The purpose of enhanced recovery pathways (ERPs) is to return patients to their baseline function as soon as possible after surgery using multimodal strategies. Evidence-based practices are used to minimize the stress response to surgery. Cornerstones of ERPs include preoperative evaluations and optimization of surgical risk, nutritional status, and functional status; patient education; limited fasting; a preoperative carbohydrate (CHO) beverage up to 2 hours before surgery; individualized fluid management; surgical approach; multimodal pain control minimizing opioids; early resumption of liquid diet; and early mobilization.

**Preoperative Optimization**

Nutrition and prehabilitation are two important aspects of ERPs. Malnutrition has been linked with poor surgical outcomes. Strategies to avoid negative protein balance, minimize insulin resistance, and modulate the immune system have been shown to be beneficial to surgical patients.

Avoiding negative protein balance is important because healing after surgery is metabolically costly. The stress response mobilizes amino acids, glucose, and free fatty acids from body stores and diverts substrate from biochemical reactions used in other metabolic pathways. An optimized patient will be able to synthesize extracellular matrix components and inflammation/growth factors as well as support macrophages, polymorphonuclear neutrophils, and fibroblasts while minimizing muscle and adipocyte breakdown. A number of tools can be used to assess the nutritional status of a patient that combine subjective and objective data, including perioperative nutrition screening.

After patients have been nutritionally risk stratified, there is evidence that 5 to 7 days of supplementation is a reasonable approach.

In the small number of patients for whom oral nutritional...
supplementation is not sufficient, the evidence for enteral over parenteral nutritional strategies in malnourished perioperative patients is not yet definitive; however, enteral feeding has been shown to have fewer complications and reduced hospital length of stay (LOS) in critically ill patients, and is preferred by most clinicians. Parenteral nutrition may have a role either as an adjunct or the sole source of nutrition, as it has shown benefit in patients with severe undernutrition.

A CHO beverage 2 hours before surgery has been shown to decrease insulin resistance. Preserved insulin activity can help to avoid hyperglycemia and its complications, reduce muscle breakdown, increase synthesis, and reduce the catabolic response to trauma. Empirically, CHO beverages also have been shown to facilitate recovery and decrease hospital LOS without increasing risk for aspiration, supporting their use in ERPs. Also, a CHO beverage may place patients in an anabolic state, which is associated with decreased protein loss.

Perioperatively administered omega-3 fatty acids, glutamine, and arginine have been shown to decrease infection rate, hospital LOS, and overall complication rate as well as modulate gut function. Several mechanisms have been proposed for these improvements. Eicosapentaenoic acid has been associated with decreased inflammation and preservation of muscle mass and fat stores after surgery. Glutamine has been shown to optimize lymphocyte production and improve the barrier function of gastrointestinal mucosa, and it plays a role in wound repair. Arginine supplementation may activate the arginine–nitric oxide pathway, leading to improved splanchic microperfusion and improved T-cell function.

Physical fitness is a strong marker for health status in the context of a number of comorbidities. Patients who increase their activity level decrease their all-cause mortality and improve functional status. Cardiopulmonary exercise testing (CPET) assesses integrated cardiovascular response to a range of physiologic stresses, and it is helpful in risk stratification and prediction of surgical outcomes. Preoperative exercise programs using CPET have been shown to improve fitness before and after surgery, but more evidence is needed regarding their effect on surgical outcomes. Some of the obstacles include low event rates in elective surgery requiring large sample sizes, heterogeneous populations, and varied exercise protocols, making it difficult to assess data in a meaningful way. Two upcoming large studies—WESFIT (Wessex Fit for Surgery Study) and PREPARE-ABC (SupPortive Exercise Programmes for Accelerating Recovery after major ABdominal Cancer Surgery)—will investigate the effect of both home- and hospital-based exercise programs on surgical outcomes that may provide insight. Possible mechanisms of benefit may include improved cardiovascular function and responsiveness, efficiency of metabolism, resilience to oxidative conditions, and ability to mobilize endothelial progenitor cells.

Wireless and Wearable Sensors For Postoperative Monitoring

Recent studies have shown that around one-third of postoperative deaths occur in hospital wards. This situation has been called failure to rescue and has been proposed to explain why hospitals with comparable postoperative morbidity rates may have very different mortality rates: Adverse outcomes can be mitigated in hospitals that have effective systems in place for early detection and prompt treatment of complications when they occur. Of note, many studies have shown that most ward patients start deteriorating hours before medical teams are called for rescue or ICU transfer. In this regard, several studies have demonstrated the value of early detection with continuous monitoring systems.

