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Advances in the Diagnosis and Treatment of Cardiovascular Diseases and Their Impact on Perioperative Anesthetic Strategies

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Abstract

Cardiovascular disease (CVD) is the leading cause of death and disability worldwide. Rapid advances in its diagnosis and treatment in recent years have profoundly influenced the perioperative management of patients undergoing surgery. This article reviews recent progress in cardiovascular disease risk assessment, pharmacotherapy, interventional techniques, and surgical procedures, and discusses the new requirements and challenges these advances pose for perioperative anesthetic management.

Keywords

Cardiovascular Disease, Anesthetic Management, Perioperative Medicine, Individualized Strategy, Risk Assessment

Background

Cardiovascular disease (CVD) is the leading cause of death and disability globally [1], and its incidence is closely associated with advancing age. With the development of an aging population structure, the number of elderly patients with CVD is rapidly increasing. Concurrently, the maturation and widespread adoption of minimally invasive interventional techniques—such as transcatheter aortic valve replacement, percutaneous coronary intervention for complex lesions, left atrial appendage closure, and cardiac resynchronization therapy—along with the continuous expansion of cardiac surgery into minimally invasive, hybrid, and complex critical care domains, have significantly altered the profile of cardiovascular patients requiring anesthesia and surgery [2-4]. The number of "complex" patients—those who are elderly, have multiple chronic comorbidities, have undergone repeated interventional treatments or surgeries, and possess extremely poor cardiac functional reserve—has markedly increased. This shift in patient demographics poses systemic challenges to anesthesiologists in terms of knowledge, technical skills, decision-making capacity, and multidisciplinary collaboration.

Over the past decade, changes in the cardiovascular treatment paradigm have necessitated refinement of anesthetic strategies. For instance, in pharmacotherapy, novel oral anticoagulants and potent $P2Y_{12}$ inhibitors are increasingly widely used. Their effects on coagulation differ from those of traditional agents, requiring the formulation of rational perioperative anticoagulation management plans [5,6]. New surgical approaches have enabled many high-risk patients to receive treatment [7], making it essential to master the corresponding assessment and management strategies. Additionally, the application of artificial intelligence-assisted risk stratification tools and biomarkers is transforming the paradigm of preoperative risk assessment [8,9]. Consequently, optimization of perioperative anesthetic management strategies has become a major focus within anesthesiology.

Advances in Cardiovascular Pharmacotherapy and Challenges for Anesthetic Management

Perioperative Management of Novel Anticoagulant and Antiplatelet Agents:

The emergence of novel anticoagulant and antiplatelet drugs has dramatically reshaped the treatment landscape for cardiovascular disease while also introducing new challenges for perioperative management. The advantages of direct oral anticoagulants (DOACs) over traditional warfarin include fixed dosing, no requirement for routine coagulation monitoring, and fewer food and drug interactions, all of which improve patient compliance and medication safety [10]. Meanwhile, more potent $P2Y_{12}$ receptor inhibitors (such as ticagrelor and prasugrel), which reversibly bind to platelet $P2Y_{12}$ receptors, provide more rapid and potent platelet inhibition than clopidogrel but are associated with an increased bleeding risk [11,12], thereby imposing greater demands on perioperative discontinuation decision-making [12].

Perioperative discontinuation and resumption decisions must be based on an individualized risk-benefit assessment that weighs the bleeding risk of the procedure against the patient's thrombotic risk. For DOACs, the discontinuation window must be precisely calculated according to renal function (creatinine clearance) to ensure that drug concentrations decline to safe levels at the time of surgery [10]. Current guidelines generally do not recommend routine bridging anticoagulation for patients receiving DOACs, based on consideration of DOAC pharmacokinetics and bleeding risk. No interruption is required for minor procedures, whereas discontinuation 24 hours before low-bleeding-risk procedures and 48 hours before high-bleeding-risk procedures is recommended [10,13].

For $P2Y_{12}$ inhibitors, longer discontinuation periods are usually required according to the pharmacokinetic properties of individual agents. Current recommendations include discontinuation at least 3 days before surgery for ticagrelor, 5 days for clopidogrel, and 7 days for prasugrel to ensure recovery of platelet function, although practices may vary among centers [12,13]. Anesthesiologists must be familiar with these principles to balance thrombotic and hemorrhagic risks appropriately.

In cases of life-threatening perioperative bleeding, specific reversal agents can be utilized. For example, idarucizumab can reverse dabigatran, whereas andexanet alfa is indicated for reversal of factor Xa inhibitors. Both agents can rapidly reverse anticoagulant effects [14,15].

