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COMPLICATIONS OF TRANSCATHETER AORTIC VALVE IMPLANTATION

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ABSTRACT

Transcatheter aortic valve implantation (TAVI) has become an established and widely adopted treatment for patients with severe aortic stenosis across all surgical risk categories. Continuous technological progress, refinements in device design, and increasing operator experience have substantially improved procedural safety and expanded indications from inoperable and high-risk patients to those at intermediate and low surgical risk. Nevertheless, despite these advancements, TAVI remains associated with a broad spectrum of complications that may adversely affect both short- and long-term outcomes. This review provides a comprehensive overview of the most clinically significant complications following TAVI, including vascular, valvular, neurological, renal, bleeding, infectious, and conduction-related events. Particular attention is given to the underlying pathophysiological mechanisms, patient- and procedure-related risk factors, and contemporary prevention and management strategies. Although the incidence of major vascular complications has decreased with the introduction of lower-profile delivery systems, these events remain clinically relevant, particularly in elderly patients and those with complex vascular anatomy. Conduction disturbances frequently require permanent pacemaker implantation, while stroke and silent cerebral embolization continue to represent major neurological concerns. Acute kidney injury and major bleeding significantly contribute to morbidity and mortality, and prosthetic valve endocarditis, although rare, carries a particularly poor prognosis. A thorough understanding of the mechanisms and predictors of post-TAVI complications is essential for optimizing patient selection, procedural planning, and post-procedural management. Ongoing innovations in device technology and procedural techniques remain fundamental to further improving clinical outcomes and minimizing procedural risk.

KEYWORDS

Transcatheter Aortic Valve Implantation (TAVI), Aortic Stenosis, Procedural Complications, Conduction Disturbances

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Introduction

Aortic stenosis is the most common acquired valvular disease in developed countries and is a significant public health problem in the aging population (Osnabrugge i in., 2013). Progressive calcification and fibrosis of the valve leaflets leads to gradual narrowing of the aortic orifice, increased left ventricular afterload and the development of myocardial hypertrophy, and consequently to heart failure, angina pectoris and syncope (Otto & Prendergast, 2014). Untreated severe, symptomatic aortic stenosis is associated with high mortality, therefore valve intervention is the only effective method to improve the prognosis (Vahanian i in., 2022). For many years, surgical aortic valve replacement was the standard of care. However, the introduction of transcatheter aortic valve implantation (TAVI) ushered in a new era in the treatment of this condition. Initially, this method was reserved for patients who were inoperable or at high surgical risk, but the rapid development of technology, improved access systems, and growing operator experience have led to the expansion of indications to include patients with intermediate, and now even low, surgical risk (Mack i in., 2019; Popma i in., 2019). Current European and American guidelines recommend the choice of treatment method based on the assessment of the Heart Team, taking into account age, surgical risk and anatomical conditions (Otto i in., 2021; Vahanian i in., 2022). Despite significant technological progress and a reduction in the frequency of periprocedural complications, TAVI remains a procedure burdened with the risk of adverse events that may affect both early and long-term treatment outcomes (Lindman i in., 2016). These complications include, among others, vascular and neurological events, conduction disturbances requiring pacemaker implantation, renal, hemorrhagic and infectious complications, and their nature depends on anatomical and clinical factors and the type of prosthesis used (VARC-3 WRITING COMMITTEE i in., 2021). Understanding the mechanisms leading to the development of complications, identifying risk factors, and implementing preventive strategies are crucial to further optimizing treatment outcomes. The aim of this paper is to comprehensively analyze the most common complications following TAVI, discussing their pathophysiology, predisposing factors, and contemporary methods of prevention and therapeutic management, in the context of the rapidly evolving technology of transcatheter valve prostheses.

