Preoperative Optimization and Enhanced Recovery Protocols in Ventral Hernia Repair

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27.1 Introduction

Along with recurrence as an important indicator of success following ventral hernia repair (VHR), perioperative wound morbidity greatly influences short- and long-term outcomes in patients. It is well reported that perioperative surgical site occurrences (SSOs), defined as infection, seroma, wound ischemia, and dehiscence, increase the risk of recurrent hernia greatly [1]. Therefore, the surgeon should optimize any and all measures that will promote wound healing, reduce infection, and enhance early postoperative recovery. In the ventral hernia population, the most common complication in the immediate perioperative period is surgical site infection (SSI) [2]. This chapter briefly reviews several pre- and perioperative measures that have been reported to decrease SSOs and shorten length of hospital stay.

Multiple patient factors such as obesity, smoking, uncontrolled diabetes mellitus, malnutrition, and surgical site contamination are all detrimental to wound healing and should be optimized prior to surgery. Wound healing as well as those with a propensity for postoperative infections are the primary targets, both of which increase the incidence of hernia recurrence. Obesity and smoking have been demonstrated to be independent risk factors for increased recurrence of abdominal wall hernias and SSO. Poor glycemic control in the remote preoperative period and perioperative and postoperative periods has repeatedly demonstrated increased risk for superficial and deep tissue infections. Similarly, patients with malnutrition have significant alterations in wound healing and immune function and will consequently have an increased incidence of postoperative SSI as well as hernia recurrence. Unfortunately, many of our patients have several of these detrimental factors at the time of hernia repair. While all these factors influence surgical outcomes and work congruently on morbidity, many can be evaluated and treated as separate entities. Herein, we aim to describe several interventions and evaluate their effectiveness in an effort to maximize outcomes for ventral hernia repair.

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27.2 Preoperative Optimization

27.2.1 Obesity

Perhaps the greatest threat for the development of incisional hernias as well as recurrence following ventral hernia repair is obesity. As BMI increases, so does the recurrence rate [3–5]. The propensity for obese patients to develop incisional hernias was noted early on by surgeons performing bariatric procedures [6]. The incidence of postoperative incisional hernia occurred in up to 40 % of patients following open gastric bypass [7]. In fact, the reduction of postoperative incisional hernias following laparoscopic gastric bypass was one of the major reasons for performing minimally invasive bariatric procedures. We have found that in patients with BMI ≥ 50, the recurrence and wound morbidity rate is prohibitively high; therefore, we no longer perform elective herniorrhaphies in this group of high-risk patients unless they have stigmata of acutely worsening symptomology (e.g., recurrent obstruction, evolving ischemia, strangulation).

Unfortunately, obesity is a very challenging entity to modify, as a lifetime of poor nutrition and/or lack of adequate physical activity are the culprits for many patients. Initial attempts for weight loss include in-office counseling to improve dietary habits and increase physical activity. During the initial evaluation, a reasonable weight loss goal is made between the patient and surgeon (e.g., 15–30 lbs). Having a dietary consult with a nutritionist can provide valuable information for patients, if available. Patients return in 3–6 months after initial consultation; if the patient demonstrates significant weight loss then surgery is typically planned. Conversely,

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if the patient fails to lose sufficient weight, or gains weight in the interim, elective surgery is postponed and other routes of weight loss are advised.

We routinely refer patients to our bariatric surgery colleagues for discussion for surgical weight loss. As many patients with obesity carry an unknown diagnosis or diabetes or prediabetes, checking a hemoglobin A1c can assist with insurance coverage of a bariatric procedure. If we are performing a bariatric procedure in a patient with an incisional hernia, we will attempt to perform the bariatric procedure without repairing the hernia and wait until the patient has lost weight before we attempt definitive hernia repair. If the bariatric procedure is performed open and the hernia is in the epigastric area, the hernia will have to be repaired during the initial operation to close the abdomen. However, the simplest hernia repair is performed at this time (e.g., primary fascial closure +/− mesh reinforcement), saving more complex hernia repairs (e.g., component separation) until after weight loss from their bariatric procedure.

