ABSTRACT

The concept of enhanced recovery after surgery – ERAS – has been in place in surgical practice in Europe since the 1990s, but its uptake in the United Kingdom has been more recent, especially its use in orthopaedic surgery. Encompassing 20 or so specific clinical practices, ERAS aims to reduce length of inpatient stay, minimise costs, and improve patient outcomes after surgery. Based on these same principles, a new model of care delivery has been developed in the United States, with similar aims. Under a multi-professional team, led by the Orthopaedic Surgeon and an Anaesthetist, this expands the provision of care from the moment the decision for surgery is made, to a period of 30 and even 90 days following discharge – what the American Society of Anesthesiologists have defined as the ‘Perioperative Surgical Home’. Preliminary results of the PSH model for patients undergoing arthroplasty surgery in the US have so far been promising. Surgical leadership must be provided to better utilise anaesthetic services in arthroplasty pathways, to reduce length of stay, readmission and move towards a model for care provision that extends to the entire perioperative period. The review aims to compare the perioperative surgical home to current UK practice and provide an evidence based summary of both surgical and non-surgical interventions to help achieve a reduction in length of stay, decrease readmissions, and improve functional outcomes as well as a discussion of the potential for integrating some of its elements into current care models.

Key words: Enhanced recovery; ERAS; Perioperative surgical home; Arthroplasty; Health economics

INTRODUCTION

Total Hip and Total Knee Arthroplasty (THA and TKA) significantly improve a patient’s quality of life[1,2]. The trauma of arthroplasty causes a derangement in normal physiology and organ dysfunction contributing to perioperative morbidity. Venous thromboembolism and non-healing wounds contribute to lengthy hospital stay and unfavourable patient outcomes. Multiple factors contribute to perioperative morbidity, as summarised in table 1[3,4].

Enhanced Recovery After Surgery (ERAS) achieves this by reducing the stress response to surgery[3,5]. Pioneered by Professor Henrik Kehlet[6], it is a relatively new concept in the UK, but has...
been adopted across surgical specialties and by an increasing number of arthroplasty surgeons.

Traditionally, LOS for colorectal resection was in the range of 9-10 days. Kehlets ‘multimodal approach to peri-operative care’ lowered inpatient stay to 2 days\textsuperscript{37}. A multimodal approach included the use of an epidural anaesthesia, early mobilisation and oral feeding with limited use of nasogastric tubes and drains. The study described the techniques in patients with a range of indications for sigmoidectomy including diverticulitis and cancer, without the use of novel technologies. However the study has a small sample, of 16 patients. The majority of these patients are American Society of Anaesthesiologist (ASA) grade 1, with a high level of preoperative function\textsuperscript{7}. The National Health Service (NHS) Enhanced Recovery Partnership Program (ERPP) has consolidated Kehlets work\textsuperscript{39}. An evidence-based approach to all aspects of surgical care, it aims to improve quality of care and deliver cost-effectiveness. It fulfills both High Quality Care for All\textsuperscript{40} and the quality and productivity criteria of the Quality and Productivity Challenge (QIPP). Surgery currently accounts for an estimated 65% of total healthcare expenditure in the US whilst the Royal College of Surgeons estimates that the total surgical costs in England, alone, is some £ 4.5 billion\textsuperscript{10,11}. Cost-saving measures are thus welcomed. A high quality, cost effective orthopaedic service is not just a UK concern but also one shared by our American counterparts\textsuperscript{12}. The problem of a variation in care and high attendant costs are well described. To counter this, initiatives have been co-opted from the world of business.

In the US, the Lean and Six Sigma methodologies, derived from Toyota and Motorola respectively, have been co-opted for arthroplasty with very promising results.

The Six Sigma aims to improve quality control. The cause of defects in a manufacturing process is removed and variability minimised. Clinically, a pathway can improve quality and realise cost effectiveness. Arthroplasty surgery, in terms of diagnosis and treatment, is fertile ground for such a pathway. Clinical pathways can improve the process, limiting needless investigations, with a corresponding decrease in expenditure ranging from $800 -$3000\textsuperscript{13}.

