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Enhanced Recovery After Surgery (ERAS) Protocols in the Field of Orthopedics and Traumatology

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ABSTRACT

Enhanced Recovery After Surgery (ERAS) protocols involve a perioperative, multimodal, and multidisciplinary approach that promotes healing across various patient groups while offering both medical and economic benefits in the field of Orthopedics and Traumatology. This review aims to increase global awareness and implementation of orthopedic ERAS programs, highlight their significance, and encourage the development of further evidence. Based on published studies and treatment guidelines, ERAS in the field of Orthopedics and Traumatology includes components such as preoperative education, anesthesia techniques, intraoperative strategies, postoperative analgesia, advancements in modern care, minimally invasive techniques, early mobilization, and metabolic optimization. In orthopedics, ERAS has been shown to reduce hospital stays, lower complication rates, and decrease healthcare costs. However, we believe that additional evidence is still needed to further support its widespread adoption.

Keywords: Earyl mobilization, orthopedic care, perioperative management.

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INTRODUCTION

Enhanced Recovery After Surgery (ERAS) is a patient-centered, evidence-based approach aimed at improving both patient experience and clinical outcomes. Originally developed for colorectal surgery, ERAS has since been adopted in orthopedic surgery. It is a process designed to reduce costs, complications, and length of hospital stay (LOS), while enhancing recovery, return to function, and overall healthcare efficiency.[1,2] Most studies to date have focused on total joint arthroplasties.[3,4] For instance, in an observational study of 4,500 patients undergoing primary hip and knee arthroplasty, a significant reduction in mortality rates was reported within a 30-90 days follow-up period after implementation of an ERAS program.[5] Today, ERAS is being applied across many areas of Orthopedics and Traumatology through a multidisciplinary approach, with ongoing efforts to expand its implementation. This review aims to highlight the global importance of the ERAS program, promote its wider adoption, and encourage further high-quality research to strengthen the evidence base. The ERAS methodology is examined across three phases of care: preoperative, intraoperative, and postoperative (Table 1). In this study, we explore the integration of ERAS protocols into orthopedic practice to achieve more effective outcomes.

Table 1. Enhanced recovery after surgery (ERAS) protocols used in orthopedics and traumatology

Preoperative Interventions	Intraoperative Interventions	Postoperative Interventions	Minimally Invasive Surgery
- Preoperative patient training - Smoking cessation programs - Anemia management (Iron supplementation, erythropoietin therapy, EPO) - Nutritional optimization (immunonutrition including arginine) - Assessment of obesity and albumin status - Patient education and group sessions - Preoperative quadriceps strengthening - Prehabilitation programs for total hip arthroplasty (THA) and total knee arthroplasty (TKA)	- ERAS-based anesthesia protocols - Use of short-acting agents - Prophylaxis for postoperative nausea and vomiting (PONV) - Regional and peripheral anesthesia - Avoidance of long-acting opioids and muscle relaxants - Neuromuscular monitoring (e.g., Train-of-Four, TOF) - Local infiltration analgesia (LIA) - Tourniquet management strategies - Administration of tranexamic acid (intravenous and intra-articular) - Use of dexamethasone	- Optimized blood transfusion strategies - Early mobilization and structured physiotherapy - Thromboprophylaxis (mechanical devices and chemical agents) - Use of autotransfusion sets - Cryotherapy and electromyographic (EMG) biofeedback - Use of continuous passive motion (CPM) devices - Walker-assisted rehabilitation	- Minimally invasive surgery (MIS) in arthroplasty and trauma - Faster recovery with less tissue trauma - MIS techniques such as intramedullary (IM) nailing and minimally invasive plate osteosynthesis (MIPO) - Reduced infection rates and blood loss - Acknowledgment of the learning curve - Careful patient selection and surgical planning - Limited use of external fixators

Preoperative Interventions

Training and Metabolic Balance

Preoperative training serves as a guideline for managing patient expectations, pain control, and the anticipated hospital stay. Yoon et al.[6] found that a personalized preoperative training program reduced hospital stay by up to 24 hours following lower extremity total joint arthroplasty. However, a Cochrane Review of nine studies failed to demonstrate a significant effect of preoperative training on pain, functional outcomes, or length of hospitalization.[7] In a prospective cohort study, Singh et al.[8] observed that current tobacco use was associated with higher rates of implant revision and deep infection in primary total hip and knee arthroplasties (THA and TKA).

