Journal of Anesthesia (2022) 36:648–660
https://doi.org/10.1007/s00540-022-03088-x

REVIEW ARTICLE

Framework, component, and implementation of enhanced recovery pathways

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Received: 30 June 2021 / Accepted: 15 June 2022 / Published online: 5 July 2022
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Abstract
The introduction of enhanced recovery pathways (ERPs) has led to a considerable paradigm shift towards evidence-based, multidisciplinary perioperative care. Such pathways are now widely implemented in a variety of surgical specialties, with largely positive results. In this narrative review, we summarize the principles, components and implementation of ERPs, focusing on recent developments in the field. We also discuss 'special cases' in ERPs, including: surgery in frail patients; emergency procedures; and patients with Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2/COVID-19).

Keywords Enhanced recovery after surgery · Frailty · Perioperative care · COVID-19

Introduction

Enhanced recovery pathways (ERPs) are a series of interventions which, when consistently applied, lead to improvements in postoperative outcomes via accelerating recovery. While the concept of enhanced recovery has been described in the 1990s [1], it was not until much later that the practice gained wider recognition. With positive results demonstrated by successful ERPs, as well as advocacy from enhanced recovery societies [2], ERPs are now widely implemented in a variety of perioperative settings. We conducted a systematic literature search on EMBASE and Medline, for relevant papers published in English between the years 2000–2021. The search terms were decided based on the American Society for Enhanced Recovery and Enhanced Recovery After Surgery (ERAS) society guidelines [2], and other common perioperative considerations. The detailed search strategy is listed in the Supplementary Table. The search was completed on December 1st, 2021, active literature surveillance continued until January 4th, 2022.

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Principles of enhanced recovery

The objectives of ERPs include minimizing postoperative complications, expediting the return to normal function, reducing length of stay and improving patient satisfaction; all of which also contribute to improved cost-effectiveness. The latter is particularly important given the principle of value-based care delivery, with implementation of Merit-based Incentive Payment Systems and Bundled Payments for Care Improvement.

One of the most important aspects in enhanced recovery is the shift of focus from the surgery itself to the wider perioperative period, as well as involvement of the multidisciplinary team [3]. Considering the expertise and skills required to manage and optimize perioperative pathways, the latter could be considered most crucial to ERP implementation.

To ensure cost-effectiveness, it is vital to select only efficacious and beneficial interventions. In addition to 'external' evidence from clinical research and expert consensus, almost all successful ERPs utilize a comprehensive system for 'internal' monitoring of intervention compliance and associated clinical outcomes [4].

Components of ERPs

A comprehensive enhanced recovery pathway includes multidisciplinary interventions spanning preoperative assessment to post-discharge follow-up, designed according to the surgical procedure, patient population and the institutional resources. Examples of these are illustrated in Fig. 1.

Preoperative measures

Prehabilitation

Prehabilitation is linked with improved outcomes [5], and consists of a 'trimodal' approach focusing on physical, psychological and nutritional domains; the latter two will be discussed in subsequent sections. Studies suggest a synergistic relationship between prehabilitation and other ERAS components, along with significant cost reductions when both were combined [6].

Preoperative exercise training is associated with a lower incidence of postoperative pulmonary complications (PPCs) and reduced hospital stay [7]. It is, however, worth noting that the clinical evidence on prehabilitation and inpatient exercise programs is conflicting [8]. Moreover, assessment and comparison of postoperative outcomes is limited by the large variation in prehabilitation regimes [5, 9]. Multiple different outcomes have been quoted in the literature; however, their direct clinical relevance has been called into question. It has been suggested that alternative measures such as long-term disability or health behavior changes should be evaluated instead [9].

Patient education and engagement

The benefits of preoperative patient education extend over clinical, psychological and economic domains [10–12]. It decreases patient anxiety, pain and length of hospital stay following surgery [12], and also leads to more positive self-image [11]. Preoperative education may also improve engagement by making the patient an active participant in their care [13], and effectively reduces hospitalization duration in patients at high risk of extended stay [10].

Despite the evidence supporting educational programs, challenges facing their implementation remain. The delivery of information that is meaningful and relevant to the patient has to be balanced against its implementation cost. Information overload can pose a problem in preoperative clinics [14], and tailored private sessions may cost more than pre-recorded general information. Encouragingly, Fecher-Jones et al. [15] describe a novel preoperative 'surgery school' aiming to achieve group education and promote healthy behavior, with 94% of participants saying they would recommend it to a friend undergoing surgery, and 46% reporting modifying at least one lifestyle factor following attendance.

