterinė aortos vožtuvo implantacija, aortos vožtuvas, protezo dislokacija, kairiojo skilvelio plyšimas

Background

With increasing life expectancy in economically developed countries, the prevalence of aortic stenosis (AS) complicated by calcinosis in the elderly is a frequent pathology. In a general population, it makes up 2.5% [1]. The prevalence of aortic stenosis is increasing by about 10% among patients over 80 years of age [2]. And in a population over 75 years old, 1 in 8 has moderate or severe aortic stenosis [3]. Whereas pathological changes of the aortic valve (AV) in elderly patients are detected in about 40% of patients, and in octogenarians, similar calcium salt deposits occur in 75% of cases [4]. It is known that in 80% of asymptomatic patients with severe AS, the condition manifests suddenly with symptoms of angina and hypertension. According to the literature, the two-year survival rate for such patients fluctuates around 50%, and when symptoms appear, the survival rate, according to some data, falls to 15% within five years [5]. Almost all patients in this age group have severe comorbidities. These patients have an increased risk of complications and adverse outcomes from AV replacement surgery. Therefore, transcatheter aortic valve implantation (TAVI) in elderly patients with comorbid conditions is the treatment of choice. But in the process of mastering this technique and introducing transcatheter methods into the practice of valve replacement, there were still many questions [5,6]. The negative outcome within a month in elderly patients was as high as 17%, and various complications after 3–4 months brought this figure up to 60% (during the period of mastering the technique) [7,8]. However, complications and mortality rates have significantly decreased with more experience and improvements in medical devices, medicines, and anaesthesia methods. According to recent data, mortality in the immediate postoperative period after TAVI does not exceed 6% [9], and the survival rate within a month after TAVI surgery was 92.9%. Other complications in the same patients result in a 78.6% survival rate after one year and 73.7% after 2 years [10]. Current data show that TAVI significantly reduces financial losses in treating these patients, as well as complications with postoperative mortality [11,12]. Given the study of all complications, causes of mortality, and risks of the procedure, various associations have issued numerous regulations and guidelines for TAVI [13]. Some things that can make complications more likely are a small sinotubular junction and fibrous ring, a very high systolic gradient because the fibrous ring is calcified, and strong predilation.

Typical complications of TAVI are paravalvular leak (PVL) leading to paraprosthetic regurgitation, valve dislocation, complete heart block, left ventricular rupture or aortic dissection, obstruction or thrombosis of coronary arteries with the development of myocardial infarction, embolic complications in the form of strokes, tamponade, and acute renal failure [14]. The complications of TAVI can be classified as intraoperative and postoperative, despite the sparing technique compared to open surgery with the use of artificial circulation. According to T.E. Imaev, A.E. Komlev, M.A. Saidov et al. [15], fibrous ring rupture was observed in 0.4–0.6% of cases, and intraoperative mortality reached 2.6%.

According to life-threatening indications, life-threatening complications require immediate surgery under bypass circulation [16]. Non-life-threatening complications after TAVI are largely determined by the diameter and material of the valve delivery system and include such risks as dissection, rupture, perforation, or total occlusion of iliac or femoral arteries and occur in 15.9% of patients [17]. Within one month after TAVI, the use of a small-diameter valve delivery system reduces such complications to 5.2%–5.9% [18,19]. The incidence of stroke is 2–5% within one month after TAVI [20]. At the same time, dyscirculatory encephalopathies after TAVI, according to brain MRI, were detected in 84% of patients who underwent percutaneous intervention, while the use of artificial circulation revealed 48% of subclinical manifestations of circulatory disorders in the brain [21]. The available literature describes cases of dislocation of prostheses, primarily in the ascending aorta [22, 23]. The authors point out that, due to the complexity of the transcatheter aortic valve replacement procedure, complications are possible even for experienced operators.

This is a clinical case that demonstrates the successful treatment of an intraoperative complication in a patient with nonrheumatic aortic valve disease during TAVI. Due to the discrepancy between the size of the first TAVI prosthesis and the size of the native aortic valve, a significant PVL was registered on Echo. After careful assessment, it was decided to deploy a second TAVI valve of a bigger size. During the deployment of the second valve, the first prosthesis dislocated into the LV cavity, causing damage to the myocardium.

Case presentation

Patient B., 70 years old, was admitted to the hospital with the following diagnosis: Acquired heart valve disease (nonrheumatic). The patient had a combination of aortic disease and predominant critical stenosis (Sao-0.5 cm²). The patient presented with complaints of pressing pain in the retrosternal region with physical exertion and at rest (FC III-IV), shortness of breath, and general weakness. The patient's medical history indicates that they have had arterial hypertension for over a decade, reaching a maximum blood pressure of 200/80 mm Hg, and have consistently received optimal medical care. Chest pain first appeared 3 years ago; symptoms of heart failure, shortness of breath, and weakness have begun to progress since then. There is no history of myocardial infarction. Suffers from bronchial asthma for a long time and regularly takes bronchodilators.