Perioperative smoking cessation has been shown to effectively reduce postoperative complications, even when initiated as late as four weeks before surgery.[9] Anemia is linked to a significantly increased risk of mortality and is an independent predictor of postoperative infection. It can prolong hospital stays and increase the likelihood of requiring blood transfusions.[10] Early detection of anemia allows for timely interventions such as iron supplementation and erythropoietin (EPO) therapy.[11,12] In addition, immunocytosis has been shown to reduce patient infections, complications, and hospital stay in the perioperative period.[13] A meta-analysis of 35 randomized clinical trials involving various malignancies reported a reduction in postoperative infection rates and a shorter length of hospital stay when patients received arginine-supplemented immunonutrition (IMN).[14] Obesity is considered a significant risk factor in orthopedic surgery, contributing to degenerative processes, increased morbidity, limited joint function, and a higher risk of infection.[15,16] In a study involving 10,117 patients with hip fractures, hypoalbuminemia alone was associated with postoperative complications, including death, unplanned intubation, mechanical ventilation for more than 48 hours, sepsis, and blood transfusion, and prolonged hospital stay.[17]

In some clinics, group-based education programs allow patients to gain mutual understanding and empathy while also learning about expectations and the postoperative recovery process.[18] According to Lepley et al.,[19] individuals with better quadriceps activation before surgery tend to show greater activation after surgery. Similarly, those with greater preoperative strength typically maintain better strength postoperatively. Some studies suggest that high-intensity preoperative training can improve muscle strength and range of motion (ROM), particularly in patients undergoing TKA. This improvement contributes to enhanced functional performance and faster postoperative recovery. Patients

undergoing THA or TKA who participate in preoperative exercise programs often experience shorter hospital stays, likely due to improved physical readiness and recovery.[20-22] However, contrasting findings also exist in the literature. Wang et al.[23] conducted a rigorous review of 22 studies and concluded that prerehabilitation had minimal impact on pain reduction, functional recovery, quality of life, length of hospital stay, and overall cost.

Intraoperative Interventions

Anesthesia in ERAS Protocol

Preparation for Anesthesia

Enhanced recovery pathways vary across institutions but include key components for anesthesiologists, such as hemodynamic optimization, the use of short-acting drugs with appropriate monitoring, prophylaxis for postoperative nausea and vomiting (PONV), protective ventilation strategies, and opioid-sparing multimodal analgesia.[24] The ERAS protocol generally includes several perioperative strategies: preoperative preparation and patient counseling, avoiding routine bowel preparation, administering preoperative carbohydrate-rich drinks, avoiding long-acting premedication, providing thromboembolism and antibiotic prophylaxis, using epidural anesthesia when appropriate, employing short-acting anesthetics and opioids during surgery, restricting parenteral sodium and fluid administration, preventing hypothermia, managing postoperative nausea and vomiting, sing non-opioid techniques for postoperative pain control, initiating early enteral feeding, stimulating gastrointestinal motor activity, minimizing nasogastric tube use, opting for arthroscopic or minimally invasive surgery when appropriate, removing drains and urinary catheters as early as possible, promoting early mobilization, and evaluating protocol adherence and outcomes.[25]

During surgical preparation, it is recommended to minimize the restriction of oral intake. Patients are advised to stop solid food consumption six hours before surgery, while clear liquids and water are permitted up to two hours before the procedure. Carbohydrate-rich fluids may also be consumed up to two hours preoperatively. These guidelines are designed to reduce the risk of aspiration. However, it is now recognized that prolonged fasting does not further decrease aspiration risk and may negatively impact patient comfort. The American Society of Anesthesiologists (ASA), along with other international guidelines, supports more flexible preoperative fasting protocols.[26] Prolonged preoperative fasting can result in adverse effects such as intraoperative hemodynamic instability, postoperative delirium, patient discomfort, and extended hospital stays.[27]

Premedication

Within ERAS protocols, premedication plays a crucial role in preparing patients for surgery. It includes aspects such as anesthesia planning, fasting guidelines, and prophylaxis for postoperative nausea and vomiting. Anesthesiologists are central to implementing premedication strategies, which enhance the overall effectiveness of the ERAS protocol. In ERAS protocols, the use of short-acting drugs is encouraged to minimize the side effects of anesthesia and analgesics. This approach should be implemented with careful monitoring throughout the perioperative period.[24]