Pathophysiology of aortic stenosis

Aortic stenosis is currently not considered a simple consequence of long-term valve "wear and tear" and passive calcium salt deposition, but rather an active, complex biological process regulated at the cellular level. A crucial role is played by valve interstitial cells (VICs), which, in response to endothelial damage, lipid influx, and accompanying inflammation—typical of the initial phase resembling atherosclerosis—become activated and their properties change. In the subsequent phase, they transform into cells with osteoblast-like characteristics, leading to an intensified and sustained calcification process, analogous to the mechanisms of bone formation. In the advanced stage of the disease, calcification is self-sustaining and less dependent on inflammatory or lipid factors. This perspective on the pathogenesis of AS explains why treatment directed solely at classic atherosclerotic factors does not effectively inhibit disease progression and suggests the need to explore therapies that affect the mechanisms of osteogenesis (Zheng i in., 2020). Bicuspid valve also plays an important role, occurring in 1–2% of the population, which leads to the development of stenosis on average about 20 years earlier, probably due to less favorable hemodynamics (Carabello & Paulus, 2009). Aortic stenosis causes impaired blood outflow from the left ventricle, leading to chronic pressure overload. Many patients also have concomitant hypertension, which further increases afterload. In response to increased afterload, the left ventricle develops cardiac hypertrophy (LVH). Traditionally, this has been considered an adaptive mechanism aimed at reducing wall stress in accordance with Laplace's law. However, clinical studies indicate that increased left ventricular mass is associated with a reduced ejection fraction and a higher risk of heart failure – regardless of the degree of aortic stenosis. Furthermore, experimental observations suggest that the lack of significant hypertrophy may be associated with a lower likelihood of progression to heart failure, which casts doubt on the unequivocal protective nature of LVH. Left ventricular hypertrophy in aortic stenosis is associated with adverse myocardial remodeling, which includes interstitial fibrosis, impaired diastolic function, and decreased coronary perfusion. The processes of fibrosis and cardiomyocyte damage are crucial, with apoptosis and oncosis playing a significant role. Consequently, LVH should be viewed not only as a compensatory response but also as an element of pathological remodeling, contributing to the development of left ventricular dysfunction and heart failure (Singh i in., 2014).

Risk factors of aortic stenosis

Aortic valve stenosis develops as a result of the interaction of aging-related factors, genetic predisposition, and classic cardiovascular risk factors. Therefore, age remains the most significant risk factor (Osnabrugge i in., 2013). In recent years, the role of genetic factors has also been emphasized, especially elevated lipoprotein(a) levels, which are associated with an increased process of valve calcification and a greater risk of progression of stenosis (Arsenault i in., 2014). Modifiable cardiovascular factors, such as hypercholesterolemia, hypertension, smoking, diabetes and obesity, are also important, as they – similarly to atherosclerosis – promote endothelial dysfunction, lipid deposition and activation of inflammatory processes within the valve leaflets (Vahanian i in., 2022). Additionally, chronic kidney disease, especially in the advanced stage, accelerates the process of calcification of valve structures through disturbances in calcium and phosphate metabolism (Gupta i in., 2022).