27.2.2 Smoking

Detrimental effects of smoking are well known, with reduction of both blood and tissue oxygen tension, as well as the deposition of collagen in healing wounds [8–10]. These effects adversely influence healing of surgical wounds, including complex wounds seen in some hernia repairs. Numerous animal and human models have studied the deleterious physiological effects of smoking and have compared wound complications in smokers versus nonsmokers. Several authors have examined the effect of smoking on postoperative wound infection and have found wound infection following repair of ventral hernias to be increased in smokers [11–13]. Smoking is also a risk factor for developing an incisional hernia following abdominal surgery [14]. Many of the initial studies involved orthopedics (tendon and fascial healing) and plastic surgery (flap viability) [15, 16]. In a study of 4855 patients undergoing elective open gastrointestinal (GI) surgery, smoking was associated with significantly increased postoperative complications [14]. With VHR frequently requiring a combination of prosthetics, tissue flaps, and GI surgery, these studies reinforce the need for smoking cessation prior to complex abdominal wall reconstruction (AWR).

Because of the harmful effects of continued tobacco use, a great deal of attention has been made on the effect of smoking cessation on reducing postoperative complications. Lindstrom et al. prospectively studied 117 patients undergoing primary hernia repair, hip or knee prosthesis, or laparoscopic cholecystectomy. Half of the patients were treated with smoking cessation therapy and nicotine patches starting 4 weeks prior to surgery, which continued for 4 weeks post-surgery. The control group was allowed to smoke as they were preoperatively. The experimental group with smoking cessation and nicotine therapy had a total postoperative complication rate of 21 % while the smoking group had almost twice the total postoperative complication rate at 41 %. This study clearly demonstrated the adverse effects of smoking; however, the study focused on total complications, and the difference in wound complications did not achieve significance [17]. The other two interesting findings from this study were that this reduction in complications occurred after 4 weeks of tobacco cessation, and a reduction in surgical site occurrence (SSO) was noted in patients using the nicotine patch. This study confirms another landmark study by this group in which volunteers were divided into four groups: smokers, nonsmokers, those who quit smoking for 30 days preoperatively, and those who quit smoking and had a nicotine patch placed. Four full thickness dermal incisions were made on each volunteer for a total of 228 incisions. The nonsmoking group had a wound site occurrence at a rate of 2 % while the smoking group had a 12 % occurrence. The group who quit smoking and those who quit smoking and had the nicotine patch had a wound occurrence rate of 2.3 %. This study indicated that smoking cessation for 30 days allows for the deleterious effects smoking to be alleviated, and the nicotine patch did not alter the beneficial influence of cessation [18]. Thus, 4 weeks may be an effective time of abstinence to reverse the complications associated with smoking. The other interesting and unexpected phenomenon is that nicotine patches did not have a deleterious effect on complications, suggesting that it is not nicotine but something else in the cigarette smoke that is deleterious. In a randomized clinical trial examining the effect of the nicotine patch on wound infection, the patients with placebo patches compared to patients wearing nicotine patches had similar wound infection rates [10]. It is now believed that nicotine in low concentration may actually promote wound healing [18, 19]. Others have observed similar reduction of postoperative complications comparing patients who had quit smoking from 3 to 6 weeks preoperatively from those who continued to smoke [20–22]. A recent meta-analysis and systematic review of the literature nicely reviews the influence of smoking on postoperative complications and the benefits of smoking cessation [23].

Because of well-substantiated association of smoking with wound complications, patients at our institution undergoing elective ventral incisional hernia repair are required to cease all smoking activity for at least 4 weeks before surgery for difficult abdominal wall hernias [11]. We allow the use of nicotine patches whenever the patient asks because there is reasonably good data indicating that nicotine is not a factor in cigarette smoke that causes problems with wound healing. Unfortunately, one cannot accurately test the patient for nicotine levels when the patch is used.

