

Enhanced recovery after surgery (ERAS)

Concepts, components, and application to spine surgery

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Abstract:

This article describes the concept of Enhanced Recovery after Surgery (ERAS) and its application to spine surgery. ERAS is a multimodal approach designed to reduce the surgical stress response and accelerate recovery following surgery. It is a multi-disciplinary, patient centred approach that employs an evidenced-based pathway of standardised care. It has been proven across a range of surgical pathways but has yet to be defined and adopted in spine surgery. ERAS pathways are needed in spine surgery. Patient recovery is often long, painful, expensive, and a highly variable experience. Consequently, ERAS programs will find great utility in this subspecialty.

Introduction:

Enhanced Recovery after Surgery (ERAS) is a multimodal approach to patient care¹ introduced to prepare patients for surgery, reduce the impact of surgery, and enable patients to recover faster. It has been adopted across a wide variety of surgical procedures in many nations, and there is consistent evidence to show that it improves recovery, reducing length of hospital stay without increasing complications, readmissions, or compromising the patient experience.²⁻⁴

ERAS rationale:

The concept of ERAS was developed by a team of academic surgeons based in Europe at the start of this century.⁵ The initial focus was on modulating and reducing the surgical stress response to major general surgical procedures. A combination of hormonal and inflammatory responses to the trauma of surgery contributes to insulin resistance; a major factor that affects surgical outcome.⁶ By

implementing components such as regional analgesia, perioperative feeding and minimally invasive surgery, perioperative insulin sensitivity is tempered, thereby improving outcomes and speed of rehabilitation. The key components of ERAS (also known as fast-track, accelerated, or rapid recovery surgery) are an evidence-based approach to care; preoperative education and physical optimisation; a multimodal opioid sparing approach to anaesthesia and analgesia to allow early mobilisation; multidisciplinary working and regular meetings including all involved disciplines; and all staff training on requirements to meet functional discharge criteria. It has been successfully introduced to a range of complex surgical procedures, such as, hip and knee replacement, rectal/pelvic surgery, colonic surgery, pancreaticoduodenectomy, and gastrectomy.⁷⁻¹¹ Organisations such as The ERAS Society (<http://erassociety.org>), ERAS Society (UK) (<http://www.erasuk.net/>), the ERAS Society USA Chapter (<http://erasusa.org/>), and the American Society for Enhanced Recovery (ASER) (<http://aserhq.org>) have been formed to promote its practice.

The application of ERAS to musculoskeletal surgery:

In musculoskeletal surgical procedures, which are most closely related to spine surgery, there is strong evidence to demonstrate that ERAS has been successfully adopted into surgical pathways, and especially within the high-volume surgical pathways such as hip and knee replacement, where reductions in LOS, with no increases in complication or readmission rates, and high patient satisfaction have been found.¹¹⁻¹⁴

A retrospective study in the UK¹⁵ compared 3000 consecutive hip and knee replacement patients on an ERAS pathway with those previously using a traditional protocol. It found the median length of stay (LOS) in the ERAS group was reduced to 3 days from 6 days, with a near significant decrease in return to theatre and mortality rates. No increase in readmissions was found in a study which followed 1731 hip and knee replacement patients on an ERAS protocol.¹⁶ A reduction of mean LOS from 4.6 to 3.1 days was found for total knee replacements, and 6.3–3.9 days for total hip replacement. ERAS principles have also been transferred successfully more complex procedures such as revision hip replacement and revision knee replacement patients. A Norwegian study¹⁷ included 82 revision hip and knee patients in its analysis of an ERAS pathway and found that it was feasible and favourable for these patients, with a mean LOS of 4.2 days for revision hip patients, and 3.9 days for revision knee patients.

Patient satisfaction is also a useful outcome when evaluating ERAS. Studies suggest that it is not negatively affected for primary hip and knee replacement patients.^{18,19} One study²⁰ found that 445 patients rated their overall satisfaction highly (median of 10 for hip replacement and 9 for knee

replacement) when rating on a scale of 1–10, with 10 being best possible satisfaction. The authors suggest that this may be because for ERAS, all sub-components of care are prioritized to ensure patient safety on leaving the hospital.

