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Editorial

ERAS/STS 2024 Expert Consensus Statement on Perioperative Care in Cardiac Surgery: Continuing the Evolution of Optimized Patient Care and Recovery

Enhanced recovery after surgery (ERAS) protocols were first introduced for colorectal surgery in 2005.[1] Although efforts to improve patient outcomes have been ongoing for decades in the cardiac surgery, anesthesia, and critical care communities, it was not until more recently that such efforts have been pursued under the umbrella of enhanced recovery.[2] It was not long ago, in 2018, that the JCVA published one of the first review articles on enhanced recovery programs (ERPs) for cardiac surgery, highlighting the potential program elements—and the lack of evidence to support many of them.[3] In fact, shortly thereafter, the JCVA published an editorial making the case for enhanced recovery in cardiac surgery as a legitimate concept.[4] It was only 1 year later that the Enhanced Recovery After Cardiac Surgery Society (ERAS® Cardiac) published the first set of recommendations for perioperative care of cardiac surgical patients.[5]

Since then, there has been significant growth in the interest and application of enhanced recovery elements described in those original recommendations, as well as pursuit of new opportunities to optimize care and improve patient recovery. These multidisciplinary multinational efforts have led to the recent publication of *Perioperative Care in Cardiac Surgery: A Joint Consensus Statement by the Enhanced Recovery After Surgery (ERAS) Cardiac Society, ERAS International Society, and The Society of Thoracic Surgeons (STS)*.[6] This expert consensus document (ECD) highlights 23 care elements, many of which were not included in the original 2019 recommendations (Table 1).[5,6]

After publication of the ERAS Cardiac recommendations in 2019, a group of international anesthesiologists and critical care physicians wrote an editorial hailing it as "an important first step," discussing several key elements, and identifying important "next steps."[7] In this current editorial, a similar group of physicians with expertise in perioperative care comment on the 2024 ECD and propose ideas on future directions.

Patient-Centered Care

Outcomes such as mortality, morbidity, and length of stay are valuable measures for improving patient care; however, the burden of surgery and subsequent recovery is borne by patients and their caregivers. Patient-centered care shifts the focus toward individual experience (illness, surgery, and recovery), healthcare priorities, personal values, and quality of life.[8] The 2024 EDC includes statements about patient engagement, patient-reported outcomes, and shared decision making. It is encouraging to see the incorporation of patient-centered metrics, such as quality of functional recovery, as primary outcomes in cardiac surgical trials.[9,10] Patient-reported outcome measures (PROMs) allow a patient to report their health, quality of life, or functional status in various domains: pain, physical, self-care, cognitive, emotional, psychological, and social.[11,12] Several PROM questionnaires have been used in cardiac surgery patients, although the questionnaires used, collection of baseline data, and time points for questionnaire delivery have been inconsistent.[13,14] For the effective use of PROMs in research, ERP development, patient-oriented perioperative care, and quality improvement initiatives, there needs to be consensus—including patient input—regarding which measures should be used and on standardizing their administration.

In comparison, patient-reported experience measures (PREMs) are focused on the patient's experience and satisfaction, with particular attention given to communication with healthcare teams, responsiveness of hospital staff, hospital environment, and discharge planning.[12] Transition of care, discharge planning, and communication have been identified as areas for improvement, and addressing them may improve patient compliance with medication instructions and reduced readmissions.[15–17] Potential areas for continued measurement and improvement of PREMs that fit within the ERP paradigm include personalization of protocols and pathways, provision

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Table 1
Summary of Elements from the ERAS Cardiac-STS 2024 Expert Consensus Document and Comparison with Previous 2019 ERAS Cardiac Recommendations for Perioperative Care in Cardiac Surgery[5,6]

