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Enhanced recovery after surgery (ERAS) and its applicability for major spine surgery

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This article examines the relevance of applying the Enhanced Recovery after Surgery (ERAS) approach to patients undergoing major spinal surgery. The history of ERAS, details of the components of the approach and the underlying rationale are explained. Evidence on outcomes achieved by using the ERAS approach in other orthopaedic and complex surgical procedures is then outlined. Data on major spinal surgery rates and current practice are reviewed; the rationale for using ERAS in major spinal surgery is discussed, and potential challenges to its adoption are acknowledged. A thorough literature search is then undertaken to examine the use of ERAS pathways in major spinal surgery, and the results are presented. The article then reviews the evidence to support the application of individual ERAS components such as patient education, multimodal pain management, surgical approach, blood loss, nutrition and physiotherapy in major spinal surgery, and discusses the need for further robust research to be undertaken. The article concludes that given the rising costs of surgery and levels of patient dissatisfaction, an ERAS pathway that focuses on

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optimising clinical procedures by adopting evidence-based practice and improving logistics should enable major spinal surgery patients to recover more quickly with lower rates of morbidity and improved longer-term outcomes.

Introduction to enhanced recovery after surgery

The concept of Enhanced Recovery after Surgery (ERAS), also called fast-track, accelerated or rapid recovery, was first introduced by Henrik Kehlet [1]. He introduced an evidence-based approach to care, designed to prepare patients for, and reduce the impact of surgery, allowing them to recover more quickly.

In colorectal surgery patients, Kehlet found that organ dysfunction (surgical stress), pain, nausea, vomiting, ileus, immobilisation, cognitive dysfunction, fatigue, traditions (e.g. drains) and logistical issues all contributed to slowing down post-operative recovery [2,3]. He concluded that whilst no single technique or drug regimen would be able to eliminate these contributors to post-operative morbidity, a better recovery could be achieved with a multimodal approach focusing on modulating the surgical stress response. This led to the introduction of enhanced recovery pathways after colorectal surgery as a successful standardised evidence-based approach in which a number of individual interventions are delivered together for improving clinical outcomes and healthcare resource utilisation [4].

Given the quality improvements found by Adamina et al. [4] in their meta-analysis with regard to ERAS and colorectal surgery, interest in enhanced recovery pathways has increased in the recent years due to the economic challenges currently faced by all healthcare providers. European countries have been quick to adopt and implement ERAS protocols. For example, in the United Kingdom (UK) the National Health Service (NHS) has been keen on implementing enhanced recovery programmes as a way to achieve productivity gains and cost savings. A recent review of the effectiveness of these programmes [5] concluded that there was consistent evidence that the programmes could reduce length of hospital stay without increasing readmissions. However, the authors cautioned that the extent to which the introduction of an enhanced recovery pathway could reduce costs will depend on the length of stay (LOS) already achieved under the existing pathway.

Given the positive results of implementing ERAS protocols, societies such as the ERAS Society (http://erassociety.org), ERAS Society (UK) (http://www.erasuk.net/), and in the past year, the American Society for Enhanced Recovery (ASER) (http://enhancedrecovery.org/) have been formed to promote the practice of enhanced recovery. The ERAS Society has been at the forefront of spreading the adoption of ERAS internationally and has issued guidelines for complex surgical procedures such as pancreaticoduodenectomy [6], gastrectomy and [7] elective colonic [8] and rectal/pelvic surgery [9] with future guidelines for more surgical procedures planned.

Components of ERAS pathways

Enhanced recovery pathways combine optimised clinical procedures with improved logistics [10] and should include the prehospital and post-discharge stages as well. The historical and previously described multimodal concept of an enhanced pathway is provided in Fig. 1 [11].