Transcatheter aortic valve implantation

Initially reserved for patients considered at high risk for classic surgical aortic valve replacement due to comorbidities, transcatheter aortic valve implantation (TAVI) has gradually expanded its indications (Zou i in., 2024). This expansion reflects the growing body of evidence from clinical trials demonstrating comparable or even superior outcomes compared to surgical treatment in various surgical risk groups (Zou i in., 2024). Improvements in transcatheter valve prosthesis technology, increased operator experience, and intensive research have contributed to the wider use of this method – from inoperable patients to patients with high and intermediate surgical risk (Postolache i in., 2023). Future studies will focus on assessing the efficacy and safety of TAVI in the low-risk patient population, which may make this method a viable therapeutic option for an even wider group of patients (Neragi-Miandoab & Michler, 2013). Significant technological progress and increasing operator experience have led to a significant reduction in the frequency of periprocedural complications, improved clinical outcomes, and wide acceptance of TAVI as a standard treatment method for severe aortic stenosis (Asmarats & Arzamendi, 2024; Möllmann i in., 2015). Despite significant improvements since the introduction of this procedure in 2002, a significant percentage of patients still experience complications that may adversely affect prognosis (Asmarats & Arzamendi, 2024). These complications, although less frequent with modern techniques, cover a wide spectrum – from mild to life-threatening – and in some cases require urgent conversion to cardiac surgery, which is associated with high mortality (Verolino i in., 2025). Understanding the extent and incidence of these complications remains crucial for optimizing patient selection, improving procedural techniques, and developing risk minimization strategies (Kalogeropoulos i in., 2022). According to the current guidelines of the European Society of Cardiology (ESC/EACTS) and the American ACC/AHA guidelines, the primary indication for TAVI is severe, symptomatic aortic stenosis in patients in whom valve intervention is indicated and the choice of method (TAVI vs. surgical valve replacement – SAVR) should be undertaken by a multidisciplinary Heart Team (Vahanian i in., 2022). TAVI is particularly recommended for elderly patients (usually ≥75 years in European guidelines) and for patients with high or intermediate surgical risk, assessed, among others, using the STS or EuroSCORE II scale (Vahanian i in., 2022). Transcatheter aortic valve implantation is a procedure in which a prosthetic aortic valve is implanted inside the native, stenotic valve using a catheter, providing an improved, less invasive alternative to standard surgical aortic valve replacement (Zou i in., 2024). This minimally invasive approach has undergone significant advancements, including improved devices and implantation strategies that have significantly reduced complication rates and improved patient outcomes (Kalogeropoulos i in., 2022). The evolution of the procedure includes the use of advanced imaging techniques, such as three-dimensional (3D) echocardiography and intravascular ultrasound, which provide better control and greater precision during valve implantation (Angioletti i in., 2024). At the same time, the design of transcatheter valve prostheses was improved by introducing systems enabling valve repositioning and re-clamping, which improved the procedure and reduced the frequency of adverse events (Badodiyawala i in., 2024). These technological and methodological advances aim to optimize valve positioning, reduce paravalvular leakage, and limit the risk of conduction disturbances, thereby increasing the safety and efficacy of TAVI (Badodiyawala i in., 2024; Ciardetti i in., 2021). Despite continuous progress, challenges remain, particularly in the long-term durability of transcatheter prostheses and the management of residual complications such as paravalvular leakage and conduction disturbances (Badodiyawala i in., 2024).

Types of TAVI

Currently, there are many designs of transcatheter valve prostheses available, differing in material composition, implantation mechanism (balloon-expandable or self-expanding) and sealing properties, the aim of which is to optimize hemodynamic parameters and minimize complications (Rosseel i in., 2023). These devices are broadly divided into balloon-expandable and self-expandable valves, each with specific advantages and limitations depending on the patient's anatomy and the nature of the pathology. Balloon-expandable valves, typically made of bovine pericardial tissue mounted on a cobalt-chromium alloy frame, allow for precise positioning and are often preferred in situations requiring precise prosthesis placement (Cribier, 2016). Self-expanding valves, on the other hand, are most often constructed on a nitinol frame (nickel and titanium alloy), exerting a continuous radial force, adapting to the anatomy of the aortic annulus, which can be beneficial in the case of severe calcifications or anatomical irregularities (Badodiyawala i in., 2024). Continuous evolution of TAVI prosthesis design and materials used, including improvements in bioprostheses and implantation systems, has contributed to a significant reduction in the number of periprocedural complications and improved long-term results (Chiarito i in., 2022). The size of vascular sheaths has also been significantly reduced, which translates into a reduction in vascular complications and an increase in the possibility of using transfemoral access as the preferred route of implantation (Cahill i in., 2020).