ERAS principles have also been transferred to other areas in orthopaedics. They were introduced into a shoulder replacement pathway at a German hospital.¹⁴ Initial evaluation was positive, and ERAS principles were found to be readily transferable. A US study²¹ compared length of stay for shoulder replacement at an orthopaedic speciality hospital (OSH) which used fast-track rehabilitation and strictly organised protocols with that at a tertiary referral centre (TRC). It found that patients at the OSH had over half-a-day shorter stay than those at the TRC, and concluded that for selected patients, the OSH offered potential clinical and financial benefits.

There is also some evidence to show the benefits of introducing ERAS to Fractured Neck of Femur (FNOF) patients^{22–25} although in a review of perioperative interventions for this group of patients the authors highlight the inherent differences between elective and emergency patients.²⁶ They caution that although there is some evidence to support individual interventions, further research is required to see how using these interventions together can improve outcomes.

Systematic reviews and meta-analyses have found ERAS to be cost effective^{27,28}; however, there have been few studies in orthopaedic surgery. A study in Denmark comparing economic costs for total knee replacement patients on an ERAS pathway with more conventional pathways found cost savings for the ERAS patients, the majority of which related to the reduction in length of stay.²⁹ A second Danish study of 87 total hip and knee replacement patients found the ERAS protocol enabled cost savings in the in the region 4000 dollars compared to a standard protocol.³⁰

The application of ERAS to spine surgery:

There is a strong theoretical case for improving surgical outcomes by introducing ERAS principles to spine surgery pathways. This has been previously highlighted, in combination with the observation that there are few studies examining the application of ERAS in spine surgery.³¹ However, more recently, the anecdotal application of ERAS principles has increased rapidly across geographical territories and different spinal procedures.

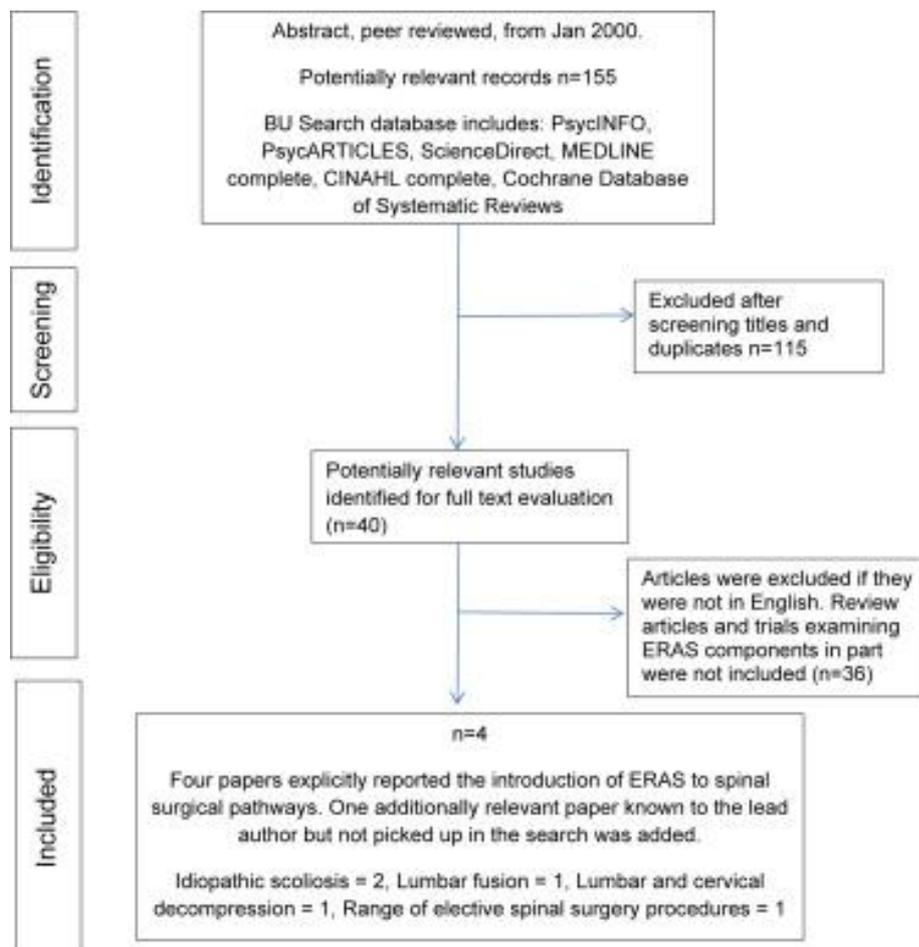
An updated literature search was therefore conducted in February 2017, with a search criteria designed to capture articles reporting across a wide range of elective spinal surgery procedures. From 155 potentially relevant articles, 4 articles were identified that described the implementation of ERAS (Fig. 1) to a spinal surgery cohort of patients. Review articles, studies examining elements of ERAS (without the rest of the pathway adequately described), and articles not in English were

