ARCHIVES OF THE TURKISH SOCIETY OF CARDIOLOGY

Official journal of the TURKISH SOCIETY OF CARDIOLOGY

Adaptation of the Enhanced Recovery After Surgery (ERAS®) Protocol in Transcatheter Aortic Valve Replacement Patients

Transkateter Aort Kapak Replasmanı Hastalarında Cerrahi Sonrası Hızlandırılmış İyileşme (ERAS®) Protokolünün Uyarlanması

ABSTRACT

Enhanced Recovery After Surgery (ERAS®) is a multimodal, multidisciplinary care and recovery protocol designed to facilitate faster recovery for patients undergoing surgery during the perioperative period. These programs aim to encourage an earlier return to normal activities by reducing complications. While ERAS® protocols have become standard practice in many surgical specialties, their application in the transcatheter aortic valve replacement (TAVI) procedure is relatively recent. TAVI patients are often high-risk and medically fragile. We believe that managing these patients with a multidisciplinary approach, such as the ERAS® protocol, during the preoperative and postoperative periods will reduce morbidity and mortality, enhance patient satisfaction, and lower hospital costs.

Keywords: Enhanced recovery after surgery, postoperative care, preoperative care, transcatheter aortic valve replacement

ÖZET

Cerrahi Sonrası Hızlandırılmış İyileşme (ERAS®) protokolü, perioperatif dönemde ameliyat geçiren hastaların daha hızlı iyileşmesini amaçlayan multimodal, multidisipliner bir bakım-iyileşme protokolüdür. Bu programlar, komplikasyonları azaltarak normal aktivitelere daha erken dönüşü teşvik etmeyi amaçlamaktadır. ERAS® protokolleri birçok cerrahi uzmanlık alanında rutin uygulama haline gelmiş olsa da transkateter aort kapak replasmanı (TAVI) prosedüründe çok yenidir. TAVI hastaları yüksek riskli kırılgan hastalardır. Bu hastaların preoperatif ve postoperatif dönemlerde ERAS® protokolü gibi multidisipliner bir yaklaşımla tedavi edilmesinin morbidite ve mortaliteyi azaltacağına, hasta memnuniyetini artıracağına ve hastane maliyetlerini düşüreceğine inanıyoruz.

Anahtar Kelimeler: Cerrahi sonrası hızlandırılmış iyileşme, postoperatif bakım, preoperatif bakım, transkateter aort kapak replasmanı

REVIEW
DERLEME

Hülya Yılmaz Ak[1]
Mustafa Yıldız[2]
Ahmet Yıldız[3]
Sait Mesut Doğan[2]
Ziya Salihoğlu[4]
Kerem Erkalp[4]
Emir Özgür Barış Ökçün[2]
Yasemin Özşahin[4]

[1]*Department of Anesthesiology and Reanimation, Kartal Dr. Lütfi Kırdar City Hospital, İstanbul, Türkiye*
[2]*Department of Cardiology, İstanbul University-Cerrahpaşa, Cardiology Institute, İstanbul, Türkiye*
[3]*Department of Cardiology, Memorial Bahçelievler Hospital, İstanbul, Türkiye*
[4]*Department of Anesthesiology and Reanimation, İstanbul University-Cerrahpaşa, Cardiology Institute, İstanbul, Türkiye*

Corresponding author:
Hülya Yılmaz Ak
✉ hulyayilmazak@gmail.com

Received: May 21, 2024
Accepted: October 20, 2024

Cite this article as: Yılmaz Ak H, Yıldız M, Yıldız A, et al. Adaptation of the Enhanced Recovery After Surgery (ERAS®) Protocol in Transcatheter Aortic Valve Replacement (TAVI) Patients. *Turk Kardiyol Dern Ars.* 2025;53(2):127–133.

DOI:10.5543/tkda.2024.98566

Since its first successful implementation in humans in 2002, transcatheter aortic valve replacement (TAVI) has become the standard of care for patients with severe aortic stenosis who face high surgical risk.[1] Although TAVI has been performed in more than 300,000 high-risk patients over the past 20 years, recent studies suggest that TAVI may serve as an alternative to aortic valve replacement (AVR) for intermediate-risk patients.[2-4] Additionally, its application in low-risk patients is steadily increasing.[5,6]

Overall, the incidence of complications following TAVI has significantly decreased due to the growing experience of operators performing the procedure, improved sizing accuracy with computed tomography, significant technological advancements in prosthesis design, and the reduced size of the sheaths. Although the incidence of complications after TAVI has decreased significantly, the rates of stroke, the need for a new pacemaker, and paravalvular leak remain higher compared to AVR, as reported in published studies.[7] Procedural complications of TAVI include vascular injuries, valve malpositioning, paravalvular leak, stroke, myocardial ischemia or injury, acute kidney injury, and heart block. Long-term complications of TAVI encompass aortic

regurgitation, stroke, myocardial infarction, prosthetic valve thrombosis, acute coronary syndrome, bleeding, permanent pacemaker implantation, and prosthetic valve endocarditis.[7,8] In the PARTNER I trials (Placement of Aortic Transcatheter Valves), the most common periprocedural complications were major arrhythmias (17%), major vascular complications (13%), major bleeding (12%), and minor vascular complications (8%).[9,10]

