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Enhanced recovery after cardiac surgery program to improve patient outcomes

BY GINA MCCONNELL, BSN, RN, CCRN; PATRICIA WOLTZ, PhD, RN; WILLIAM T. BRADFORD, MD; J. ERIN LEDFORD, PharmD, BCPS-AQ CARDIOLOGY, BCCCP; AND JUDSON B. WILLIAMS, MD, MSH

Abstract: This article details the obstacles of implementing a cardiac-specific enhanced recovery after surgery (ERAS) program in a 919-bed not-for-profit community-based health system and the benefits of ERAS programs for different patient populations.

Keywords: cardiac surgery, enhanced recovery after surgery, ERAS, implementation, quality improvement

ENHANCED RECOVERY after surgery (ERAS) was first popularized in Denmark in the 1990s and spread throughout western Europe, primarily for patients undergoing major abdominal surgeries.¹ Now commonplace, ERAS programs follow evidence-based standards to improve patient outcomes by minimizing postoperative trauma and pain, reducing complications, expediting recovery after surgical procedures, decreasing the length of stay, and cutting the overall cost of care.^{2,3} The protocols address inflammation, metabolism, endocrine function, pain, and surgical and anesthetic complications.⁴

The ERAS Society has published updated guidelines for many types of surgeries, including gastrointestinal (GI), orthopedic, and gynecologic procedures.⁵ This article describes the first designated ERAS program

for cardiac surgery (ERAS-cardiac) and details the implementation, challenges, and success of the program in a 919-bed not-for-profit community-based health system in the US.

Procedure-specific protocols

Core components of ERAS programs generally include:^{5,6}

- medical optimization
- patient education
- minimization of invasive procedures
- multimodal opioid-sparing analgesia
- preemptive mitigation of complications
- early mobilization.

Scientific evidence supporting procedure-specific ERAS protocols has increased dramatically in the last 5 years; these programs have reduced length of stay by up to 50% in GI surgeries.^{1,7-9} Reductions in

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complications, readmissions, and costs have also been reported for various surgical specialties, including GI, gynecologic, urologic, orthopedic, and esophageal surgery.^{4,10-13}

ERAS protocols were developed to enhance clinical outcomes, improve patient satisfaction, and reduce opioid use, but they had not been applied to cardiac surgery until recently.⁵ Although many evidence-based practices have been applied to cardiac surgery, including fast-track protocols and advances in perioperative cardiac care,^{14,15} no society guidelines, ERAS framework, or even a consensus for cardiac surgery had been developed before the authors initiated this project.

As a not-for-profit health system with a long history of cardiovascular and thoracic surgical care, our organization promotes the health and well-being of our community by providing the best care and value through continuous quality improvement. The possibility of improving cardiac surgical outcomes was viewed as a quality improvement imperative by the authors, the heart center leadership, and the health system administration. The team used a knowledge-to-action (KTA) framework to help guide the creation and integration of an ERAS-cardiac protocol (see *KTA framework*).¹⁶

Creating an ERAS-cardiac protocol

After learning about the impact of ERAS pathways in other surgical populations, a nurse educator in the cardiothoracic intensive care unit (CTICU) initially pursued the idea. After stakeholder buy-in was obtained, members of the multidisciplinary team completed a review of existing literature, which identified gaps between existing ERAS protocols and an ERAS protocol appropriate for cardiac surgery. The different risk factors and contraindications of a cardiac population that commonly undergoes cardiopulmonary bypass, extracorporeal support, hypothermia, and hemodynamic manipulations in surgery differ from those of the surgical patients of other specialties. To develop a comprehensive set of cardiac-specific ERAS components, each component described below went through rigorous review to evaluate the risks and benefits until the multidisciplinary team reached a consensus that would comprise the ERAS-cardiac protocol (see *Components of the ERAS-cardiac protocol*).

ERAS-cardiac components **Preadmission protocol**

Without an acute condition precipitating urgent or emergent surgery, many procedures are considered

elective—including surgery for patients with coronary artery disease without evidence of ongoing ischemia and those with valvular heart disease without acute cardiac dysfunction. For elective cardiac surgeries, preadmission interventions often occur over weeks and include evaluation and optimization of organ function, nutritional status, and physical fitness, as well as patient education to minimize modifiable risk factors.