excluded. One additional study, was not picked up by the search but was known to the lead author, and highly relevant, and so was added to the review.³² Of the five pertinent articles, one described the implementation of ERAS to a whole elective spinal surgery service,³² two papers examined idiopathic scoliosis surgery,^{33,34} one looked at lumbar spinal fusion,³⁵ and one described a series of lumbar and cervical spinal decompression patients.³⁶

The paper examining the adoption of ERAS to a whole elective spinal service was based in the UK, and had the hospital had organisational experience of adopting ERAS to hip and knee replacement patients.³² It is a well written and methodical quality improvement report, with a clear description of how they developed the ERAS pathway using inputs across professions and patients, and by reviewing the literature for the best evidence. The spinal consultants agreed 12 descriptions of elective spinal surgery to improve team communications and help standardise care, and defined an earliest expected day of discharge for each description which helped nurses and therapists to plan to mobilise patients appropriately, and ensure consistency. The standardisation of logistical principles associated with all spinal surgeries was the overarching aim, with generalizable elements of ERAS which could be applied across all types of surgery applied.

Specific ERAS elements included the preoperative use of carbohydrate drinks, laxatives, a written leaflet on what to expect following surgery, and an estimated discharge date. More minimally invasive techniques were used for a number of the procedures, and tranexamic acid was given to patients having longer operations. A standardised anaesthetic regimen was developed to avoid large doses of intraoperative opioids and use short acting anaesthetics, alongside a standardised multimodal analgesia regimen designed to reduce opioid use.

Following surgery but on the same day, consultants would see all patients and encourage mobilisation. Food and drink would be offered to patients on the day of surgery, and a leg bag would be used if ongoing urinary catheterisation was required. Daily aims were agreed with patients each day, and consultants would do daily ward rounds to ensure there were no factors to prevent patients from going home. An experienced community-based nursing team were able to follow-up on wound care and analgesia advice to prevent readmissions, and all patients had a follow-up appointment arranged at discharge.



The implementation of the ERAS pathway was found to be successful, with length of stay reduced from a mean of 6 days before its introduction to 2.9 days, and readmissions reduced from 7% to 3%. In addition, a median of 100% of patients rated their care as good or excellent. This paper demonstrates the clear improvements that can be achieved with the implementation of ERAS when general ERAS principles (not procedure specific) are applied as part of a structured quality improvement initiative. Whilst a breakdown of improvements by procedure was not provided by the authors, short stay procedures such as lumbar and cervical discectomy were included, and just as Venkata and Van Dellen³⁶ demonstrated, these could be discharged home on the day of surgery when ERAS principles were adopted. However, Blackburn et al.³² also included more complex and traditionally longer stay procedures such as posterior scoliosis correction were included, and given an expected LOS of 5 days for children, and 7 days for adults.

The two studies looking at the implementation of ERAS for adolescent idiopathic scoliosis surgery, also indicated that ERAS can be successfully introduced to this pathway, and that LOS can be reduced to 3–4 days.^{33,34} In one study mean length of stay was reduced by 1.7 days to 4 days after the rapid recovery pathway was fully introduced for 84 patients.³⁴ In this paper, the authors present the details and results of a systematic quality improvement journey, with clear details of the