Given the rapid increase in non-operating room anesthesia (NORA) cases in recent years, it is expected that such cases will constitute the majority of procedures in the near future. Consequently, anesthesiologists will increasingly apply NORA practices in cardiac catheterization laboratories (CCL). In the CCL, although anesthesiologists and cardiologists may have different priorities, their shared objectives must remain patient safety, high-quality care, and favorable outcomes.

The purpose of this article is to share our experiences and provide insights that we believe will contribute to the current literature, with the aim of guiding the development of TAVI and Enhanced Recovery After Surgery (ERAS®) protocols anticipated to be established in the near future.

ERAS® Protocol

Since the publication of the first ERAS® consensus document for colon surgery in 2005, protocols have been developed and adapted to various specialties in numerous studies.[11-13] ERAS® is a multimodal, multidisciplinary care-improvement protocol designed to facilitate faster recovery for patients undergoing surgery during the perioperative period. These programs aim to encourage an earlier return to normal activities by minimizing complications.

The ERAS® protocol has been extensively researched and adapted for nearly all types of surgery. Its application in cardiovascular surgery is becoming increasingly widespread, with several studies recommending its use.[14,15] Although the ERAS® Association has not yet established a guideline specifically for NORA, the adoption of ERAS® protocols, particularly for major cardiac procedures, has been shown to reduce complications, enhance patient comfort and safety, and improve both the quality and efficiency of care.[16] While major cardiac procedures such as endovascular aneurysm repair, thoracic endovascular aneurysm repair, transcatheter mitral valve repair, and TAVI are not classified as surgical procedures, they are considered highly specialized and high-risk interventions. Research on applying the ERAS® protocol to TAVI is still in its early stages.[17] However, we anticipate that ERAS® principles will be applied to other cardiac procedures in the near future, leading to broader adoption.

The ERAS® protocol outlines recommended practices during the preoperative, intraoperative, and postoperative care phases for TAVI patients. Preoperative recommendations include optimizing nutrition, promoting mobilization, implementing physical therapy, and improving respiratory function. During intraoperative management, it is crucial for experienced cardiac anesthesiologists to lead the procedure, with a preference for short-acting anesthetics to minimize the risk of delirium and support early functional recovery. Postoperative care emphasizes the rapid removal of cannulas, catheters, and other devices; early ambulation; resumption of feeding and bowel/urinary function; and the use of non-opioid analgesia whenever possible.

ABBREVIATIONS

AVR	Aortic valve replacement
CAM-ICU	Confusion assessment method for the ICU
CCL	Cardiac catheterization laboratories
ERAS	Enhanced Recovery After Surgery
ICU	Intensive care unit
NORA	Non-operating room anesthesia
PARTNER I trials	Placement of Aortic Transcatheter Valves
POD	Postoperative delirium
PONV	Postoperative nausea and vomiting
RVP	Rapid ventricular pacing
TAVI	Transcatheter aortic valve replacement
TEE	Transesophageal echocardiography

Preoperative Management According to the ERAS® Protocol

Preoperative Patient Education

Prior to preparing for the TAVI procedure, preoperative education is provided for both the patient and their family members. All patients receive a detailed overview of the preoperative and postoperative care components, including nutrition, hydration, bowel preparation, and infection control, during their first outpatient visit. The patient and their next of kin are thoroughly informed about the perioperative ERAS® instructions, which include key goals for preoperative preparation. This education is delivered by a specialized education nurse trained in this field. The role of the dedicated education nurse is to guide patients through the preoperative process, addressing all their questions and alleviating any anxiety. Intensive preoperative education appears to have a positive impact on the hospital length of stay, particularly among patients enrolled in the ERAS® protocol.[18-20]

Frailty

Frailty is a complex, multisystem biological process characterized by a decline in physiological reserve associated with aging. It is increasingly common in surgical populations and has a significant impact on postoperative recovery.[21] Frailty is associated with various perioperative and postoperative complications, including prolonged postoperative recovery time, increased risk of stroke, extended hospital stays, and higher mortality rates. With an aging population and the growing number of elderly patients undergoing surgery, managing frailty during the perioperative period is poised to become one of the most significant challenges for healthcare providers.[22] The Clinical Frailty Scale, the Frailty Index, the Frailty Phenotype, and the Katz Index of Independence in Activities of Daily Living are the most commonly used tools for assessing frailty.[22,23] The TAVI patient population typically consists of high-risk elderly individuals with multiple comorbidities. The routine application of frailty indices prior to TAVI has been shown to be predictive of morbidity and mortality.[21,22,24] In our clinic, we prefer to use the Frailty Index for assessment.