Delaying surgery gives patients time to recover from the events that led to the discovery of an operable lesion. Accordingly, preadmission interventions and rehabilitation aimed at optimizing a patient's health status to minimize surgical stress and promote recovery is a key component of ERAS programs. This is accomplished by the early identification of comorbidities and referrals to primary care providers or consulting healthcare providers as needed.

Patients and families also receive preoperative nutritional, respiratory, and physical therapy education taught by designated nurse educators. This includes education about early ambulation, incentive spirometry, sternal precautions, infection prevention, and secondary disease prevention.

Physical functional capacity, a strong predictor of outcomes after general surgery, has not been studied extensively in patients undergoing cardiac surgery, but the assessment of functional capacity may aid in evaluating perioperative risk and influencing interventions.^{17,18} Preoperative rehabilitation, or “prehabilitation,” is the process of augmenting functional capacity to prepare patients for the stress of the perioperative period. It can reduce hospital stays by 3 or more days.^{18,19} In inpatient settings, occupational and physical therapists assess physical function capacity with ambulation and stair climbing tests. In outpatient settings, patients undergo ambulation testing in the cardiac surgery clinic.

KTA framework¹⁶

The team used a KTA framework to implement the ERAS-cardiac protocol. The KTA framework describes a dynamic process with two components: knowledge creation and an action cycle. Each component has multiple phases that can influence or be influenced by other phases occurring sequentially or simultaneously.

Knowledge creation begins with locating and synthesizing evidence to create tools or products, such as clinical practice guidelines or protocols. Then, the action cycle describes the integration of that knowledge into practice. Action phases include:

- adapting knowledge to a local context
- assessing the barriers and facilitators to utilization
- selecting, tailoring, and implementing interventions
- monitoring usage
- evaluating outcomes
- sustaining practices.

Tobacco smokers are more likely to experience postoperative complications, including delayed wound healing, pulmonary complications, and mortality.²⁰ Smoking cessation at least 4 weeks before coronary artery bypass graft surgery reduces the risk of major pulmonary complications such as endotracheal reintubation, tracheostomy, atelectasis, and pneumonia.²¹ Debate continues internationally regarding surgery on patients who smoke, and we continue to balance the urgency of surgical interventions with patient optimization on a case-by-case basis.²²

Alcohol abuse and misuse are likely causes of subclinical myocardial dysfunction, immunosuppression, and decreased hemostasis—increasing the risk of hemodynamic instability, infection, and bleeding.^{23,24} Similar to smoking cessation, abstinence from alcohol is not treated as a prerequisite for surgery. However, some evidence suggests that abstaining for 1 month before colorectal surgery reduces postoperative morbidity in patients who abuse alcohol.⁹ Accordingly, patients are advised to abstain from or decrease their alcohol intake for as long as possible before cardiac surgery.

Preoperative protocol

A component of many ERAS protocols is minimized preoperative fasting with carbohydrate (CHO) loading before anesthesia delivery.^{5,9} Although consensus is lacking in regard to the best CHO source, dose, and volume,²⁵ adults with normal gastric emptying consume a clear 12 oz complex CHO beverage with 24 g of CHO a minimum of 2 hours before arriving in the OR at our facility.^{1,9} This may help maintain euvolemia without increasing aspiration risk.^{9,26,27}

Preoperative treatment with clear oral complex CHOs has the following benefits:⁹

- increased insulin levels
- reduced postoperative insulin resistance

- maintenance of glycogen reserves
- decreased protein breakdown
- improved muscle strength.

CHO loading for patients undergoing elective cardiac surgery has been controversial due to the high prevalence of diabetes in this patient population and possible gastroparesis (delayed gastric emptying) associated with higher-than-usual opioid requirements. Other concerns include perioperative aspiration and fear that the administration of CHOs might precipitate hyperglycemia. Current evidence, however, suggests that these patients derive similar benefits from minimized preoperative fasting without increased risk.⁹

Multimodal, opioid-sparing analgesia is another key to ERAS programs. Treatment options are limited in cardiac surgery due to the risk of adverse reactions. For example, the use of nonsteroidal anti-inflammatory drugs (NSAIDs) such as naproxen, ketorolac, and ibuprofen is limited by the risk of bleeding and renal impairment, as well as a higher risk of death.²⁸

Despite these limitations, alternative analgesics with proven efficacy for the cardiac surgery population are available.^{29,30} As part of a multimodal approach to pain management in the cardiac surgery population, the non-opioid analgesics acetaminophen and gabapentin are given beginning in the preoperative phase and continued throughout the perioperative period.