The review aims to provide an evidence based insight into the concept of the North American perioperative surgical home (PSH) and to compare and contrast it with the European enhanced recovery (ER) pathway in TKA/THA.

**METHODOLOGY**

A piecemeal adaptation of ER took place throughout the UK NHS in the early 2000s\textsuperscript{14}. Economic austerity and rationalisation of healthcare spending has led to the Department of Health championing ER. The resultant Enhanced Recovery Partnership Program (ERPP) has led to the widespread implementation of enhanced recovery (ER). The principles of ER can yield many benefits for arthroplasty surgery. A large cohort study of 6000 patients, comparing an ER arthroplasty cohort to a traditional control found that ER patients can reduce length of stay (LOS) and need for blood transfusion\textsuperscript{15}. Others have corroborated these findings\textsuperscript{12-20}. Other advantages include reduction of both 30-day incidence of myocardial ischaemic events ($p = 0.03$) and 30-day mortality ($p = 0.03$)\textsuperscript{17}. The cause for this is not clear, with the authors pointing out that the ER cohort have a higher prevalence of comorbidities including diabetes and ischaemic heart disease amongst others. However the ER patients suffered fewer cardiac ischaemic events. However others have discovered no difference in 90-day mortality ($p = 0.80$) for TK A patients on an ERP compared to those on traditional protocols\textsuperscript{19}.

One large series described an ER arthroplasty pathway\textsuperscript{21}. Pre-operatively, a comprehensive consultant anaesthetist-led pre-assessment of the patient took place. Tests were ordered according to a protocol. The pre-assessment minimised day of surgery case cancellations\textsuperscript{21}. Patients attended an interactive pre-operative education class, in which patients were provided with a detailed overview of the inpatient journey. The patients arranged their own admission dates, reducing the chances of patient-initiated cancellation. Finally, discharge planning began pre-operatively and risk assessments identified those patients likely to have a longer LOS. On the day of surgery, admissions were staggered, according to the time of the surgery. Patients had less anxiety and avoided a lengthy pre-operative fast\textsuperscript{21}.

The movement from previous dogma, with fasting commenced from midnight prior to surgery, is evidence based. “Nil by mouth from midnight” was recommended to prevent the risk of aspiration but this was based on the false principle that the ingestion of food was equivalent to a full stomach\textsuperscript{22}. Recommendations endorsing minimal perioperative fasting now mirror the findings of a Cochrane review, a systematic review of 38 studies which found that fasting for 6 hours for solid food and 2 hours for clear fluids are completely safe\textsuperscript{22}. Another Cochrane review of 27 trials, 1976 patients, including 4 orthopaedic studies, discovered that the use of pre operative carbohydrate loading, a cornerstone of ERAS, reduced post operative insulin resistance whilst also significantly reducing the length of hospital stay by 0.30 days (95% confidence interval, 0.56-0.04)\textsuperscript{24}. Post operative insulin resistance is an independent predictor of length of inpatient stay. Other clinical benefits include a 34% reduction in in-hospital mortality and 41% reduction in acute renal failure, demonstrated by one study infusing insulin to induce normoglycaemia in surgical ICU patients\textsuperscript{25}.

Both ER and the PSH promote minimal perioperative fasting and early recommencement of food\textsuperscript{24}.

<table>
<thead>
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<th>Table 1 Factors contributing to perioperative morbidity.</th>
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<tr>
<td>Pre-operative</td>
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<td>Underlying disease/co-morbidity; Pre-operative anemia; Inadequate hydration; Inadequate nutrition.</td>
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Spinal anaesthetic with a local nerve block was favoured. Spinal anaesthesia can both prevent DVT and postoperative deficiencies in cerebral and pulmonary functions as well as limiting intraoperative blood loss, minimising blood transfusion post-operatively⁴⁻⁷.

Post-operative pain was addressed with multimodal pain management techniques, to promote early recovery of function⁵⁻⁷,⁹⁻¹⁰. Such multimodal pain management has made both earlier ambulation and earlier discharge from hospital⁵⁻⁻⁹⁻¹¹. Other benefits include lower blood transfusion rates for TKA patients on ERAS pathways. Furthermore, units that discontinued use of IV fluids sooner after surgery, and avoided patient-controlled analgesia, were more likely to mobilise their patients earlier and had shorter LOS⁴⁻¹².