New Heart Failure Therapies and Their Interactions with Anesthesia:

The treatment paradigm for heart failure has evolved from traditional neurohormonal antagonism (e.g., ACE inhibitors/ARBs) to more comprehensive multi-pathway interventions. Angiotensin receptor-neprilysin inhibitors (ARNIs), such as sacubitril/valsartan, exemplify this shift. ARNIs are combination drugs composed of the neprilysin inhibitor sacubitril and the angiotensin II receptor blocker valsartan. Their unique mechanism of action has demonstrated significant advantages in the treatment of chronic heart failure by exerting dual effects: on the one hand, inhibiting neprilysin to increase natriuretic peptide levels, thereby promoting diuresis, natriuresis, and vasodilation; on the other hand, blocking angiotensin II receptors, resulting in more potent blood pressure reduction, reversal of ventricular remodeling, and improved hemodynamic effects [16].

Sodium-glucose cotransporter 2 inhibitors (SGLT2i), such as empagliflozin and dapagliflozin, have evolved from glucose-lowering agents into foundational therapies for heart failure. Their cardioprotective effects arise from multiple mechanisms, including osmotic diuresis to reduce cardiac preload, improved myocardial energy metabolism efficiency, and attenuation of myocardial inflammation and fibrosis, resulting in significant cardiovascular benefits [17]. The widespread use of these drugs means that an increasing number of patients receiving them will undergo surgery, thereby raising new challenges for perioperative management.

Perioperative management must focus on the effects of ARNIs and SGLT2i on anesthesia. During the perioperative period, patients experience acute blood volume changes, anesthetic-induced vasodilation, and surgical stress. The potent vasodilatory and diuretic effects of ARNIs may lead to excessive blood pressure reduction and provoke refractory hypotension, particularly when combined with anesthetics or other antihypertensive agents, or in patients with relative hypovolemia, in whom the risk is even greater [18]. Moreover, an acute decrease in renal perfusion pressure, especially during major surgery or when vasopressor support is required, may increase the risk of acute kidney injury [19]. Therefore, heightened vigilance is essential during the perioperative period regarding marked blood pressure fluctuations and renal hypoperfusion potentially induced by ARNIs. Because ARNIs can significantly reduce sympathetic nervous system activity [20], thereby increasing patient sensitivity to anesthetics and intraoperative vasodilators, withholding these agents for 24 hours before surgery is generally recommended, along with preparation of potent vasoactive drugs.

For patients receiving SGLT2i, routine preoperative fasting combined with the diuretic effects of these agents can readily reduce effective circulating blood volume, thereby increasing the risks of intraoperative hypotension and acute kidney injury. In addition, SGLT2i are associated with a rare but serious complication—euglycemic diabetic ketoacidosis—in which surgical stress, relative insulin deficiency, and reduced oral intake collectively promote lipolysis and ketone body production. Importantly, this ketoacidosis may occur despite normal or only mildly elevated blood glucose levels [21]. Therefore, perioperative ketone body monitoring is necessary, and discontinuation of SGLT2i for 3–4 days before surgery is generally recommended to minimize the risks of perioperative ketoacidosis and volume depletion. Anesthesiologists must be familiar with the pharmacological properties of these novel agents and be prepared to anticipate and effectively manage the hemodynamic and metabolic disturbances they may cause.

Specific Anesthetic Requirements Driven by Advances in Cardiovascular Interventional and Minimally Invasive Surgical Techniques

Anesthetic Coordination for Transcatheter Structural Heart Disease Interventions:

Transcatheter structural heart disease interventions primarily include transcatheter aortic valve replacement (TAVR), transcatheter mitral valve repair or replacement (TMVR), transcatheter tricuspid valve intervention, and left atrial appendage closure (LAAC) [7]. Different procedures impose specific requirements on anesthetic management. For example, TAVR utilizes various access routes, including transfemoral, transapical, and transseptal approaches. Among these, the transfemoral approach, because of its minimally invasive nature, often employs local anesthesia or local anesthesia combined with sedation, whereas the transapical approach, being more invasive, usually requires general anesthesia. During critical stages of valve deployment, such as balloon inflation or valve positioning, rapid ventricular pacing is often required to induce a temporary reduction in cardiac output. Therefore, anesthetic management must coordinate brief periods of apnea or adjusted ventilation strategies to minimize cardiac motion and ensure precise implantation [22]. Beyond standard vital sign monitoring, continuous invasive arterial pressure monitoring provides real-time feedback regarding circulatory fluctuations, and transesophageal echocardiography (TEE) plays an irreplaceable role in assessing valve position and function, as well as identifying acute complications such as paravalvular leak and cardiac tamponade [23,24].