Acetaminophen, which provides analgesic and antipyretic effects, is available as a tablet, suppository, and I.V. solution. While I.V. administration may achieve a greater peak concentration faster than oral or rectal routes, the minimum plasma concentration required for analgesia is unknown, and no differences in the pain scores between formulations have been observed.^{31,32} As no studies compare preoperative acetaminophen to placebo directly, the overall effect is unknown, but acetaminophen may reduce intra-

Components of the ERAS-cardiac protocol

Consulting phase

- Preoperative information, education, and counseling
- Preoperative optimization of comorbidities
- Decreased use or cessation of alcohol and tobacco products
- Preoperative optimization of nutritional status

Preoperative phase

- Preoperative fasting for 8 hours except for CHO loading 2 to 4 hours before surgery
- Preoperative initiation of multimodal analgesic
- Minimization of anxiolytic agents

Intraoperative phase

- Intraoperative opioid administration
- Intraoperative multimodal analgesia
- Minimization of intraoperative crystalloid
- Initiation of postoperative sedation

Postoperative phase

- Early extubation
- Optimization of pulmonary function
- Continuation of multimodal analgesia
- Prophylaxis to prevent postoperative nausea and vomiting
- Bowel motility regimen
- Glycemic control
- Diet advanced as tolerated
- Early mobilization to chair and ambulating as tolerated
- Removal of lines and drains as soon as no longer needed.

operative opioid use and improve postoperative pain scores.^{29,33,34}

The routes of administration, however, have different effects on hemodynamics. In a recent study, over 30% of patients required an intervention after I.V. acetaminophen-induced hypotension.³⁵ Cardiac surgery patients may not tolerate these effects, as many develop vasoplegia during and following cardiopulmonary bypass. Routine use of the I.V. formulation may also be cost-prohibitive for most

institutions, as each dose can be 100 to 200 times more expensive than tablets.

Oral acetaminophen has been used in ERAS protocols and reduced mean pain intensity rating scores, postoperative nausea and vomiting, and the use of supplemental opioids and NSAIDs.^{28,36} As part of the ERAS-cardiac regimen, acetaminophen tablets or liquids were administered every 6 hours for 5 days. Patients with liver dysfunction may receive lower doses of acetaminophen.

Originally developed as an anti-epileptic drug, oral **gabapentin** is commonly used to treat neuropathic pain.²⁸ Combined with acetaminophen, preoperative gabapentin has become an integral part of many multimodal ERAS regimens. Gabapentin is associated with reduced opioid requirements after surgery and thus recommended throughout the perioperative period.³⁷ Compared with opioids, which cause well-known adverse reactions such as oversedation and respiratory depression, gabapentin also has a more favorable safety profile. The predominant adverse reaction is sedation, but tremors and involuntary muscle contractions have been reported.⁹

Evidence is sparse for the preoperative administration of gabapentin, but it may improve intra- and postoperative pain.³⁰ Our institution administers gabapentin orally for inpatients in the OR and for patients being admitted in the preoperative holding area. Because the predominant adverse reaction is sedation, patients age 75 and older receive a lower dose to minimize that risk. Gabapentin is renally eliminated, so dosages for patients with severe renal impairment may also be reduced to prevent drug accumulation.^{9,38}

Intraoperative protocol

Our ERAS cardiac surgery protocol continues with multimodal analgesia in the OR.

Opioids remain a keystone of intraoperative pain control. With a short onset, a quick elimination half-life, and minimal effects on histamine release, fentanyl is the most commonly used opioid.³⁷ Due to adverse drug reactions, however, opioid administration is usually limited with alternative, multimodal nonopioid analgesia.³⁷ Conservative fluid management in the OR to minimize volume overload and maintain euvolemia reduces surgical stress.¹

Postoperative protocol

Multimodal analgesia in the ERAS-cardiac protocol is continued in the postoperative setting with continuation of acetaminophen, gabapentin, and an opioid.³⁷ Early extubation is a general ERAS goal that also pertains to cardiac surgery.⁵ The vast majority of our cardiac patients are extubated within the first 6 hours in the CTICU to allow for stabilization and pressor management.