Anesthesia Technique and Anesthetic Agent Selection

The choice of anesthesia technique and anesthetic agent should prioritize rapid recovery and a minimal side effect profile. When appropriate, regional anesthesia is preferred. Epidural opioid administration is generally not recommended, as it may increase the risk of nausea and vomiting. However, in suitable cases, thoracic epidural anesthesia and analgesia can offer several benefits. Local infiltration techniques, regional anesthesia, and peripheral nerve blocks are also commonly used within ERAS protocols. Anesthetic agents with short durations of action and minimal side effects are favored, as they support faster recovery in accelerated rehabilitation pathways. Inhaled anesthetics and intravenous hypnotics are commonly used in general anesthesia. Among inhaled agents, desflurane offers advantages due to its short duration of action. Propofol is often preferred because of its short duration of action, its suitability for both induction and maintenance of anesthesia, and its ability to reduce postoperative nausea and vomiting. For induction with propofol, a dose of 1.5-2.5 mg/kg is typically used. For maintenance, dose-controlled infusion (TCI) ranges include 4-12 mg/kg/h or 2-6 µg/mL. Avoiding excessively deep anesthesia can help accelerate recovery.[28] Nitrous oxide is generally avoided due to its association with increased nausea and vomiting, accumulation in third spaces, and thrombotic morbidity.[29]

Monitoring the depth of anesthesia is beneficial, as it reduces unnecessary drug use and facilitates faster recovery. The use of long-acting opioids should be minimized. When selecting opioid agents, it is important to consider that continuous infusion increases the context-sensitive half-life over time. Remifentanil, administered at 0.05-2 µg/kg/min, has been shown to provide effective intraoperative analgesia and shorten extubation time after surgery.[28] Neuromuscular blockers are commonly used in general anesthesia to facilitate intubation, improve mechanical ventilation conditions, and enhance the quality of the surgical field. However, the use of long-acting muscle relaxants is considered a disadvantage

in ERAS protocols. Instead, short- and intermediate-acting agents are preferred to minimize the risk of postoperative complications and residual blockade.[30] Residual blockade can delay recovery and increase the risk of postoperative complications such as desaturation, airway obstruction, and reduced muscle strength. Therefore, the use of neuromuscular monitoring techniques, such as the train-of-four (TOF) method, is essential to avoid residual block and reduce the incidence of postoperative complications. The use of reversal agents is recommended when the TOF ratio is below 0.9. Sugammadex, used to reverse the effects of aminosteroid muscle relaxants, is faster and safer than traditional agents; however, it should be noted that these agents can increase costs.[31] Epidural analgesia was once considered the gold standard for postoperative pain control following lower extremity total joint arthroplasty. However, its use has declined due to the risk of spinal hematoma in patients receiving chemoprophylaxis for embolism.[32] Nerve blocks can be administered either before or after the surgical procedure, depending on timing and other clinical considerations. Peripheral nerve blocks are commonly used in modern orthopedic surgery as a minimally invasive approach during the perioperative period. They reduce the need for intensive care and lower anesthesia-related risks, particularly in patients with high ASA scores. However, complications can occur if these techniques are not performed by experienced clinicians.[33]

Intraoperative Analgesic Drugs

Dexamethasone, a long-acting corticosteroid, is commonly used for the prophylaxis of postoperative nausea and vomiting. When administered at higher doses (>0.1 mg/kg), it has also been shown to provide effective analgesia, reduce opioid consumption, and shorten hospitalization time.[34]

Local Infiltration Analgesia (LIA)

Local ınfiltration analgesia can be administered by injecting analgesics into and around the joint, or by placing a postoperative wound catheter for permanent infiltration. However, some authors avoid using catheters due to the potential risk of infection. The technique is widely accepted for its simplicity and relative safety, although evidence supporting its effectiveness is limited. When used with multimodal drug combination after TKA, the LIA technique can significantly improve pain control at rest and during movement, leading to higher patient satisfaction.[35,36]

Tourniquet

Using a tourniquet only during cementing has been shown to significantly reduce tourniquet time compared to its use from incision to arthrotomy closure. While this approach may lead to a slightly greater decrease in hemoglobin levels, it does not significantly affect postoperative pain, narcotic use, knee range of motion, or functional outcomes. Additionally, it may reduce the incidence of clinically significant thromboembolic events and minor postoperative complications.[37]