In an orthopaedic ERAS pathway at the preoperative stage, where possible, a patient with comorbidities should be optimised so that they have the best possible fitness for surgery, and primary care providers should be well informed on pain treatment and other factors of post-operative care once a patient has left hospital. Preoperative education is accepted as an essential part of practice [12] and should include informing patients on how long they can expect to be in hospital, agreeing discharge criteria, managing expectations and reducing anxiety [10].

Once in hospital, a number of clinical aspects should be included within the pathway, such as a multimodal approach to anaesthesia and analgesia, which allows early mobilisation and rehabilitation.

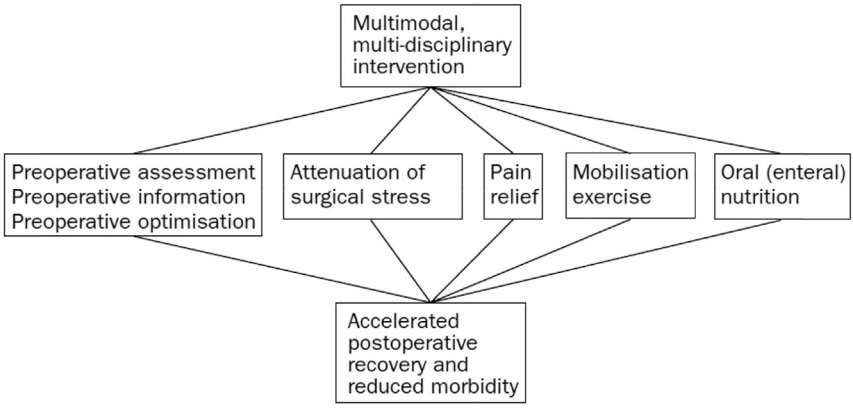

Fig. 1. Multimodal concept of early postoperative rehabilitation (Kehlet and Dahl, 2003).

Well-defined functional discharge criteria and principles of care should be accompanied by a written care plan and optimisation of organisational processes and logistics. Regular meetings with all involved disciplines (surgeons, anaesthesia providers, nursing staff, physiotherapists, nutritionists, radiologists, operating room nurses and non-clinical staff) are important in order to sustain the process and ensure that all ERAS elements are always delivered. All clinical and non-clinical staff members should be trained on the principles of enhanced recovery, its evidence base, and on the requirements to meet functional discharge criteria. Constant evaluation of the enhanced recovery pathway with outcomes such as LOS, complications, readmissions and patient satisfaction is essential, as any barrier or facilitator affecting these outcomes within the clinical and organisational aspects of the pathway can be identified and acted upon.

The underlying principle of ERAS: modulating the surgical stress response

One of the founding concepts of enhanced recovery is that by minimising the patient's stress response to the surgery, patients are able to recover more quickly and thereby have a shorter length of

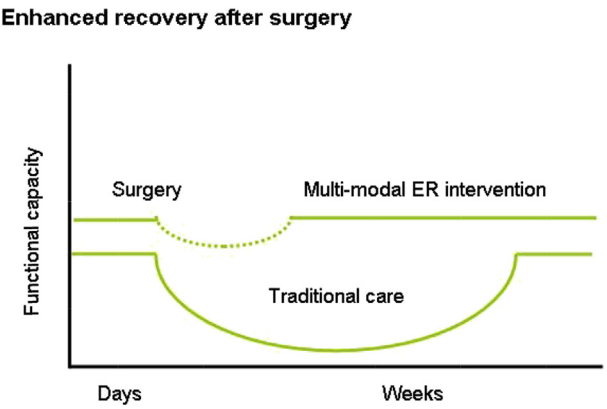

Fig. 2. Traditional perioperative care often results in the patient being exposed to unnecessary metabolic/nutritional debilitation resulting in a prolonged recovery interval. A multimodal enhanced recovery programme seeks to prevent such decline, thereby allowing patients to recover more quickly (Fearon, 2012).

hospital stay (see Fig. 2[13]). A thorough review detailing the pathophysiology of the surgical stress response with relevance to the ERAS pathway components has been previously presented in Ref. [14].