An estimated 13% to 67% of patients experience postoperative nausea and vomiting due to fasting, ileus, activation of the sympathetic nervous system, or adverse reactions to medication.³⁹ Early ambulation, opioid avoidance (when possible), and gum chewing are adjuncts to improve bowel motility and minimize risk.¹

An aggressive bowel regimen is also implemented on postoperative day 1, and the diet is advanced as tolerated. Clear liquids are first given when there are no clinical concerns for aspiration and the patient's mental status allows. Regular food is introduced for the next meal. Patients are out of bed in a chair and ambulating with assistance by postoperative day 1.

Overcoming barriers to implementation of the ERAS-cardiac program

Barrier	Description	Intervention
Lack of evidence for ERAS principals in cardiac surgery	No ERAS guidelines for cardiac surgery in existence	Literature review undertaken for each individual ERAS component; subject-matter experts consulted.
Physician preferences	Surgeon, anesthesiologist, and intensivist individual preferences	Champions empowered from each group to allow standardization and agreement on pathways of care; IT consultation for standard order sets.
Financial	No grants or facility funding mechanism existed to pay for the CHO drink, gum, and nonopioid analgesia	Costs initially absorbed by unit-level nursing. Meetings with health system administration regarding value added in reduced length of stay and complications. The payment model for gum and drink was changed.
Engagement and education of staff	Hundreds of staff from all relevant outpatient and inpatient units, practices, and service lines, as well as disciplines such as nurses, physicians, advanced practice providers, technicians, therapists, pharmacists, and nutritionists	The ERAS-cardiac champion and leadership team repeatedly met with all involved team members.

Evaluation of ERAS implementation strategies

Strategy	Definition	Evaluation
Dissemination	Strategies to increase awareness, knowledge, attitude, and intention to adopt an intervention. Includes communication strategies designed to change beliefs and behaviors.	<ul style="list-style-type: none"> Reached 100% of leadership and nearly 100% of clinicians. All were educated and bought into implementing a standardized protocol. Attitudes continue to improve with successful implementation, and preliminary data show improving outcomes.
Implementation process	Team strategies for planning, selecting, and integrating interventions into practice	<ul style="list-style-type: none"> Evidence review involved all disciplines. All cardiac surgery patients are entered into the pathway as early as possible. Delays in care and modifications to multimodal analgesia are reconciled with inclusive group meetings and communications.
Integration	Team strategies to integrate evidence-based interventions into practice	<ul style="list-style-type: none"> Physician order sets were built into the EHR ERAS-cardiac pathway is under construction Designated ERAS nurse coordinator Regular audit and feedback Regular informational meetings and emails Multidisciplinary team accepting of the standardized approach.
Capacity building	Strategies to increase individual motivation and self-efficacy	<ul style="list-style-type: none"> Clinician input into evaluation of fall outs (failure to follow all steps in a care protocol, for whatever reason) and process changes fosters engagement.
Scale-up	Strategies that allow implementation across multiple settings	<ul style="list-style-type: none"> Other disciplines requested and received education and tools for implementing other ERAS protocols. Program was adapted for available resources at a smaller facility and successfully implemented.

Integrating the ERAS-cardiac protocol into practice

Our ERAS-cardiac stakeholders believed successful implementation would require a standard approach without deviation. Before implementing the ERAS-cardiac program, the nurse champion reached out to institutions across the country with successful noncardiac programs to understand potential barriers. The other ERAS coordinators identified staff buy-in from intensivists, perfusionists, physician assistants, anesthesiologists, and individual care units (outpatient, OR, ICU, and step-down) as essential to the program. (See *Overcoming barriers to implementation of the ERAS-cardiac program*.)