There is an increasing trend toward using deep sedation combined with local anesthesia instead of routine general anesthesia for procedures such as TAVR. Local anesthesia with sedation can shorten hospital stay, reduce the use of vasoactive drugs, and potentially lower medical costs [25,26]. However, sedation combined with local anesthesia requires a high degree of patient cooperation to maintain immobility during the procedure, and in the event of emergency complications such as cardiac tamponade, coronary artery obstruction, or vascular rupture, conversion to general anesthesia may be delayed [26]. In contrast, general anesthesia provides more stable airway control and physiological conditions, greatly facilitates procedural performance, and establishes favorable conditions for emergency rescue. Therefore, it remains the preferred anesthetic modality for complex cases, such as transcatheter mitral valve replacement in severe mitral annular calcification, specific high-risk access routes (e.g., transapical access), or procedures with anticipated prolonged duration [27,28].

The identification and emergency management of intraoperative complications are core responsibilities of the anesthesia team. Critical situations that may arise during transcatheter cardiac interventions include severe paravalvular leak, coronary artery obstruction, circulatory collapse, stroke, and heart block [29]. Anesthesiologists must rely on TEE and continuous hemodynamic monitoring for early recognition of these complications. For example, acute hypotension accompanied by TEE evidence of pericardial effusion strongly suggests cardiac tamponade, whereas new-onset left ventricular outflow tract obstruction may be related to abnormal valve positioning after implantation [23,28]. Emergency protocols include immediate initiation of advanced life support and administration of vasoactive agents to maintain perfusion pressure, preparation for urgent establishment of extracorporeal circulatory support, and readiness for temporary or permanent pacemaker implantation in cases of severe conduction block. This process requires close collaboration among anesthesia, interventional, and surgical teams to ensure rapid decision-making and seamless transition to emergency rescue measures [27].

Anesthetic Management for Minimally Invasive and Robot-Assisted Cardiac Surgery:

Minimally invasive and robot-assisted cardiac surgical procedures, such as minimally invasive direct coronary artery bypass (MIDCAB), totally thoracoscopic cardiac surgery, and robot-assisted cardiac surgery, are characterized by the use of small incisions or ports, thereby avoiding traditional median sternotomy [30]. These procedures frequently require one-lung ventilation (OLV) to provide a clear surgical field. Hypoxic pulmonary vasoconstriction in the non-ventilated lung, together with surgical manipulation, can increase right ventricular afterload and subsequently affect right ventricular function. In addition, surgical maneuvers may induce arrhythmias or hemodynamic instability. Therefore, the anesthesia team should prepare contingency plans for the management of sudden massive hemorrhage or emergency conversion to open sternotomy due to technical difficulties [31].

The major advantages of minimally invasive surgery include reduced tissue trauma and less postoperative pain, thereby creating favorable conditions for the implementation of enhanced recovery after surgery (ERAS) protocols. Integration of anesthetic management into the ERAS pathway for cardiac surgery involves several important measures, including goal-directed fluid therapy based on dynamic indices such as stroke volume variation to optimize fluid administration and avoid volume overload; active warming strategies to prevent intraoperative hypothermia; and promotion of early postoperative extubation and mobilization through meticulous selection and titration of anesthetic agents, thereby shortening hospital stay [31].

Integration of Perioperative Risk Assessment and Individualized Anesthetic Strategies

Precision Risk Assessment Based on Artificial Intelligence and Biomarkers:

Traditional cardiac risk scoring systems, such as the Revised Cardiac Risk Index (RCRI) and the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) model, are valuable for predicting cardiac complications in patients undergoing noncardiac surgery, although they have certain limitations. These models, which are primarily based on clinical markers and electrocardiographic assessment, can effectively discriminate among low-, intermediate-, and high-risk populations [32]. However, when evaluating increasingly complex patient populations—such as those with multiple cardiovascular conditions, those who have undergone novel cardiovascular procedures (e.g., transcatheter aortic valve implantation), or those with specific pathophysiological states—traditional scoring systems may fail to adequately capture individualized risk [33]. Therefore, clinical decision-making still requires comprehensive judgment integrating detailed medical history, physical examination, and modern diagnostic methods [34].