The use of pulse oximeters to continuously monitor blood oxygen saturation (SpO2) and heart rate in 2,841 orthopedic patients—many of them receiving opioids—was associated with a significant decrease in the number of rescue events and ICU transfers. The use of a piezoelectric contact-free sensor (placed under the mattress) to continuously monitor heart rate and respiratory rate in 2,314 medico-surgical patients was associated with a significant decrease in the number of calls for cardiac arrest and hospital LOS. More recently, the use of wireless sensors to monitor vital signs (SpO2, heart rate, blood pressure, respiratory rate), automatically calculate an early-warning score, and alert nurses in case of deterioration was associated with a significant decrease in the number of cardiac arrests and mortality.

Multiple sensors and monitoring systems are now available for proactive monitoring in ambulatory patients. Smart software has been developed to filter artifacts and prevent alarm fatigue to fuse vital signs into wellness indexes or warning scores, which are used for the easy and visual detection of clinical deterioration, or even the prediction of adverse events beforehand.

Wireless and wearable sensors can help to detect clinical deterioration at a very early stage in ward patients. By triggering timely interventions, these sensors potentially can decrease the number of ICU admissions, cardiac arrests, and postoperative deaths. The next chapter of physiologic monitoring might be written beyond the operating room and the ICU.

Fluid Management

Intraoperative hemodynamic optimization is associated with reduced postoperative complications and improved outcomes. There is strong evidence to suggest that both excessive and inadequate fluid administration can increase morbidity and mortality. Fluid administration based on traditional static variables such as mean arterial pressure (MAP) and central venous pressure (CVP) are inadequate. Analysis shows that 25% to 35% of blood volume can be lost before vital signs are affected. MAP is poorly correlated with oxygen delivery, and its targets do not confer mortality benefit. CVP is heavily influenced by venous tone and does not reflect intravascular volume. Urine output can be affected by release of antidiuretic hormone during surgery and increase in the renin–angiotensin–aldosterone system, and it does not reflect organ function. Integrating all clinical data with situational awareness is only recommended for procedures of low intraoperative risk.

Analyzing research data on this topic is challenging. Studies of protocols based on traditional hemodynamic variables are difficult to compare. Liberal fluid administration in one case may be considered restrictive by another investigator, and very few studies have focused on whether a patient has a normal intravascular volume with low vascular tone versus hypovolemia. There has been a growing body of evidence that the amount of fluid administered is not as important as when it is administered. The Postoperative Quality Initiative I Workgroup has presented a framework for stratifying patients into subgroups that may benefit from advanced monitoring to guide fluid therapy based on characteristics of patients and procedures.

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Goal-directed fluid therapy (GDT) aims to improve organ function by optimizing oxygen delivery (DO₂). Dynamic flow indexes allow a provider to accurately determine cardiac preload, and predict whether fluid administration at any given moment will increase stroke volume, cardiac output, and therefore DO₂. This strategy has led to faster return of bowel function, decreased risk for postoperative nausea and vomiting (PONV), reduced hospital LOS, and in high-risk patients, reduced morbidity. This paradigm shift does not come without challenges. Staying at the optimal portion of the Frank-Starling Curve requires measurement of stroke volume.

Some controversy exists when comparing GDT with other fluid administration strategies, as at least one trial has shown no clinically consequential difference in hospital LOS and no significant difference in complication rate when added to an ERP. This trial, however, enrolled 64 patients and may be underpowered to detect meaningful postoperative outcomes. A recent meta-analysis by Rollins and colleagues demonstrated a reduction in ICU LOS and earlier return to bowel function in a subgroup analysis of 10 GDTF studies that were conducted in an enhanced recovery environment.

Fluids are a powerful IV medication capable of causing harm if administered incorrectly. GDTF improves care by allowing a provider to adopt a fluid administration strategy tailored to an individual patient. Certain risk-defined subgroups of patients are most likely to benefit from advanced monitoring. Additional adequately powered studies are required to compare clinically useful outcomes within an ERP.