The patient's condition has been worsening since October 2020, when the pressure, chest pain, and dyspnoea from physical exertion began to bother him more often. Between October 19, 2020, and October 28, 2020, he was hospitalized with the diagnosis of coronary heart disease (CHD). Braunwald classified his angina as unstable and functional class III. Grade III aortic valve stenosis. The patient has a second-degree tricuspid valve insufficiency. Pulmonary hypertension. CHF with a preserved EF of 66% falls under class III (NYHA). The patient has second-degree arterial hypertension with a risk score of 4. Coronaroangiography on October 24, 2020. Left-type coronary blood flow. The LMCA's trunk was clear, with a smooth contour. The LAD was clear throughout. AI – all the way through. All the way through, the CX was passable. RCA: clear, small caliber (Figure 1).

The echocardiography test from October 20, 2020 revealed sclerosis and dilatation of the ascending aorta, AV calcification, critical stenosis, and AV insufficiency due to an increase in the gradient on the AV. LV myocardial hypertrophy. LV diastolic dysfunction type II. The LV myocardium's contractility is reduced. Moderate PH. On November 23, 2020, the patient was hospitalized at the Research Institute of Cardiology and Internal Medicine in the interventional cardiology department for elective transcatheter aortic valve replacement.

Laboratory and diagnostic tests revealed an increase in blood creatinine of 138 µmol/l. PCR for COVID-19 from November 18, 2020: negative. The department conducted inpatient instrumental and diagnostic tests, including a 6-minute walk test on November 23, 2020, which measured 105

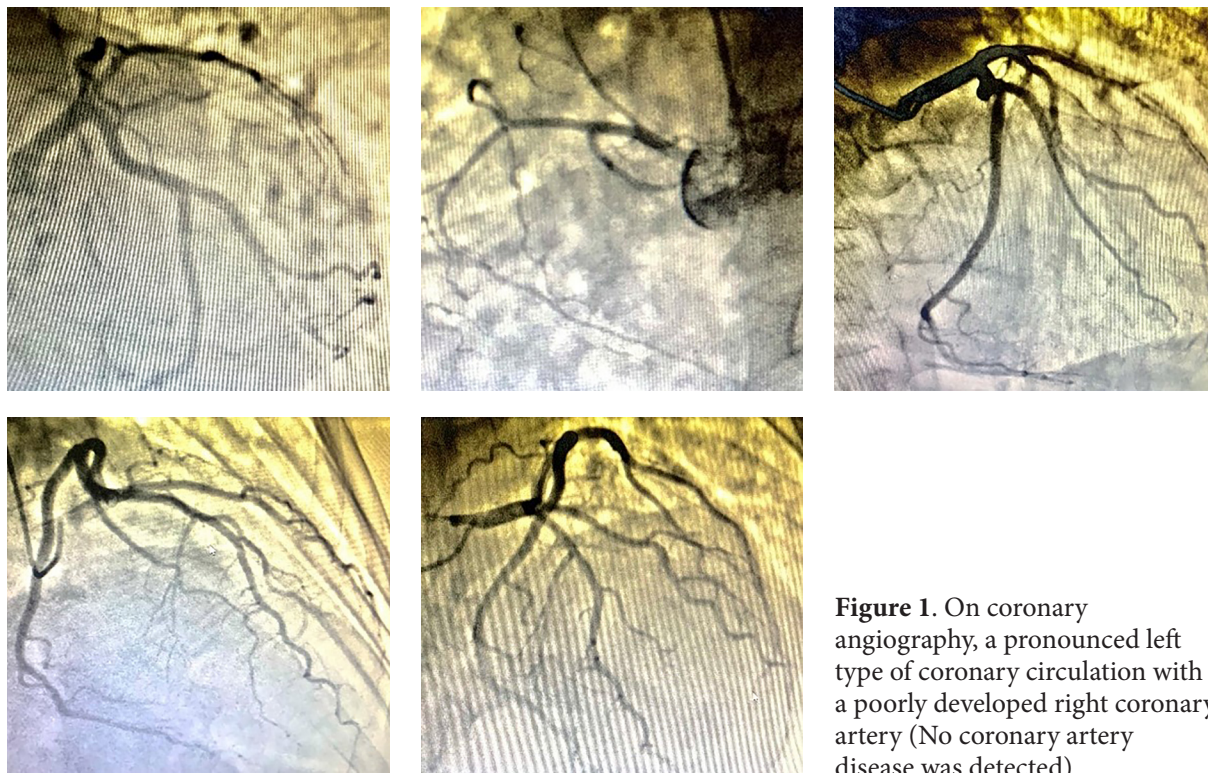


Figure 1. On coronary angiography, a pronounced left type of coronary circulation with a poorly developed right coronary artery (No coronary artery disease was detected).

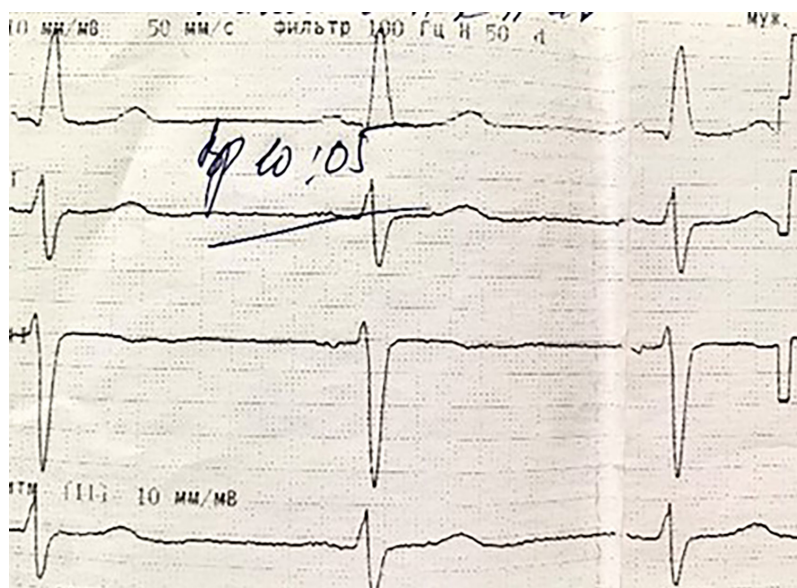


Figure 2. ECG on admission 23.11.2020.