In summary, the surgical stress response can be divided into the inflammatory response which results in an imbalance between the pro-inflammatory and anti-inflammatory cytokines, and the metabolic response, which leads to catabolism and increased cardiovascular demands. The pro-inflammatory mediators and catabolic hormones elicit metabolic changes, characterised by hyperglycaemia and protein catabolism, which lead to physiological disturbances that affect recovery [14]. The components of the stress response are numerous and, depending on the type of surgery, may include to a greater or lesser extent anxiety, pain, tissue damage, ileus, hemodynamic disturbances, cognitive dysfunction, hypoxia, sleep disturbance and hypothermia. A key physiological change resulting from the inflammatory response is the relatively acute development of insulin resistance. However, there is now evidence that perioperative insulin resistance can be modulated by providing a preoperative carbohydrate drink, [15] thus reducing post-operative complications and improving recovery times [14].

ERAS outcomes in orthopaedic surgery

There is very persuasive evidence and experience to support the use of enhanced recovery pathways for primary hip and knee replacement patients [10,16–19]. In their recent review article, Aasvang et al. [20] summarise that ERAS can be routinely applied to all hip and knee replacement patients (with no age, preoperative functional ability, or co-morbidity restrictions) in order to achieve a length of hospital stay of 1–3 days with discharge to home, a reduced incidence of cardiac and venous thromboembolism complications and reduced post-operative delirium and cognitive dysfunction.

The conclusions drawn in the study by Aasvang et al. [20] are confirmed in a study comparing 1500 primary hip and knee replacement patients on an enhanced recovery pathway with 3000 patients using a traditional protocol; the median LOS decreased from 6 to 3 days, saving 5418 bed days [21]. The 90-day mortality rate was significantly reduced, and transfusion requirements were reduced. Readmission rates remained unchanged. Enhanced recovery pathways have also been found to be feasible and safe for more complex groups of patients such as the elderly [22]. Starks et al.19 found that after the introduction of an enhanced recovery pathway, the most marked decrease in LOS was for patients aged $\geq$85 years, with no negative effects on morbidity and mortality rates.

Whilst enhanced recovery in orthopaedics was first adopted in the high-volume procedures of primary hip and knee replacement, the concepts are now being applied successfully to more complex and surgically variable procedures such as revision joint replacement, and also other peripheral joints such as shoulder replacement, and in non-elective pathways such as fractured neck of femur patients. A feasibility study of 29 patients undergoing a revision total knee replacement for non-septic reasons, using a fast-track protocol, found outcomes to be similar to those for primary total knee replacement with regard to LOS and morbidity [23]. The median LOS was 2 days, no deaths occurred within 3 months, readmission rates were low, and there were high levels of patient satisfaction. A study in Norway [24] evaluated the introduction of a fast-track pathway for 82 revision hip and knee replacement patients. It found a mean LOS of 4.2 days for revision hip patients and 3.9 days for revision knee patients. The study found low revision rates of 3.7% and 7.1% for revision hip and knee patients, respectively. Patient-reported outcome scores and function scores were better for all groups, and there was a high level of patient satisfaction. In the case of shoulder arthroplasty, an initial evaluation in Germany found that a rapid recovery protocol reduced the LOS by 2 days [25]. Hospitals are now reporting reductions in the LOS when implementing ERAS for fractured neck of femur patients [26–29].

ERAS in major spinal surgery

There appears to be a strong theoretical case for the introduction of the principles of ERAS to major spinal surgery pathways supported by clinical and economic arguments in keeping with the more high-volume orthopaedic procedures such as hip and knee replacement. There is an increasing demand for major spinal surgery, and there are wide variations in LOS, complication rates, post-operative

pain and functional recovery. Spinal procedures are often associated with especially high levels of pain on the first post-operative day [30]. Lumbar fusion (one to two levels), lumber fusion (three or more levels) and complex spinal reconstruction were three of the six most painful procedures in the review of Gerbershagen et al. [31] on pain intensity across 179 different surgical procedures.