Finally, smartphone apps and wearable fitness devices have been successfully used to promote physical activity; a balanced diet; adherence to blood pressure and blood sugar monitoring; and smoking cessation—all of which improve postoperative outcomes [16]. Alternative technological avenues may also be beneficial: a comprehensive, multipurpose digital platform improved patient engagement, provided education and maintained timely contact with care providers in total knee arthroplasty with a reduction in length of stay [17].

Nutrition and hydration

Carbohydrate loading with clear, high-carbohydrate drinks prior to surgery minimizes post-operative insulin resistance and protein catabolism [18], reducing their attendant consequences. The addition of preoperative whey protein has also

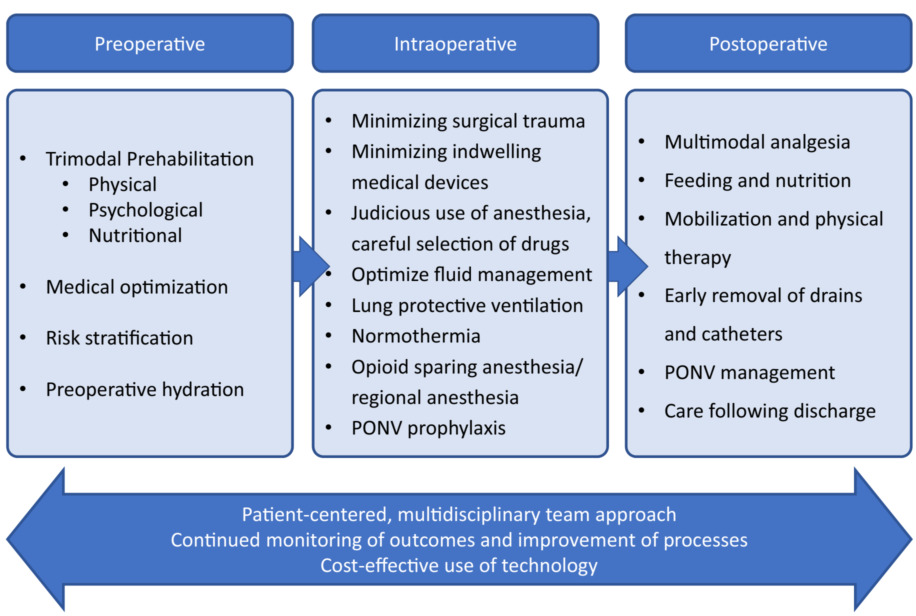

Fig. 1 Enhanced recovery pathway framework and example interventions

been associated with improved recovery [19]. Another major advantage conferred is a reduction in anxiety and mouth dryness [20], which improves patient comfort. However, preoperative carbohydrate loading remains controversial due to the quality of some underlying studies and a lack of evidence demonstrating a clear reduction in clinical complications [21]. Ljungvist et al. [21] also mention that there is marked variation in carbohydrate drinks advocated for preoperative use, with only a few having undergone formal testing.

Immunonutrition (IM) has attracted considerable interest; its use is associated with decreased length of stay and reduced inflammation [22]. A systematic review suggested that IM provision reduced the incidence of infectious complications; however, the recommendation grade was weak [23]. In addition, a 2018 Cochrane review called for larger and better-quality studies on the topic [24]. With financial implications of ERAS components also relevant in today's system, where hospitals are paid via a negotiated bundled payment reimbursement model, a protocol combining IM/probiotics/carbohydrate loading prior to thoracic surgery was shown to decrease direct hospital costs by USD $2198 per patient [25].

Optimization of medical complications

With advancements in medicine, increasing numbers of patients with complex, chronic medical issues undergo surgery. Optimizing such conditions preoperatively increase the body's ability to cope with surgical stressors, and are associated with more positive outcomes [26].

Active smoking is linked with numerous perioperative complications [27]. Trials implementing 4-week cessation programs have shown encouraging results in reducing wound healing [28]. The duration of smoking cessation is also relevant—programs spanning at least 4 weeks are effective in reducing respiratory complications, whereas 'short term' programs are not associated with significant changes in complication rates [29]. Nicotine replacement therapy and tailored counseling sessions are an effective supplement to these initiatives [30]. Despite the preoperative period being a unique 'teachable moment', there remains a remarkably high risk of postoperative resumption [31]; therefore, long-term initiatives should be considered.