Novel biomarkers provide important evidence for preoperative risk assessment. High-sensitivity cardiac troponin (hs-cTn) and B-type natriuretic peptide (BNP)/N-terminal pro-B-type natriuretic peptide (NT-proBNP) are key indicators for assessing subclinical myocardial injury and cardiac dysfunction. Elevated preoperative hs-cTn or BNP/NT-proBNP levels are strong predictors of perioperative cardiac complications and adverse long-term outcomes [8]. In studies involving pregnancy complicated by cardiovascular disease, dynamic changes in NT-proBNP levels during pregnancy have been shown to correlate with cardiac functional status [9]. Incorporating these biomarkers into risk assessment frameworks may improve the identification of high-risk patients. Furthermore, other biomarkers such as growth differentiation factor-15 (GDF-15) have also demonstrated predictive potential, although additional evidence is still required [8]. In patients undergoing cardiac surgery, postoperative myocardial injury markers, such as cardiac troponin I (cTnI), may also be used to evaluate the myocardial protective effects of interventions.

Artificial intelligence (AI) and machine learning models offer new opportunities for the development of more precise individualized risk prediction tools. By integrating large-scale electronic health record data—including continuous vital signs, laboratory parameters, medication information, and numerous additional variables—machine learning algorithms can construct predictive models that outperform traditional scoring systems [35]. These models can dynamically integrate cardiopulmonary reserve, end-organ functional reserve, surgical variables, and biomarker trajectories, achieving predictive performance (c-statistic up to 0.79) superior to that of the static American Society of Anesthesiologists (ASA) classification [35].

A study involving patients undergoing noncardiac surgery demonstrated that an AI-enhanced electrocardiographic score (QCG-Critical score), derived from ECG images obtained within 30 days before surgery, predicted 30-day postoperative mortality with predictive performance significantly superior to traditional models such as the European Society of Cardiology surgical risk classification and the Revised Cardiac Risk Index. In addition, it performed well in predicting 7-day mortality, unplanned coronary intervention, prolonged mechanical ventilation, and acute heart failure [36]. Similarly, an AI-based ECG-atrial fibrillation model (AI-ECG-AF model), which predicts the risk of postoperative atrial fibrillation within 30 days using preoperative sinus rhythm ECG data, significantly improved predictive performance [37]. By analyzing raw imaging data from cardiac imaging modalities such as echocardiography and cardiac magnetic resonance imaging, machine learning models can automatically and accurately quantify parameters including ejection fraction and myocardial strain. These models can identify subclinical myocardial dysfunction with an accuracy of up to 85% in predicting heart failure, thereby enabling earlier and more precise assessment of postoperative acute heart failure risk [38]. Such models have substantial potential for identifying high-risk patients preoperatively, optimizing medical resource allocation, and guiding anesthetic strategy and perioperative monitoring [35].

Individualized Hemodynamic Management:

Goal-directed hemodynamic therapy has evolved beyond the traditional management paradigm centered solely on blood pressure and heart rate, shifting toward individualized management based on each patient's specific cardiovascular pathophysiological condition. This approach requires anesthesiologists to possess a thorough understanding of the hemodynamic characteristics associated with different cardiac diseases. For example, according to left ventricular ejection fraction, heart failure can be categorized into heart failure with preserved ejection fraction (HFpEF) and heart failure with reduced ejection fraction (HFrEF) [39]. HFrEF is primarily characterized by impaired myocardial contractility, whereas HFpEF is characterized by ventricular diastolic dysfunction and increased ventricular stiffness [40]. This fundamental pathophysiological distinction results in markedly different responses to anesthetic agents, intravascular volume status, and hemodynamic changes, thereby placing extremely high demands on refined and individualized anesthetic management.

In patients with HFpEF, the management focus is maintaining a relatively slow heart rate and adequate preload while avoiding hypertension that may worsen left ventricular diastolic dysfunction. In contrast, management of HFrEF requires optimization of preload and afterload, and positive inotropic support may be necessary. In patients with severe aortic stenosis, maintenance of sinus rhythm, adequate intravascular volume, and coronary perfusion pressure is critical, whereas patients with aortic regurgitation are particularly sensitive to afterload changes [34]. In cardiac surgery, especially in patients with valvular disease or heart failure, management requires a delicate balance between preload and afterload, with close attention to the effects of myocardial contractility and valvular function on hemodynamics [41,42]. In major vascular surgery, controlling blood pressure fluctuations and maintaining organ perfusion are essential, whereas in major noncardiac surgery, the primary focus is mitigating the effects of surgical stress on pre-existing cardiovascular disease and preventing complications such as myocardial ischemia and acute exacerbation of heart failure [41].