Preoperative Period Habits

In patients with a history of alcohol abuse, metabolic stress response and immune function are often impaired. These individuals also face an increased risk of perioperative bleeding, wound infection, and cardiac complications. The risks rise

proportionally with the amount of alcohol consumed, and daily consumption exceeding five drinks or 60 grams of ethanol increases perioperative risk by 200–400%. To mitigate these risks, it is recommended to cease alcohol consumption at least four weeks before surgery.[25,26] Similarly, smokers have an increased risk of perioperative and postoperative complications.[27] The risk of perioperative complications is two to five times higher in patients with chronic heart or lung disease who smoke. Smoking also leads to increased mucus production and damage to the tracheal cilia, which raises the incidence of pulmonary infections. Respiratory function typically improves approximately eight weeks of smoking cessation.[27] Furthermore, smoking cessation at least four weeks before surgery has been shown to enhance wound healing.[28] In our clinic, we recommend that patients cease smoking and alcohol consumption at least four weeks prior to the TAVI procedure.

Preoperative Nutrition

Patients undergoing TAVI are typically elderly, have significant comorbidities, and may often be dependent and malnourished. Patients with malnutrition should be thoroughly evaluated before the procedure. Those with serum albumin levels below 3.0 g/dL should initiate oral nutritional support 7 to 10 days prior to the procedure.[14] As part of preoperative preparation, a specific dietary program focusing on healthy eating, increased protein intake, and reduced sodium intake is recommended. The ERAS® Association advises oral intake of clear fluids up to 2–4 hours before anesthesia induction to maintain hydration. The ERAS® guidelines further recommend the intake of a clear drink containing 12.5% carbohydrate with appropriate safety content: 800 mL the night before surgery and 400 mL two hours before surgery.[12] Studies have demonstrated that consuming oral clear fluids up to two hours before the induction of anesthesia does not increase the risk of aspiration, enhances patient satisfaction, and helps maintain fluid and electrolyte balance. Additionally, it promotes wound healing, reduces infection rates, shortens operative time (particularly in major surgeries), and decreases postoperative nausea and vomiting.[29] However, in TAVI patients, the absolute fasting period should be extended to six hours due to the increased risk of aspiration, especially in patients scheduled for transesophageal echocardiography (TEE) for valve control after the procedure.[14]

Preoperative Anemia

Preoperative anemia is an independent predictor of postoperative complications and mortality.[30,31] Given that TAVI patients are typically elderly and chronically ill, the prevalence of chronic anemia in this population is high.[32] While TAVI is not typically associated with a high risk of bleeding under normal circumstances, correcting anemia preoperatively is crucial. The etiology of anemia should be thoroughly investigated and addressed before the procedure. As recommended by the ERAS® protocol, iron, folate, vitamin B12 supplements, and/or erythropoietin should be administered according to the patient's specific deficiencies, starting at least 3–4 weeks prior to the elective procedures.[25] While blood transfusion may be considered for patients with severe anemia and/or those at risk of excessive blood loss, it is important to remember that transfusion-related complications are associated with increased mortality and morbidity.[33]

Cognitive Assessment

Cognitive dysfunction has been linked to prolonged postoperative hospitalization, increased complications, and higher long-term mortality rates.[34] The Mini-Cog test is a simple, three-step assessment (tree-word registration, clock drawing, and tree-word recall). It is effective in identifying potential cases of post-procedural cognitive decline and patients at risk of delirium.[35] If a Mini-Cog score is ≤ 3 or if the clock drawing is abnormal, the patient should be referred for a formal geriatric neurological evaluation. If cognitive impairment is identified early using the Mini-Cog test, it becomes possible to anticipate which patients are at the highest risk for delirium following a TAVI procedure. Postoperative delirium (POD) is characterized by the decompensation of cerebral function in response to stressors such as major surgery.[36] POD is a common complication after TAVI due to the advanced age and frailty of the patient population. Patients experiencing POD after TAVI have double the length of hospital stay and nearly a threefold increased risk of post-procedure rehospitalization and mortality.[37]