Preoperative optimization of hemoglobin may be achieved with iron supplementation and more recently, recombinant human erythropoietin. This combination has been shown to reduce the need for allogeneic blood transfusion [32]. However, a study found that despite preoperative erythropoietin leading to a 50% reduction in transfusion rates, it entailed an 'unacceptably high' extra cost of €785 per patient [33]. Interestingly, Hardy et al. [34] observed that preoperative anemia did not detract from the benefits of an ERP for elective colorectal surgery. Despite anemic patients having greater preoperative comorbidities, such as arrhythmias and renal failure, they did not experience more postoperative complications and had similar ERP compliance. The benefits of ERPs were attributed to their multimodal and multidisciplinary nature.

Intraoperative measures

Surgical consideration

Minimally invasive surgery (MIS) is widely practiced due to its extensive benefits which are not limited to the aesthetic; it also works synergistically with ERPs [35].

There is ongoing development and research in MIS. The number of port sites in video-assisted thoracoscopic surgery (VATS) has decreased from four to two [36], with studies demonstrating the feasibility of a single-port approach and its association with lower pain plus reduced hospital stay [37] However, a uniportal approach for lung cancer surgery has been linked with lower survival [38]. Port placement is also under investigation, with a uniportal subxiphoid approach for VATS lobectomy shown to be safe and associated with significantly less postoperative pain [39]. In addition, robotic surgical techniques have demonstrated favorable outcomes in ERPs [40].

Fluid management

There is a trend towards preoperative euvolemia, avoidance of prolonged fasting, and avoidance of routine use of bowel preparation in colorectal surgery [41]. Conversely, crystalloid over-administration is associated with bowel edema and respiratory failure [42], and some have suggested critical thresholds of fluid administration or postoperative weight gain as an indicator for adverse outcomes [43].

Concerns have arisen regarding restrictive fluid regimens and the risk of acute kidney injury (AKI) especially with concurrent administration of nephrotoxic agents [44]. Postoperative AKI is associated with poor clinical outcomes [45], and it is suggested that intraoperative oliguria may be used to screen for AKI [46], along with the presence of pre-existing chronic kidney disease [44] and low albumin levels [45]. The RELIEF study compared patients receiving a liberal versus restrictive fluid therapy [47], with the latter associated with a significantly higher AKI incidence, renal replacement therapy and surgical site infection.

Notably, individualized goal-directed fluid therapy (GDFT) is associated with lower morbidity and mortality, faster recovery of bowel function and risk reduction of PPCs [48]. The FEDORA trial randomized patients to routine fluid administration or goal-directed hemodynamic management using trans-esophageal Doppler. Notably, trans-esophageal Doppler guidance did not reduce the median intraoperative fluid volume, but significantly reduced the incidence of AKI, ARDS and length of stay [49]. This is corroborated in a recent meta-analysis by Shen et al. [50], which advocated the safety and continued use of GDFT. Indiscriminate use of restrictive fluid therapy approach is of questionable benefit and may precipitate AKI in at-risk patients. GDFT may not necessarily reduce perioperative fluid administration at a population level, but optimizes fluid administration in high-risk patients, and surgeries with high fluid shift or insensible losses.

Multimodal analgesia and minimizing opioid use

The use of multimodal analgesia is a key ERAS component—extensive evidence indicates this is more effective than single agent therapy, posing a lower risk of adverse side effects [51]. It is proposed that multimodal analgesia could eliminate the need for opioids, thereby avoiding opioid-related adverse events [52]. Opioid-free anesthesia is indeed feasible [53]; however, there is currently limited evidence that it is associated with superior outcomes when compared to an 'opioid-minimization' approach [54].

Other pharmacological agents of interest include NMDA antagonists due to their role in modulating opioid-induced hyperalgesia as well as the development of neuropathic pain [55]. The selective alpha-2 agonist dexmedetomidine has also been associated with improved postoperative outcomes when administered perioperatively in ERPs [56]. Continuous lidocaine infusion has been utilized over a range of specialties; however, there is limited evidence to suggest its efficacy or superiority [57].