meters. The patient's ECG showed sinus bradycardia upon admission on November 23, 2020. The patient experienced sinus bradycardia, registering a heart rate of 52 beats per minute. The cardiac electric axis is deviating sharply to the left. There is a blockage in the anterior-superior branch of the left bundle (Figure 2).

Management and Outcome

Considering the high risk of open-heart surgery due to the patient's age, concomitant pathology of the lungs and kidneys, and the presence of symptoms of critical aortic stenosis, the multidisciplinary

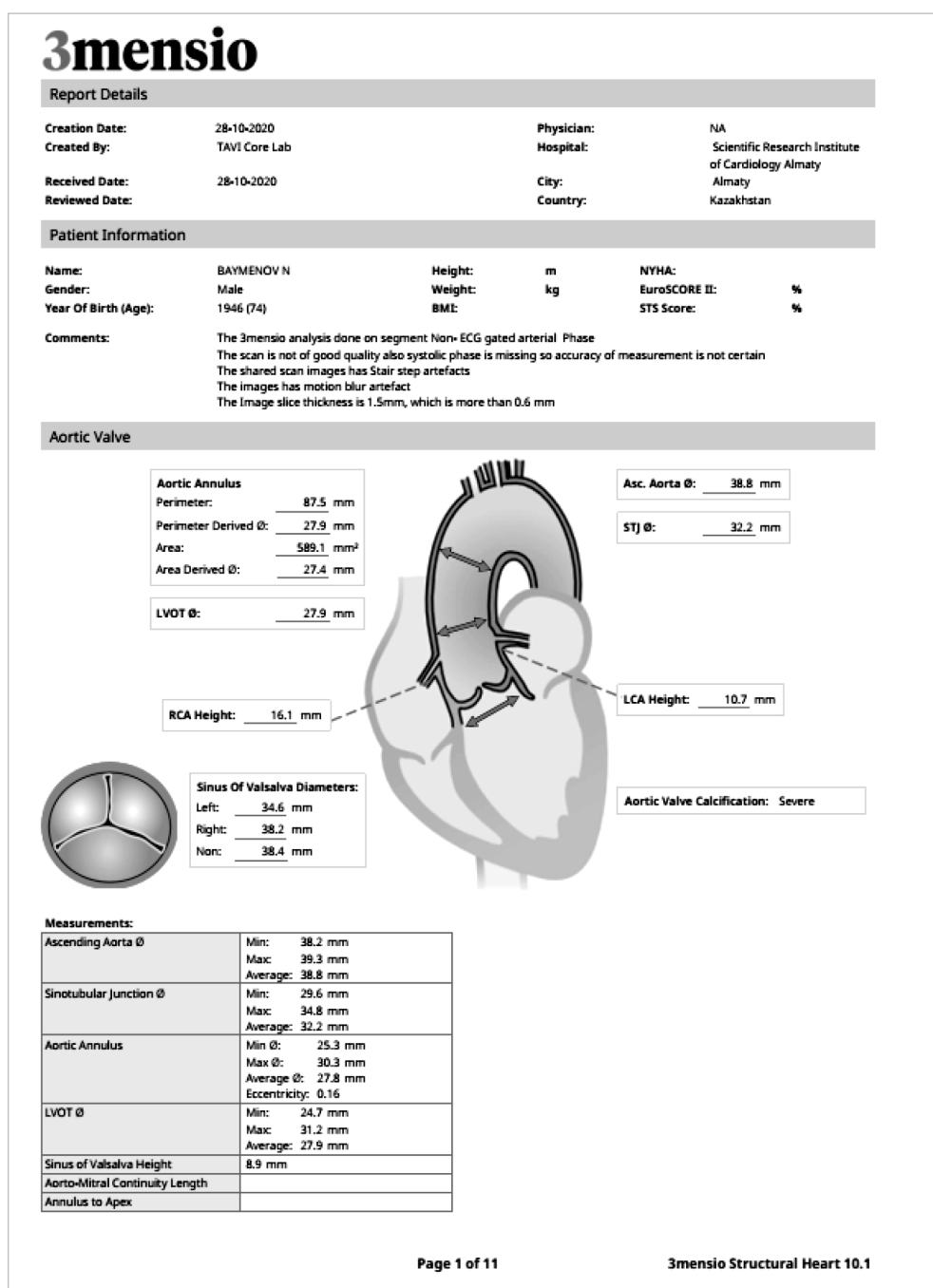


Figure 3. Data results A.

nary team decided to perform transcatheter implantation of the MYVAL 27.5 mm aortic valve. The preliminary size of the implantable prosthesis was calculated based on the data of the CT scan with reconstruction and the obtained measurements (Figures 3–5).