27.2.3 Diabetes

While glycemic control throughout all phases of patient management is important, preoperative reduction in baseline glycosylated hemoglobin (Hgb A1c) is essential for optimal outcomes. Studies have demonstrated reduced wound healing and increased postoperative complications in diabetic patients undergoing a variety of surgical procedures [24–26]. In elective cases, it has been shown that glucose control in the 30–60 days prior to surgery is beneficial in decreasing perioperative complications. Dronge et al. evaluating patients from Veterans Administration hospitals found that SSIs were reduced in patients whose HbA1c was less than 7 % and recommended that HbA1c less than 7 % is a preoperative target to aim for [27]. We routinely postpone elective herniorrhaphy for patients that fail to reach this target and schedule VHR after their diabetes is sufficiently controlled. Postoperative glycemic control is discussed later in this chapter in the Postoperative Optimization section.

27.2.4 Nutrition and Metabolic Control

In an era of evidence-based surgical and medical practice, recommendations for nutrition therapy of the surgical patient are supported by abundant large observational studies, over 40 randomized controlled trials (RCTs), as well as numerous meta-analyses and systematic reviews. Every surgical patient has a highly variable metabolic and immune response to major surgery regardless of preexisting nutritional state. Suboptimal outcomes are clearly associated with malnutrition [28]. This was undoubtedly shown in the large Preoperative Risk Assessment Study done by the U.S. Department of Veterans Affairs. This prospective trial included >87,000 patients from 44 separate medical centers where investigators collected 67 variables on each patient. This study reported the single most valuable predictor of poor outcome and increased morbidity was a serum albumin less than 3.0 g/dL [29]. Kudsk et al. confirmed this observation that that albumin, although not a marker of nutritional status, is a good surrogate marker for poor surgical outcome [30]. However, not all ventral hernia or AWR patients will derive the same benefit from nutrition therapy intervention either preoperatively or postoperatively. Previously well-nourished patients with a relatively minor surgery and those expecting short length of hospital stay derive little benefit from early nutrition therapy. On the other hand, the majority of patients undergoing major AWR with an expected extended length of stay in the hospital as well as intensive care unit stay at moderate to severe nutrition risk will appreciate significant outcome benefits from early attention to nutrition. While this has not been shown definitively in hernia surgery, it has been well demonstrated for major visceral surgical procedures [31]. In patients undergoing emergent or urgent AWR secondary to obstruction or infection who are preoperatively malnourished, these benefits of attention to nutrition are even greater. Several factors influence these benefits, including route and timing of delivery, content of nutrient substrate, and efforts to promote patient mobility. Recent data supports a preoperative assessment and nutritional intervention if the patient meets high-risk criteria [32]. Several nutritional scoring systems have recently been proposed with only one [Nutrition Risk Score 2002 (NRS 2002)] being validated in surgical population [33].