Due consideration of regional anesthetic (RA) techniques is now an established part of ERPs, with changes in RA practice reflecting the latter's continuously evolving nature. Novel development and application of RA techniques are exciting progress, such as: fascial plane chest wall blocks in cardiac surgery; PENG block for hip fracture; and iPACK block for posterior knee pain [58]. New combinations of blocks are also being studied [59], along with the relative superiority between various RA techniques for a given surgery [60]. In addition, continuous catheter blockade offers superior pain control, therefore, better physiotherapy conditions [61], and decreased rates of opioid abuse [62]. Another option is the use of longer acting local anesthetic formulations, such as liposomal bupivacaine, which has demonstrated long-lasting analgesic efficacy in wound site infiltration [63]. However, there is limited evidence regarding its superiority compared to nonliposomal formations when used in regional anesthesia [64].

Looking to the future, there may be a role for pharmacogenomics testing in ERPs [65]. With drug pharmacokinetics (and their consequent clinical effects) differing between patients, genetics-guided pharmacotherapy to optimize drug choice may be another field to watch.

Minimize drains and catheters

Drain placement impedes mobility and increased drain numbers are associated with greater pain [66]. In addition, early chest drain removal is safe, facilitating movement and recovery post cardiothoracic surgery [67]. Avoidance of routine prophylactic drain placement in certain procedures can reduce morbidity and length of stay without adversely impacting other surgical outcomes [68]. Wherever pleural drains are indicated, it is recommended that digital drains are utilized due to their portable nature enabling early mobilization [69]. Compared with conventional drains, they reduce variability in clinical decision-making, are associated with: reduced air leak duration; costs; and shorter length of stay [70]. In addition, location of drain insertion may also influence postoperative outcomes. Transperitoneal placement of a mediastinal drain following esophagectomy is associated with reduced postoperative analgesic use compared to transthoracic placement [71].

Similarly, multiple studies have indicated that early removal of urinary catheters is not associated with increased re-catheterization, and similar/less catheter-associated UTI rates are observed [72]. Moreover, avoidance of routine urinary catheterization in abdominal surgery [73], is associated with a decrease in delayed discharges [73] and intravenous fluid administration [74].

PONV prophylaxis

PONV is estimated to occur in 30% of surgical patients, resulting in delayed recovery, increased risks of surgical complications and also adversely affects ERP compliance [75]. As outlined in the 2020 PONV consensus guideline by Gan et al. [76], optimal management of PONV requires multi-component interventions and risk assessment of patients. Comprehensive consideration of surgical/anesthetic/patient factors enables establishment of a tailored plan to provide the best perioperative care [77].

A recent meta-analysis [78] showed moderate to high certainty evidence behind the use of seven single drugs from different drug classes for PONV prophylaxis. It was recommended that further studies are undertaken to investigate potential side effects, and to evaluate the effect of these drugs in higher risk populations with more comorbidities. Novel agents for PONV prophylaxis are being investigated, with studies indicating the efficacy of dexmedetomidine [79] and acupuncture [80].

Postoperative measures

Postoperative mobilization and physiotherapy

While strategies for early mobilization are commonly incorporated in ERPs, the evidence base is limited. Definitions of postoperative mobilization in the literature are heterogeneous: 'mobilization' differs from 'ambulation' in terms of physical demand, yet may fall under the same umbrella [81]. In addition, an observed association between late mobilization and greater incidence of postoperative complications (and the converse) could be explained by medical/surgical sequelae impeding mobilization, as compared to the lack of mobilization causing poor outcomes. Studies may, therefore, be difficult to interpret, leading to a lack of high-quality evidence [81]. Trials may also be limited by the lack of patient-reported outcomes [82], which can paint an incomplete picture of recovery.

Studies have evaluated the feasibility and benefits of wearable technology in postoperative resumption of activity [83]. Fitness trackers have been trialed independently [84], or in conjunction with animated visualizations [85] to aid motivation. These interventions have been linked with shorter hospitalization duration and improved postoperative mobilization [84, 85]. Furthermore, these devices enable objective quantification of postoperative mobilization (e.g., step count) which facilitates monitoring of recovery, and also provide high quality data for research [86].

Postoperative nutrition

In contrast with previous practice, the safety and benefits of early enteral nutrition have now been demonstrated in major abdominal surgeries [87]. In addition, a targeted 'gastrointestinal rehabilitation' program comprising of other ERAS components such as optimizing analgesia and early nasogastric tube removal was associated with improved clinical outcomes when combined with early postoperative enteral nutrition [88]. It appears that a comprehensive "enhanced nutritional pathway" optimizing both pre and postoperative nutrition is beneficial [89]. From a pragmatic point of view, the most significant institutional barrier towards successful adoption of nutritional practices was lack of education for patients and providers [90], hence reinforcing the need for effective perioperative patient counseling and staff training.