IV cannula, catheters, and drains were removed where possible after surgery to promote independence and normalisation of self⁵⁻¹⁰. A consensus on post operative drain use has not been met. One systematic review and meta-analysis evaluated the benefits of the use of drains in primary THA in 16 studies (n = 2705). The use of drainage was found to increase total blood loss and blood transfusion requirements (p < 0.05)⁴⁻¹⁵. Another systematic review evaluated the use of drains in TKA in 6 studies and concluded that there was no difference in terms of drainage, recovery of knee flexion and reduction in swelling length of hospital stay, (p < 0.05)⁴⁻¹⁶. However, Middleton et al. considered the lack of a drain encouraged an earlier return to normal activities⁴⁻¹⁻¹⁷.

Evidence examining successful ER strategies in colorectal surgery concluded that the early discontinuation of the catheter led to a reduced LOS⁴⁻¹⁸,⁴⁻¹⁹. Intensive physiotherapy encouraged early ambulation and active range of movement (ROM), while simultaneously proactively dealing with swelling by use of elevation and ice⁴⁻¹⁻²⁰.

Postoperatively the evidence suggests that the earlier the commencement of physiotherapy, the earlier the discharge⁴⁻¹⁻²¹. One study looking at early mobilisation of TKR patients enrolled to an ER programme, patients were discharged, on average 69 hours earlier than control patients⁴⁻²⁻²³. LOS from this ER protocol was 4 days, compared to the previous traditional pathway LOS of 7.8 days⁴⁻²⁻²¹. Such a programme is recommended as best practice by NHS Evidence. Besides clinical benefits, there were marked cost effectiveness benefits with gross savings at £275 per bed amounting to £247,500 or £5,893 per 100,000 population⁴⁻²⁻²⁰. Studies have also demonstrated overall higher patient satisfaction for those on ERPs post-surgery than those on traditional pathways⁴⁻²⁻²⁴,⁴⁻²⁻²⁵. Machin described a study comparing arthroplasty patients on standard pathways to those on enhanced recovery pathways. Satisfaction was evaluated according to a 5 point scale and the EQ-5D health questionnaires. Mean patient satisfaction score of 4.07 in ER patients was significantly higher than the control, 3.68 (p = 0.037). Such findings was mirrored in postoperative health score between the ER and control groups 74.1 to 64.7 respectively, (p = 0.0029)⁴⁻²⁻²².

The NHS ERPP defines a successful ER programme as one in which the patient: (1) Is medically optimised for surgery; (2) Has the best possible perioperative management and; (3) Experiences the best post-operative rehabilitation.

The ‘Perioperative Surgical Home’ (PSH) addresses such requirements. It is defined, by the American Society of Anaesthesiologists, as a “patient centered model designed to improve health, the delivery of health care and to reduce the cost of care”. It extrapolates from the concept of a ‘medical home’⁴⁻²⁻²⁴. Although perhaps not readily familiar to European audiences, a medical home is a term whose principles are well understood in American clinical practice. It refers to “patient-centred, comprehensive, coordinated, accessible and committed to quality and safety” medicine⁴⁻²⁻²⁵. The term, coined by the American Academy of Pediatrics, referred to centralization of medical records with a special focus on those children with chronic conditions or disability⁴⁻²⁻²⁶. The PSH model builds upon ER principles and expands the medical care from the time the decision for surgery is made, to a period of 30 days post-discharge.

PSH has three principles: improving quality of care, improving the service delivery, and reducing the cost of care, mirroring the underlying principles of the ERPP (Table 2). In an anaesthetist and surgeon led team, with the anaesthetist uniquely positioned to function as a ‘perioperativist’⁴⁻²⁻²⁷, co-ordinating pre-operative work-up, anaesthesia and post-operative medical and pain management⁴⁻²⁻²⁸. The PSH empowers the patient to have greater choice through shared and informed decision making, from the point of referral when assessing the individual needs of patients prior to surgery, to the management of personalised patient care during and after surgery.