In terms of the economic argument, rates of lumbar fusion procedures are reported to be increasing rapidly, particularly for lumbar spinal stenosis and degenerative spondylolisthesis in older patients, and fusion rates differ markedly among surgeons and country, suggesting differing opinions on the management of patients [32]. In England, over 10,000 spinal fusion operations were recorded in 2013/14, a 20% increase from 2011/12; [33,34] in the US, a 15-fold increase in the rate of complex fusion procedures was reported from 2002 to 2007, from 1.3 to 19.9 per 100,000 beneficiaries in the population insured by Medicare. Aggregated hospital charges also increased by 40% for this population even though the overall procedure cost fell in this time interval, [35] possibly indicating greater surgical complexity (e.g. more extensive disease/more total levels fused) or a longer LOS.

Surgical complexity can lead to an increased LOS; however, studies by Gruskay et al. [36] and Kanaan et al. [37] suggest that there is scope to reduce LOS. In the study by Gruskay et al. [36], in 103 patients undergoing elective, open, one-to three-level posterior lumbar instrumented fusion (with or without decompression) they found that intraoperative events did not affect LOS, whilst potentially modifiable post-operative events did. The average LOS for patients with a post-operative complication was 5.1 ± 2.3 days vs. 2.9 ± 0.9 days for patients with no complications ($p < 0.001$). These findings are in line with those of Kanaan et al. [37] who carried out a retrospective review of 593 patients who had had laminotomy, laminectomy or arthrodesis at a US hospital. Using a structural equation model for their analysis, they found an average LOS of 4.01 (± 2.73) days, with postsurgical factors relating to the patient's function again predicting the highest variation in LOS. Evidence for variation in perioperative practice is provided by a 2015 evaluation of surgical practice for patients undergoing lumbar spinal fusion surgery in the UK [38]. The authors found that surgical practice was diverse, with wide variation in the management of components known to be relevant in successful ERAS pathways for other orthopaedic procedures. For example, only 39% of surgeons provided written information sheets/booklets to patients preoperatively. All surgeons ensured that patients were mobile within 3 days of surgery, with most (83%) ensuring that they were mobile by day 1. Seventy per cent of surgeons used a post-operative protocol/pathway, although more than half did not employ defined discharge criteria. Post-operative physiotherapy was provided routinely to patients of 87% surgeons. Advice on return to function was tailored to individual patients by 58% surgeons, and their advice on when to return to sitting varied from immediately to 6 weeks, returning to driving, sex and work from 1 week to 6 months, and sport and heavy lifting from 2 weeks to 9 months.

Evidence to support the application of ERAS pathways to major spinal surgery

In order to ascertain the applicability of applying ERAS principles to major spinal surgery, a literature review was undertaken to ascertain the current state of ERAS adoption. A total of 111 potentially relevant articles were identified which were reduced to 15 after removing duplicates and screening for relevance. For the purpose of this narrative review, major spinal surgery was defined as a complex fusion (360° spinal fusion by single incision, any combination of anterior with either transverse process or posterior fusion technique, or fusion of more than two disc levels), although some articles reviewed include simple fusion (single surgical approach and one or two disc levels/fusion involving 2/3 vertebrae) [35] and decompression. The method of selection of studies is presented in Fig. 3.

Despite the wide-reaching search strategy designed to capture any potentially relevantly articles, there was a scarcity of published literature examining the use of enhanced recovery pathways (not just multimodal pain management) in major spinal surgery. Of the resulting 15 articles, four articles were helpful in examining the applicability of ERAS to major spinal surgery [39–42], with only one article explicitly referring to the introduction of an enhanced recovery pathway for spinal surgery patients [42]. The clinical details provided by Mathieson et al. [41], in their comparative study of introducing a multimodal analgesic and antiemetic treatment protocol to 85 consecutive patients undergoing major spinal surgery, were most analogous to fast-track publications on primary hip and knee replacement from Danish centres.