Postoperative ileus prevention

Due to the central role of nutrition in recovery, several studies have investigated the potential benefits of interventions to promote gastrointestinal (GI) motility. Chewing gum use following colorectal surgery [91] and Cesarean section [92] is associated with lower incidence of postoperative ileus, potentially via increasing vagal tone [91].

There has been an increased interest in prokinetics, such as alvimopan, a peripherally acting μ-opioid receptor antagonist with limited central nervous system penetration [93]. However, a recent meta-analysis calls for further trials to draw a definitive conclusion regarding its efficacy [94]. Other agents being evaluated include: pyridostigmine, caffeine and routine laxative use [95]. Neuromodulation via tibial nerve stimulation has also shown encouraging results [96].

Despite prolonged postoperative ileus (POI) adding significant costs to healthcare [97], and being one of the leading causes of readmissions [98], there remain many questions to be answered. Many have called for a fixed definition of POI given the current lack of consistency [99]. This is challenging as POI presents as a spectrum of disorders, although a system of classification has been proposed [99]. In addition, POI-specific management varies widely between ERPs and is of limited efficacy [100]. Smoking is a known risk factor in POI development [101], but it is unknown whether cessation programs have a significant impact on reducing their incidence. There is also some evidence to suggest involvement of the gut microbiome (GM) in POI development [102], and there may be scope for GM manipulation via probiotic therapy [103].

Care after discharge

Postdischarge issues include pain, mobility, nausea and vomiting. Opioid prescriptions following discharge are a major concern, as patients may continue taking them for months following day case surgeries [104]. Multi-system changes are required to minimize this risk, including: provision of multimodal analgesia; restrictions on post-discharge opioid prescriptions; and tighter control of repeat opioid prescriptions in the community.

Postdischarge exercise programs have demonstrated significantly faster functional recovery in lower limb orthopedic surgeries [105]. However, there exists significant heterogeneity in rehabilitation recommendations, and worryingly some are not based on evidence of clinical best practice [106]. It is recommended that outcome-based studies with an emphasis on identifying clinically beneficial modalities and metrics are necessary to enable meaningful standardization [106]. In addition, with the trend towards personalized medicine, plans and targets for rehabilitation should also draw on patient characteristics including: socioeconomic status; expectations surrounding recovery and muscle strength [107]. It is also suggested that for future research surrounding specific rehabilitation interventions, a distinction should be made between a 'standard' recovering patient and more complex patients, such as those on preoperative opioids, due to a potential difference in motivation and engagement with rehabilitation [107]. The latter may require more intensive and supervised activities, with implications for decision-making around resource allocation.

Post-discharge surveillance is an important part of the pathway, as patients may have additional care needs once home [108]. A survey indicated that the post-discharge telephone checkup was valued most highly out of all ERAS components postoperatively [109], follow-up calls aided in answering unexpected questions patients had post discharge (despite prior attempts to optimize knowledge) [110] and relieving the isolation faced by patients ‘left alone with their illness’ [111]. Active post-discharge surveillance programs are cost-effective, as postoperative issues may be resolved in the outpatient setting thereby reducing readmission or emergency department presentation [112].

The use of patient-reported outcomes (PROs) for monitoring is increasingly being studied, with a consensus statement released in 2018 [113]. Defined as ‘any clinical measure that comes directly from the patient without interpretation of the medical team’, they assess the physical, mental and social domains of patients’ well-being [113]. PROs enable assessment of outcomes important to the patient, offering a more comprehensive view of recovery [113]. They may be delivered via a mobile device platform enabling patient–provider engagement in perioperative care, or digital platforms facilitating real-time remote monitoring [114]. However, challenges to their implementation include: lack of standardization, therefore, difficulty in drawing comparisons [115]; potentially extensive duration of assessment, whereby some modules may not be of relevance to all patients [116]; and lack of integration into patients’ electronic hospital health records [117]. Despite this, PROs mark a further step in the direction towards personalized medicine in ERPs and are another tool to evaluate ERP quality.