Complications of TAVI

Despite the rapid development of TAVI technology and the growing experience of operators, this procedure is still associated with a risk of complications that can significantly impact the clinical course and prognosis of patients. Therefore, careful qualification and detailed pre-procedural planning, particularly including computed tomography (CT) assessment, are crucial. This analysis allows for precise determination of the aortic annulus dimensions, the distribution and severity of calcifications, and the distance of the coronary artery ostia from the virtual basilar annulus, which allows for prediction of the risk of paravalvular leak, coronary artery occlusion, or conduction disturbances (Badodiyawala i in., 2024; Gaze, 2023). Intra- and early post-procedural complications include aortic damage resulting from excessive radial force of the prosthesis, paravalvular leak, impaired coronary flow, stroke, cardiac tamponade, and valve displacement (Shirzadi i in., 2019). Although the introduction of new generations of prostheses and the improvement of implantation techniques have significantly reduced the frequency of these events, their occurrence highlights the need for close cooperation of the multidisciplinary team (Heart Team) both at the stage of qualification and implementation of the procedure (Badodiyawala i in., 2024). In parallel, research is being conducted on new generation prostheses equipped with more effective sealing systems and greater adaptability to diverse anatomical conditions, which aims to further reduce the risk of complications. Acute kidney injury remains a significant clinical problem, sometimes requiring renal replacement therapy, which is mainly related to exposure to the contrast agent and transient hemodynamic instability during the procedurę (Spaccarotella i in., 2011). However, one of the most common complications after TAVI is conduction disturbances, including atrioventricular block and left bundle branch block, which may require implantation of a permanent pacemaker and occur in 8.5–25.9% of patients in the first month after the procedurę (Li, 2019). The incidence of new-onset left bundle branch block depends largely on the type of prosthesis used and may range from approximately 4% to as much as 65% (Hyun & Lee, 2023). Self-expanding prostheses, especially those with a longer frame design, have a greater tendency to damage the conduction system due to the sustained radial force and deeper seating in the left ventricular outflow tract (Pauldine, 2018). In turn, balloon-expandable valves exert intense, short-term pressure upon expansion, which may also lead to injury to conductive structures, although the mechanism and dynamics of damage differ from those observed in the case of self-expanding prostheses (Kalogeropoulos i in., 2022). Additional factors that increase the risk of permanent conduction disturbances include pre-existing ECG abnormalities, excessively oversized prosthesis and implantation too deep (Annink i in., 2024; Shah i in., 2023).