To achieve precise individualized therapy, advanced hemodynamic monitoring technologies are indispensable. In patients with complex cardiovascular disease, transesophageal echocardiography (TEE) plays an irreplaceable role in the real-time assessment of cardiac filling status, systolic and diastolic function, valvular function, and diagnosis of acute complications. It is widely used perioperatively in cardiac surgery, major vascular surgery, and transplant surgery, greatly improving surgical success rates and patient safety [43]. In addition, technologies such as pulse contour analysis for cardiac output monitoring and noninvasive cardiac output monitoring can provide continuous dynamic hemodynamic data, facilitating precise titration of fluid therapy and vasoactive medications [44]. Echocardiography, cardiac magnetic resonance imaging, and invasive hemodynamic monitoring also influence prognosis through assessment of right heart function in conditions such as mitral valve surgery [45]. Therefore, anesthesiologists should be proficient in the application and interpretation of these advanced monitoring techniques.

Conclusion

Advances in cardiovascular disease diagnosis and treatment technologies, particularly the widespread adoption of novel pharmacotherapies, minimally invasive interventional and surgical approaches, and emerging assessment and diagnostic tools, have reshaped the perioperative management of surgical patients with cardiovascular disease. Anesthetic practice must therefore undergo a strategic transition from traditional, relatively standardized perioperative care toward precision medicine centered on cardiovascular pathophysiology throughout the entire perioperative period. The requirements associated with new technologies and procedures should be integrated into a goal-directed and individualized management framework to achieve optimal patient outcomes. Progress in cardiovascular medicine presents both major challenges and historic opportunities for anesthesiology, which plays a critical role in ensuring surgical safety and promoting long-term recovery in patients with cardiovascular disease.

In the future, artificial intelligence and machine learning algorithms are expected to integrate multidimensional data to provide more accurate risk prediction and clinical decision support. Novel biomarkers may enable earlier and more specific detection of myocardial injury and physiological stress. Emerging pharmacological agents, through improved preoperative optimization and enhanced intraoperative and postoperative management, may further reduce perioperative risk. In addition, precision treatment protocols guided by genetic testing may minimize interindividual variability in drug responses caused by genetic polymorphisms. Multidisciplinary collaboration and telemedicine are also expected to play increasingly important roles throughout the perioperative period in optimizing long-term patient outcomes. With the rapid advancement of medical science and technology, a new perioperative management model integrating precise assessment, intelligent monitoring and decision-making, proactive intervention, and systematic personalized management is likely to emerge.

Conflict of Interest

The authors have read and approved the final version of the manuscript. The authors have no conflicts of interest to declare.

References

[1] Shi H, Xia Y, Cheng Y, Liang P, Cheng M, Zhang B, Liang Z, Wang Y, Xie W. Global burden of ischaemic heart disease from 2022 to 2050: projections of incidence, prevalence, deaths, and disability-adjusted life years. Eur Heart J Qual Care Clin Outcomes. 2025 Jun 23;11(4):355-66. [**PMID**: 38918062]

[2] Wang K, Geng B, Shen Q, Wang Y, Shi J, Dong N. Global, regional, and national incidence, mortality, and disability-adjusted life years of non-rheumatic valvular heart disease and trend analysis from 1990 to 2019: Results from the Global Burden of Disease study 2019. Asian Cardiovasc Thorac Ann. 2023 Oct;31(8):706-22. [**PMID**: 37674443]

[3] Sear JW, Higham H. Issues in the perioperative management of the elderly patient with cardiovascular disease. Drugs Aging. 2002;19(6):429-51. [**PMID**: 12149050]

[4] Pilkington M, Egan JC. Noncardiac surgery in the congenital heart patient. Semin Pediatr Surg. 2019 Feb;28(1):11-17. [**PMID**: 30824128]

[5] Basu Roy P, Tejani VN, Dhillon SS, Damarlapally N, Winson T, Usman NUB, Panjiyar BK. Efficacy and Safety of Novel Oral Anticoagulants in Atrial Fibrillation: A Systematic Review. Cureus. 2023 Oct 2;15(10):e46385. [**PMID**: 37927673]

[6] Bainey KR, Marquis-Gravel G, Belley-Côté E, Turgeon RD, Ackman ML, Babadagli HE, Bewick D, Boivin-Proulx LA, Cantor WJ, Fremes SE, Graham MM, Lordkipanidzé M, Madan M, Mansour S, Mehta SR, Potter BJ, Shavadia J, So DF, Tanguay JF, Welsh RC, Yan AT, Bagai A, Bagur R, Bucci C, Elbarouni B, Geller C, Lavoie A, Lawler P, Liu S, Mancini J, Wong GC. Canadian Cardiovascular Society/Canadian Association of Interventional Cardiology 2023 Focused Update of the Guidelines for the Use of Antiplatelet Therapy. Can J Cardiol. 2024 Feb;40(2):160-81. Erratum in: Can J Cardiol. 2024 Jul;40(7):1367. [**PMID**: 38104631]