27.2.5 Preoperative Metabolic Preparation for Surgical Intervention

The concept of preoperative preparation of the patient with specific metabolic and immune active nutrients acquired a clinical following after several landmark studies by Gianotti and colleagues [34–36]. These well-done investigations demonstrated benefit in lowering perioperative complications by adding the amino acid arginine and the omega-3 fatty acids, docohexanoic acid (DHA) and eicospentanoic acid (EPA), for 5 days preoperatively. They reported major morbidity could be reduced by approximately 50 % in patients undergoing major foregut surgery, including esophageal, stomach, or pancreas procedures. This benefit was noted in both the well-nourished and malnourished patient populations [36, 37]. The revelation that even well-nourished patients would benefit was a paradigm shift from the notion that correction of malnutrition alone was the only important factor [34, 36]. In these studies, the patients consumed 750 mL to 1 L per day of the metabolic-modulating formula in addition to their regular diet. The formula used by Gianotti and Braga contained additional arginine, [omega]-3 fatty acids, and nucleic acids, and resulted in significant decreases in infectious morbidity, length of hospital stay, and hospital-related expenses [34–36]. In a recent meta-analysis and systematic review of the evidence including 35 articles, Drover et al. reported that these arginine-containing nutritional supplements yielded a significant benefit in lowering infectious complications across the several surgical specialties included. This meta-analysis also reported a signal for a decrease in length of hospital stay [37]. The exact mechanisms of the active ingredients are yet to be completely elucidated. However, it has been shown that fish oils have multiple mechanisms, including attenuating the metabolic response to stress, altering gene expression to minimize the proinflammatory cytokine production, beneficially modifying the Th1 to Th2 lymphocyte population to lower the inflammatory response, increasing production of the anti-inflammatory lipid compounds “resolvins and protectins,” and regulating bowel motility via vagal efferents [38–43]. Arginine has been reported to have a multitude of potential benefits in the surgical populations. These include improved wound healing, optimizing lymphocyte proliferation, and enhancing blood flow via nitric oxide vasodilation effects [44, 45]. The influence of the Ribonucleic Acid (RNA) found in these preoperative formulas has theoretical benefits that have yet to be well elucidated in mammalian trials [45].

Another area of metabolic manipulation of growing interest is preoperative carbohydrate loading [46]. This metabolic strategy utilizes an isotonic carbohydrate solution given at midnight on the night before surgery, then 3 h preoperatively to maximally load the tissues with glycogen prior to the surgical stress [47]. In most Western surgical settings, the "routine" is for the patient to fast after dinner the night before surgery and remain nothing by mouth (*nil per os*, NPO) after midnight prior to surgery in the am. Essentially following this "routine," glycogen stores are nearly depleted prior to the surgical insult. Soop et al. [48], Fearon et al. [49], and more recently Awad [50, 51] have demonstrated the beneficial effects of carbo-loading in several animal and clinical studies. Caution with direct cause and effect conclusions here is needed as most large humans studies dealing with carbo-loading were done as part of several preoperative interventions with the experimental groups receiving multimodality treatment, including avoidance of drains, controlled perioperative sodium and fluid administration, epidural anesthesia, and early mobilization in addition to the carbo-loading [46]. These carbohydrate loading studies have consistently reported several metabolic benefits including significantly reduced insulin resistance, decreased postoperative nitrogen loss, and better retention of muscle function [48, 49].

27.3 Peri- and Postoperative Optimization

27.3.1 Surgical Site Infection

Surgical site infections (SSIs) following incisional hernia repair has been reported to be higher than that noted with other cases designated as clean cases. It has also been shown that if the index case from which the hernia developed had a wound infection then subsequent incisional hernia repair will have a higher level of infection than would be expected from a clean case [52]. Virtually all incisional hernias greater than 4–6 cm will require mesh for optimal durable repair. In general, if a permanent synthetic mesh is used and becomes infected, the ability to sterilize the mesh and completely eradicate the infection without removing the mesh is rare. Synthetic mesh clearance rates following mesh-related wound infections are reported between 10 and 70 % and will depend on the type of mesh involved. PTFE-based meshes remain the most difficult and virtually impossible to clear, followed by multi-filament polyester, while macroporous polypropylene yields the best chance of clearance [53, 54]. The clearance rates are dependent on the type of mesh used, location of mesh placement and the extent of contamination, as well as the viability of the tissue and host defenses [1, 53]. In addition, infected mesh is associated with costly morbidities such as prolonged wound management, enterocutaneous fistulae, as well as recurrent hernia. These complications can be quite severe and expose the patient to significant morbidity and even mortality. Treating the complications of infected mesh is also quite expensive [54]; therefore, all reasonable measures should be taken to prevent wound or mesh infection.