Multimodal Analgesia

The goal of pain control within an ERP is to optimize patient comfort, facilitate functional recovery, and minimize side effects. Pain rarely can be completely ablated in the perioperative period and can be exacerbated by activities encountered in the postoperative period, such as ambulation, coughing, and incentive spirometry use. Minimizing the influence of pain during the recovery period involves avoiding the effects of inflammation, surgical stress response, and immobilization. Multimodal analgesia involves interventions at each stage of pain signal transduction while using opioids sparingly in order to avoid side effects such as PONV, ileus, delirium, and delayed mobilization. Decreased opioid use during the perioperative period also may offer long-term improvements in chronic pain and cancer recurrence. Patient education, regional anesthesiologic, and pharmacologic adjuncts are employed before, during, and after surgery to greatly reduce the amount of opioids administered.

A preoperative discussion offers an opportunity to set goals for pain control, educate patients on strategies to reduce pain, and reinforce pain control behaviors. It also forms the basis for establishing preoperative analgesia use, baseline pain, and aggravating/relieving factors. On the day of surgery, neuraxial and/or peripheral neural blockade strategies may be employed. Spinal opioids have been shown to reduce pain and opioid requirements in abdominal surgery. Thoracic epidurals have been shown to offer superior analgesia compared with parenteral opioids. Additionally, results have shown that these epidurals decrease mortality, risk for arrhythmia, deep vein thrombosis, respiratory depression, atelectasis, pneumonia, ileus, and PONV, and shortened time to recovery of bowel function in open surgery. These benefits have not been consistently observed in laparoscopic surgery, and the potential for sympathetic blockade may outweigh the potential benefits. Transversus abdominis plane blocks have been shown to reduce pain scores and opioid consumption in both laparoscopic and open procedures. Prophylactic preoperative oral and IV medications aimed at reducing pain associated with inflammation and its transmission, such as acetaminophen, selective cyclooxygenase-2 inhibitors, and gabapentinoids, have all been shown to improve analgesia, reduce opioid consumption, and avoid their side effects. Following IV administration, acetaminophen has demonstrated more effective CNS penetration compared with oral and rectal routes.

A number of intraoperative analgesic adjuncts also have been shown to improve functional recovery. Systemic lidocaine reduces opioid consumption, improves gastrointestinal end points, and shortens hospital LOS when regional strategies are not possible. Ketamine reduces analgesic requirement and PONV through inhibition of N-methyl-d-aspartate receptors. A single dose of dexamethasone also offers analgesic benefit, most likely through a reduction in inflammation without an increase in rates of infection or delayed wound healing.

Conclusion

Multimodal strategies have demonstrated significant clinical benefits in pain control, limiting noxious effects of opioid medications and enhancing functional recovery. The techniques used will ultimately depend on an individual patient’s willingness to participate, comorbidities, coordination and communication between providers, and the available equipment.

The following is a summary of the top abstract submitted to the ASER 2017 Congress, as selected by the authors.

How Adherence to Enhanced Recovery After Surgery Protocols Impacts Patient Outcomes Post Radical Cystectomy Surgery

Hong T, Bisaillon A, Mayson K

ERPs can be difficult to implement due to the multimodal strategies implemented by surgeons, anesthesiologists, nurses, patient educators, and clinical coordinators. An ERP was instituted for radical cystectomy at Vancouver General Hospital, in Vancouver, British Columbia, Canada, with 40% improvement in morbidity. This study compared the outcomes of a total of 242 patients pre- and post-ERP implementation. It also further subdivided post-implementation patients into those who adhered to the program (>75% compliance) and those who did not (<75% compliance). The criteria for compliance reflected 12 well-recognized specifically defined ERP components (eg, early mobilization, oral intake), and used common end points to measure outcomes (ie, hospital LOS, number of cases with at least one complication, surgical site infection,
urinary tract infection, sepsis/septic shock, transfusions, ileus, readmission). The data show a decrease in almost all end points post-implementation. However, many of them failed to reach statistical significance due to the small sample size. A much more striking difference is seen when the pre-implementation data was compared with the post-implementation group with high adherence, defined as at least 75% adherence to the ERP components. Of note, the number of cases with at least one complication decreased by 51% (odds ratio, 0.58; confidence interval, 0.35-0.95; P=0.015). The rates of overall morbidity fell from 31.1% to 21.1% (P=0.09), a 32% reduction following implementation. Impressive improvements also were seen in rates of sepsis/septic shock and ileus, implying that increased adherence to ERP improves surgical outcomes.

References