[7] Davidson LJ, Davidson CJ. Transcatheter Treatment of Valvular Heart Disease: A Review. JAMA. 2021 Jun 22;325(24):2480-94. [**PMID**: 34156404]

[8] Bakker EJ, Ravensbergen NJ, Poldermans D. Perioperative cardiac evaluation, monitoring, and risk reduction strategies in noncardiac surgery patients. Curr Opin Crit Care. 2011 Oct;17(5):409-15. [**PMID**: 21677577]

[9] Csengeri D, Unger E, Weimann J, Huntgeburth M, von Kodolitsch Y, Zeller T, Blankenberg S, Kirchhof P, Diemert A, Schnabel RB, Sinning CR, Zengin-Sahm E. Pregnancy & cardiovascular disease: the PREG-CVD-HH registry. Cardiovasc Diagn Ther. 2024 Dec 31;14(6):1058-69. [**PMID**: 39790199]

[10] Sunkara T, Ofori E, Zarubin V, Caughey ME, Gaduputi V, Reddy M. Perioperative Management of Direct Oral Anticoagulants (DOACs): A Systemic Review. Health Serv Insights. 2016 Dec 13;9(Suppl 1):25-36. [**PMID**: 28008269]

[11] Schilling U, Dingemanse J, Ufer M. Pharmacokinetics and Pharmacodynamics of Approved and Investigational P2Y12 Receptor Antagonists. Clin Pharmacokinet. 2020 May;59(5):545-66. [**PMID**: 32056160]

[12] Schoerghuber M, Pregartner G, Berghold A, Lindenau I, Zweiker R, Voetsch A, Mahla E, Zirlik A. How do type of preoperative $P2Y_{12}$ receptor inhibitor and withdrawal time affect bleeding? Protocol of a systematic review and individual patient data meta-analysis. BMJ Open. 2022 Mar 28;12(3):e060404. [**PMID**: 35351733]

[13] Moster M, Bolliger D. Perioperative guidelines on antiplatelet and anticoagulant agents: 2022 update. Curr Anesthesiol Rep. 2022;12:286-96.

[14] Cortese F, Calculli G, Gesualdo M, Cecere A, Zito A, De Vito F, Carbonara R, Carbonara S, Cortese AM, Ciccone MM. Idarucizumab: What Should We Know? Curr Drug Targets. 2018;19(1):81-88. [**PMID**: 28950812]

[15] Noordergraaf FA, Alings M. Andexanet Alfa and its Clinical Application. Heart Int. 2020 Jun 19;14(1):20-23. [**PMID**: 36277667]

[16] Cruz Rodriguez JB, Cu C, Siddiqui T. Narrative review in the current role of angiotensin receptor-neprilysin inhibitors. Ann Transl Med. 2021 Mar;9(6):518. [**PMID**: 33850915]

[17] Yamani N, Shaikh FN, Sarfraz S, Khan HK, Wasim MF, Paracha AA, Almas T, Mookadam F, Unzek S. Efficacy of Sodium-Glucose Cotransporter-2 inhibitors in heart failure patients treated with dual angiotensin

receptor blocker-neprilysin inhibitor: An updated meta-analysis. Ann Med Surg (Lond). 2021 Sep 8;70:102796. [**PMID**: 34589210]

[18] Escobar C, Luis-Bonilla J, Crespo-Leiro MG, Esteban-Fernández A, Farré N, Garcia A, Nuñez J. Individualizing the treatment of patients with heart failure with reduced ejection fraction: a journey from hospitalization to long-term outpatient care. Expert Opin Pharmacother. 2022 Oct;23(14):1589-99. [**PMID**: 35995759]

[19] Masuda T, Nagata D. Glomerular pressure and tubular oxygen supply: a critical dual target for renal protection. Hypertens Res. 2024 Dec;47(12):3330-37. [**PMID**: 39397109]

[20] Bunsawat K, Ratchford SM, Alpenglow JK, Stehlik J, Smith AS, Richardson RS, Wray DW. Sympathoinhibitory effect of sacubitril-valsartan in heart failure with reduced ejection fraction: A pilot study. Auton Neurosci. 2021 Nov;235:102834. [**PMID**: 34186274]