27.3.2 Skin Preparation and Decolonization Protocols

The data on choice of skin preps immediately prior to incision is now well sorted out. Two major trials have recently been published; the first from an excellent surgical ID group in Virginia. Swenson et al. reported in a prospective trial in over >3200 patients iodine skin preps were superior to chlorhexidine preps [55]. Soon after the Swenson paper was published, a prospective randomized clinical trial with intention to treat analysis in over 800 patients was published, reporting that chlorhexidine was superior to iodine preps [56]. Swenson went back and analyzed the data from both studies. This analysis revealed the key to lower infections was the alcohol in the preps; Duraprep® and Chloraprep® had equivalent surgical infection risk, and iodine prep without alcohol was most commonly associated with infections [57]. Regarding hair trimming, it has been the standard of care for several years that clippers rather than razor be used to clear the surgical site hair that would interfere with the surgical site [58]. Surgical site barriers and skin sealants have not been studied well in ventral hernia repair. The data on these applications is widely variable with reports from beneficial to detrimental. The data on skin sealants and surgical site barriers are far too inconsistent to make any recommendation to use these in ventral hernia repair or AWR. Also, the use of preoperative showers with antiseptic soaps to decrease SSIs has been inconsistent. Showering with antiseptic agents such as chlorhexidine or Betadine when compared to showering with soap have no proven benefit [59]. Most of these studies are underpowered or were studied in a widely heterogeneous population, which makes consistent results near impossible. Many of the early studies do report a decrease in skin bacterial colonization at time of surgery but have not shown a consistent decrease in SSI. Few of the smaller studies have shown benefit of preoperative chlorhexidine shower in reducing SSI but these are in the minority [60]. This inconsistency in the literature led to the Cochrane analysis in 2012 to conclude preoperative showers with antiseptics have no significant benefit [59, 61].

Preoperative nasal clearance of *Staphylococcus aureus* in the preoperative has gained significant popularity in the last several years following a landmark paper published by Bode et al. in the *New England Journal of Medicine*, 2010 [62]. This paper was closely followed by a second manuscript Kim et al. supporting the concept of *Staphylococcus* clearance preoperatively to decrease post-op wound infections [63]. In the Bode study, 6771 patients were screened for on admission with approximately 1200 being positive for *S. aureus*. They then prospectively randomized, with an intention to treat analysis, the patients carrying *S. aureus* to twice daily mupirocin applied to the nostrils with once daily chlorhexidine shower vs. placebo. They reported a 42 % decrease in *S. aureus* postoperative infections in the treated group. The logistics of screening then treating those positive is a bit cumbersome and requires consistency and patient compliance, but when done according to protocol is clearly cost effective. It is our practice to avoid random nasal swab methicillin-resistant *Staphylococcus aureus* (MRSA) screening; instead we treat high-risk patients (previous MRSA infection, co-habitant with MRSA, recently hospitalized within 6 months, living in a nursing facility or prison, currently on broad-spectrum antibiotics, etc.) with mupirocin ointment applied intranasally for 5 days prior to the date of surgery.