historical pathway, the transition period, and the implementation of ERAS. An excellent pathway algorithm, detailing their ERAS pathway is available online (<http://www.chop.edu/clinical-pathway/spinal-fusion-post-op-adolescent-idiopathic-scoliosis-ais-clinical-pathway>). The authors present Statistical Process Control (SPC) data for compliance to ERAS processes, and outcomes such as LOS and pain. This illustrates and confirms the link found previously in ERAS pathways, that high process compliance is linked to improved outcomes,⁵ and that compliance to 80% or more of the elements of the ERAS protocol is required to improve outcomes.³⁷ Gornitzky et al.³³ and Muhly et al.³⁴ both conclude that a standardised multi-modal analgesic strategy, can facilitate early discontinuation of intravenous opioids whilst achieving effective pain control to allow early mobilisation and accelerated recovery. The two papers, were performed by the same group and include an analgesic regime including preoperative gabapentin and acetaminophen, intraoperative methodone and acetaminophen, and postoperative PCA and diazepam supplemented with gabapentin, acetaminophen, and ketorolac; with ambulation and full diet from day 1 post-op.

Wang et al.³⁵ demonstrated the successful implementation of ERAS to a cohort of 42 patients undergoing one- or two-level lumbar transforaminal interbody infusion, utilising a novel minimally invasive surgical approach with ERAS components. This successful implementation is supported by two articles excluded from the literature search. A Danish study³⁸ found that by applying a comprehensive multimodal pain treatment to major spinal surgery patients, in line with enhanced recovery principles of reducing opioid consumption, less opioids were consumed on post-operative days 1 ($p=0.024$) and 2 ($p=0.048$) compared to pre-intervention consumption and the 41 complex fusion patients were mobilised earlier from bed ($p=0.003$). Length of stay in the surgical department also lowered from 9 days pre-intervention to 7 days post-intervention, although this was not statistically significant. Work has been carried out recently in Germany to further develop fast-track protocols in spinal surgery. Fleege et al.³⁹ introduced a fast-track protocol (2014b) for their patients undergoing stabilisation of one or two segments for degenerative lumbar spine pathologies, and reduced LOS by 4.7 days, as well as increasing patient satisfaction. In accordance with enhanced recovery concepts, the protocol included a patient education day the week before surgery involving the multi-disciplined team; a strictly followed treatment plan, supervised by physiotherapists, in which the patient was actively involved enabling mobilization on the day of surgery; and early discharge planning using fixed criteria which had been previously agreed with the patient.

ERAS Strategies

At its core ERAS is about improving patient outcomes and speeding up a patient's recovery following surgery. There are 24 traditional elements of ERAS care,⁵ and so therefore the focus in ERAS is to optimise every aspect of a patient's journey and promote the patient as an active participant in their recovery process and rehabilitation. Successful pathways are delivered by multi-disciplinary teams working across traditional professional silos, and departmental boundaries such as outpatient clinics, preoperative units, the operating theatre, and the ward. Engaging all of the stakeholders in the surgical pathway is essential in order to choose the right clinical steps and combine these with the necessary process and system changes to ensure that they are delivered every time for every patient. It is only by optimising the logistical features as well as the clinical steps that it is possible to improve the patients' pathway.

Experience from exemplars, highlights that the ERAS approach is multimodal by definition.¹ Therefore, coherent multi-disciplinary team working is critical, and regular meetings to discuss ERAS process compliance, patient outcomes, and how to improve the pathway are essential. Commonly members of this team will include surgeons, anaesthetists, nurses, dieticians, physiotherapists, occupational therapists, and managers. Frequently, an ERAS nurse or project manager co-ordinates the activities of the ERAS team, and they will lead on training new staff, collecting process and outcome data, and distributing pathway related instructions and updates. Ongoing audit of the ERAS care processes is essential to sustain performance, and the ERAS Society has developed a specific system for this purpose called the ERAS Interactive Audit System, which is based on the ERAS Society guidelines, and is available internationally. The series of ERAS Society guidelines have grown since the initial consensus document for colonic resection in 2005.⁴⁰ There are now 12 published guidelines, with ERAS Society Spinal Surgery guidelines planned for publication in 2017. The effectiveness of the ERAS guidelines have been tested, with publications showing that adoption of the care process defined by the guidelines, improves surgical outcomes.^{41; 42}

The original and generic components of ERAS are presented in Table 1, with an explanation of their target effect. With the exception of Muhly et al.³⁴ the reporting of the intervention (the ERAS pathway) across the papers was incomplete. This meant it was difficult to accurately highlight which components of ERAS had been adopted in each pathway, and to what degree there was compliance to each component. This means, that without a complete description of the ERAS pathway, other clinicians cannot reliably implement interventions, and other researchers cannot easily replicate or

build on research findings.⁴³ Future work should therefore concentrate on producing spinal procedure specific guidelines.