[21] Stöllberger C, Finsterer J, Schneider B. Adverse events and drug-drug interactions of sodium glucose co-transporter 2 inhibitors in patients treated for heart failure. Expert Rev Cardiovasc Ther. 2023 Jul-Dec;21(11):803-16. [**PMID**: 37856368]

[22] Contrera P, Cushing M. AANA Journal Course: Update for nurse anesthetists--part-4--transcatheter aortic valve replacement. AANA J. 2013 Oct;81(5):399-408. [**PMID**: 24354078]

[23] Bleakley C, Monaghan M. 3D transesophageal echocardiography in TAVR. Echocardiography. 2020 Oct;37(10):1654-64. [**PMID**: 32608098]

[24] Hilberath JN, Oakes DA, Shernan SK, Bulwer BE, D'Ambra MN, Eltzschig HK. Safety of transesophageal echocardiography. J Am Soc Echocardiogr. 2010 Nov;23(11):1115-27; quiz 1220-1. [**PMID**: 20864313]

[25] Attizzani GF, Alkhalil A, Padaliya B, Tam CC, Lopes JP, Fares A, Bezerra HG, Medallion B, Park S, Deo S, Sareyyupoglu B, Parikh S, Zidar D, Elgudin Y, Popovich K, Davis A, Staunton E, Tomic A, Mazzurco S, Avery E, Markowitz A, Simon DI, Costa MA. Comparison of Outcomes of Transfemoral Transcatheter Aortic Valve Implantation Using a Minimally Invasive Versus Conventional Strategy. Am J Cardiol. 2015 Dec 1;116(11):1731-36. [**PMID**: 26433275]

[26] Villablanca PA, Mohananey D, Nikolic K, Bangalore S, Slovut DP, Mathew V, Thourani VH, Rode's-Cabau J, Núñez-Gil IJ, Shah T, Gupta T, Briceno DF, Garcia MJ, Gutsche JT, Augoustides JG, Ramakrishna H. Comparison of local versus general anesthesia in patients undergoing transcatheter aortic valve replacement: A meta-analysis. Catheter Cardiovasc Interv. 2018 Feb 1;91(2):330-42. [**PMID**: 28738447]

[27] Brecker SJ, Bleiziffer S, Bosmans J, Gerckens U, Tamburino C, Wenaweser P, Linke A; ADVANCE Study Investigators. Impact of Anesthesia Type on Outcomes of Transcatheter Aortic Valve Implantation (from the Multicenter ADVANCE Study). Am J Cardiol. 2016 Apr 15;117(8):1332-38. [**PMID**: 26892451]

[28] Khan JM, Babaliaros VC, Greenbaum AB, Foerst JR, Yazdani S, McCabe JM, Paone G, Eng MH, Leshnower BG, Gleason PT, Chen MY, Wang DD, Tian X, Stine AM, Rogers T, Lederman RJ. Anterior Leaflet Laceration to Prevent Ventricular Outflow Tract Obstruction During Transcatheter Mitral Valve Replacement. J Am Coll Cardiol. 2019 May 28;73(20):2521-34. Erratum in: J Am Coll Cardiol. 2019 Jul 30;74(4):595. [**PMID**: 31118146]

[29] Guerrero M, Dvir D, Himbert D, Urena M, Eleid M, Wang DD, Greenbaum A, Mahadevan VS, Holzhey D, O'Hair D, Dumonteil N, Rodés-Cabau J, Piazza N, Palma JH, DeLago A, Ferrari E, Witkowski A, Wendler O, Kornowski R, Martinez-Clark P, Ciaburri D, Shemin R, Alnasser S, McAllister D, Bena M, Kerendi F, Pavlides G, Sobrinho JJ, Attizzani GF, George I, Nickenig G, Fassa AA, Cribier A, Bapat V, Feldman T, Rihal C, Vahanian A, Webb J, O'Neill W. Transcatheter Mitral Valve Replacement in Native Mitral Valve Disease With Severe Mitral Annular Calcification: Results From the First Multicenter Global Registry. JACC Cardiovasc Interv. 2016 Jul 11;9(13):1361-71. [**PMID**: 27388824]

[30] Mei J, Jiang ZL, Wang C. Advances in minimally invasive cardiovascular surgery in China. Chinese Journal of Cardiovascular Research. 2025;23(4):289-92.

[31] Jin ZX. Issues and countermeasures in cardiopulmonary bypass during minimally invasive cardiac surgery. Chinese Journal of Extracorporeal Circulation. 2020;18(6):321-23.