Representative physicians were identified and empowered to build consensus, and informatics personnel were consulted for uniform order sets. Ensuring that each clinician and discipline affected by the pathway

felt valued as a contributor was vital to addressing the barriers to ERAS adoption at our organization. For example, in patients with significant comorbidities and frailty, some anesthesia providers were concerned about risk of aspiration with oral consumption of a CHO drink 2 hours before surgery. Surgical preferences and varied procedural approaches were also common barriers to standardization.

An ERAS-cardiac leadership team was formed and met frequently to address ongoing barriers, create standardized electronic health records (EHRs), educate staff, and set a go-live date. The public relations department assisted in developing branded patient information and a checklist for the staff. An ERAS coordinator, the nurse champion in this case, served as the communication link between multidisciplinary team members and groups. Nearly every

full-time staff member was educated by the nurse champion, and designated staff was responsible for the daily observation of ERAS structures and processes.

Surgeons, anesthesia providers, administrators, managers, educators, ICU nurses, advanced practice providers, step-down nurses, dietitians, and pharmacists all participated in implementing the standardized pathway, as well as outpatient, preoperative, intraoperative, and discharge staff. The leadership team still meets monthly to discuss the program's effectiveness, address concerns, and consider any warranted modifications.

Monitoring and sustaining knowledge

Sustaining the ERAS-cardiac program has become less of a challenge over time, but the nurse champion continues to play a major role in addressing issues and facilitating

improvements. All licensed independent providers and nurses monitor the patient's well-being carefully. Clinical pharmacists lead audits and monitor opioid use, and dedicated data analysts collect ERAS program data, including length of stay, re-admission, and clinical outcomes.

Promising results

The ERAS-cardiac program went live in April 2017 for all urgent and nonemergent adult cardiac surgery patients scheduled to recover in one CTICU within the healthcare system. An evaluation of the program's 1-year outcomes is currently in press.⁴⁰ The success of the implementation strategies we report on here are organized using an implementation strategy classification framework that summarizes strategies by aligning them with relevant theories to identify potential gaps.⁴¹ The framework names, defines, and describes strategies by those who enacted it, the action targets, and the intended implementation outcomes (see *Evaluation of ERAS implementation strategies*). The five strategy classes include:

- dissemination
- implementation process
- integration
- capacity-building
- scale-up.

Dissemination strategies used to inform, engage, and solicit buy-in at all clinical and leadership levels before the ERAS-cardiac go-live date reached 100% of leadership and nearly 100% of clinical staff.

Process strategies ensured multidisciplinary involvement in all phases, which was critical to ensuring all clinicians were on board. This all-at-once approach minimized staff confusion, facilitated process adoption, and allowed for rapid cycles of improvement in ERAS core components for patients recovering in the CTICU. Patients are now started on ERAS interven-

tions as soon as possible, and this strategy, along with regular team meetings, has allowed leadership to vet and pilot modifications while ensuring safety and quality.

The integration of evidence-based interventions has been facilitated by physician order sets in the EHR. Currently, we are building an ERAS-cardiac pathway in the EHR that will facilitate compliance and save time in the auditing process and with outcome indicators.

The role of the ERAS nurse champion in facilitating team meetings and communicating with support systems across the care continuum cannot be overstated. They have been key to integrating evidence-based interventions into practice successfully.

Regular follow-up by the ERAS coordinator and, if needed, the ERAS leadership team ensures disciplinary engagement and ongoing quality improvement. With preliminary success in implementing a novel program and positive but anecdotal patient feedback, clinician motivation to implement ERAS interventions is high. Upon request, the ERAS leadership team also provided guidance, education, and written tools to disseminate the pathway for successful use in a thoracic surgery population.

Buy-in for value-based care

The ERAS-cardiac program is an example of value-based care applied to a specific surgical specialty with goals, including improved patient and staff satisfaction, earlier recovery, reduced costs, and a reduction in opioid use. Continuous quality improvement with the assimilation of new evidence and the monitoring of clinical outcomes will make the ERAS-cardiac program sustainable. We look forward to sharing data from the program once it is available. ■

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All authors are affiliated with WakeMed Health and Hospitals in Raleigh, N.C.: Gina McConnell and Patricia Woltz in the Department of Nursing, William T. Bradford in the Department of Anesthesia, J. Erin Ledford in the Department of Pharmacy, and Judson B. Williams in the Department of Surgery.

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