Care Element	JAMA 2019	ATS 2024
Patient engagement through shared decision-making	LOE IIa; COR C-LD	Low
Establishment of multidisciplinary team	*Not included*	Moderate
Auditing of process measures for program adherence and clinical outcomes	*Not included*	Moderate
Multifaceted screening and risk assessment	*Not included*	Moderate
Multicomponent prehabilitation	LOE IIa; COR B-R	Low
Limiting NPO status for clear fluids to >2 hours before surgery	LOE IIb; COR C-LD	Low
TEE in moderate-risk or high-risk patients.	*Not Included*	Moderate
Mechanical ventilation with lung protective strategies	*Not Included*	High
Continuing mechanical ventilation while on CPB	*Not Included*	Moderate
Avoiding PA catheters in low-risk patients	*Not Included*	Moderate
Standard use of CNS monitoring	*Not Included*	Moderate
Risk assessment and prophylaxis for PONV	*Not included*	Moderate
Goal-directed perfusion while on CPB	*Not included*	Low
Facilitate extubation within 6 hours of surgery	LOE IIa; COR B-R	Moderate
Selective use of intraoperative or immediate postoperative extubation in low-risk patients	*Not included*	Low
Screening and comprehensive care model to reduce AKI	LOE IIa; COR B-R	Moderate
Early postoperative ambulation and upper extremity exercise	*Not included*	Moderate
Goal-directed fluid and hemodynamic therapy.	LOE I; COR B-R	Moderate
Multimodal analgesia with opioid stewardship.	LOE I; COR B-NR	Moderate
Chest wall regional analgesia	*Not included*	Moderate
Comprehensive patient blood management program	*Not included*	Moderate
Prevention of postoperative atrial fibrillation	*Not included*	Moderate
Routine systematic screening and nonpharmacologic treatment of postoperative delirium	LOE I; COR B-NR	High
Surgical site infection reduction bundle	LOE I; COR B-R	High

Recommendations are categorized by the Level of Evidence: high, moderate, and low, including the grading for similar elements (if included) from the previous 2019 recommendations.
Abbreviations: AKI, acute kidney injury; ATS, *Annals of Thoracic Surgery*; CNS, central nervous system; CPB; cardiopulmonary bypass, COR, confidence of recommendation; JAMA, *Journal of the American Medical Association*; LOE, level of evidence; NPO, nil per os; PA, pulmonary artery; PONV, postoperative nausea and vomiting; TEE, transesophageal echocardiography.

of timely health status updates and patient education, improvements in the hospital environment, and options for patients for self-reporting concerns and recovery progress.

Finally, an area that has not been well studied in the cardiac surgical population is post-intensive care syndrome (PICS), in which the patient experiences new/worsening impairment that persists beyond discharge in at least 1 of the physical, cognitive, and mental health status domains.[18-20] The incidence of PICS in the general critical care population can be as high as 50% at 1 year, often with deficits in multiple domains.[21,22] The pathophysiology is multifactorial: inflammation, catabolism and anabolic resistance, mitochondrial dysfunction, impaired cellular/tissue regeneration, immune suppression, muscle wasting, neuropsychiatric disorders, delirium, and chronic organ injury can all contribute.[23] PICS has been associated with psychological and emotional distress, financial loss, and even increased mortality.[24-26] Formal screening tools for PICS have been proposed.[27] Efforts to prevent or treat PICS have included community-based physical therapy, various peer-support and transitional care models, increased post-discharge follow-up, and post-intensive care unit (ICU) recovery centers; the efficacy of these interventions have yet to be fully studied, however.[18,20,28-31] Unfortunately, studies on the incidence, prevention, detection, and treatment for PICS have been conducted almost exclusively in the general intensive care patient population. Very little is known about this entity in cardiac surgery, making it an interesting area for future study within the perioperative patient-centered care paradigm, including the establishment of systematic screening and reporting.[32,33]