The patient underwent surgery. On November 24, 2020, the patient underwent endovascular aortic valve replacement. Procedure progress: We treated the puncture area three times with betadine and once with alcohol. The arterial access was transfemoral on the left; a pigtail catheter was inserted into the noncoronary sinus, venous on the left through the CFV, and for temporary pacing, the electrode was inserted into the RV cavity. Under general anaesthesia, the right common femoral artery was isolated. A 6F intramedullary tube was placed in the arterial lumen. Using an AL II catheter, a

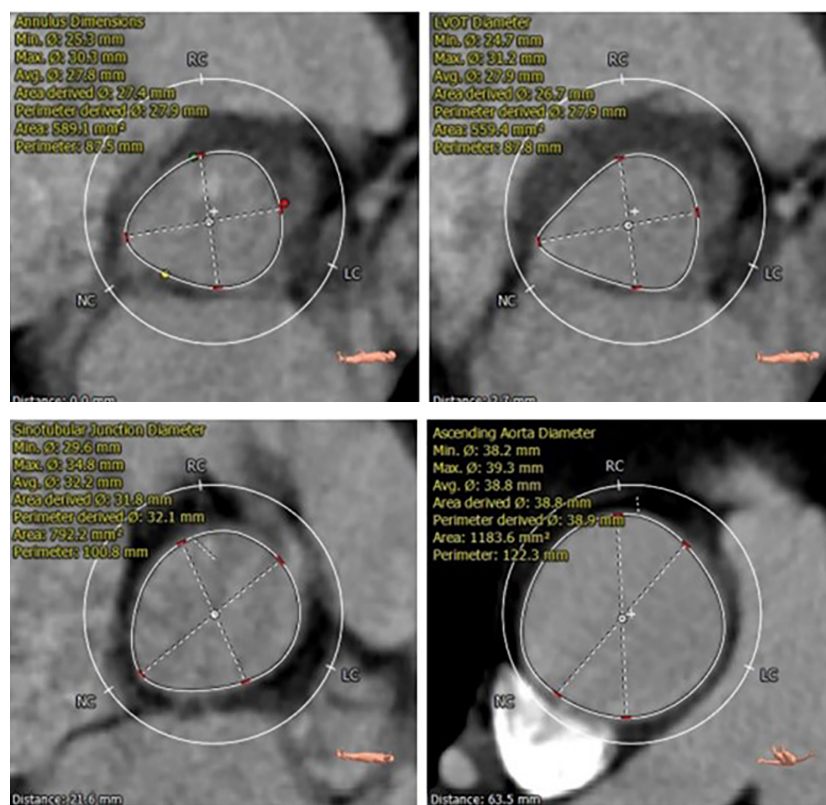


Figure 4. Data results B.

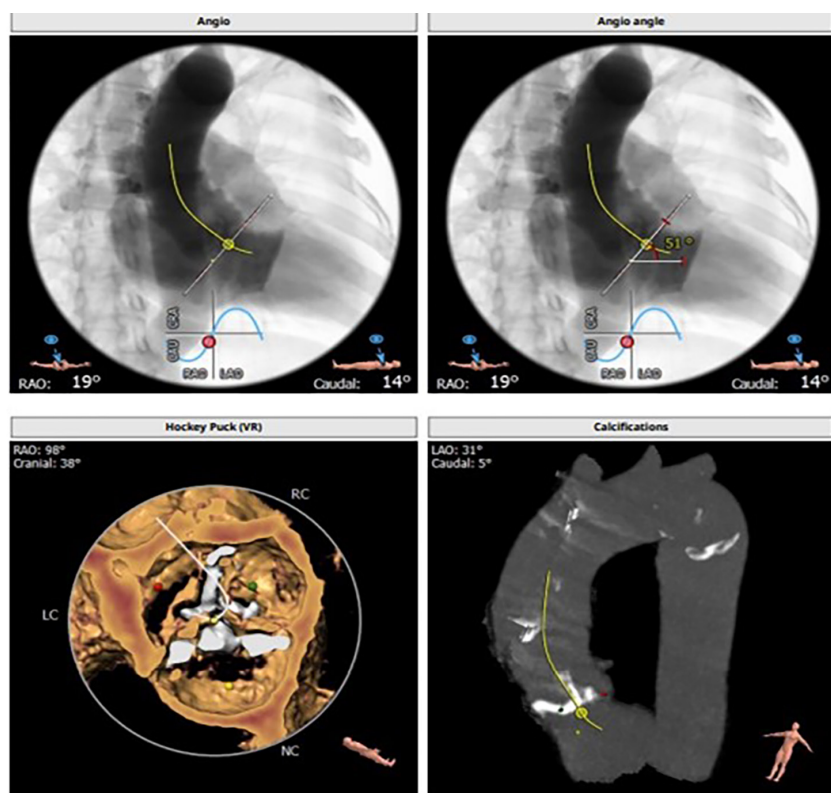


Figure 5. Data results C.

