Review Article

# Challenges and opportunities in enhanced recovery after surgery programs: An overview

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## ABSTRACT

Enhanced Recovery After Surgery (ERAS) programs were developed as evidence-based, multi-disciplinary interventions in all the perioperative phases to minimise the surgical stress response, reduce complications, and enhance outcomes. The results across various surgical procedures have been positive, with a reduction in medical complications, a reduction in length of hospital stay, and a reduction in care costs without increased re-admission rates. However, implementation for many institutions has not been easy and suboptimal at best. The robust and pervasive adoption of these programs should be based on effective change management, dynamic and engaged clinical leadership, adherence to the principles of continuous quality improvement programs, and the adoption of evidence-based and data-driven changes in pathway development and implementation. Rapid cycle, randomised/quasi-randomised quality improvement projects must be the core foundation of an ERAS program. Finally, research methodologies should focus on controlling for adherence to the core elements of the pathways and testing for the effectiveness of an individual intervention in a randomised controlled trial.

**Keywords:** Enhanced recovery after surgery, machine learning, perioperative medicine, perioperative research, surgical complications

## INTRODUCTION

Enhanced recovery after surgery (ERAS) programs were introduced into the surgical practice over two decades ago as evidence-based, multi-disciplinary interventions in all the perioperative phases of a patient's surgical journey that work synergistically to minimise the surgical stress response, reduce complications, and enhance outcomes.[1-3] Although the benefits of ERAS pathways in improving surgical outcomes are well-recognised, the implementation for many institutions has not been easy and suboptimal at best.

This narrative review discusses the challenges of implementing robust and sustainable ERAS pathways in evolving surgical practice and presents an approach to future research in perioperative medicine.

## METHODS

### Search strategy and source selection

This narrative review focuses on the challenges in implementing robust, pervasive, and sustainable ERAS pathways.

*Relevant Databases:* PubMed, Embase, Medline, Scopus, and Web of Science

*Search Terms:* 'fast-track surgery', 'enhanced recovery after surgery', 'perioperative medicine', 'perioperative



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care', 'surgical outcomes', 'prehabilitation', 'learning health system'

*Inclusion/Exclusion Criteria:* Included studies published in English between 2014 and 2024, focusing on enhanced recovery after surgery programs and perioperative medicine. Excluded studies include those unrelated to perioperative care and non-English publications.

## DISCUSSION

### Perspectives on the current challenges and opportunities with ERAS programs: The path forward

The basic premise of the ERAS pathways is to coordinate surgical and perioperative care in a patient-centred, recovery-focused paradigm to minimise perioperative surgical stress response, minimise postoperative complications, and return the patient to their baseline or better functional status safely and efficiently. Throughout the care journey, it is necessary to understand the steps in the patient's recovery and evaluate why the patient is not meeting the procedure-specific goals and timelines for the recovery trajectory. This requires delineating the various factors contributing to the risk of postoperative complications and delayed recovery on a patient and procedure-specific basis. Such an approach should allow the refinement of elements based on the current understanding of perioperative pathophysiology in a fully implemented ERAS program.

#### *Why does implementing a robust, ERAS program continue to be a challenge?*

Organisations with engaged and supportive clinical leadership, experience in change management, and ongoing successful quality improvement programs have expanded ERAS programs across their practice.[4] However, many organisations face the challenges of consistently implementing the ERAS principles.[5] For effective and robust implementation of ERAS programs, the focus should be beyond minimising the length of stay (LoS).[6-13]

To progress further, we must close the 'knowing-doing' gap in implementing evidence-based intraoperative and postoperative elements of care. While the framework for an ERAS program minimises unnecessary variations, the actual care has to be tailored to an individual patient based on their risk of developing procedure-specific medical and surgical complications and enhance their post-surgical recovery trajectory.[14]

Another challenge in implementing an ERAS program is the lack of rigorous auditing and tracking compliance with critical elements of care.[15] Effective and engaged clinical leadership, understanding the local culture and context conducive to change management, deliberate introduction and evaluation of evidence-informed interventions, and investment in data management and analysis are critical to meeting and maintaining compliance with crucial elements.[16-18]

#### *Why is the surgical patient still at risk?*

Kehlet and Mythen discussed this question over a decade ago.[19] In this era of outcomes research and patient-centred value-based care, perioperative medicine's focus has shifted from preoperative risk prediction to adding targeted interventions to optimise the patient's condition for the surgical procedure.[20-23] Most risk prediction models were not developed in the context of enhanced recovery and the rapidly changing surgical care paradigm. With the recent application of machine learning techniques to healthcare, we need to develop procedures and patient-specific dynamic models for accurate surgical risk prediction in the future.[24,25] More importantly, we must use the risk prediction models to direct targeted optimisation efforts during the preoperative period.[26] However, it is critical to institute and evaluate interventions only when a cause-effect relationship exists between targeted preoperative optimisation interventions.[27,28]

### Building on the progress and evolving with the advancements in surgical care and patient expectations: Perspectives on instituting core elements *(data-driven)* and expanding the scope of ERAS programs

It is well understood that there is a direct association between increasing protocol adherence to the elements in an ERAS pathway and improved outcomes.[29] Therefore, it is critically important to develop procedure-specific ERAS pathways with well-defined elements in each perioperative phase (preoperative, intraoperative, and postoperative) of a patient's surgical journey and institute a strict audit system to capture adherence/compliance to the individual elements of care.

