



Enhanced Recovery After Cardiac Surgery: Where Do We Stand?

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Abstract

Purpose of Review Enhanced recovery after surgery (ERAS) protocols are multimodal and multi-professional strategies to enhance postoperative convalescence and thereby reduce the length of hospital stay and hospital-associated complications. This review provides an up-to-date overview about basic principles of enhanced recovery after surgery protocols, their transfer into cardiac surgery, and their current state of evidence. It is supposed to offer clinical implications for further adaptations and implementations of such protocols in cardiac surgery.

Recent Findings ERAS protocols are a story of success in numerous surgical disciplines and led to a paradigm shift in perioperative care and the establishment of ERAS Cardiac Society, a non-profit organization that provides evidence-based guidelines and recommendations for further development of enhanced recovery protocols, trying to harmonize the many existing efforts of individual approaches for cardiac surgery.

Summary Promising results from comprehensive ERAS protocols in cardiac surgery emerged. Nevertheless, there is a paucity of high-quality data about holistic approaches in cardiac surgery and further efforts need to be promoted.

Keywords ERAS · Enhanced recovery · Fast Track · Cardiac surgery · Minimally invasive surgery

Introduction

Enhanced recovery after surgery (ERAS) protocols are multimodal and multi-professional strategies to reduce physiological and psychological stress and thus decrease the appearance of postoperative complications and the length of hospital stay [1–3].

Initially established by Danish surgeon Dr. Kehlet in 1997, ERAS protocols proved to be efficient in colorectal surgery, demonstrating a reduction of healthcare-associated infections

and major advantages in length of hospital stays and cost-effectiveness [4, 5]. Those findings resulted in a paradigm shift in perioperative care, leading to the adoption of such protocols in a variety of surgical disciplines [6]. Numerous protocols, often referred to as “Fast Track” surgery, tend to apply only certain elements of ERAS principles, promoting a well-sounding but unprotected concept, often useful to attract media and patient attention, but rarely appropriate to live up to the holistic approach of enhanced recovery protocols. ERAS protocols were designed to cover up the entire journey of the patient, starting with preoperative patient education up to the point of early ambulation and follow-up care [7••]. Ultimately, ERAS society was established to deliver certified and evidence-based recommendations for pancreatic surgery [8], bariatrics [9], urology [10], otolaryngeal head and neck surgery [11], gynecology [12], and many more in development.

Cardiac surgery (CS) in particular offers a wide variety of complex pathologies, leads to high healthcare expenditures, and has to care for increasingly old patients who typically present with multiple comorbidities. That adds to the challenge of designing protocols that provide good treatment outcomes while having costs in control. With ongoing progress in developing less invasive surgical approaches and decreasing

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lengths on cardiopulmonary bypass (CPB), the number of patients being eligible for ERAS protocols in CS is increasing. Nonetheless, there is an apparent paucity of high-quality data on ERAS protocols in CS. For this reason, adoption and further enhancement of ERAS programs should be encouraged.

Basic Principles of ERAS

As a non-profit organization founded in 2010, ERAS society has published a range of guidelines and consensus papers for numerous surgical disciplines since then [7•]. Main principles of all modern ERAS protocols that apply to every surgical discipline are (a) providing extended patient information, (b) the reduction and modification of posttraumatic stress, (c) efficient analgesia, and (d) maintaining or restoring patient autonomy [13•].

(a) Extended patient information

Patient information in enhanced surgery protocols exceeds the traditional form of information and consent, which is often focused on the forensic aspects of possible complications. It is rather seen as a psychologically educative measure to improve mental readiness for surgery. It includes detailed information about the expected process and the patient's active role in his or her recovery. This kind of information and education is deemed to reduce the imbalance of knowledge about what is going to happen to the patient in the course of the hospital stay and is supposed to allow for motivation through inclusion. It has shown to improve the transition from hospital to community [14] and can reduce fear and postoperative analgesic use [15, 16]. Reduction of fear and analgesic use, on the other hand, might help improve postoperative convalescence [17, 18].

(b) Reduction of posttraumatic stress

Utilization of minimally invasive surgery goes hand in hand with ERAS methodology, as a reduction of trauma results in a reduction of inflammatory stress response, fewer postoperative complications, and shorter hospital length of stay (LOS) [19, 20]. Creating smaller access trauma therefore might reduce pain and analgesic use.

A new nutritional intake regimen, disregarding the long-existing practice of preoperative fasting in favor of oral carbohydrate loading, could demonstrate a positive effect on postoperative insulin resistance [21]. A reduction in insulin resistance beneficially alters the catabolic response following surgical trauma and eases the metabolic changes of postoperative stress response [22]. A third component in the reduction of posttraumatic stress is early mobilization as it plays an important role in the prevention of muscular and cardiovascular deconditioning [23]. Recovery can be accelerated and

appearance of respiratory infections and venous thrombembolisms can be reduced [7•].

(c) Analgesia

Inadequate perioperative analgesia results in sympathetic activation which can lead to the development of delayed gastrointestinal motility or other organ dysfunctions [5].