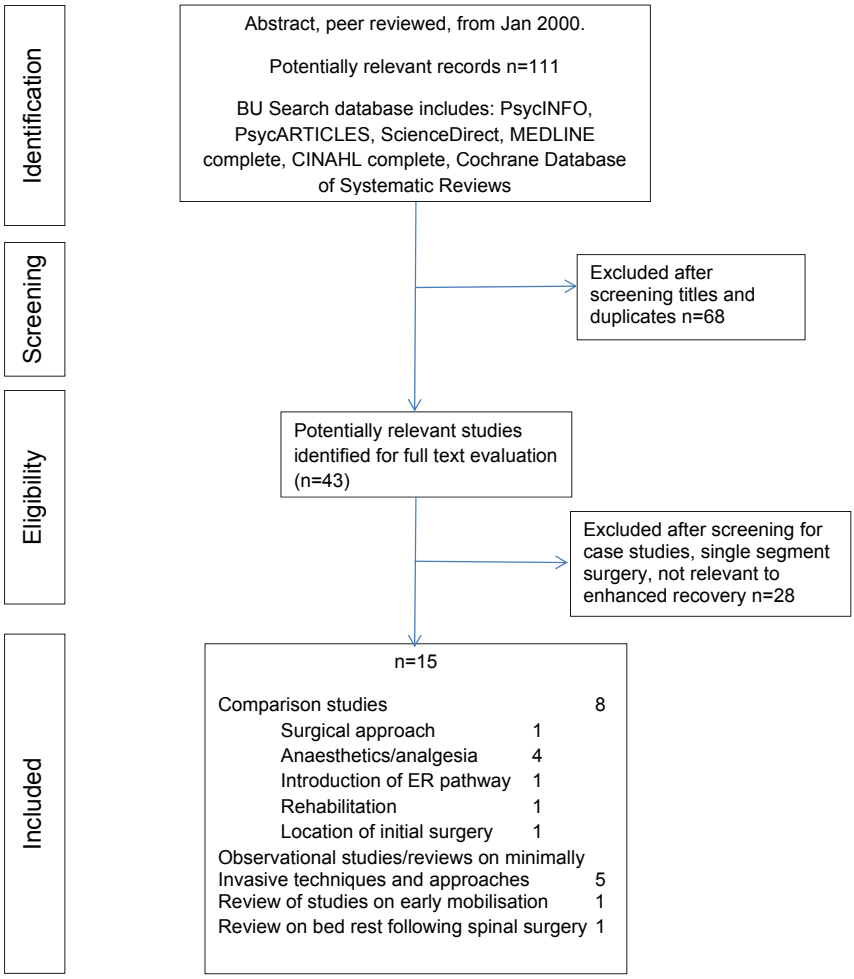

Fig. 3. Selection of studies. Flow chart presenting the retrieved, excluded and analysed papers about spinal surgery and enhanced recovery.

The study [41] introduced a comprehensive multimodal analgesic and antiemetic treatment protocol to 41 consecutive patients undergoing major spinal surgery and compared them to a pre-intervention group of 44 patients. The multimodal pain treatment included acetaminophen, non-steroidal anti-inflammatory drug (NSAID), gabapentin, dexamethasone, S-ketamine and epidural pain treatment or PCA morphine. The results showed that post-operative opioid consumption was significantly reduced in the intervention group, post-operative mobilisation was improved, and there were low levels of nausea, sedation and dizziness post-operatively. The LOS of the intervention group was 7 days, 2 days less than the pre-intervention group. Although clinically significant, the reduction in LOS was not statistically significant.