Vascular complications

Vascular complications after TAVI occur within the first 30 days in approximately 4–38% of patients and include, among others, aortic annulus rupture during valve implantation and vascular damage associated with the introduction of large-diameter access systems (Condado & Block, 2016). However, in recent years there has been a marked decline in the rate of serious vascular complications – from approximately 17% in the first clinical trials to approximately 2.5% in newer cohorts of low-risk patients – which has been attributed to the introduction of smaller diameter sheaths and more flexible delivery systems (Monigari i in., 2019; Voigtländer & Seiffert, 2018). Despite this, vascular complications remain more common after TAVI than after surgical aortic valve replacement in some comparative studies (Angioletti i in., 2024). In patients over 85 years of age, the risk of vascular events is almost three times higher, which is associated with greater vascular fragility and a higher incidence of peripheral artery disease (van den Brink i in., 2022). Anatomical risk factors include extensive calcification of the arterial wall and an unfavorable ratio of the sheath diameter to the artery diameter, which increase the likelihood of significant vessel damage (Chew i in., 2017). The most common complications include arterial dissection, vessel perforation and acute thrombosis, sometimes requiring urgent endovascular intervention or surgical treatment (Pauldine, 2018). In patients with tortuous iliofemoral arteries, the use of large-diameter sheaths may lead to retroperitoneal hemorrhage – a potentially life-threatening complication, often manifested by a sudden, unexplained drop in blood pressure (Holy & Abdel-Wahab, 2017). In case of sudden hemodynamic collapse, it is necessary to urgently exclude five critical conditions: retroperitoneal bleeding, aortic dissection, cardiac tamponade, coronary artery ostium obstruction and acute severe aortic regurgitation (Manolis & Manolis, 2017). In addition to major vascular damage, a significant cause of access site bleeding is the ineffectiveness of closure systems, especially in obese women with small, calcified arteries (Kalogeropoulos i in., 2022). The use of sheaths with a diameter greater than 19F is associated with a significantly higher risk, with approximately 22% of patients experiencing serious vascular complications and 16% experiencing life-threatening hemorrhage (Latham i in., 2018). In addition, up to 21% of cases involve minor vascular complications such as local hematomas, often classified according to the strict VARC-2 criteria despite their minor clinical significance (Gonska i in., 2021). The introduction of percutaneous suture closure systems and the use of the latest generation of TAVI platforms have significantly reduced the incidence of severe vascular complications compared to the early development of this technique (Gonska i in., 2021; Kochman i in., 2016). Nevertheless, women remain at increased risk of serious vascular complications and coronary artery occlusion, which is associated with, among other things, a smaller diameter of the femoral arteries and lower height (Ferreira i in., 2023). It has been shown that a sheath diameter to iliofemoral artery diameter ratio exceeding 1.13 is a significant predictor of major vascular complications, and in women the risk of bleeding complications is approximately 50% higher and inversely proportional to body mass index (Mohadjer i in., 2020; Parche, 2020). Additional risk factors include greater vessel tortuosity and smaller diameter of the iliofemoral arteries (Rashedi & Otto, 2022).

Valve complications

Advanced calcifications in the aortic annulus and left ventricular outflow tract are a significant risk factor for iatrogenic annulus damage, including rupture. Meta-analyses indicate that this complication occurs more frequently in patients with bicuspid valves than in those with tricuspid valves (Lisi i in., 2024). In addition to the risks associated with annulus integrity, prosthetic function may be compromised by coronary artery occlusion, a rare but potentially fatal complication occurring in less than 1% of native valve procedures and most often involving the left main coronary artery (Gomes i in., 2021). This risk is particularly high in valve-in-valve procedures and in patients with low-lying coronary artery ostia, and is further increased in women, who are more likely to have a lower sinourethral junction height and smaller sinuses of Valsalva (Mohadjer i in., 2020). Mechanical obstruction of the coronary artery ostium may occur when the prosthesis frame or the sealing cuff is positioned directly above the vessel ostium, requiring immediate emergency measures such as percutaneous coronary intervention or urgent coronary artery bypass grafting (Annink i in., 2024). In case of unfavorable anatomy, the BASILICA technique is used to reduce the risk of obstruction, which involves deliberately cutting the native or bioprosthetic flap using an electrified guide wire, which allows for the preservation of coronary flow after implantation of the prosthesis (Mohadjer i in., 2020). Alternatively, the chimney-stenting technique is used, which involves implanting a stent along the valve frame to maintain vessel patency, which shows favorable medium-term results, although it may complicate future access to the coronary arteries (Patel i in., 2020). Incomplete expansion or improper adhesion of the prosthesis to the aortic annulus may lead to significant paravalvular leakage, the severity of which depends on both the design of the prosthesis and the distribution of calcifications within the valve leaflets (Kalogeropoulos i in., 2022). Correct valve size selection is also crucial – intentional oversizing to limit leakage may result in aortic annulus rupture or aortic root perforation, while undersizing increases the risk of prosthesis migration or embolization (Onishi i in., 2018). Additional challenges arise when using self-expanding prostheses with supra-annular leaflet positioning, in which the bioprosthesis is placed higher on the frame and closer to the coronary artery ostia, which may complicate future access to the vessels (Yeats i in., 2022). To facilitate re-cannulation, operators can choose valves with larger stent meshes or a lower sealing cuff (Arshi i in., 2020). In some cases, especially when using Evolut R/PRO prostheses or with significant oversizing in relation to the diameter of the sinuses of Valsalva, the inability to selectively cannulate the coronary arteries may affect up to 35% of patients (Kalogeropoulos i in., 2022). It has also been shown that an implantation depth of ≤6 mm significantly affects the orientation of the new valve and the possibility of subsequent access to the coronary ostia (Weferling i in., 2021). More and more attention is being paid to the precise positioning of the prosthesis commissures during primary implantation, which allows to avoid their overlap with the coronary artery ostia and to maintain the possibility of effective treatment of any future acute coronary syndromes (Arshi i in., 2020).