Most of the experience and published literature on ERAS programs involve colorectal surgery, demonstrating increasing adherence to pathways associated with decreased postoperative complications.[30] In a large,

prospective multi-centre cohort study, the modifiable factors significantly associated with optimal recovery included anaemia management, laparoscopic approach, and overall compliance with ERAS recommendations.[31]

In summary, although most of the evidence is from colorectal surgery, patient education and engagement, preoperative medical and functional optimisation including anaemia correction, avoidance of prolonged fasting, minimal access surgical approach and avoidance of drainage and catheters, rational and optimal fluid therapy with first 24-hour postoperative fluid balance <1500 mL, multi-modal preventive analgesia, and early mobilisation and feeding are the core principles of care for the ERAS pathways.

### *Combining ERAS principles with minimal access approaches to surgery*

With the broader adoption of the minimal access approach (laparoscopic and robot-assisted) in cavitary surgical procedures, the minimal access approach to surgery needs to be incorporated as an integral element of an enhanced recovery program in the appropriate method and patient. Some studies have reported no differences in complication rates and LoS between open and laparoscopic/robotic-assisted colon or bladder surgeries on ERAS pathways.[32,33] A systematic review and meta-analysis on laparoscopic versus open colon surgery with or without an ERAS program showed that laparoscopy offered independent advantages beyond ERAS care.[34] However, the laparoscopy and fast-track multi-modal versus standard care (LAFA) study[35] and several systematic reviews support the added benefits of combining laparoscopy with an enhanced recovery program.[34,36,37]

### *Developing ERAS programs for outpatient and short-stay surgical procedures*

Outpatient and short-stay surgical practice is rapidly growing as a cost-effective and patient-centric care delivery response to the increasing cost of inpatient care and non-sustainable healthcare expenditures for increasingly complex procedures.[38-40] As the science and practice of outpatient and short-stay surgery grow and mature, we need to incorporate the principles of enhanced recovery programs into outpatient and short-stay practice to enhance patient safety while providing higher-quality and value-based care.[41] As this practice grows, clinical and research focus must be on robust audit efforts, standardised recovery criteria for discharge, efficient monitoring programs (including remote monitoring) for early detection of complications, tracking patient discharge disposition, and accurate registry of post-discharge visits or re-admission to any acute care facility or hospital after outpatient and short-stay procedures. This will help develop hypothesis-generating research protocols and data-informed patient- and procedure-specific care pathways for outpatient and short-stay surgical procedures.[42] We need to understand better, analyse, and address the issues and concerns related to implementing ERAS from the perspective of patients' experiences. Understanding patients' perceptions of negative experiences and problems with the program (e.g., the psychological burden of early discharge) and how these influence adherence to ERAS protocols can improve the quality and scope of ERAS implementation across all practice settings.[43-47]

## Perspectives on future research opportunities in enhanced recovery programs

### *Understanding and managing patient's risk for post-surgical complications and delayed recovery*

Contributory preoperative factors for a patient's risk for postoperative complications, delayed recovery, and mortality include co-morbid burden, functional status, frailty, and the urgency of the surgical procedure (i.e. elective versus emergency).[48] Further research is needed on the type and timing of preoperative optimisation and objective monitoring of the intervention and patient outcomes, particularly with prehabilitation and frailty.[49] Recent research interest has been in studying the preoperative inflammatory state (burden) of a patient and the identification of 'high' inflammatory responders to in-vitro stress and its correlation to post-surgical complications.[50-52] These new developments in 'multi-omics' will help evaluate the role of inflammatory-immune responses in postoperative inflammatory dysregulation and surgical recovery and the specific role of minimally invasive surgery, glucocorticoids, statins, and/or specific cytokine antagonists in modulating these responses.

The trajectory of post-surgical recovery is dependent on critical intraoperative factors, which include the degree of surgical stress (i.e. neuro-endocrine and inflammatory immunological responses to surgery),[53] as well as the surgical approach (i.e. minimal access versus open)[54] and anaesthetic strategies (e.g. anti-inflammatory medications,[55] pain control,[56] and minimising oxygen debt[57]).