Perioperative Management According to the ERAS® Protocol

Prevention of Hypothermia

Perioperative hypothermia is defined as a drop in body temperature below 36˚C, starting within one hour before anesthesia and continuing into the postoperative period.[38] Perioperative hypothermia can lead to numerous complications, including prolonged anesthetic drug effects, impaired coagulation, increased bleeding, a greater need for transfusions, heightened risk of wound infections, extended hospital stays, postoperative tremors. Additionally, it can elevate anxiety, oxygen consumption, heart rate, blood pressure, and plasma catecholamine levels, all of which are critical to patient safety and satisfaction.[39] Since TAVI patients are often elderly, they are more susceptible to rapid and frequent occurrences of perioperative hypothermia. To prevent hypothermia, patients should remain covered during transfer to the operating room. In the operating room, perioperative temperature should be monitored continuously. Normothermia should be maintained using heating blankets, forced-air heaters, and similar devices both before and after anesthesia.[40] Studies have shown that initiating active warming preoperatively is effective in preventing hypothermia during the perioperative period.[41]

Anesthesia Administration

TAVI patients should be anesthetized by an experienced cardiac anesthesiologist capable of managing both the high-risk patient population and the complex hemodynamic challenges of the procedure. The choice of anesthetic technique during TAVI often correlates with the learning curve of the procedural team. With growing team experience, advancements in valve technology, and improvements in imaging techniques, conscious sedation has gained prominence as the preferred approach. Conscious sedation offers several advantages, including early detection of neurological complications (e.g., delirium), shorter procedural times, quicker recovery, and reduced postoperative care needs.[42] However, general anesthesia is preferred in cases where TEE is required during the procedure or in patients with difficult valve placements. One should be prepared for any hemodynamic

instability during the procedure, ensuring both adequate monitoring and the availability of emergency medications. Monitoring should include a 5-electrode electrocardiogram, pulse oximetry, capnography, body temperature measurement, invasive arterial monitoring, bladder catheterization, external defibrillator pads, and a central venous catheter if required. Monitoring tools such as bispectral index and near-infrared spectroscopy (NIRS) should also be utilized as needed. Emergency medications, including vasopressors and inotropic agents, must be readily available. A significant decrease in cerebral NIRS values has been observed during systemic hypotension induced in the rapid ventricular pacing (RVP) phase of the TAVI procedure. When NIRS values remain significantly low during RVP, the risk of cerebral complications and delirium may increase.[43] At our center, NIRS monitoring is routinely performed during the TAVI procedure to enable early detection of cerebral events. In terms of drug selection, short-acting anesthetics should be prioritized, while benzodiazepines should be avoided due to their association with increased delirium incidence. Agents with strong cardiac depressant effects, such as propofol and barbiturates, should be used cautiously. Opioids should be administered at the lowest possible doses. Nonsteroidal anti-inflammatory drugs should be avoided for pain control at the end of the procedure due to their risks of platelet dysfunction and kidney damage. Instead, paracetamol should be administered at regular intervals as an alternative to opioid analgesics.

Fluid Management

An essential component of the ERAS program is maintaining fluid and electrolyte balance and ensuring adequate tissue perfusion. Studies have shown that targeted fluid therapy reduces postoperative morbidity in high-risk patients undergoing major surgery.[44,45] High-risk patients are defined as those with limited physiological reserve, severe cardiopulmonary or valvular disease, renal or hepatic insufficiency, or those scheduled for extensive surgical procedures.[46] As TAVI patients fall into this high-risk category, the application of targeted fluid therapy is critical. The goal of targeted fluid therapy is to maintain normovolemia, using advanced monitoring devices that measure pulse volume variation, pulse pressure variation, and cardiac index.[29] In our clinic, we routinely implement targeted fluid therapy for TAVI patients.

Management of Postoperative Nausea and Vomiting

The overall incidence of postoperative nausea and vomiting (PONV), one of the most unpleasant experiences during the perioperative and postoperative periods, is estimated to be 20-30%. In high-risk patients, this rate can increase to as high as 70%.[47] Several risk factors contribute to the occurrence of PONV. Female gender, a history of motion sickness or PONV, and non-smoking status are notable risk factors. Anesthetic factors, such as the liberal use of volatile anesthetic gases, nitrous oxide, and opioids, also play a significant role in the development of PONV. Furthermore, the risk of PONV rises with the duration of the procedure, as prolonged use of anesthetic agents further increases susceptibility.[48] The Apfel score is the most commonly used tool to predict the risk of PONV. It is particularly effective when combined with targeted therapeutic interventions, especially in high-risk patients.[49,50]

To prevent PONV, agents known to induce vomiting should be avoided during the perioperative period, and a combination of antiemetics should be used.[48] Additional strategies to reduce nausea and vomiting include administering high concentrations of oxygen during anesthesia, minimizing fasting time, incorporating carbohydrate loading in the preoperative period, and opting for regional anesthesia techniques whenever possible. Opioids should also be avoided for postoperative pain control.