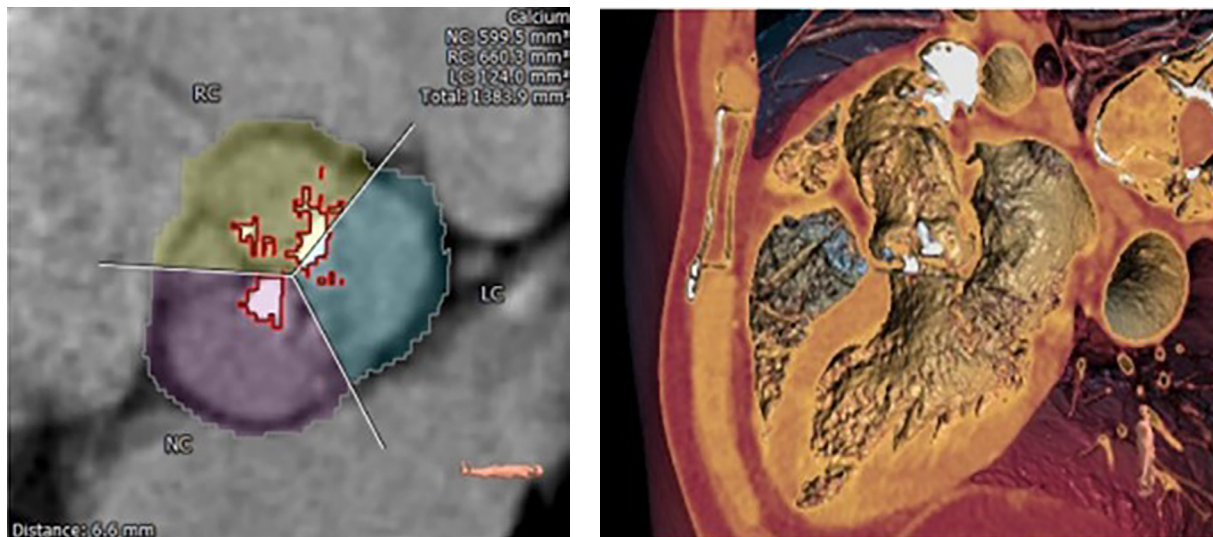


Figure 6. The MYVAL 27.5mm valve was implanted and paraprosthetic contrast delivery into the left ventricle was registered.

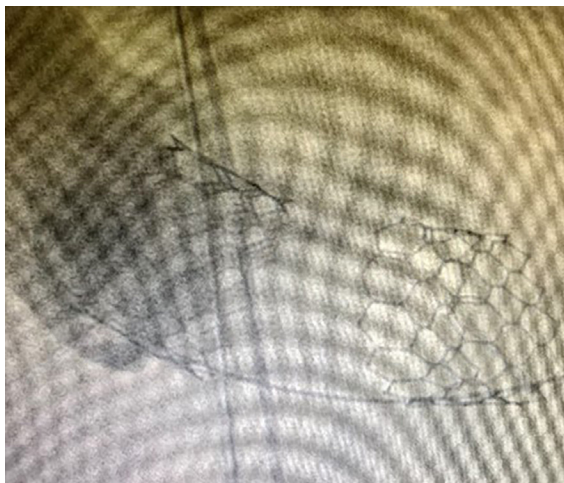


Figure. 7. Migration of the first valve into the left ventricular cavity during the installation of the second valve.

straight guidewire was guided into the left ventricle through the stenosed AV orifice. The guidewire was then replaced with an Amplatzer Super Stiff. A 14-Fr intramedullary tube was inserted into the femoral artery lumen. Predilation of the AV was performed (Balloon 20x40mm) for 45 seconds. The aortic valve delivery system was inserted into the aortic root by the guidewire. MYVAL 27.5 mm valve implantation was performed under the fluoroscopy control with simultaneous RV stimulation of 170 beats/min. The control aortography and echo showed a 2- to 3-degree paravalvular leak (Figure 6).

Due to the presence of a PVL, it was decided to implant a larger MYVAL 29 mm valve inside the first valve. The technique of placing a larger prosthesis into a small size was used – stretching the nitinol mesh of the stent by ballooning. A guidewire (delivery device) was inserted for the second valve to perform valve-to-valve implantation. Problems with getting the delivery device into the left ventricle happened during the delivery of the second valve. This made it easier for the first valve to move into the left ventricular outflow tract (Figure 7) during the implantation of the second valve.

During the second prosthesis implantation, there was a sharp drop in BP to 60/40 mmHg. Asystole on an ECG monitor. On the screen, there are indicators of contrast agent effusion into the peri-



Figure 8. Removed bioprosthesis for TAVI – MYVAL 27.5mm.

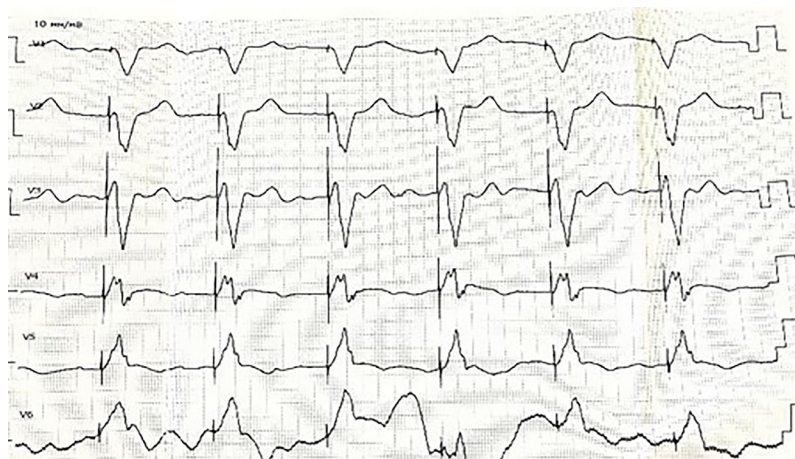


Figure 9. ECG from 24.11.2020: ECS rhythm, clearly imposed, HR 86 bpm.

cardial space. Resuscitation was immediately initiated. Cardiac tamponade was confirmed under TEE. Emergency pericardiocentesis and autohemotransfusion were performed. Cardiac surgeons were informed, and the patient was urgently transferred to the cardiac surgical unit.