Scope of ERPs and special cases

ERPs for older/ more frail patients

Studies report that older patients enrolled into ERPs have significantly longer lengths of stay and higher rates of complications [118]; Studniarek et al. [118] propose that individualized elderly specific ERAS protocols are adopted to mitigate this. In addition, it could be argued that such observations do not take into account these patients’ naturally longer postoperative recovery, and ERPs may still improve outcomes when compared to a control group. Indeed, studies report that frailty and advanced age are not associated with significantly lower ERP compliance [119], while high ERP compliance in frail patients is independently associated with positive outcomes. Moreover, when compared to conventional postoperative management, enhanced recovery interventions in elderly and frail patients are associated with significantly shorter lengths of stay, with no significant increase in complication or readmission rates [120]. The routine use of frailty scores has been proposed [121] to allow clinicians to better tailor perioperative care, including: better patient selection for surgery [122]; identifying those who benefit most from Geriatrician/MDT input [123]; and more accurate discharge planning [124].

Further research directions may include quantifying the effect of ERPs on significant hospital-acquired geriatric syndromes, such as delirium and functional decline [125]. In addition, there is an increasing incidence of surgical patients with Chronic Critical Illness (CCI), associated with a new frailness phenotype underpinned by catabolism, immunosuppression and inflammation following severe pro-inflammatory insults, such as trauma or sepsis [126]. More studies are required to investigate the effect of ERPs on CCI development, or conversely the benefits of ERPs in CCI patients presenting for surgery.

ERPs in emergency surgery

While time for pre-operative optimization is limited, emergency patients may nevertheless benefit from other aspects of ERPs. It is feasible to conduct brief preoperative patient education, while adopting the intraoperative and postoperative interventions of ERPs [127]. Such measures are associated with significantly shorter hospital stay, and lower rates of postoperative complications [128]. Furthermore, the benefits of ERAS in emergency surgery may be more far-reaching than initially assumed. In a meta-analysis by Lohsiriwat et al. [129], patients undergoing ERP-based emergency colorectal cancer resection were commenced on adjuvant chemotherapy approximately 2 weeks earlier than those receiving conventional therapy. With postoperative complications being a major cause of delayed chemotherapy and the latter associated with worse overall survival, the benefits of ERPs may thus extend further than the immediate postoperative duration.

Another obstacle identified is reduced ERP compliance in patients undergoing emergency surgery [130], which may be explained by patients presenting with greater physiological derangements; emergent procedures are associated with higher rates of uncontrolled pain /PONV/ileus; as well as potential conversion of laparoscopic to open surgery. The latter is an independent prognostic factor predicting impedance in implementing ERP items in emergency appendectomy [130]. Paduraru et al. [131] suggested the need for a specific ERP protocol tailored to this patient group to improve adherence. This is now discussed in recent ERAS society guidelines, including specific clinical management, such as: early diagnosis; prompt resuscitation and antimicrobial administration [132].

The literature investigating ERPs in the emergency setting mainly focuses on colorectal surgery, and more research on the feasibility and effects of ERAS on other surgical disciplines is awaited.

COVID-19: accelerating the implementation and necessity of ERPs

The 2019 Coronavirus pandemic has posed numerous challenges to the delivery of healthcare globally, with new variants possessing the potential to cause yet another overwhelming wave of infection. In spite of this international health crisis diverting resources away from elective surgery, it is argued that the pandemic may well be a catalyst to accelerate ERP implementation [21]. Facing an immense backlog of surgical cases, there is an increasingly urgent need to optimize perioperative care and reduce hospitalization. Several centers have successfully implemented ERPs, observing a reduced postsurgical length of stay *sans* a rise in complications or readmission [133], Spinelli et al. [134] described shorter inpatient stays in patients undergoing colorectal surgery during the pandemic compared to a similar cohort in the previous year, despite their center having a long-established ERP. This was attributed to greater ERP compliance stemming from increased patient commitment to reducing hospitalization duration, thereby limiting potential virus exposure.

Other methods of reducing hospitalization include: home prehabilitation [135]; ambulatory surgery (extending to mastectomy and hip/knee arthroplasty) and effective use of technology. Novel developments of the latter in these times of duress have been termed ‘disruptive innovation’ and include virtual clinic appointments [136] and the use of smartwatches to monitor patient recovery [137]. These have been shown to be effective and interestingly, some have argued that there is no point going back to face-to-face clinics [136]. This is not a perfect panacea, as there may be certain aspects of the clinical consult which are not possible to complete virtually, and it may be more challenging for clinicians to build rapport via these means [138]. Furthermore, lack of access to telemedicine may potentially widen socioeconomic gaps [138].