In their study evaluating the introduction of an enhanced recovery pathway to their patients undergoing stabilisation of one or two segments for degenerative lumbar spine pathologies, Fleege et al. [42] found that the LOS was reduced by 4.7 days. Their new pathway included a patient education school usually held a week prior to admission, mobilisation on the day of surgery, a strict rehabilitation programme taking into account the patient's own assessment and an early discharge plan based on

established criteria. In their review of the literature on procedures in spinal fusion surgery relevant to ERAS, Fleege et al. [43] found evidence that intraoperative blood loss and blood transfusion could be reduced significantly by optimising the patient's position, and introducing warming measures to maintain body temperature. These positive effects could also be supplemented using local infiltration of anaesthesia and vasoconstrictive drugs, along with high-dose administration of tranexamic acid. They found that the use of an epidural catheter significantly reduced post-operative, systemic analgesic use, thus enabling early mobilisation, and that drains and corset treatment could be restricted to complex cases only. The review concluded that these procedures contributed to a shorter hospital stay and quicker recovery times and promoted patient satisfaction.

Evidence to support the application of ERAS components to major spinal surgery

ERAS by its definition is a multimodal and multidisciplinary approach where the aggregation of marginal gains achieved by employing all of the ERAS components together contributes to the improvement in overall outcomes for patients. Whilst the current literature for examining the introduction of ERAS pathways in major spinal surgery is sparse, the individual components of ERAS have been investigated in isolation (but not in combination with all other elements of an ERAS pathway). Fig. 1 illustrates that the key components of ERAS should include preoperative education and optimisation, attenuation of the surgical stress response and pain through multimodal techniques, early mobilisation and optimised nutrition where appropriate.

Preoperative education

Preoperative education is a cornerstone of the ERAS pathways in hip and knee replacement. Patients should be given details of the operation, how long they can expect to be in hospital, the requirements for discharge and details of their recovery. Whilst a recent systematic review [44] found no robust evidence to link preoperative education to reductions in pain, LOS and morbidity, it did significantly reduce pre-operative anxiety. The authors note that the lack of rigorous trials in this area may contribute to these findings, especially given the positive experiential evidence of leading ERAS centres who value highly the contribution of preoperative education and who continue to regard it as an integral part of ERAS pathways [12].

A literature review in 2012 [45] found limited studies on preoperative education relating specifically to spinal surgery. They cautioned that although there were similarities to other orthopaedic patients, there were differences including type and amount of pain, use of an external brace, risk of post-operative ileus, limitations after surgery and possible complications; hence more specific research is needed. Fleege et al. evaluated [42] the introduction of enhanced recovery principles to their spinal surgery patients; they found that 99% of attendees to the patients' school replied in a survey that it was good or very good, and 100% replied that the information given was good or very good. The patients also found it very helpful to be able to speak to a patient who had already undergone surgery. Fleege et al. [42] reported that the information provided to patients motivated them to become mobile.

Multimodal pain management

A review of the evidence for multimodal pain management in spinal surgery [30] provided good evidence to support the use of many of the agents used in multimodal therapy, and there is a comprehensive chapter within this edition dedicated to the topic. Multimodal pain management techniques are a vital component of ERAS pathways, and when combined with other ERAS elements have been successful in accelerating recovery across a range of surgical procedures.

Surgical approach

New surgical techniques including minimally invasive techniques have rapidly evolved in spinal surgery over recent years, and a recent systematic review and meta-analysis of the effectiveness of

surgery for lumbar spinal stenosis was undertaken [46]. There was no difference in the effectiveness of the most commonly used surgical techniques to improve outcomes. This is in line with the findings on the role of minimally invasive surgery in hip and knee replacements, which show that there is insufficient evidence to indicate that surgical technique by itself is likely to make a significant difference in recovering or reducing soft tissue trauma [47].