Urgently, with continuous chest compression and mechanical ventilation through the Ambu bag, the patient was delivered to the operating unit, intubated, and connected to the ventilator. After treatment of the operating field with povidone iodine, a longitudinal sternotomy was performed without haemostasis. During the revision, hemopericardium and ventricular fibrillation were noted, along with a transmural defect measuring 2x3 cm on the anterolateral surface of the left ventricle, located between the diagonal branches of the anterior descending artery. Within a few seconds, the ascending aorta and right atrium were cannulated with a two-level cannula, “torpedo blood circulation”. Selectively, the left coronary artery underwent cardioplegia, “Kustadiol”. The right superior pulmonary vein provided drainage to the left ventricle. An attempt to suture the defect with parallel perfusion was unsuccessful. A suture eruption was observed. Implanted MYVAL 29 mm valve removed.

On November 24, 2020, from 3:05 to 6:50 p.m., during surgery, the surgeon replaced the aortic valve with a “Medtronic Hancock No. 25” biological prosthesis using bypass circulation. The surgeon sutured the defect in the anterolateral wall of the left ventricle. The transcatheter valve from the left ventricle was removed (Figure 8). The CATS blood-sparing system was installed.

The native valve leaflets were fibrotic, calcified, and had an incomplete closure. The right coronary cusp ruptured. The aortic valve was dissected. The defect in the anterolateral wall region of the left ventricle was repaired with a double-row suture (mattress + coiled) and Prolene 3.0 suture using xenopericardial strips. A Medtronic Hancock No. 25 biological prosthesis was implanted in the aortic position with 15 U-shaped sutures. Double-row continuous suture to the aorta (Prolene 4/0). Prevention of air embolism. The clamp was removed from the aorta. Myocardial electrodes were sutured. In the early postoperative period, the patient developed a complete atrioventricular block, and a temporary pacemaker was installed. The rhythm is imposed by the pacemaker with a heart rate of 80 per minute (Figure 9).

Once the hemodynamics stabilize, the IC ends. Decannulation. Hemostasis. Installed drains in the anterior mediastinum and the left pleural cavity. The sternum is osteosynthesized. Sutures are used for subcutaneous fat and skin. An aseptic bandage was applied. The drains are connected to the blood-saving CATS system. The patient was transferred to the ICU on an imposed rhythm.

Echo from November 25, 2020: poor ultrasound window. Visualization is extremely difficult. In the dynamics of EF, 43%. The fluid level in the pericardium exceeds 1.0 cm along the inferior

wall, with a maximum pressure of 16–18 mm Hg. X-ray from November 29, 2020: At the time of the test, there was mild congestion in the root zones. Cardiomegaly. The aorta has atherosclerosis. The right side exhibits signs of pleural effusion. The CT scan from December 7, 2020 revealed signs of a left-sided pleural effusion. The lower lobe of the left lung exhibits atelectasis. Left-sided lower lobe pneumonia. Congestive changes in the lungs. Operated heart. A complete transverse blockade persisted for 18 days after the aortic valve implantation, after which the independent sinus rhythm was restored. The temporary pacemaker was removed. In the follow-up X-ray of the OGK, the signs of pneumonia, atelectasis, and exudative pleurisy had resolved. In the control examination for echocardiography on AC, there is no pathological gradient, regurgitation of 1 degree, and an EF 50%.

In the postoperative period, the patient developed neurological disorders due to a transient ischemic attack. No complications were observed from the side of the postoperative wound or the implanted prosthesis. The patient was transferred to a specialized clinic for follow-up care and the correction of neurological complications. After one month of follow-up, the patient recovered both cognitive and neurological functions. The function of the implanted aortic valve is not impaired. Hemodynamics is unaffected. With the acquisition of experience and the improvement of technical characteristics, the results of TAVI have improved. However, it is necessary to consider not only the patient's clinical status but also the issues of organizing and managing the process.

Discussion

The likelihood of developing such a complication is low, but it exists [22,23]. If the size of the valve is correctly calculated, taking into account the fact that a PVL may occur, it is possible to repeat the inflation of the balloon with high pressure. If the valve is mismatched with a small diameter, then paravalvular leaks will always develop, and the probability of valve dislocation is very high, which happened in this case.

Thus, from the literature sources and having studied the remaining documents during the analysis of the medical records, the following conclusions were made.