Prehabilitation and Nutrition

Preparing a patient for surgery includes ensuring that their physical and mental status is optimized and their physiologic reserve is maximized prior to undergoing the stresses of cardiac surgery in the recovery thereafter.[34] The 2024 ECD advocated for multicomponent prehabilitation, which has been described as a 3-legged model of prehabilitation comprising physical exercise, identifying and correcting nutritional deficiency, and psychological/cognitive assessment and counseling.[35] Preliminary evidence has shown that this is beneficial in reducing postoperative complications, muscle wasting, and length of stay.[36,37] However, prehabilitation has yet to be universally adopted and is not done in many cardiac surgical centers. Numerous obstacles to adoption have been identified, including cost, poor interdisciplinary communication, a limited preoperative intervention window, and patient education and participation.[38-42] Given the significant resource demands required to establish and maintain a prehabilitation program, any best-practice and implementation recommendations from societies such as ERAS Cardiac may help reduce the barriers

to entry. Additional evidence is needed to clarify certain questions: how long is prehabilitation required to be effective, is it safe, and what are the minimum components required to derive benefit?[43] Prospective studies of prehabilitation in cardiac surgery patients are underway, and hopefully the results will lead to clinical recommendations similar to those that currently exist for noncardiac surgery.[44-46]

Although multicomponent prehabilitation includes preoperative nutritional optimization, nutritional support throughout the perioperative period is not included in the 2024 ECD. The effects of inadequate nutritional support are well documented in the critical care literature. Acute nutritional deficiencies, further aggravated by any preexisting malnutrition, can lead to loss of muscle mass, increased infection, and organ dysfunction.[47,48] Ultimately, this has been shown to result in delayed weaning from mechanical ventilation, increased ICU length of stay, high readmission rates, greater healthcare costs, poor functional recovery, and reduced quality of life after hospital discharge.[49-54] Nutritional deficiency and delayed correction frequently occur in the cardiac surgery population, illuminating a knowledge gap for further improvements and making it a potential target for standardized care protocols to further improve patient outcomes.[52,55-57] Should additional evidence for nutritional support in cardiac surgery patients become available, including the roles of enteral nutrition, parenteral supplementation, immune modulating agents, and micronutrients, this may become a consideration for future ERP recommendations.

Hemodynamic Management

Hemodynamic management is a mainstay of perioperative care in cardiac surgical patients. Although goal-directed therapy is included in the 2024 ECD, additional areas remain to be explored moving forward. One such area is to modernize the traditional approach of setting the same minimally acceptable mean arterial pressure (often 65 mmHg) for most patients and instead consider individualized goals for pressure, flow, and oxygen delivery. Personalized hemodynamic management and patient-specific resuscitation are concepts that have been described in the noncardiac literature.[58-60] These concepts involve setting hemodynamic goals based on the patient's measures of autoregulation, baseline blood pressure, and clinical features of adequate oxygen delivery, then adjusting these goals during the dynamic resuscitation and recovery phase.[58,59,61] If this approach is pursued in cardiac surgery patients, there likely will need to be additional considerations for patients with elevated venous pressure. Volume overload has been associated with prolonged ventilation, kidney injury, cognitive dysfunction, and increased length of stay following cardiac surgery.[62-64] Setting a goal for mean perfusion pressure rather than arterial pressure alone may improve outcomes.[65,66] The use of point-of-care ultrasound to measure hepatic and portal vein flow parameters may offer noninvasive detection of organ congestion and risks for morbidity, including kidney injury and delirium.[67-70] Finally, continued development of monitoring technology for measuring oxygen delivery at the cellular/mitochondrial level may provide more suitable targets for adjusting hemodynamic goals.[71-73]

Beyond providing clinicians with pressure measurements, invasive arterial monitoring itself has potentially disruptive developments on the horizon. An arterial waveform generated from invasive monitoring provides significantly more information than can be appreciated by the naked eye.[74] Mulder et al. evaluated 45 different waveform features in a computer model of hemodynamic instability and identified principal components that can distinguish intravascular volume, left ventricular contractility, or systemic vascular resistance as the primary cause.[75] Furthermore, analysis of the arterial waveforms also has been show to aid the prediction of impending hypotension. Machine learning was applied to a database of 1,334 surgical and ICU patients, with more than 500,000 minutes of arterial monitoring and a combined 3,022 waveform features per cardiac cycle.[76] This resulted in the generation of an algorithm that can reliably predict hypotension as much as 15 minutes before the event occurs, with better sensitivity and specificity than other common parameters currently used clinically in noncardiac surgery.[77] This algorithm since has been shown to predict hypotensive events in elective cardiac surgery patients between 5 and 15 minutes beforehand, with sensitivity and specificity in the range of 74% to 84%.[78] Finally, the recently completed HYPE-2 trial (results not yet published) evaluated the effect of intervening on hypotension prediction technology to reduce hypotensive episodes in the ICU following cardiac surgery.[79]