Table – ERAS strategies. The original core ERAS Society Guideline components described by Ljungqvist et al.⁵ for colonic resection. Reproduced with permission.

	ERAS component	Target effect
Preadmission	Cessation of smoking and excessive intake of alcohol	Reduce complications
	Preoperative nutritional screening and, as needed, assessment and nutritional support	Reduce complications
	Medical optimisation of chronic disease	Reduce complications
Preoperative	Structured preoperative information and engagement of the patient and relatives or carers	Reduce anxiety, involve the patient to improve compliance with protocol
	Preoperative carbohydrate treatment	Reduce insulin resistance, improve well-being, possibly faster recovery
	Preoperative prophylaxis against thrombosis	Reduce thromboembolic complications
	Preoperative prophylaxis against infection	Reduce infection rates
Intraoperative	Prophylaxis against nausea and vomiting	Minimise postoperative nausea and vomiting
	Minimally invasive surgical techniques	Reduce complications, faster recovery, reduce pain
	Standardised anaesthesia, avoiding long-acting opioids	Avoid or reduce postoperative ileus
	Maintaining fluid balance to avoid over or under hydration, administer vasopressors to support blood pressure control	Reduce complications, reduce postoperative ileus
	Epidural anaesthesia for open surgery	Reduce stress response and insulin resistance, basic postoperative pain management
	Restrictive use of surgical drains	Support mobilisation, reduce pain and discomfort, no proven benefit of use
	Removal of nasogastric tubes before reversal of anaesthesia	Reduce the risk of pneumonia, support oral intake of solids
Postoperative	Control of body temperature using warm air flow blankets and warmed intravenous infusions	Reduce complications
	Early mobilisation (on the day of surgery)	Support return to normal movement
	Early intake of oral fluids and solids (offered the day of surgery)	Support energy and protein supply, reduce starvation-induced insulin resistance
	Early removal of urinary catheters and intravenous fluids (morning after surgery)	Support ambulation and mobilisation
	Use of chewing gums and laxatives and peripheral opioid blocking agents (when using opioids)	Support return of gut function
	Intake of protein and energy-rich nutritional supplements	Increase energy and protein intake in addition to normal food
	Multimodal approach to opioid sparing pain control	Pain control reduces insulin resistance, supports mobilisation
	Multimodal approach to control of nausea and vomiting	Minimise postoperative nausea and vomiting and support energy and protein intake
	Preparation for early discharge	Avoid unnecessary delays to discharge
Audit of outcomes and process in a multiprofessional, multi-disciplinary team on a regular basis	Control of practice (a key to improve outcomes)	

Summary

The implementation of ERAS pathways across surgical procedures has seen a paradigm shift in how surgical care is delivered. There is strong evidence to support the adoption of ERAS pathways across a broad range of non-spine surgery procedures, and there is emerging evidence to suggest that ERAS principles can have the same effect across spine surgery.

The demand for spine surgery is increasing, and the wide variations in practice, LOS, complication rates, post-operative pain and functional recovery suggestive that improvements are possible. The

literature demonstrates that even incomplete implementation of ERAS is helping to improve patient outcomes. These findings, in combination with the success of ERAS in other procedures, are indicative that ERAS pathways should be applicable to spine surgery patients. However, there is a need for spine surgery specific guidelines, detailing the process to allow for more widespread adoption, whilst allowing for procedure specific adaption due to the range of different spine surgery procedures, and the often, high chronicity of pain state pre-operatively, and high level of disability. Due to the substantial potential improvements to patient recovery if ERAS can be adopted, it's implementation should be a priority for all spine surgery multi-disciplinary teams.

7. Disclosure

Thomas W Wainwright, Tikki Immins, and Robert G Middleton report no proprietary or commercial interest in any product mentioned or concept discussed in this article.

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