1. The dislocation of the aortic valve was apparently due to a lack of good fixation in the fibrous ring of the aortic valve and a mismatch between the size of the prosthesis and the fibrous ring [24].
2. Cardiac tamponade and LV rupture occurred when the second valve was inserted during the delivery system, which pushed the first prosthesis into the left ventricular cavity and damaged the anterior wall of the left ventricle [25].
3. Damage to the left ventricle with the first prosthesis and ongoing resuscitation measures, including chest compressions, led to further traumatic rupture of the left ventricle's myocardial wall [26].
4. Effective resuscitation measures and timely delivery of the patient to the operating room allowed the team of cardiac surgeons to successfully replace the aortic valve, remove the TAVI valve, and suture the rupture of the LV wall [27].
5. Transient neurological complications arising after surgery are associated with large blood loss and impaired cerebral circulation during resuscitation measures [28].
6. A well-organized, interdisciplinary service contributed to the positive outcome in this case [29].

Based on the above, the following recommendations. It is necessary to very carefully calculate the size of the prosthesis to be implanted in order to avoid the development of paravalvular leaks (fistulas). When installing the second prosthesis, carrying out the delivery system requires caution and careful control to avoid dislocation of the first valve into the left ventricular cavity. When carrying out resuscitation measures, especially chest compressions, in the presence of a delivery system (with a prosthesis) in the left ventricular cavity, it is necessary to take into account the risk of developing a

traumatic myocardial rupture. Consider the possibility of urgent removal of the delivery system and selective cardioplegia with the introduction of the patient into anesthesia, cerebral hypothermia, and mechanical ventilation. It is recommended to perform transcatheter aortic valve implantation in the presence of cardiac surgical support.

Conclusion

TAVI is an increasingly utilized procedure for treating severe aortic stenosis in high-risk patients. While generally safer than open surgical aortic valve replacement, TAVI still carries significant risks of complications, some of which can be life-threatening emergencies.

This case highlights the potential for catastrophic complications like valve dislodgement, ventricular rupture, and cardiac tamponade to occur even in experienced centres. Precise sizing to avoid prosthesis–patient mismatch and careful valve deployment technique is critical to prevent such disasters. When they do occur, rapid interdisciplinary response involving emergency resuscitation, pericardiocentesis, and prompt transfer to cardiac surgery is essential for patient survival. Avoidance of chest compressions during resuscitation for cardiac arrest in the setting of an indwelling transcatheter valve may also be prudent to prevent further myocardial injury. Selective administration of cardioplegia and cerebral protection rather than conventional ACLS may be a better temporizing approach preoperatively.

While serious complications like this patient experienced are uncommon, their rapid recognition and treatment require a true multidisciplinary systems-based approach to optimize outcomes. As TAVI continues expanding to lower-risk patients, meticulous procedural planning and backup emergency pathways become even more paramount.

Ethics approval

A study was approved by the Ethics Commission of Al-Farabi Kazakh National University, No. 83904.

Consent for publication

Consent for publication has been obtained from the patient in writing, however, their identity is not disclosed.

Availability of data and material

The authors confirm that the data supporting the findings of this study are available in the article.

Competing interests

The authors declare that they have no competing interests.

Funding

No funding was obtained for this study.

Authors' contributions: RT, KA, AK, IK and SA contributed to the acquisition, analysis, conception, design, and drafting of the work. RT, IK and SA contributed to the final draft, revisions, upload and submission of the final revised work. All authors have agreed to both be personally accountable for their contributions and ensured that questions related to the accuracy or integrity of any part of the work, even ones in which one was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature.