Perioperative corticosteroid dosing regimens have been used to modify the inflammatory-dysregulated state in response to early markers of inflammatory-immune response.[58] Further research is needed on the role of high-dose systemic glucocorticoids in mitigating the undesirable inflammatory effects after specific surgery, reducing fatigue and pain, and enhancing clinical recovery in the appropriate patient population.[59] In addition, future research efforts are needed to evaluate perioperative pain management in special patient populations (e.g. pain catastrophisers, chronic opioid users, pain-sensitised patients, and patients at risk for chronic opioid use).[60] While much progress has been made in highlighting the need for patient- and procedure-specific pain management strategies,[12] further research needs to focus on the acute and subacute transitional pain management programs to provide safe and effective analgesia that facilitates early mobilisation and avoidance of pain-mediated complications.[56]

Goal-directed or optimal fluid therapy has been a significant component of ERAS programs.[61] The main goal of intraoperative fluid therapy, haemodynamic optimisation, and resuscitation to patient-specific physiologic targets is maintaining aerobic metabolism and avoiding or treating oxygen debt.[62] Therefore, fluid therapy must always be considered along with blood management and optimisation of haemodynamic parameters to meet predefined physiological targets and maintain adequate tissue perfusion in an individual patient.[63] The routine physiologic indices of resuscitation/haemodynamic optimisation in clinical practice indicate oxygen delivery ($DO_2$). However, to evaluate oxygen debt properly, measurable elements of oxygen consumption (VO2) and tissue perfusion must be assessed.[64] Furthermore, any intervention that aims to optimise macrocirculation will only be effective if it results in improved microcirculatory perfusion and adequate oxygen delivery to the cells, or 'haemodynamic coherence'.[65] Therefore, future perioperative fluid therapy and haemodynamic optimisation research should focus on avoiding oxygen debt by maintaining tissue perfusion through a 'multi-modal and individualised' approach.[66]

In a disease/anatomic operation-specific enhanced recovery program, a single pathway is usually used to standardise the postoperative phase of care.[67] However, an individual patient's risk for procedure-specific postoperative surgical complications varies depending on preoperative patient-specific factors and conditions, intraoperative surgical findings, and surgical factors (e.g. surgeon skill, variations in the surgical procedure itself, and surgical unit experience). Hence, the postoperative pathway and care must be risk-adjusted for procedure-specific complications in an individual patient.[68] Further research is needed to develop risk-adjusted postoperative care pathways for all major surgical procedures. This will help minimise unnecessary variation in care yet personalise care delivery in a procedure-specific, patient-centred, recovery-focused paradigm.

With the changing demographics of surgical patients globally, more complex procedures are undertaken in older and sicker patients.[69] Postoperative complications are reported to occur after one in every five surgical procedures.[70] There is a strong association between postoperative complications and reduced long-term survival.[71] It is well known that derangements in vital signs usually precede adverse events in the postoperative period. To minimise the risk of high-grade complications, patient care pathways and programs have to move beyond early warning systems to add continuous vital sign monitoring (CVSM) and rapid response.[72] In a single-centre before-and-after study, continuous monitoring of patient vital signs using wearable monitoring technology linked wirelessly to hospital systems was associated with reduced unplanned intensive care unit (ICU) admissions and rapid response team calls.[73] Larger studies are needed to confirm CVSM's generalisability in minimising complications and ICU admissions and evaluate its impact on patient survival. Future research should also further evaluate machine learning predictive algorithms and their utility to improve the predictive capacity and value of CVSM technologies.

### *Measuring outcomes: Standardising definitions and measures of recovery*

Patients rarely are 'back to normal functional state' at the time of discharge and continue to suffer from various symptoms, functional limitations, and disabilities for an extended period.[74] There has been very little focus on recovery after discharge from the hospital as an outcome measure. In addition, what constitutes 'recovery' has lacked a uniform definition.[8] Defining and measuring recovery after surgery in clinical practice has traditionally focused on 'meeting the discharge criteria' – tolerating oral intake, ambulating without assistance, and pain with oral medications. Nevertheless, from a patient's perspective, recovery is a return to normal functioning (e.g. physical activity,

activities of daily living, and quality of life).[75] As recovery is a continuous process, recovery measures should be validated for repeat measures after discharge. They should provide real-time recovery data for timely intervention when the expected trajectory for return to baseline (or better) function is unmet.[76] Currently, there is growing interest in assessing later stages of recovery, including patient-reported outcomes and quality of recovery scores, days alive and at home up to 30 days after surgery, and longer-term disability-free survival using the World Health Organization Disability Assessment Schedule 2.0 (WHODAS 2.0) scale.[77] It must be understood that patient-reported outcomes are not always synonymous with objective parameters of functional recovery. Patient-reported (sometimes subjective) outcomes could demonstrate improvement without concurrent improvements in the objective assessment of function and activity.[78] In such patients, reasons for limitations to functional activities and reduced physical activity need to be evaluated. A better understanding of the characteristics and pathophysiology of procedure-specific (e.g. joint replacement surgery versus major abdominal surgery) and core recovery measures will help design future interventional trials to enhance post-discharge functional recovery on a procedure- and patient-specific basis.[48]