The Perioperative Surgical Home aims to: (1) Standardise and increase the reliability of care using evidence-based practices and guidelines, to reduce variability in utilisation of resources; (2) Reduce last-minute operative case cancelation, reduce peri-operative complications and re-admission rates, and decrease LOS, thereby leading to reduced costs of care; (3) Improve overall satisfaction of patients, physicians, nurses, and all other allied health professionals; (4) Provide quality and performance improvement measures, and comply with all regulatory requirements.

The University of California Irvine has spearheaded the PSH concept for arthroplasty, drawing on experience with ERAS, Lean and Six Sigma methodology. Results are very promising. The incidence of blood transfusion was a median of 6.2% (95% confidence interval 2.9-11.4%) with a 30 day readmission of 0.7% (0.0-3.8%) an inpatient mortality of and in-hospital mortality was 0.0 (0.0-7.0%). Patient satisfaction was high with a 98% percentile Press Ganey satisfaction score, providing a solid foundation for the PSH practical use⁴⁻²⁻²⁹,³⁻⁰. Before surgery, the anaesthetic team oversees clinical testing. The patient’s medical condition is optimised. Performed 3-4 weeks prior to the planned admission, further testing or medical intervention can be completed without the need to cancel or reschedule surgery. Garson et al. demonstrated a case cancellation rate of 0.7%⁴⁻³⁻⁰. Furthermore the use of a clinical pathway curtails unnecessary investigation. Three studies reported a statistically significant decrease in the cumulative number of gratuitous tests⁴⁻³⁻¹. A multidisciplinary pre-operative assessment clinic, in which patients are assessed by an anaesthetic-led team, can limit unplanned intensive care unit (ICU) admissions, and reduce LOS on high dependency unit (HDU) and ICU, as well as decreasing mortality rates, for complex orthopaedic surgery patients⁴⁻³⁻².

Before surgery, the PSH team can educate the patient about the surgery itself, post-operative rehabilitation and different types of anaesthesia. Patients’ expectations are aligned to the reality of post-operative rehabilitation. The education process allows patient participation in the decisions regarding their care and gives an opportunity to the PSH team to plan, thereby decreasing surgical care inefficiency throughout the inpatient stay. The evidence is somewhat mixed, with regards to the benefits of patient education. Moulton et al. establishes that those attending a preoperative education class prior to a elective THR led to a reduced length of stay compared to non attenders (3.55 vs 4.27 days, p = 0.046)⁴⁻³⁻³. Another study examining patient education prior to TKA concluded that the education group had a mean reduced length of stay to that of the conventional group (5 days vs 7 days, p ≤ 0.01)⁴⁻³⁻⁴.
Time scale

Time period about inpatient admission and immediate post-operative. From decision for surgery to 30 days post-discharge.

Pre-operative phase

Anaesthetic assessment;
Physiological Optimisation;
Patient education with advice beginning from general practitioner and pre-operative class;
Ability to choose operation date.

Multidisciplinary patient assessment in PACT (pre-operative assessment, consultation, treatment) clinic;
Early pre-admission assessments;
Identify and minimise complications;
Individualised protocol for assessment;
Health systems to centralise care of patient;
Pre-habilitation of patient to optimise targeted patient for surgery.

Intra-operative phase

Staggered admission;
Use of regional anesthetics;
Goal directed fluid therapy;
Predictable surgical technique;
Minimally invasive surgery;
Copious analgesia/anti-emetics;
Appropriate prophylactic antibiotics.

Standardised protocol governing fluid resuscitation, and others;
Multimodal analgesia;
Opioid analgesics for breakthrough pain;
Improve operating room flow/efficiency.

Post-operative phase

Normalise patient activity and mobilise;
Encourage oral intake;
Rationalise IV access;
Venous thromboembolic prophylaxis;
Well defined discharge criteria, reducing readmission;
Early preparation of discharge medication;
Telephone consultation post-discharge.

Early mobilisation;
Limit factors preventing discharge;
Coordinate and communicate discharge plan to inpatient unit/intensive care.

However a Cochrane review discovered that such education only decreased inpatient stay by a single day, concluding that the intervention may not offer any additional benefits.