ERP components are included based on their efficacy, and protocol changes have been suggested in the light of the pandemic. These include routine preoperative COVID testing of patients, along with modifications in surgical/anesthetic technique to minimalize the risk of viral transmission. Regional anesthetic techniques are preferred over general anesthesia, although data [139] has emerged indicating that anesthetic airway procedures may not generate as high a quantity of aerosols as was previously thought. Concerns have been raised regarding aerosolization during laparoscopic insufflation; however, a recent systematic review [140] has shown no evidence of viral transmission via laparoscopic surgery.

Careful consideration of resource allocation is another theme that has arisen in the wake of the pandemic. The ERAS MDT may undergo skillset-based streamlining, as members may be redeployed to other hospital areas [141]. In the primary care setting, a Singaporean study described increased numbers of community nurses providing home-based care to orthopedic patients while successfully maintaining subsidized costs [142].

With theatre space being a valuable commodity, patients may undergo risk-assessment to prioritize waiting lists, with various scoring systems proposed, such as MESA and MeNTS [143]. In contrast, a COVID-19 specific risk-scoring system that can be applied across various surgical disciplines and tailored as per individual patients’ clinical status is potentially more accurate, however, has not been developed or validated yet [144]. Doglietto et al. [145] discovered that symptomatic COVID-19 patients undergoing surgery face a greater mortality risk, and are more prone to cardiorespiratory complications. Clinicians may be managing more complex patients, with a paucity of perioperative data on COVID-survivors, those with long-COVID or patients with newer variants. With further research, we hope that more light will be shed on this.

Implementation strategy, teamwork, representations from different stake holders, keys to success

Perhaps one of the main challenges in implementing ERPs is the issue of protocol compliance. It is not uncommon to see compliance of less than 50% in parts of the pathway [4], this is due to barriers, such as resistance to change and lack of coordination [3]. Actions to promote participation include involving all stakeholders in program/pathway design, designating local champions, staff engagement and education. In practice, the process can often be complicated by existing organizational structures within the institutions. Experienced and enthusiastic leaders are often required to promote and maintain these changes.

The optimal number of ERP components required remains a matter of controversy, and multiple studies have attempted to identify ‘core’ pathway components or formulate the minimum number of ERP elements required [146]. A nationwide observational study observed that the level of ERP utilization was independently associated with incrementally improved complication odds, and better outcomes are linked with more elements used [146]. However, the inclusion of multiple elements may be perceived as overly complex [21]. In a recent review by Ljungvist et al. [21], it was concluded that organizations should be guided by outcomes and evidence-based data in the creation of institution-specific ERPs.

While numerous studies have reported successful implementation of ERPs, variability in institutional characteristics such as case load, case mix, resources and procurement often limits inter-institutional translatability and external validity of the pathways. Interestingly, a recent study described a 'causal latent variable model', a modern statistical method able to account for patient heterogeneity [147]. Formal validation of the model is still awaited. In addition, most studies describe the efficacy of entire pathways rather than the value of individual interventions. Memtsoudis et al. [148] also noted that a significant proportion of the enhanced recovery literature is not based on randomized patient cohorts, which increases the risk of study bias; moreover, the research focus has shifted from minimizing complications to minimizing the length of hospital stay. The latter is felt to be an inappropriate measure of ERP success, and alternative validated measures have been proposed, such as: the Dutch Appropriateness Evaluation protocol [149], a marker evaluating the appropriateness of hospital stay in case of delayed discharge; and days at home up to 30 days after surgery (DAH_{30}) which is felt to be more patient-centered [150].

Conclusions

The beauty of ERPs lies in their flexible and rapidly evolving nature, with their aim to improve perioperative outcomes using multimodal, evidence-based interventions. ERPs reflect a paradigm shift from empirical practices which are often variable, to the formation of standardized and evidence-driven pathways supported by an active international network of professional societies. Some argue that they are not only standard care for surgical patients, but are crucial in enabling the effective delivery of perioperative care in this time of global crisis. We anticipate the next few years to be an exciting time for further developments in this field, driven by technological advances and high-quality research.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00540-022-03088-x.

Declarations

Conflict of interest All authors declare that they have no conflict of interest.

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