As recommended by the ERAS® protocol, a multimodal approach should be adopted for PONV prophylaxis. Patients with one or two of the aforementioned risk factors should receive two-drug combination prophylaxis using first-line antiemetics, such as serotonin antagonists (e.g., ondansetron), dopamine antagonists (e.g., droperidol), and corticosteroids (e.g., dexamethasone). If PONV persists despite this two-drug prophylaxis, treatment should involve agents from different drug classes than those used for prophylaxis, including antihistamines (e.g., promethazine), anticholinergics (e.g., scopolamine), and other second-line agents such as metoclopramide.[48]

Postoperative Management According to the ERAS® Protocol

If the patient's hemodynamics are stable the same day as the procedure, it is recommended to discontinue invasive monitoring (e.g., invasive arterial catheter, urinary catheter, etc.) and transition to noninvasive monitoring. Since the introduction of transcatheter aortic valve replacement (TAVI) in 2002, techniques for advanced vascular access and closure have evolved rapidly due to technological advancements and increased practitioner experience. Although these advances have reduced the incidence of vascular complications, such complications remain among the most serious and frequent issues.[51] Arterial or venous sheaths inserted during the procedure should be removed and inspected at regular intervals, provided the clotting time is less than 140 seconds.[17]

Delirium in the Intensive Care Unit

Patients must be monitored in the intensive care unit (ICU) following a TAVI procedure. These patients are at high risk for delirium due to their intensive care unit stay, advanced age, and multiple comorbidities. As such, routine screening for delirium is essential, with appropriate treatment initiated as necessary. Several screening tools are available for detecting delirium in the ICU. The Confusion Assessment Method for the ICU (CAM-ICU) and the Intensive Care Delirium Screening Checklist are the most commonly used tools. CAM-ICU is particularly user-friendly and practical. Patients are classified as "CAM positive" if they have delirium and "CAM negative" if they do not exhibit symptoms of delirium.[52] In our clinic, we routinely use CAM-ICU for delirium screening in patients.

Respiratory Exercises

General anesthesia is associated with a higher incidence of postoperative pulmonary complications,[53] which can impact postoperative mortality and morbidity. These potential complications should be carefully considered when selecting an anesthetic approach. In studies conducted during the development of the ERAS® protocol, it is recommended that each patient receive incentive spirometry training during the preoperative period and maintain a chart for volume monitoring.[54] In the postoperative

period, once the patient is admitted to the intensive care unit, regular respiratory physiotherapy should be supplemented with the use of incentive spirometry and consistent chart documentation. This should be encouraged at regular intervals, either by the patient or with the assistance of a relative or nurse.[17]

Mobilization

Early mobilization is a key component of the ERAS® protocol and is strongly recommended. The timing of mobilization varies based on the location and extent of the surgical procedure.[18] For TAVI patients, early mobilization guidelines recommend that patients should be out of bed and seated in a chair within six hours following a transfemoral approach or within three hours for alternative approaches (e.g., transaortic, transapical, suprasternal, or subclavian).[17] Patients who undergo early procedures are encouraged to begin walking on the same day, while those undergoing later procedures should start walking early the next morning. Walking three laps around the unit is recommended as a daily walking goal. A physiotherapist or nurse should accompany the patient during these walks. Daily walking distances should be recorded and reviewed by the physician.

Postoperative Analgesia

Several studies have shown that opioid use in the ICU can increase the likelihood of delirium, particularly in elderly patients.[55,56] However, it is also important to note that untreated severe pain can predispose patients to delirium.[56] For TAVI patients, severe postoperative pain is generally not expected if the procedure concludes without complications. Regular administration of paracetamol is typically sufficient for pain management. Nonsteroidal anti-inflammatory drugs should be avoided when possible due to their potential to cause platelet dysfunction and kidney damage.

Discharge

As TAVI patients are high-risk individuals, their care continues at home or in a care center after hospital discharge. If necessary, additional support, such as nursing or physiotherapy, may be provided. In the absence of complications, patients are usually monitored in the intensive care unit on the day of the procedure and discharged within two to three days. A few days after discharge, the patient is contacted by phone to obtain information about their recovery. A follow-up visit is scheduled within one month, usually around two weeks after discharge.[57] This check-up is conducted by interventional cardiologists, accompanied by a cardiologist experienced in TAVI imaging, particularly echocardiography, and involved in the TAVI procedure. After the initial check-up, the patient should attend follow-up appointments at regular intervals (e.g., every 30 days to 3 months) for a duration of 12 months. Following this period, regular cardiac rehabilitation is recommended.

Conclusion

While the ERAS® protocol has become routine practice in many surgical specialties, its application to the TAVI procedure is relatively new. TAVI patients are high-risk and fragile. We believe that managing these patients with a multidisciplinary approach, such as the ERAS® protocol, during the preoperative, intraoperative, and postoperative periods will reduce morbidity and mortality, enhance patient satisfaction, and lower hospital costs.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – H.Y.A., M.Y.; Design – A.Y.; Supervision – K.E.; Resource – E.Ö.B.Ö.; Analysis and/or Interpretation – Y.Ö.; Literature Review – Z.S., S.M.D.; Writing – H.Y.A., K.E.; Critical Review – M.Y.