References

1. Bokeria LA, Milievskaia EB, Kudzoeva ZF. Cardiovascular Surgery-2017. Diseases and congenital anomalies of the circulatory system. *Publ House Bakulev Nat Cent Cardiovasc Surg*. 2018;1:58-60.
2. Eveborn GW, Schirmer H, Heggelund G, Lunde P, Rasmussen K. The evolving epidemiology of valvular aortic stenosis. The Tromsø Study. *Heart*. 2012;99(6):396-400. <https://doi.org/10.1136/heartjnl-2012-302265>
3. Nkomo VT, Gardin JM, Skelton TN, Gottdiener JS, Scott CG, Enriquez-Sarano M. Burden of valvular heart diseases: a population-based study. *Lancet*. 2006;368(9540):1005-1011. [https://doi.org/10.1016/s0140-6736\(06\)69208-8](https://doi.org/10.1016/s0140-6736(06)69208-8)
4. Bokeria LA, Gudkova RG. Cardiovascular Surgery-2005. Diseases and congenital anomalies of the circulatory system. *Publ House Bakulev Nat Cent Cardiovasc Surg*. 2006;1:34-36.
5. Otto CM, Mickel MC, Kennedy JW, et al. Three-year outcome after balloon aortic valvuloplasty. Insights into prognosis of valvular aortic stenosis. *Circulation*. 1994;89(2):642-650. <https://doi.org/10.1161/01.cir.89.2.642>
6. Salaun E, Mahjoub H, Dahou A, et al. Hemodynamic Deterioration of Surgically Implanted Bioprosthetic Aortic Valves. *J Am Coll Card*. 2018;72(3):241-251. <https://doi.org/10.1016/j.jacc.2018.04.064>
7. Litvack F, Jakubowski AT, Buchbinder NA, Eigler N. Lack of sustained clinical improvement in an elderly population after percutaneous aortic valvuloplasty. *Amer J Card*. 1988;62(4):270-275. [https://doi.org/10.1016/0002-9149\(88\)90224-x](https://doi.org/10.1016/0002-9149(88)90224-x)
8. Rahimtoola SH, Morton M, Pantely G. Effects of successful, uncomplicated valve replacement on ventricular hypertrophy, volume and performance in aortic stenosis and in aortic incompetence. *Amer J Card*. 1978;41(2):381. [https://doi.org/10.1016/0002-9149\(78\)90300-4](https://doi.org/10.1016/0002-9149(78)90300-4)
9. Yakovlev VA, Korolev BE. Degenerative aortic stenosis – the threat of the 21 century. *New Saint Peter J*. 2006;4:23-27.
10. Puri R, Nissen SE, Arsenault BJ, et al. Effect of C-Reactive Protein on Lipoprotein(a)-Associated Cardiovascular Risk in Optimally Treated Patients with High-Risk Vascular Disease. *JAMA Card*. 2020;5(10):1136-1143. <https://doi.org/10.1001/jamacardio.2020.2413>
11. Shevchenko YL, Cherepanin IM. *Bicuspid aortic valve*. Nauka; 1996.
12. Shcherbakova EM. Population aging: global trends. *Demos Week*. 2013;1:601-602.
13. Demoscope. 2021. <http://demoscope.ru/weekly/2014/0601/barometer601.pdf>
14. Blanke P, Weir-McCall JR, Achenbach S, et al. Computed Tomography Imaging in the Context of Transcatheter Aortic Valve Implantation (TAVI)/Transcatheter Aortic Valve Replacement (TAVR): An Expert Consensus Document of the Society of Cardiovascular Computed Tomography. *JACC Cardiovasc Imaging*. 2019;12(1):1-24. doi:10.1016/j.jcmg.2018.12.003
15. Bouma BJ, van den Brink RBA, van der Meulen JHP, et al. To operate or not on elderly patients with aortic stenosis: the decision and its consequences. *Heart*. 1999;82(2):143-148. <https://doi.org/10.1136/hrt.82.2.143>
16. Imaev TE, Komlev AE, Akchurin RS. Transcatheter aortic valve implantation. State of the problem and prospects in Russia. *Rational Pharmac Card*. 2015;11(1):53-59. <https://doi.org/10.20996/1819-6446-2015-11-1-53-59>
17. Kamenskaya OV, Loginova IY, Kretov EI, et al. Efficiency of transcatheter aortic valve implantation in patients with high surgical risk: long-term results of a single-center prospective study. *Rus J Card*. 2019;1:56-61. <https://doi.org/10.15829/1560-4071-2019-1-56-61>
18. Molchanov A, Romashkin V, Urvantseva I. Long-term results of surgical treatment of aortic defects in elderly patients. *Ulya Med Bio J*. 2019;2:57-65. <https://doi.org/10.34014/2227-1848-2019-2-57-65>
19. Perrot N, Thériault S, Pibarot P, et al. Genetic Variation at the LPA Locus and Risk of Calcific Aortic Valve Stenosis in Patients Undergoing Cardiac Surgery. *Atherosclerosis Supplements*. 2018;32:82. <https://doi.org/10.1016/j.atherosclerosisup.2018.04.248>
20. Arsenault BJ, Boekholdt SM, Dubé MP, et al. Lipoprotein(a) Levels, Genotype, and Incident Aortic Valve Stenosis. *Circ Cardiovas Gen*. 2014;7(3):304-310. <https://doi.org/10.1161/circgenetics.113.000400>
21. Shevchenko YL. Prediction of postoperative complications in elective surgery. *Khirurgiia*. 2003;10(59):6-14.
22. Salinas P, Moreno R, Lopez-Sendon JL. Transcatheter aortic valve implantation: Current status and future perspectives. *World J Cardiol*. 2011;3(6):177-185. doi:10.4330/wjc.v3.i6.177
23. Vendrik J, van den Boogert TPW, Koch KT, Baan J Jr. Balloon-Expandable TAVR Prosthesis Dislocates into the Ascending Aorta. *JACC Case Rep*. 2019;1(2):101-104. doi:10.1016/j.jaccas.2019.05.026

24. Esposito G, Kumar N, Pugliese F, et al. Predictors of post-TAVI conduction abnormalities in patients with bicuspid aortic valves. *Open Heart*. 2022;9(2):e001995. <https://doi.org/10.1136/openhrt-2022-001995>
25. Nowak R, Ali MJ. Endoscopic coronary catheter dacryoplasty for failed DCR in wegener's granulomatosis. *Ocul Immun and Inflam*, 2023;31(3):599-600. <https://doi.org/10.1080/09273948.2022.2032200>
26. Kamilova U, Nuritdinov N. Evaluation of the comparative effectiveness of rosuvastatin and atorvastatin in patients with heart failure. *Atherosclerosis*, 2020;315:E276-E276.
27. Nuritdinov N, Kamilova U. Left ventricular diastolic function in the patients with chronic heart failure. *J of the Amer Coll of Card*, 2018;72(16):C167-C167. <https://doi.org/10.1016/j.jacc.2018.08.748>
28. Nuritdinov N, Khamraev A. Comparative efficiency of spyronolactone and eplerenon in patients with chronic heart failure. *Kard v Belar*, 2020;12(2):270-275. <https://doi.org/10.34883/PI.2020.12.2.012>
29. Bartoszewicz M, Czaban SL, Bartoszewicz K, et al. Bacterial bloodstream infection in critically ill patients with COVID-19: A retrospective cohort study. *Ther Advan in Infect Dis*, 2023;10:20499361231207178. <https://doi.org/10.1177/20499361231207178>