Blood loss

Patients undergoing major spinal surgery are at risk of excessive blood loss, which may result in immunologic reactions, transmission of infections, or even transfusion-related acute lung injury. In addition, there is risk of spinal epidural haematoma formation which may lead to spinal cord or cauda equina compression [48]. Tranexamic acid has been successfully used as part of an enhanced recovery pathway in hip and knee replacement [49,50], and a recent meta-analysis of spinal surgery studies concludes that the use of tranexamic acid appears to be effective in reducing blood loss, the volume of blood transfusion, the transfusion rate and the post-operative partial thromboplastic time [48]. Pre-operative autologous blood donation in elective major spine surgery has also been observed to be effective in reducing allogeneic transfusion, although inclusion in the programme can increase the risk of being transfused [51,52]. Effective management, in case of blood loss, is a vital component of peri-operative care (and hence ERAS) in complex spinal surgery, and as such, a dedicated chapter on 'Perioperative Blood Conservation Strategies' is provided in this edition.

Nutrition

Major spinal surgery can be associated with significant post-operative decrease in nutritional parameters in a population that was well nourished prior to surgery [53]. The body has higher basal energy requirements after major surgery and this can increase morbidity, delay wound healing and hospital LOS [54]. A study by Mandelbaum et al. [55] found that of 37 patients undergoing staged anterior and posterior spinal reconstructive surgery, 84% became malnourished during their hospital stay, 77% had reduced serum albumin levels following both procedures and 92% had significantly decreased total lymphocyte count. The malnourished patients had higher levels of postoperative complications and a significantly longer LOS for the second operative procedure (16.2 days vs. 12.4 days, $p < 0.05$).

Enhanced recovery pathways aim to optimise the nutritional status of patients by assessing moderate-to high-risk patients prior to surgery, and giving oral nutrition supplements with macronutrients and micronutrients [50] to complement the patient's diet. A Cochrane review [56] concluded that pre-operative carbohydrate treatment was associated with a slight reduction in the LOS compared to placebo or fasting in patients undergoing elective surgery.

Regarding spinal surgery, there is some evidence that the use of total parenteral nutrition (TPN) might benefit patients undergoing staged spinal reconstructive procedures. A randomised study by Hu et al. [57] compared the use of TPN in 16 patients undergoing the staged procedures with 19 patients undergoing the surgery who had not had TPN. Patients who had not received TPN were significantly more likely to have depleted albumin levels and were more likely to develop post-operative infectious complications, compared to the group who had TPN. The authors concluded that the use of TPN may result in a decrease in complications and highlighted the importance of identifying those patients at risk of malnutrition as they could benefit from nutritional supplementation post-operatively.

Physiotherapy

There is a theoretical basis to suggest that physiotherapy and exercise interventions when used preoperatively, immediately post-operatively and post-discharge may improve functional recovery and reduce LOS. Regarding hip and knee replacement, there is supportive evidence that early mobilisation on the day of surgery reduces LOS [17,18,58]. However, there remain questions over the right type, dose and timing of exercise both preoperatively, in hospital and post discharge [59].

With relevance to spinal surgery, a randomised study of 60 lumbar fusion patients assessed the cost-effectiveness of a prehabilitation (preoperative exercise) and early rehabilitation intervention [60]. Patients were randomised to either a prehabilitation and early rehabilitation intervention ($n = 28$) or to standard care ($n = 32$). The intervention was started 2 months before surgery and included preoperatively an exercise programme; information about the surgery, post-operative mobility and rehabilitation; optimisation of analgesic treatment; and protein drinks. Following surgery, the intervention included balanced pain therapy with self-administered epidural analgesia; intense mobilisation on the day of surgery; enteral nutrition; and a rehabilitation programme aimed to discharge on the 5th post-operative day. Patients in the intervention group met recovery milestones significantly faster than the standard care group (1–6 days vs. 3–13 days, $p = 0.001$) and left the hospital significantly earlier (median 5 (3–9) days vs. 7 (5–15) days, $p = 0.007$). The intervention group also experienced significantly less pain and less low back pain intensity, and were more satisfied with their treatment and outcome compared to standard care. Early mobilisation has been found to reduce morbidity and the LOS for spinal surgery patients elsewhere [39,61]; however, its benefits for patients with certain complex spinal reconstructions are being discussed [40].