Use of AI for Writing Assistance: No artificial intelligence-assisted technologies were used in this article.

Conflict of Interest: The authors have no conflicts of interest to declare.

Funding: The authors declared that this study received no financial support.

References

1. Webb JG, Blanke P, Meier D, et al. TAVI in 2022: Remaining issues and future direction. *Arch Cardiovasc Dis*. 2022;115(4):235-242. [CrossRef]
2. Postolache A, Sperlongano S, Lancellotti P. TAVI after more than 20 years. *J Clin Med*. 2023;12(17):5645. [CrossRef]
3. Reardon MJ, Van Mieghem NM, Popma JJ, et al. Surgical or transcatheter aortic-valve replacement in intermediate-risk patients. *N Engl J Med*. 2017;376(14):1321-1331. [CrossRef]
4. Leon MB, Smith CR, Mack MJ, et al. Transcatheter or surgical aortic-valve replacement in intermediate-risk patients. *N Engl J Med*. 2016;374(17):1609-1620. [CrossRef]
5. Popma JJ, Deeb GM, Yakubov SJ, et al. Transcatheter aortic-valve replacement with a self-expanding valve in low-risk patients. *N Engl J Med*. 2019;380(18):1706-1715. [CrossRef]
6. Mack MJ, Leon MB, Thourani VH, et al. Transcatheter aortic-valve replacement with a balloon-expandable valve in low-risk patients. *N Engl J Med*. 2019;380(18):1695-1705. [CrossRef]
7. Costa G, Zappulla P, Barbanti M, et al. Pacemaker dependency after transcatheter aortic valve implantation: Incidence, predictors and long-term outcomes. *EuroIntervention*. 2019;15(10):875-883. [CrossRef]
8. Carroll JD, Mack MJ, Vemulapalli S, et al. STS-ACC TVT registry of transcatheter aortic valve replacement. *J Am Coll Cardiol*. 2020;76(21):2492-2516. [CrossRef]
9. Kapadia SR, Leon MB, Makkar RR, et al. 5-year outcomes of transcatheter aortic valve replacement compared with standard treatment for patients with inoperable aortic stenosis (PARTNER 1): A randomised controlled trial. *Lancet*. 2015;385(9986):2485-2491. [CrossRef]
10. Díez JG. Transcatheter aortic valve implantation (TAVI): The hype and the hope. *Tex Heart Inst J*. 2013;40(3):298-301.
11. Fearon KC, Ljungqvist O, Von Meyenfeldt M, et al. Enhanced recovery after surgery: A consensus review of clinical care for patients undergoing colonic resection. *Clin Nutr*. 2005;24(3):466-477. [CrossRef]
12. Brindle M, Nelson G, Lobo DN, Ljungqvist O, Gustafsson UO. Recommendations from the ERAS® Society for standards for the development of enhanced recovery after surgery guidelines. *BJS Open*. 2020;4(1):157-163. [CrossRef]
13. He L, Lu L, Su S, Lin Q, Sheng C. Top 100 most-cited articles on enhanced recovery after surgery: A bibliometric analysis and visualized study. *Front Surg*. 2022;9:845946. [CrossRef]
14. Engelman DT, Ben Ali W, Williams JB, et al. Guidelines for perioperative care in cardiac surgery: Enhanced recovery after surgery society recommendations. *JAMA Surg*. 2019;154(8):755-766. [CrossRef]
15. McGinigle KL, Spangler EL, Pichel AC, et al. Perioperative care in open aortic vascular surgery: A consensus statement by the Enhanced Recovery After Surgery (ERAS) Society and Society for Vascular Surgery. *J Vasc Surg*. 2022;75(6):1796-1820. [CrossRef]
16. Erkalp K. Girişimsel kardiyolojide ameliyathane dışı anestezi uygulamalarında ERAS®'ın hasta güvenliği üzerine etkileri. In: Erkalp K, Salihoğlu Z, eds. *Kardiyovasküler Cerrahi ile Girişimsel Kardiyolojide ERAS® Etkileri*. 1st ed. Ankara, Türkiye: Türkiye Klinikleri; 2021:78-80.