Standardised protocols governing fluid resuscitation, blood transfusion and antibiotic administration guide anaesthetic care. The use of drains by the surgical team is minimised. Goal directed therapy, the anaesthetic initiative to optimise perioperative outcomes monitors haemodynamic parameters and oxygen delivery is described in a number of enhanced recovery protocols. It is usually utilised in surgery with a high risk of mortality, usually > 5%.

One RCT examined goal directed therapy versus control therapy in elective THA. There was no difference in length of inpatient stay but the median number of complications were reduced in the goal directed therapy. The use of drains by the surgical team is minimised. Goal directed therapy, the anaesthetic initiative to optimise perioperative outcomes monitors haemodynamic parameters and oxygen delivery is described in a number of enhanced recovery protocols. It is usually utilised in surgery with a high risk of mortality, usually > 5%.

After surgery, standardised protocols outlining effective analgesia, early involvement of physiotherapy and early ambulation - starting on the day of surgery - can stave off complications, reduce costs, and lead to a reduction in LOS. The concept of multimodal analgesia begins two days before surgery, with the administration of non-steroidal anti-inflammatory drugs (NSAIDs), followed by oral medications (including paracetamol and opioid analgesia) in the holding area before the patient is taken to the operating theatre. Predose to protocols and completing required documentation may be taxing. Lastly, extra financial investment to set up such a model may initially be required.

However, the release of bed capacity, generated by reduction in length of stay, reduced case cancellations, and better operating theatre throughput, should enhance its appeal. Moreover, a reduction in unnecessary pre-operative and post-operative patient testing (as recommended by the ‘Choose Wisely’ programme of the American Board of Internal Medicine in partnership with the ASA), and improved matching of staffing and resource allocation to patients’ requirements, may produce considerable cost savings. Furthermore, if ER becomes incorporated into the Best Practice Tariff for primary hip and knee arthroplasty, as recommended by the British Orthopaedic...
Mirza YH et al. A comparison of 2 techniques to decrease cost and improve quality during hip and knee arthroplasty

Association, this will further enhance its appeal.

As the group at the University of Alabama concluded, “a health care organisation must be willing to purchase the value created by a PSH model”[40].

ERAS programmes are based on well-defined clinical protocols that rely on the performance of very specific items, and can essentially be viewed as a subset of the PSH[21,65]. These protocols will therefore be largely similar both in the UK and the US. The PSH is itself a larger conceptual framework that includes coordination of care for the entire patient journey. PSH protocols may vary significantly between institutions, being dependent on the surgical and anaesthetic services available, and the local peri-operative environment in which it is employed[60]. Current practice in the UK, however, would not support the transfer of direct responsibility of in-patient care to the anaesthetic team as seen in the US. This might be revisited in the future if LOS were driven down to approach that of the US, where day case arthroplasty is fast becoming a reality. As the surgeon is the first and last point of contact through the patient’s journey, from initial consultation, to outpatient follow-up, it may be most appropriate for surgeons to lead this initiative in close partnership with anaesthetic colleagues. Being at the forefront of change may better enable surgeons to choose the services their patients require, and may be advantageous in the allocation of resources and practical support[64,65].

CONCLUSION

Adopting new practices in delivering safe and effective arthroplasty surgery remains challenging. The advantages of ERAS are now well documented and this is now the gold standard. Incorporating principles from the PSH programme may see further improvements. Developing a UK PSH model requires cooperation between surgeons and anaesthetists to integrate new pathways into pre-existing models of care delivery. Sharing ownership of this process will allow greater cooperation, improving the patient experience by dividing up pre- and post-operative care into its constituent parts, each of which can then be overseen by the most appropriate specialist. Many units already employ specific pre-operative assessment clinics in order to optimise patient risk factors prior to surgery. Specialist pain teams are also involved to deliver safe and effective analgesia peri-operatively. Coordination and integration of these teams into a protocol-driven framework may yield the predictable improvements in quality of care, LOS, readmission rates, and the experience patients are increasingly demanding. Furthermore, these programmes may also be attractive to healthcare commissioners, who may consider them as an opportunity to drive down costs whilst potentially increasing the quality of the care. As such, the orthopaedic community should take up the challenge of driving safe changes in practice, to develop the best possible services for our patients.

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