[32] Johnson EP, Monsour R, Hafez O, Kotha R, Ackerman RS. Major Perioperative Cardiac Risk Assessment: A Review for Cardio-Oncologists and Perioperative Physicians. Clin Pract. 2024 May 17;14(3):906-14. [**PMID**: 38804403]

[33] Dunkelgrun M, Schouten O, Feringa HH, Noordzij PG, Hoeks S, Boersma E, Bax JJ, Poldermans D.

Perioperative cardiac risk stratification and modification in abdominal aortic aneurysm repair. Acta Chir Belg. 2006 Jul-Aug;106(4):361-66. [**PMID**: 17017685]

[34] Sirvinskas E. Anestezijos savitumai ligoniams, sergantiems sirdies voztuvu ligomis, ne sirdies operaciju metu [Peculiarities of anesthesia for patients with valvular heart disease during non-cardiac surgery]. Medicina (Kaunas). 2003;39(8):730-38. Lithuanian. [**PMID**: 12960451]

[35] Li Y, Xiao H, Zheng H, Wang R. Precise perioperative assessment and anesthesia strategy for painless gastrointestinal endoscopy in high-risk cardiovascular disease patients. iScience. 2026 Jan 20;29(4):114746. [**PMID**: 41858632]

[36] Choi HM, Kim Y, Kim J, Park J, Lee JH, Yoon YE, Oh IY, Song IA, Cho Y. Artificial intelligence-enhanced ECG score for perioperative risk assessment in non-cardiac surgery. Eur Heart J Digit Health. 2026 Feb 12;7(2):ztag006. [**PMID**: 41695567]

[37] Han C, Soh S, Park JW, Pak HN, Yoon D. Artificial Intelligence-Based Electrocardiogram Model as a Predictor of Postoperative Atrial Fibrillation Following Cardiac Surgery: Retrospective Cohort Study. J Med Internet Res. 2025 Nov 10;27:e77164. [**PMID**: 41213128]

[38] Yasmin F, Shah SMI, Naeem A, Shujauddin SM, Jabeen A, Kazmi S, Siddiqui SA, Kumar P, Salman S, Hassan SA, Dasari C, Choudhry AS, Mustafa A, Chawla S, Lak HM. Artificial intelligence in the diagnosis and detection of heart failure: the past, present, and future. Rev Cardiovasc Med. 2021 Dec 22;22(4):1095-13. [**PMID**: 34957756]

[39] Bowen RES, Graetz TJ, Emmert DA, Avidan MS. Statistics of heart failure and mechanical circulatory support in 2020. Ann Transl Med. 2020 Jul;8(13):827. [**PMID**: 32793672]

[40] Pagel PS, Tawil JN, Boettcher BT, Izquierdo DA, Lazicki TJ, Crystal GJ, Freed JK. Heart Failure With Preserved Ejection Fraction: A Comprehensive Review and Update of Diagnosis, Pathophysiology, Treatment, and Perioperative Implications. J Cardiothorac Vasc Anesth. 2021 Jun;35(6):1839-59. [**PMID**: 32747202]

[41] O'Glasser AY, Manjarrez EC. Perioperative Care of Heart Failure, Arrhythmias, and Valvular Heart Disease. Med Clin North Am. 2024 Nov;108(6):1053-64. [**PMID**: 39341613]

[42] Lüsebrink E, Lanz H, Kellnar A, Karam N, Kapadia S, Makkar R, Abraham WT, Latib A, Leon M, Sannino A, Shuvy M, Guerrero M, Fam N, Butler J, Adamo M, Rudolph V, Tang GHL, Stocker TJ, Rommel KP, Lurz P, Thiele H, Massberg S, Praz F, Prendergast B, Hausleiter J. Management of acute decompensated valvular heart disease. Eur J Heart Fail. 2025 Apr;27(4):630-49. [**PMID**: 39663714]

[43] Liang J, Ma X, Liang G. Transesophageal echocardiography: Revolutionizing perioperative cardiac care. Biomolecules & Biomedicine. 2025 Jan;25(2):314-26. [**PMID**: 39151094]

[44] Pinsky MR, Brophy P, Padilla J, Paganini E, Pannu N. Fluid and volume monitoring. Int J Artif Organs. 2008 Feb;31(2):111-26. [**PMID**: 18311728]

[45] Bacchi B, Stefanini A, Mandoli GE, Lorusso F, Toto G, Pastore MC, Cabrucci F, Bonacchi M, Cameli M, Bisleri G. Right Ventricle Function: The Role of the Forgotten Chamber in Mitral Valve Surgery. Curr Cardiol Rep. 2025 Jan 9;27(1):13. [**PMID**: 39786499]