Along with investigating pharmacologic and fluid administration strategies to support hemodynamics, temporary mechanical circulatory support (tMCS) is another important aspect of patient care. There has been a marked increase in use of tMCS devices in the past decade.[80] Given the resource demands and its application in high-risk critically ill patients, tMCS is both a topic of debate and an area requiring ongoing education and research.[81-85] One area particularly relevant to enhanced recovery is the application of preoperative tMCS to optimize high-risk patients prior to cardiac surgery.[86-88] This concept aligns with one of the core tenants of ERPs, namely the pursuit of increasing a patient's physiologic reserve and resiliency before exposure to the injurious effects of surgery and cardiopulmonary bypass.[34,89] As device technology and clinician expertise improve, tMCS will have a growing role in the perioperative care of cardiac surgical patients, making it an important future topic for education, standardization of best practices, and quality improvement efforts.

Organ Injury

Although impaired recovery following cardiac surgery is multifactorial, variable, and dynamic, it often shares the common aspect of organ injury or dysfunction.[90] Healthcare providers need to improve the processes for risk stratification, continuous screening for early identification of impending dysfunction, and activation of rescue bundles/teams to optimize physiology and prevent further dysfunction and injury. The 2024 ECD provides a framework for this approach as it relates

to acute kidney injury (AKI). This approach has been shown to reduce the incidence of AKI following cardiac surgery.[91] Other organ systems and related interventions aimed at reducing injury are mentioned, including central nervous system monitoring with screening for delirium and lung protective mechanical ventilation complemented by early extubation strategies; however, a defined process from screening to therapy is not provided for these organ systems as it is for AKI. Other systems, such as gastrointestinal, dermatologic, endocrine, and metabolic, are under-represented in the 2024 ECD despite their known incidence and associated morbidity following cardiac surgery.[92-95] Finally, when organ injury leads to life-threatening complications, there needs to be an emphasis on timely diagnosis and escalation of therapies to prevent mortality. This concept of "failure to rescue" is emerging as an important quality metric in cardiac surgery.[96] Screening, prevention, and treatment of organ injury can be challenging, but continued progress across all systems offers an opportunity to improve patient outcomes and minimize harm when injury does occur.

Artificial Intelligence

The application of existing and emerging technologies has been increasing steadily, as has the associated expenditure of healthcare dollars.[97] The numerous aspects of technology applications in healthcare include big data, wearables and the internet of medical things, telehealth and remote monitoring, and artificial intelligence (AI), including machine learning (ML).[98-102] AI algorithms are improving at an exponential rate, and their integration into the cardiac perioperative space is currently underway.[101] Application of an ML approach has been shown to improve risk assessment for kidney injury and mortality after cardiac surgery.[103,104] These efforts likely represent just the start of a widening scope of applications for ML and AI.[105] Radiologists have leveraged AI to improve diagnostic accuracy, an approach now being applied to echocardiography.[106-108] Combining ML with closed-loop devices can provide automated delivery of anesthesia and resuscitation.[109-111] Ongoing AI interpretation of patient data throughout the perioperative period has the potential to generate dynamic risk assessment models and redirect healthcare support accordingly.[112-114]

Although the future applications of AI in healthcare are numerous and intriguing, several barriers remain to be overcome, including patient privacy and safety, government regulations and policies, algorithm bias, and uncertainly regarding the optimal interface of AI and human contributions (including oversight).[115-117] Given the expanding role of technology in healthcare, particularly in AI and ML, this is an area likely to be incorporated into future ERPs and other quality improvement endeavors.