17. Sola M, Ramm CJ, Kolarczyk LM, et al. Application of a multidisciplinary enhanced recovery after surgery pathway to improve patient outcomes after transcatheter aortic valve implantation. *Am J Cardiol*. 2016;118(3):418-423. [CrossRef]
18. Cavallaro P, Bordeianou L. Implementation of an ERAS pathway in colorectal surgery. *Clin Colon Rectal Surg*. 2019;32(2):102-108. [CrossRef]
19. Yediyıldız MB, Yılmaz R, Büyükbezirci G, et al. Evaluation of the relationship between preoperative patient anxiety level and health literacy. *J Contemp Med*. 2023;13(3):540-544. [CrossRef]
20. Younis J, Salerno G, Fanto D, Hadjipavlou M, Chellar D, Trickett JP. Focused preoperative patient stoma education, prior to ileostomy formation after anterior resection, contributes to a reduction in delayed discharge within the enhanced recovery programme. *Int J Colorectal Dis*. 2012;27(1):43-47. [CrossRef]
21. Green P, Woglom AE, Genereux P, et al. The impact of frailty status on survival after transcatheter aortic valve replacement in older adults with severe aortic stenosis: A single-center experience. *JACC Cardiovasc Interv*. 2012;5(9):974-981. [CrossRef]
22. Puls M, Sobisiak B, Bleckmann A, et al. Impact of frailty on short- and long-term morbidity and mortality after transcatheter aortic valve implantation: Risk assessment by Katz Index of activities of daily living. *EuroIntervention*. 2014;10(5):609-619. [CrossRef]
23. Theou O, Squires E, Mallery K, et al. What do we know about frailty in the acute care setting? A scoping review. *BMC Geriatr*. 2018;18(1):139. [CrossRef]
24. Stortecky S, Schoenenberger AW, Moser A, et al. Evaluation of multidimensional geriatric assessment as a predictor of mortality and cardiovascular events after transcatheter aortic valve implantation. *JACC Cardiovasc Interv*. 2012;5(5):489-496. [CrossRef]
25. Feldheiser A, Aziz O, Baldini G, et al. Enhanced Recovery After Surgery (ERAS) for gastrointestinal surgery, part 2: Consensus statement for anaesthesia practice. *Acta Anaesthesiol Scand*. 2016;60(3):289-334. [CrossRef]
26. Tonnesen H, Rosenberg J, Nielsen HJ, et al. Effect of preoperative abstinence on poor postoperative outcome in alcohol misusers: Randomised controlled trial. *BMJ*. 1999;318(7194):1311-1316. [CrossRef]
27. Mitchell C, Garrahy P, Peake P. Postoperative respiratory morbidity: Identification and risk factors. *Aust N Z J Surg*. 1982;52(2):203-209. [CrossRef]
28. Sorensen LT, Karlsmark T, Gottrup F. Abstinence from smoking reduces incisional wound infection: A randomized controlled trial. *Ann Surg*. 2003;238(1):1-5. [CrossRef]
29. Brown JK, Singh K, Dumitru R, Chan E, Kim MP. The benefits of enhanced recovery after surgery programs and their application in cardiothoracic surgery. *Methodist Debakey Cardiovasc J*. 2018;14(2):77-88. [CrossRef]
30. Leichtle SW, Mouawad NJ, Lampman R, Singal B, Cleary RK. Does preoperative anemia adversely affect colon and rectal surgery outcomes? *J Am Coll Surg*. 2011;212(2):187-194. [CrossRef]
31. Musallam KM, Tamim HM, Richards T, et al. Preoperative anaemia and postoperative outcomes in non-cardiac surgery: A retrospective cohort study. *Lancet*. 2011;378(9800):1396-1407. [CrossRef]
32. Rheude T, Pellegrini C, Michel J, et al. Prognostic impact of anemia and iron-deficiency anemia in a contemporary cohort of patients undergoing transcatheter aortic valve implantation. *Int J Cardiol*. 2017;244:93-99. [CrossRef]
33. Shander A, Javidroozi M, Ozawa S, Hare GM. What is really dangerous: Anaemia or transfusion? *Br J Anaesth*. 2011;107(1):i41-i59. [CrossRef]
34. Yajima S, Nakanishi Y, Matsumoto S, et al. The mini-cog: A simple screening tool for cognitive impairment useful in predicting the risk of delirium after major urological cancer surgery. *Geriatr Gerontol Int*. 2022;22(4):319-324. [CrossRef]
35. Borson S, Scanlan J, Brush M, Vitaliano P, Dokmak A. The mini-cog: A cognitive 'vital signs' measure for dementia screening in multi-lingual elderly. *Int J Geriatr Psychiatry*. 2000;15(11):1021-1027. [CrossRef]
36. van der Wulp K, van Wely M, van Heijningen L, et al. Delirium after transcatheter aortic valve implantation under general anesthesia: Incidence, predictors, and relation to long-term survival. *J Am Geriatr Soc*. 2019;67(11):2325-2330. [CrossRef]