Pain-free patients, on the other hand, showed a reduction of postoperative complications and hospital LOS [24]. For enhanced recovery protocols, sufficient analgesia is a matter of utmost importance, as early mobilization and frequent physiotherapy units after surgery demand for active and collaborating patients.

(d) Patient autonomy

Even with possible restrictions in their everyday life caused by a disease, most patients lead a more or less independent and self-regulated life. A hospital stay marks a severe interference in a patient's autonomy. Tubes, catheters, and restrictions might limit the movement; there are regulations to follow and schedules to stick to. Hence, it is a central aspect of ERAS protocols to support patients in regaining their autonomy as soon as possible, utilizing all of the resources mentioned above.

ERAS Cardiac and Certified Guidelines

The successful implementation of abovementioned ERAS key elements in many non-cardiac surgery disciplines set the foundation for the establishment of ERAS Cardiac Society, a subgroup within ERAS Society. The multitude of complex pathologies, surgical approaches, and coexisting comorbidities in CS pose a great challenge to the development of comprehensive protocols. Additionally, the use of CPB triggers systemic inflammatory response syndrome, which complicates the postoperative recovery phase [25]. Preexisting protocols in CS suggested feasibility of applying certain elements of ERAS [26, 27], while numerous studies demonstrated that an early extubation is safe [28] and LOS on the intensive care unit (ICU) can be significantly shortened [29, 30]. Furthermore, the establishment of short-acting narcotics proved to be beneficial for early extubation and helped decrease ICU LOS in consequence of shorter ventilation times [31]. Nevertheless, reproducible guidelines that consider the complete perioperative process of ERAS in CS were not available. For this reason, newly founded ERAS Cardiac Society worked out evidence-based expert consensus recommendations on the basis of ERAS principles. A systematic literature review process to focus aspects of promising approaches and harmonize them into a scalable guideline led to the publication of the first ERACS guidelines manuscript [32•]. It provides a

summarization of key elements for implementation, marked with class of evidence and level of recommendation. Graduation of evidence and recommendation was performed according to “The evolution and future of ACC/AHA clinical practice guidelines” from Jacobs et al. [33]. A selection of key recommendations from class I to class IIb are summarized in Table 1. While some recommended elements like goal-directed fluid therapy and early extubation might already be well established, some others might be more unfamiliar to some cardiac specialists. Some recommendations will need fundamental changes, which require a realignment of infrastructure and human resources. Offering a prehabilitation program, for example, requires an interdisciplinary collaboration, involving representatives from every involved profession (e.g., physiotherapy, cardiac surgeon, anesthesiologist),

weeks prior to surgery. Feasible programs to assess a patient’s eligibility and to evaluate the programs efficacy are necessary. An example that makes clear that implementation of ERAS in CS is not only a matter of applying a protocol, but that it requires a willingness to change and break with long-established patterns. Salenger et al. recently published a guideline which emphasizes the complexity of successful implementation [34••]. Forming an ERAS program for CS is described as a multilayered process, starting with communicating the need for change. The following steps need to be a gap analysis in current organizational structures and a substantial team building. Once a feasible program is designed, monitoring compliance is challenging but essential. An implementation checklist is attached to the publication in order to encourage and facilitate a deployment in every setting.

Table 1 Summarization of recommendations adapted from “Guidelines for Perioperative Care in Cardiac Surgery Enhanced Recovery After Surgery Society Recommendation” Engelman et al. [32••]

(a) Before surgery

Class I recommendations

- Stoppage of smoking and hazardous alcohol consumption 4 weeks prior to surgery

Class IIa recommendations

- Preoperative measurement of HbA_{1c} for risk stratification
- Preoperative measurement of serum albumin for risk stratification
- Preoperative correction of nutritional deficiency
- Prehabilitation (regular exercising and augmentation of functional capacity prior to surgery)
- Patient engagement tools (utilization of printed or e-health material for patient education)

Class IIb recommendations

- Clear liquids can be given up to 2 to 4 hours before general anesthesia
- Preoperative carbohydrate loading

(b) During surgery

Class I recommendations

- Surgical site Infection reduction (topical *S. aureus* eradication, cephalosporin before skin incision, depilation protocols)
- Antifibrinolytic therapy using tranexamic acid or aminocaproic acid during on-pump CS

Class IIa recommendation

- Rigid sternal plate fixation instead of wire cerclage

(c) After surgery

Class I recommendation

- Perioperative glycemic control
- Opioid sparing pain management
- Postoperative daily delirium screening
- Prevention of hypothermia
- Goal directed fluid therapy

Class IIa recommendation

- Insulin infusion
- Chemical thromboprophylaxis from the 1st postoperative day
- Early extubation within 6 hours of ICU arrival
- Avoidance of nephrotoxic agents in patients with positive urinary biomarkers

Current Adaptations of ERAS in Cardiac Surgery

In 2016, Wong et al. provided a third update to a systematic Cochrane database review, including 28 controlled trials that compared Fast Track care to routine care in adult cardiac surgery [30]. Fast Track protocols needed to contain a time-directed extubation protocol or usage of low-dose opioid-based general anesthesia to be considered. Fast Track protocols proved to be noninferior regarding postoperative complications and mortality in low- to moderate-risk patients. Although ICU LOS and time to extubation were significantly reduced in both Fast Track protocols, no differences in total hospital LOS were shown.