### *Research methodology and design*

Randomised controlled trials (RCTs) are the gold standard in clinical research. Well-designed multi-centre RCTs are valuable for understanding the cause-effect relationship in tightly coupled unimodal relationships between the intervention and related outcomes in the study. However, the practice of perioperative medicine and ERAS programs are not unimodal and involve multi-modal or bundled interventions, which raises the question of whether RCTs are the right research methodology for studying ERAS programs.[48] There has been a recent trend towards large pragmatic RCTs in anaesthesiology and perioperative medicine to address questions about generalisability, cost, and the complex nature of multi-modal perioperative care.[79] One of the challenges with this approach, and perhaps the reason for negative findings from these large pragmatic RCTs, is the wide variation in general practice across the study sites and the inability to control for consequential variables impacting outcomes.[80]

Given the above reasons, research in perioperative medicine and ERAS programs is challenging.[81] Surgical practice, anaesthetic techniques and strategies (e.g. multi-modal pain management including regional analgesia, nausea and vomiting prophylaxis, haemodynamic optimisation), and postoperative care are rapidly evolving. Hence, a study design that applies to the changing practice paradigm and influences care, outcomes, and value must be procedure-specific with well-defined and standardised outcome measures in the correct setting (inpatient versus outpatient) and done in a reasonable time frame.[82] It is critically important that the care pathway (e.g. bundled perioperative care) in an ERAS program be well-defined and evidence-based.[43] Overall, the design of future clinical trials in an ERAS program must depend on the question evaluating a single intervention in the bundle (as in an RCT) or the efficacy of the program in a patient-procedure-specific scenario (as in a large observational cohort study).

## Enhanced Recovery After Surgery and Perioperative Medicine as a Learning Health System Program

Recent advances in medical technologies, pharmacotherapeutics, omics, data science, machine learning, and research methodologies have significantly improved knowledge generation and its wider clinical application for progress in medicine, healthcare delivery, and population health. This is mainly the result of the transition of knowledge generation to being more relevant, patient-centric, continuous, and data-driven.[83] However, given the complexity of working through the enormity of clinical data, rapidly changing technologies, socio-economic patient factors and health outcomes, and questions on value-based care, a learning health system (LHS) has been proposed as a way of organising health systems and digital interventions better to meet the needs of current health delivery challenges.[84] The Institute Of Medicine (IOM) offered the first working definition of the LHS as a system 'in which science, informatics, incentives, and culture are aligned for continuous improvement, innovation, and equity—with best practices and discovery seamlessly embedded in the delivery process, with individuals and families as active participants in all elements, and new knowledge generated as an integral by-product of the delivery experience'.[85] An LHS encompasses 'continual improvement and innovation' from new knowledge captured as an integral byproduct of the delivery experience and meets the IHI Triple Aim of health care.[86,87]

An ERAS program is an ideal LHS exercise as it covers all the domains of a LHS initiative—science (evidence-driven

clinical pathway development and implementation), collaboration (multi-disciplinary), informatics (multiple data points from the entire perioperative continuum), and incentives (economic incentives for efficient, effective, and safe care; professional incentives to accelerate real-time learning; and demand incentives from the public for a higher performing health system), and culture (change management).[83]

## CONCLUSIONS

Despite wide implementation and reported success of ERAS pathways across various practice settings and countries, many opportunities lie ahead to learn from the experiences to date and understand the challenges to make this a viable patient-centred, recovery-focused, outcome-driven, value-based care program implemented to scale. Continued efforts need to rely on the principles of implementation science and appropriate research methodology. For the pervasive, robust, and sustainable implementation of ERAS programs, we need to focus on change management, implementing evidence-based interventions, developing robust audit and compliance tracking mechanisms, standardising definitions for procedure-specific outcome measures, understanding patient and procedure-specific recovery, studying recovery trajectory after discharge from the hospital, and implementing patient-reported outcomes and measures of patient engagement and experience in a rapidly changing surgical and perioperative practice. Rapid cycle, randomised/quasi-randomised quality improvement projects must be the core foundation of an ERAS program as we develop these initiatives under the learning health system paradigm to overcome the current challenges in healthcare delivery and meet the IHI Triple Aim of health care.

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### Conflicts of interest
There are no conflicts of interest.

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