Neurological complications

Stroke remains the most serious neurological complication after TAVI and most often occurs within the first 48 hours of the procedure. Its mechanism of occurrence is usually embolic and involves the displacement of embolic material—such as fragments of calcified valve leaflets, thrombi, or arterial wall components—during catheter manipulation and graft deployment within the aortic arch (Fassa i in., 2013). To reduce the risk of embolism, cerebral protection systems such as Sentinel have been introduced, which are designed to capture and remove released material before it reaches the cerebral circulation (Vy i in., 2018). Although the use of these devices has shown a significant reduction in the volume of new ischemic lesions visible on magnetic resonance imaging, large clinical trials to date have not unequivocally confirmed a statistically significant reduction in the frequency of clinically apparent strokes at 30 days of follow-up. In addition to symptomatic ischemic events, so-called silent cerebral embolism is an almost common occurrence during TAVI. Imaging studies, especially diffusion-weighted magnetic resonance imaging sequences, reveal numerous, small hyperintense foci, which, although often without obvious neurological symptoms, may be associated with subtle cognitive decline in the long term (Aurigemma i in., 2022). Neurological complications therefore remain a significant clinical challenge requiring further research into effective prevention strategies and optimization of surgical techniques.

Renal complications

Acute kidney injury (AKI) is a common complication following TAVI and is most often associated with the administration of iodinated contrast agents and periprocedural hemodynamic instability. It can lead to prolonged hospitalization and a significant increase in long-term mortality. The incidence of AKI varies and depends primarily on baseline renal function, the presence of chronic kidney disease, and the volume of contrast administered; in some cases, permanent renal replacement therapy is necessary. In addition to the direct nephrotoxic effects of contrast, the development of AKI is also associated with transapical access, which is more often associated with episodes of intraprocedural hypotension and an enhanced inflammatory response than transfemoral access, increasing the risk of renal function deterioration. Furthermore, manipulation of large-diameter access systems can lead to renal embolism and renal infarction, highlighting the multifactorial nature of renal injury in this population. The occurrence of AKI after TAVI is associated with a more than six-fold increase in 30-day mortality (Jimenez Diaz i in., 2022; Jager i in., 2012). The percentage of patients requiring newly initiated hemodialysis after the procedure ranges from 1.4% to 15.7% and depends on the initial glomerular filtration rate and comorbidities such as hypertension or chronic obstructive pulmonary disease (Annink i in., 2024). To reduce the risk of AKI, strategies to reduce the volume of contrast administered have been implemented, including the use of 3D transesophageal echocardiography and smaller profile sheaths (14 F), which reduced both the amount of contrast and the incidence of vascular complications contributing to secondary deterioration of renal function (Terré i in., 2017). In cases of urgent TAVI procedures, the risk of acute kidney injury and the need for renal replacement therapy is significantly higher than in elective procedures (Sattar i in., 2024). Pre-procedural assessment of estimated glomerular filtration rate (eGFR) is crucial to identify patients requiring hydration optimization and consideration of alternative imaging methods that limit exposure to iodinated contrast (Lorente-Ros i in., 2024). Importantly, despite the increased risk of periprocedural AKI, a significant proportion of patients with chronic kidney disease experience stabilization or even improvement in eGFR after TAVI, which is likely due to improved cardiac output and renal perfusion after correction of aortic stenosis (Piewluang & Rattanaprasert, 2025). In clinical practice, "ultra-low contrast" protocols are increasingly used, which involve a single contrast injection for pigtail catheter positioning, followed by implantation of the prosthesis under the guidance of fluoroscopy and pre-procedural tomography markers (Higuchi i in., 2018). Maintaining proper volemia through individually tailored fluid intake or controlled diuresis – based on the assessment of right atrial pressure and volume status – is another important preventive strategy (Ayala i in., 2024; Rivera i in., 2023; Sattar i in., 2024). However, it has not been clearly demonstrated so far that the choice of anesthesia strategy (conscious sedation vs. general anesthesia) significantly reduces the risk of kidney damage (Lorente-Ros i in., 2024).