Conclusion

In comparison to elective hip and knee replacement, there are potential reasons as to why practice and outcomes are so diverse and why ERAS has not been implemented more widely within major spinal surgery. There is a wide range of indications for, and subsequently, different procedures included within the term major spinal surgery. However, given the rising costs of surgery and levels of patient dissatisfaction post operatively [62], an ERAS pathway, focusing on optimising clinical procedures by adopting evidence-based practice, and improving logistics, is likely to enable patients to recover more quickly, thereby reducing the LOS and hospital costs. It is expected that guidance on practices such as preoperative education, multimodal pain management, strategies to reduce blood loss, early mobilisation and post-discharge rehabilitation should be included in the pathway. However, procedure-specific adaptions and additions to these components may be required, as more is understood about the application of ERAS to major spinal surgery.

Summary

There is strong evidence to suggest that adopting ERAS pathways in procedures such as colorectal surgery and hip and knee replacement surgery can provide benefits such as reduction in the LOS, a decrease in morbidity and cost savings. As yet, there is limited evidence to suggest that ERAS principles have been adopted into major spinal surgery; however, the components of ERAS such as multimodal pain management strategies have been implemented with success. The demand for major spinal surgery is increasing, and there are currently wide variations in LOS, complication rates, post-operative pain and functional recovery suggestive that improvements are possible. The literature suggests that components of ERAS used in isolation such as patient education, multimodal pain management, strategies to minimise blood loss and physiotherapy are successful. These findings, in combination with the success of ERAS in other procedures, are indicative that ERAS pathways should be applicable to major spinal surgery patients. However, there is a need for robust studies, detailing both process and outcome, to be completed on firstly the introduction of ERAS pathways as a whole and then on optimising individual components of the ERAS pathway. In parallel, understanding the subgroups of procedure and patient, included within the term “major spinal surgery, that ERAS works most effectively for would be important. Given the significant potential improvements to patient recovery if ERAS principles can be successfully integrated, the adoption and careful evaluation of ERAS pathways should be a priority for major spinal surgery multidisciplinary teams.

Practice points

- ERAS is a multimodal approach aimed at accelerating post-operative recovery and reducing morbidity
- ERAS has been successfully applied (with no age, preoperative functional ability or co-morbidity restrictions) to hip and knee replacement patients and has reduced LOS to 1–3 days and post-operative morbidity
- There is currently very limited procedure-specific evidence for the application of ERAS pathways in major spinal surgery
- In principle, ERAS pathways should benefit major spinal surgery patients; however, this has to be confirmed by rigorous research.
- In isolation and when not evaluated as part of an ERAS pathway, there is evidence to support the implementation of key ERAS components such as patient education, multimodal pain management, strategies to minimise blood loss and early mobilisation.
- ERAS pathways in major spinal surgery may need to be adapted due to the chronicity of pain state preoperatively and the complexity and variation in spinal procedure.

Research agenda

- There is a paucity of research examining the application of ERAS to major spinal surgery with the few relevant studies being non-randomised and non-blinded.
- However, the results of these studies and the evidence from other orthopaedic and complex general surgical procedures suggest that further enquiry with more robust methodologies should be undertaken.
- Such studies are warranted as a future increase in major spine surgery likely requires the need for a treatment approach that can decrease perioperative morbidities such as immobilisation and pain.
- Due to the relative heterogeneity of surgical procedures and patient histories in major spinal surgery when compared with joint replacement, future studies should explicitly present compliance to both ERAS components and clinical outcomes as well as complete details of patient demographics and surgical procedure.

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Not applicable.

Conflict of interest

Thomas W Wainwright reports that he is the treasurer of the ERAS Society (UK).

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