Fleming et al. contributed to ERAS by implementing an enhanced recovery protocol in a prospective observational study, comparing 52 patients undergoing CS after implementation of an ERAS protocol to 53 historic patients [26]. The protocol was based on recommendations from a consensus review in colorectal surgery, containing a more holistic perioperative approach. Detailed preoperative patient education, avoidance of prolonged fasting periods prior to surgery, preoperative carbohydrate beverages, optimization of analgesia with avoidance of long-acting opioids, prevention of postoperative nausea and vomiting, early enteral nutrition postoperatively, and early mobilization were applied. As a result, significantly fewer patients in the ERAS group presented with one or more postoperative complications. Additionally, reduced postoperative pain scores were documented. Hospital LOS remained unchanged in both groups.

The randomized clinical trial of Li et al. randomly assigned a total of 226 patients to a routine group or ERAS pathway [35]. Preoperative elements of the comprehensive protocol contained preoperative patient education and psychological counselling, as well as an erythropoietin injection and carbohydrate loading. Patients received a paravertebral nerve block for pain management. After surgery, catheters and tubes were removed on the first postoperative day and injection of erythropoietin was continued until the patient's hemoglobin level was above 10 g/dl. A significant reduction in major postoperative complications, such as acute renal failure, delirium, stroke, infarction, or heart block, was shown. Patients showed no differences in adverse events on 1, 3, and 6 months of follow-up after hospital discharge.

Di Eusanio et al. demonstrated safety and feasibility of minimally invasive aortic valve surgery, using rapid deployment valves in combination with a minimally invasive extracorporeal circulation system [36]. Anesthetic management included low-dose opioid-based anesthesia, normothermic temperature management, a time-directed extubation protocol, and early onset of physiotherapy units and rehabilitation programs. Despite robust evidence missing, the overall reduction of surgical stress is expected to be associated with faster recovery and increased patient comfort.

The most extensive implementation of an enhanced recovery protocol in CS yet was described by Williams et al., who published the 1-year results of the first US-based ERAS cardiac program in 2019 [37]. The program included preoperative patient education, carbohydrate loading, opioid-sparing analgesic management, goal-directed insulin infusions, and rigorous bowel management. A total of 489 historic patients were compared to 443 patients undergoing ERAS protocol. A significant reduction in gastrointestinal complications, hospital, and ICU LOS was demonstrated and patient as well as staff satisfaction was increased.

At the University Heart and Vascular Center Hamburg, our group established an enhanced recovery protocol for minimally invasive heart valve pathologies [38]. Key elements of this protocol are a dedicated prehabilitation program, on-table extubation in the OR, and early postoperative mobilization. Establishment of the ERAS program resulted in safe and fast postoperative recovery of the patients and an economic benefit of up to 1900€ per patient [39]. The data collected in this retrospective cohort analysis made way for the INCREASE study (INterdisziplinäre und sektorenübergreifende Versorgung in der HerzChiRurgiE am Beispiel von minimal-invasiven Herzklappeneingriffen), a randomized clinical trial, which will start in June 2021 and is expected to provide high-quality data about the organization and execution of ERAS protocol in the minimally invasive treatment of heart valve pathologies and their potential transfer into standard-of-care treatment.

Conclusion

After the triumphal procession of ERAS in a variety of surgical specialties, promising results from comprehensive protocols in CS are gradually emerging. The many efforts being undertaken indicate an increasing willingness to shape inclusive future programs that cover up the entire journey of the patient, showing integration and improvement of pre-, intra-, and postoperative elements. After implementation of the ERAS protocols, it becomes clear that they could not only demonstrate a noninferiority but even contribute to the safety of specific patient collectives undergoing CS. Due to the safety and benefits of ERAS, it will play a key role in modern CS in the near future.

The relatively slow adoption of evidence-based elements, although some of the knowledge has been around for a long time, emphasizes the importance of communicating the need for change. In times when incremental professionalization in healthcare may have a tendency of driving different professions further apart, than to make them work together in a better way, ERAS can contribute to a manner of interdisciplinarity and cooperation. Although the convenience of sticking to reliable workflows and procedures is comprehensible, it has to

be a matter of duty for a contemporary clinician to strive for a patient-centered and all-embracing healthcare system.

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Declarations

Conflict of Interest Alexander Gebauer¹, Dr. Johannes Petersen¹, Johanna Konertz¹, Dr. Jens Brickwedel¹, Dr. Leonie Schulte-Uentrop¹, Prof. Dr. Dr. Hermann Reichenspurner¹, Prof. Dr. Evaldas Girdauskas^{1,2} declare they have no conflict of interest.

Human and Animal Rights and Informed Consent All reported studies/experiments with human or animal subjects performed by the authors have been previously published and complied with all applicable ethical standards (including the Helsinki declaration and its amendments, institutional/national research committee standards, and international/national/institutional guidelines).

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