Conduction disorders and pacemaker implantation

Mechanical interaction between the prosthetic frame and the structures of the cardiac conduction system often leads to the development of new conduction disturbances, such as left bundle branch block (LBBB) or high-degree atrioventricular block. A particularly high risk of permanent pacemaker implantation is observed in patients with end-stage renal disease, in whom extensive calcification of the valve and left ventricular outflow tract contributes to conduction system damage (Grundmann i in., 2022). The depth of prosthesis implantation within the left ventricular outflow tract and the type of valve used are also of key importance – especially self-expanding designs, whose chronic radial force may exacerbate damage to the bundle of His. Newly developed conduction abnormalities require close telemetric monitoring, as progression from transient intraventricular delays to complete heart block may occur with delay, particularly in patients with a short membranous ventricular septum. Recent data indicate that technological advances and the use of smaller access systems have contributed to a gradual decrease in the frequency of permanent pacemaker implantation, despite the changing proportions of balloon-expandable and self-expandable prostheses (Landes i in., 2017). Modern valve repositioning systems allow for optimization of valve height in the aortic annulus, which has stabilized the pacemaker implantation rate at approximately 10–15% for most modern platforms (Cesna i in., 2017). Despite these improvements, the development of persistent conduction abnormalities remains a significant concern, especially as indications for TAVI expand to younger populations. Both chronic right ventricular apical pacing and persistent left bundle branch block are associated with reduced ejection fraction, increased hospitalizations for heart failure, and higher long-term mortality (Gomes i in., 2021; Mao i in., 2025). The mechanism underlying these adverse effects is electromechanical dyssynchrony and decreased cardiac output associated with chronic right ventricular pacing (Firstenberg i in., 2021; Tirado-Conte i in., 2018). For this reason, many clinicians recommend a few days of observation before deciding to implant a permanent pacemaker, especially when the high-degree block is transient (Young Lee i in., 2015). Although in practice most pacemakers are implanted within 48–72 hours after the procedure, a delayed implantation strategy may identify patients with transient conduction disturbances, although the lack of reliable predictors of recurrence of heart block makes this period clinically challenging (Ball i in., 2018; Ghannam i in., 2019; Xi i in., 2019). It is estimated that approximately half of procedure-induced heart blocks are transient, which in selected cases may allow the avoidance of long-term pacing or even consideration of device removal (Ghannam i in., 2019). In order to reduce unnecessary implantations, the Wenckebach block test can be used during post-procedure follow-up, as it shows a high (98.7%) negative predictive value for the need for permanent pacing in patients without characteristic ECG changes (Novelli i in., 2023). Risk factors for failure to return to normal conduction include a larger aortic annulus and concomitant diabetes (Ghannam i in., 2019). In situations where pacemaker implantation is unavoidable, physiological pacing strategies, such as His bundle or left bundle branch pacing, are increasingly being considered to reduce the risk of dyssynchrony and secondary left ventricular systolic dysfunction (Mao i in., 2025; Young Lee i in., 2015). However, it should be remembered that approximately 16% of patients implanted with a self-expanding prosthesis may experience late conduction loss within the first year after the procedure (Ghannam i in., 2019). In response to the risk of chronic right ventricular pacing, modern programming algorithms, such as AV search hysteresis, are being introduced to maximize intrinsic atrioventricular conduction. Leadless pacing systems are also gaining increasing interest, representing a minimally invasive alternative that can reduce complications associated with traditional pacing systems. (Mazzella i in., 2021; Young Lee i in., 2015).