Tranexamic Acid (TXA)

The routine use of TXA has been shown to significantly reduce perioperative blood loss and the need for allogeneic blood transfusion in total joint arthroplasty.[38] Evidence in the literature suggests that a combination of intravenous and intra-articular TXA administration is more effective at reducing total blood loss than intravenous TXA alone.[39,40] In a review of topical tranexamic acid use in spinal surgery, hospitalization duration was found to be reduced by 18.26% in patients receiving tranexamic acid compared to the control group.[41]

Postoperative Interventions

Postoperative Blood Transfusion

Blood transfusion rates after TKA vary across studies. For example, one study reported a transfusion rate of 17.9% following TKA.[42] In another study, transfusion rates after primary total knee arthroplasty (pTKA) decreased from 17.6% to 0.7%, while in revision THA (rTKA), the rate dropped from 19.4% to 2.6%.[43] In another study, an autotransfusion set was used in place of a postoperative hemovac drain for all patients, with an average of 560 mL of blood reinfused 4.6 hours after skin closure. Only one patient (5.2%) required a single unit of blood transfusion on the first postoperative day.[44] However, the authors of this review do not have personal experience with this method.

Postoperative Exercise

Physical therapy and rehabilitation are critical components of early postoperative recovery. Y. Gleicher et al.[45] demonstrated that mobilizing patients on the first postoperative day after total knee arthroplasty significantly reduced the length of hospital stay. Abnormalities in articular sensory receptors and spinal reflex pathways are believed to occur following trauma. Therapeutic strategies to address these issues include strengthening exercises, electromyographic biofeedback, and cryotherapy.[46-48]

Postoperative Thromboprophylaxis

Mula et al.[49] reported that the incidence of symptomatic deep vein thrombosis (DVT) was 0.77% following total hip arthroplasty, 0.05% following total knee arthroplasty, and 0.55% after hip fracture surgery. Pulmonary embolism (PE) rates were reported as 0.46% for THA, 0.27% for TKA, and 0.96%

for hip fracture surgery. ERAS protocols generally include both mechanical prophylaxis (e.g., sequential compression devices) and pharmacologic prophylaxis (e.g., low-molecular-weight heparin).[50]

Continuous Passive Motion (CPM)

Continuous passive motion (CPM) devices and walkers (e.g., NEO-GAIT) are commonly used in rehabilitation following knee arthroplasty. In a study published in 2021,[51] patients who underwent total knee arthroplasty showed better rehabilitation outcomes when using a walker compared to a CPM device.

Minimally Invasive Surgery

Minimally Invasive Arthroplasty

Minimally invasive total knee arthroplasty has been associated with faster recovery in terms of total blood loss, visual analog scale (VAS) scores, ROM, flexion range, and the ability to perform straight leg raises. However, surgery and tourniquet times were significantly longer compared to conventional TKA techniques.[52,53] Although the results are heterogeneous in joint replacement, it is generally accepted that current evidence does not demonstrate a clear superiority of minimally invasive surgery (MIS) to conventional joint replacement techniques.[54,55]

In minimally invasive procedures, the complexity of surgical techniques and the associated learning curve must also be considered. For example, in total knee arthroplasty, minimally invasive surgery approaches have been associated with shorter hospital stays and faster functional recovery, although surgical time may be longer.[52] Additionally, studies have shown that minimally invasive techniques yield similar outcomes to traditional methods in terms of long-term complication risks.[56] While minimally invasive arthroplasty offers the benefits of reduced trauma and quicker recovery, factors such as patient-specific characteristics and the complexity of the surgical approach should be carefully evaluated. To minimize the risk of complications in such surgeries, careful evaluation of patient selection and surgical techniques is important. Given the limited availability of long-term data, the purported benefits of MIS remain questionable. However, the authors do not have direct experience in this area.

Minimally Invasive Trauma Surgery

Although ERAS is widely discussed in orthopedics in the context of arthroplasty, it is also applicable to orthopedic trauma surgery. In recent years, significant advancements have been made in the treatment of fractures using internal fixation methods. Whereas earlier focus was placed primarily on alignment and fracture reduction, current approaches increasingly emphasize the preservation of soft tissue integrity and biological viability at the fracture site.