37. Tilley E, Psaltis PJ, Loetscher T, et al. Meta-analysis of prevalence and risk factors for delirium after transcatheter aortic valve implantation. *Am J Cardiol*. 2018;122(11):1917-1923. [CrossRef]
38. Rauch S, Miller C, Bräuer A, Wallner B, Bock M, Paal P. Perioperative hypothermia-A narrative review. *Int J Environ Res Public Health*. 2021;18(16):8749. [CrossRef]
39. Simegn GD, Bayable SD, Fetene MB. Prevention and management of perioperative hypothermia in adult elective surgical patients: A systematic review. *Ann Med Surg*. 2021;72:103059. [CrossRef]
40. Burger L, Fitzpatrick J. Prevention of inadvertent perioperative hypothermia. *Br J Nurs*. 2009;18(18):1114-1119. [CrossRef]
41. Moola S, Lockwood C. Effectiveness of strategies for the management and/or prevention of hypothermia within the adult perioperative environment. *Int J Evid Based Healthc*. 2011;9(4):337-345. [CrossRef]
42. Ak HY. Anesthetist approach to transcatheter aortic valve implantation (TAVI). *Kosuyolu Heart J*. 2018;21(1):91-92. Turkish. [CrossRef]
43. Seppelt PC, Mas-Peiro S, De Rosa R, et al. Dynamics of cerebral oxygenation during rapid ventricular pacing and its impact on outcome in transfemoral transcatheter aortic valve implantation. *Catheter Cardiovasc Interv*. 2021;97(1):E146-E153. [CrossRef]
44. Miller TE, Roche AM, Mythen M. Fluid management and goal-directed therapy as an adjunct to Enhanced Recovery After Surgery (ERAS). *Can J Anaesth*. 2015;62(2):158-168. [CrossRef]
45. Hamilton MA, Cecconi M, Rhodes A. A systematic review and meta-analysis on the use of preemptive hemodynamic intervention to improve postoperative outcomes in moderate and high-risk surgical patients. *Anesth Analg*. 2011;112(6):1392-1402. [CrossRef]
46. Pearse RM, Harrison DA, MacDonald N, et al; OPTIMISE Study Group. Effect of a perioperative, cardiac output-guided hemodynamic therapy algorithm on outcomes following major gastrointestinal surgery: A randomized clinical trial and systematic review. *JAMA*. 2014;311(21):2181-2190. Erratum in: *JAMA*. 2014;312(14):1473. [CrossRef]
47. Gan TJ, Meyer TA, Apfel CC, et al. Society for ambulatory anesthesia guidelines for the management of postoperative nausea and vomiting. *Anesth Analg*. 2007;105(6):1615-1628. [CrossRef]
48. Gustafsson UO, Scott MJ, Hubner M, et al. Guidelines for perioperative care in elective colorectal surgery: Enhanced Recovery After Surgery (ERAS®) Society recommendations: 2018. *World J Surg*. 2019;43(3):659-695. [CrossRef]
49. Apfel CC, Korttila K, Abdalla M, et al. A factorial trial of six interventions for the prevention of postoperative nausea and vomiting. *N Engl J Med*. 2004;350(24):2441-2451. [CrossRef]
50. Kappen TH, Moons KG, van Wolfswinkel L, Kalkman CJ, Vergouwe Y, van Klei WA. Impact of risk assessments on prophylactic antiemetic prescription and the incidence of postoperative nausea and vomiting: A cluster-randomized trial. *Anesthesiology*. 2014;120(2):343-354. [CrossRef]
51. Sardar MR, Goldsweig AM, Abbott JD, et al. Vascular complications associated with transcatheter aortic valve replacement. *Vasc Med*. 2017;22(3):234-244. [CrossRef]
52. Raiten JM, Gutsche JT, Horak J, Augoustides JG. Critical care management of patients following transcatheter aortic valve replacement. *F1000Res*. 2013;2:62. [CrossRef]
53. Kirmeier E, Eriksson LI, Lewald H, et al; POPULAR Contributors. Post-anaesthesia pulmonary complications after use of muscle relaxants (POPULAR): A multicentre, prospective observational study. *Lancet Respir Med*. 2019;7(2):129-140. Erratum in: *Lancet Respir Med*. 2019;7(2):e9. [CrossRef]

54. Swaminathan N, Kundra P, Ravi R, Kate V. ERAS protocol with respiratory prehabilitation versus conventional perioperative protocol in elective gastrectomy- A randomized controlled trial. *Int J Surg*. 2020;81:149–157. [CrossRef]
55. Duprey MS, Dijkstra-Kersten SMA, Zaal IJ, et al. Opioid use increases the risk of delirium in critically ill adults independently of pain. *Am J Respir Crit Care Med*. 2021;204(5):566–572. [CrossRef]
56. Clegg A, Young JB. Which medications to avoid in people at risk of delirium: A systematic review. *Age Ageing*. 2011;40(1):23–29. [CrossRef]
57. Fortmeier V, Rudolph TK. Follow up management after transcatheter aortic valve implantation. *Dtsch Med Wochenschr*. 2022;147(16):1047–1055. German. [CrossRef]