27.3.3 Perioperative Antibiotics

According to Guidelines that were developed jointly by the American Society of Health-System Pharmacists (ASHP), the Infectious Diseases Society of America (IDSA), the Surgical Infection Society (SIS), and the Society for Healthcare Epidemiology of America (SHEA), patients undergoing routine ventral hernias repair should be given prophylactic antibiotics using a first generation cephalosporin [64]. The antibiotics should be given with adequate time to allow for levels in the tissue to reach a level above the minimum inhibitory concentration (MIC) for the bacteria for which one is trying to inhibit; usually this is at least 30 min prior to incision [65]. Antibiotics should be redosed, if necessary, during the operation as indicated based on duration of surgery, half-life of antibiotic being used, blood loss, and use of cell saver. Antibiotics are not given postoperatively as several well-done randomized trials have shown no benefit of dosing prophylactic antibiotics after the skin has been closed [64, 66–69]. These outcomes have been similar across several surgical disciplines. Most hospitals now have preoperative protocols, and in large surveys, over 90 % of procedures are getting the correct antibiotic for prophylaxis according the published guidelines. The place where the prophylaxis is commonly inadequate is in patients with a body mass index (BMI) of >30. In a recent large survey, only 66 % of patients received prophylactic dosing to reach adequate serum levels when BMI was over 30 [70]. According to ASHP guidelines it is recommended that all patients under 120 kg receive 2 g cefazolin, while those at or above 120 kg be given 3 g cefazolin, then redosed every 4 h for extended surgeries. Interestingly, because of shorter half-lives antibiotics such as ampicillin-sulbactam, cefoxitin, and piperacillin-tazobactam are redosed every 2 h when used for intraoperative prophylaxis, according to ASHP recommendations [64].

There are conflicting data regarding the risk of subsequent wound infection in patients with a history of prior infection that has healed, with some studies demonstrating increased rates of wound infection [71, 72] while others show no significant difference [73]. At our institution, we consider a previous wound infection as a definite risk factor for subsequent wound infection. We attempt to use appropriate prophylactic antibiotics when culture results of the initial infection are available. If the patient has had a previous abdominal wall MRSA infection, we will add vancomycin for prophylaxis. In these patients, we also prefer biologic or bioresorbable meshes as our reinforcing prosthetics [4]. This is especially important in patients who have had previous infections with MRSA involving synthetic mesh even when no overt signs of infection have been present for up to 10 years. The foreign body yields the substrate for the biofilm to adhere to and allow bacteria to flourish. Once this occurs, the bacteria have adequate numbers for quorum sensing. Within the bacterial colony, intracellular signals allow some bacterial cells in the colony to change phenotypically with some becoming dormant, some actively dividing, and some becoming planktonic [74]. Several papers have speculated that if previous mesh infection was present, the patient should no longer be treated with prophylaxis but treated empirically with a full course of antibiotics [74]. One must be cautious of overusing vancomycin prophylaxis without adequate indications as data show an increased risk of methicillin-*sensitive S. aureus* (MSSA) wound infection when vancomycin is used over a standard beta-lactam antibiotic [75]. For this reason, we commonly use both cefazolin in addition to vancomycin for prophylaxis in patients with high risk for MRSA infection, which is also discussed in the ASHP therapeutic guidelines [64].

For those patients with ongoing wound infections, infected mesh, active fistulae, etc., our primary goal is removal of all infected elements and foreign bodies. Prior to definitive hernia repair we debride all infected tissue, excise all infected mesh(es), sutures, and other foreign bodies, and perform any necessary gastrointestinal resections with anastomoses, as appropriate. For many cases where the bioburden of bacteria is high, we will stage the repair with a negative pressure dressing and close the abdomen with a Vicryl or biologic mesh and perform a subsequent hernia repair, likely with a biologic or biosynthetic resorbable mesh at some point in the future depending on the patient's condition, nutritional status, and degree of contamination [76].

27.3.4 Postoperative Blood Glucose Management

Thee first 24 h of the postoperative period appears to be especially important for glucose control, as hyperglycemia results in nonfunctional or poorly functional neutrophil activity. Hyperglycemia has been shown to alter chemotaxis, pseudopod formation, phagocytosis, and oxidative burst which can prevent the early killing of bacteria entering the wound during surgery [77].