To protect soft tissue and promote faster fracture healing, more minimally invasive surgical techniques are now preferred. These approaches aim to reduce infection risk, minimize blood loss, allow for smaller incision, shorter operative time, and enable earlier discharge. As a result, secondary hospitalizations can be reduced. The authors use external fixators for limited indications, as they are difficult to manage and typically require a second surgery. Additionally, external fixators carry a risk of pin tract infections. They are typically used as a temporary solution in patients requiring damage control surgery, particularly in Type 3B/C open long bone fractures, knee dislocations, and open-book pelvis fractures, as classified by the AO system (Arbeitsgemeinschaft für Osteosynthesefragen classification system). For unstable diaphyseal fractures of long bones, the authors prefer intramedullary nailing, which aligns with the bone's natural physiology and allows for early mobilization and weight-bearing. Minimally invasive plate osteosynthesis is the method of choice for metaphyseal fractures of long bones.

Hip Fractures

The authors' approach to hip fractures emphasized that trauma patients, particularly elderly individuals with hip fractures, should be operated on as soon as possible, in accordance with ERAS principles. Delays in surgery increase the risk of cardiovascular, nephrological, metabolic, gastrointestinal, and neuropsychiatric complications. To reduce the risk of decubitus injury, attention is given to bed hygiene, genital area cleanliness, and proper patient positioning during hospitalization. These practices are also regularly communicated to the patient's relatives. In addition to chemical and exercise-based prophylaxis, anti-embolic stockings are recommended to help prevent thromboembolic events. For elderly patients with hip fractures who require urgent surgery, consultations are conducted with internal medicine, pulmonology, cardiology, neurology, and anesthesiology specialists. These consultations are carried out in a coordinated manner, with close communication maintained among all involved physicians. The least invasive anesthetic technique is preferred in collaboration with the anesthesia team. Whenever possible, regional, local, or block anesthesia is chosen to minimize the risk of perioperative complications. In the early postoperative period, patients admitted to the ward begin with bed exercises, progressing to sitting on the edge of the bed and eventually standing and mobilization. Quadriceps and ankle exercises are encouraged to prevent thromboembolism and to help restore muscle strength. The

patient's initial standing is conducted under the supervision of family members, nursing staff, and the attending physician. To reduce the risk of falls, patients are assisted to a standing position using a walker after first being positioned at the edge of the bed. The patient's ability to stand and take their first steps is a significant milestone in meeting both physical and emotional expectations. We observe that the ability to stand and walk has a strong impact on both the physiological and psychological well-being of the patient. From the immediate postoperative period onward, vital signs, pain scores, physical examinations, and laboratory follow-up, including hemogram and biochemistry tests, are regularly monitored.

RESULTS

Although ERAS has gained widespread acceptance in many surgical specialties, there are relatively few reports and systematic studies evaluating its application in orthopedics, largely due to the complexity of cases in this field. Some studies report that ERAS is associated with improved clinical outcomes, including reduced LOS and fewer postoperative complications. However, other reports indicate that ERAS may not significantly influence outcomes following orthopedic surgery. As a result, the effectiveness of ERAS in enhancing postoperative recovery in orthopedics remains a topic of ongoing debate.

Orthopedic patients are exposed to significant anesthetic and surgical trauma, pain, hunger, an increased risk of deep vein thrombosis, and other stressors. Therefore, a holistic approach to patient care is essential throughout the entire treatment process. Minimally invasive techniques, metabolic optimization, and early surgical intervention enhance the effectiveness of ERAS protocols in orthopedics. A comprehensive perioperative approach combined with early rehabilitation can accelerate recovery.

However, most studies are not randomized controlled trials, and follow-up durations are often less than five years. Additionally, since ERAS is a perioperative process involving many variables, large patient groups are needed in each study to evaluate specific outcomes for each component. Collaborating with multiple centers would also improve the reliability of the results. Finally, the definition of ERAS can still vary across institutions.

ERAS is a patient-centered, evidence-based approach designed to improve both patient experience and clinical outcomes. Following its success in colorectal surgery, ERAS has been adopted in orthopedic procedures. It can be described as a process that reduces costs, complications, and length of hospital stay, while enhancing recovery, return to function, and overall healthcare efficiency.

CONCLUSION

In this study, we explore the relationship between ERAS protocols and orthopedic surgery to evaluate their effectiveness. Based on the available evidence, we believe that ERAS is a safe and effective approach that can accelerate recovery, reduce dependence on costly pain medications, and increase patient satisfaction.

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