Evidence

ERPs have been scrutinized for the paucity of high-quality evidence in all the pathway elements.[118,119] Of the 23 elements in the 2024 ECD, only 3 had a high level of evidence, whereas 15 had a moderate and 5 had a low level of evidence. Based on the ERAS Cardiac grading rubric, this means that almost 90% of the elements are likely or very likely to have further research impact confidence in the estimate of effect.[120]

Looking beyond the elements themselves, what evidence suggests implementation of an ERP improves postsurgical outcomes? Although multiple studies have demonstrated improved outcomes (mostly reduced length of stay) after implementation of an ERAS recovery program, most of these are retrospective pre-post analyses.[121-123] Li et al reported reduced intubation time (7.2 hours vs 8.8 hours; $p < 0.0001$), total complications (19 vs 37; $p = 0.01$), readiness for discharge (6.0 days vs 7.0 days; $p = 0.01$), and cost (¥69,202 vs ¥77,058; $p = 0.002$) after implementation of a comprehensive ERP in a prospective randomized controlled trial.[124] Another interesting recently applied approach is to correlate ERP element compliance at the individual patient level to recovery outcomes. Using this methodology, Hoogma et al. showed that every 10% increase in compliance was associated with a lower risk for any complication (odds ratio, 0.60; 95% confidence interval [CI], 0.46-0.79; $p = 0.0003$) and a higher probability of earlier hospital discharge (hazard ratio, 1.25; 95% CI, 1.10-1.43; $p = .0008$).[125] Although these efforts are important contributions, continued research will be necessary to generate the high-quality evidence required to encourage cardiac surgical institutions to expend the necessary time and resources to implement an ERP.

A significant barrier to pursuing research in cardiac surgery ERPs is the lack of clear and universally accepted definitions for both the elements themselves and measures of compliance.[126] An initial effort in this regard has been made by the ERAS Cardiac Society with a published consensus document outlining proposed data elements that should be collected in an ERP.[127] Although a valuable first step, this does not provide sufficient precision, specificity, or granularity to provide a data variable framework for those undertaking research in this domain.

What interventions are required to qualify as multimodal analgesia or comprehensive care to reduce AKI, as prescribed in the 2024 ECD? Are their core and/or minimum components required for an effective infection reduction bundle or patient blood management program? Once we have agreed on definitions for each element, what are the minimal thresholds of their application to qualify as being compliant? Finally, what are the outcomes that we should be measuring? These questions will need to answered before the 2024 ECD recommendations can be properly studied and results compared among institutions.

Conclusions

The publication of Perioperative Care in Cardiac Surgery: A Joint Consensus Statement by the Enhanced Recovery After Surgery (ERAS) Cardiac Society, ERAS International Society, and The Society of Thoracic Surgeons (STS) highlights the ongoing evolution of perioperative care for cardiac surgery patients. It is encouraging to see the addition of new elements

in several categories. Organ-specific recommendations, such as lung-protective ventilation, patient blood management, prevention of atrial fibrillation, and central nervous system monitoring, will help improve postoperative recovery. However, there also are important new elements within the categories of implementation (ie, multidisciplinary team and audit) and patient-centered care (ie, engagement, use of PROMs, and shared decision making). Overall, the 2024 EDC is inclusive and comprehensive, but enhanced recovery is by nature an iterative process.[128,129] Therefore, while appreciating the current efforts that led to creation of this list of consensus recommendations, it also is important to consider additional elements for optimizing patient recovery. The ideas put forward in this editorial are by no means exhaustive, certainly there are several other areas for future development in perioperative care. Hopefully those discussed in this editorial represent innovative and impactful ideas for future directions of research, quality improvement, and optimizing patient care in cardiac surgery.

Declaration of Use of Generative AI

The authors declare that they have not used any type of generative artificial intelligence for the writing of this manuscript, nor for the creation of tables or corresponding captions.

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