Infectious complications

Infective endocarditis of prosthetic valves is a rare but exceptionally serious complication following TAVI. Its incidence is estimated at approximately 1.1% per year, and mortality in the first year can exceed 60%. The microbiological profile differs somewhat from that observed after surgical valve replacement, with Enterococcus bacteria being more frequently isolated, reflecting the advanced age of the population undergoing TAVI and the predominance of transfemoral access. Prophylaxis includes not only standard perioperative antibiotic therapy but also rigorous adherence to aseptic techniques during catheterization, as the inguinal puncture site increases the risk of translocation of skin flora into the bloodstream. Diagnosing endocarditis in this group of patients can be challenging, as classic symptoms such as fever or the appearance of a new murmur may be masked by comorbidities or the presence of a paravalvular leak. In many cases, multimodal imaging, including transesophageal echocardiography and PET/CT, is necessary to confirm the diagnosis. In-hospital mortality in the course of infective endocarditis after TAVI remains high and amounts to approximately 41.8%, with most clinical cases occurring within the first 12 months after valve implantation (Mazur i in., 2023). This complication, despite its relatively low frequency, constitutes a significant clinical challenge due to diagnostic difficulties, limited surgical treatment options in this population and a very serious prognosis.

Hemorrhagic complications

In addition to access site injuries, significant complications following TAVI include gastrointestinal bleeding and spontaneous intracranial hemorrhage, which significantly increase post-procedural morbidity. This risk is further exacerbated by the intensive anticoagulant and antiplatelet therapy used to prevent prosthetic leaflet thrombosis and stroke in the early phase of recovery. Heyde's syndrome is particularly relevant in the elderly population undergoing TAVI, where relief of the high pressure gradient across the aortic valve can improve anemia associated with gastrointestinal angiodysplasia. However, it also requires careful balancing of antiplatelet therapy to avoid severe, life-threatening hemorrhages. In the early postoperative period, cerebral microhaemorrhages may also occur, visible in magnetic resonance imaging as small, pinpoint foci, which highlights the vulnerability of cerebral microcirculation in the perioperative period (Lassalle, 2022). One of the most serious bleeding complications remains acute cardiac tamponade, most often resulting from perforation of the ventricular wall by a rigid guidewire or temporary pacing lead. This complication is associated with a sharply worsening prognosis and a significant decrease in survival after the procedure (van Ginkel i in., 2021). In-hospital mortality in patients with tamponade reaches approximately 44%, and although the basic treatment method is urgent pericardiocentesis, in cases of aortic annulus or left ventricular free wall rupture, cardiac surgery may be necessary (van Ginkel i in., 2021).

Conclusions

Transcatheter aortic valve implantation is now a well-established treatment for severe aortic stenosis, whose rapid technological and procedural advances have significantly improved patient safety and clinical outcomes. The expansion of indications from inoperable populations to include patients at high, intermediate, and now also low surgical risk confirms the effectiveness of this technique and its growing role in modern interventional cardiology. Despite significant progress, this procedure is still associated with a risk of complications that can impact patients' short- and long-term prognosis. Although TAVI is an increasingly safe and effective procedure, it remains a complex intervention requiring high technical precision, operator experience, and close postoperative follow-up. Understanding the mechanisms of complications, identifying risk factors, and implementing preventive strategies are fundamental to further optimizing treatment and improving long-term outcomes in patients with aortic stenosis.

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