Postoperative glycemic control was initially shown to be of benefit in preventing complications in a large study of primarily cardiac patients [78]. In the early 2000s, meticulous glucose control (80–110 mg dL) was very popular in surgical ICU patients. This popularity was stimulated by a large randomized control trial showing a significant decrease in mortality when strict glucose control protocols were instituted [78]. However, this has subsequently been shown not to be the case, as the risk of hypoglycemia and its complications outweigh the risk of meticulous glycemic control [79]. Additionally, postoperative hyperglycemia has been shown to be a strong predictor of postoperative SSI. Using a multivariate regression model in a retrospective study of 995 patients Ramos et al. correlated postoperative infections, demonstrating that postoperative hyperglycemia was a strong indicator of the probability of postoperative infection. In this study, every 40-point increase from 110 mg/dL serum glucose increased the risk of infection by 30 % [80]. Ata et al. examined the records of 1561 patients undergoing general or vascular surgery and found that postoperative glucose of greater than 140 mg/dL was the only significant predictor of SSIs [81]. The target blood glucose level in the immediate perioperative period appears optimal in the 120–160 mg/dL range.

27.3.5 Miscellaneous Techniques and Treatments to Reduce Risk

Additional measures reported to decrease post-op infectious complications include antibiotic impregnated suture, wound protectors, perioperative patient warming, intra-operative and postoperative hyper-oxygenation, as well as others. While initial enthusiasm for antibiotic impregnated sutures was high, there had been limited literature supporting its routine use. However, over the last several years, additional data have shown a reduction in SSIs with the use of antimicrobial sutures. A meta-analysis of 15 RCTs demonstrated favorable outcomes with triclosan-coated sutures in the majority of these studies [82]. Decreased SSIs have been seen in a range of procedures utilizing antibiotic sutures including breast, colorectal or other bowel cases, pancreaticobiliary, cardiovascular, as well as other operations [82–87]. Currently, no studies exist for the use of such sutures in patients with complex ventral hernias, which typically include higher rates of wound morbidity including SSIs. While we have not utilized antibacterial sutures in our practice of complex VHR, they do appear safe, and there appears to be sufficient data to proceed with future trials evaluating efficacy in this high-risk group.

Intraoperative wound protectors are designed to protect from desiccation, contamination, and mechanical trauma. They have also been said to decrease wound infections. No data on wound protectors in hernia surgery is available to date. To date, at least six randomized clinical trials have been done for colorectal and other GI surgeries. Four studies reported no benefit in lowering SSIs while two showed benefit. When weighing the quality of the studies and using the Grade system to evaluate studies, the review trends toward no benefit [88, 89].

The concept of patient warming to prevent SSI has received significant attention in the past 10 years, and now most operating rooms have patient warming as part of the protocol to minimize SSI. Several observational studies reported a significant correlation between hypothermia and SSI. The theoretical belief is that euthermia helps maintain better perfusion to skin, and better oxygen tension at the skin level will decrease SSI [90]. Hypothermia has also been associated with adverse influence on the immune function. T-cell mediated antibody production and reduction in both oxidative and non-oxidative killing of bacteria by neutrophils [91]. These concepts were supported by two moderate-sized RCTs, both showing hypothermia is significantly associated with an increase in SSI. A large case-controlled study done using the NSQIP (National Surgery Quality Improvement Program) database appears to not have confirmed these earlier findings [92].

Supplemental Perioperative Oxygenation (Hyperoxia) has been well investigated, but unfortunately not in hernia surgery. The concept that adequate oxygenation is required for neutrophil and macrophage killing of bacteria and the association that surgical wounds have a much lower partial pressure of oxygen than normal tissue makes this an attractive hypothesis for lowering SSI [93]. Two landmark studies in colorectal surgery patients showing benefit in reducing SSI lead to multiple protocols of using supplemental oxygenation [94, 95]. This led to a large study with governmental funding of 1400 patients showing no benefit [96]. A more recent meta-analysis favors supplemental oxygen protocols in the higher risk population such as colorectal surgery patients [97]. Although no direct studies have been done in abdominal wall reconstruction, this population carries risks of SSI very similar to colorectal surgery patients.

Perioperative antibiotic use commonly results in antibiotic associated diarrhea (AAD) in an estimated 20 % of patients, with perioperative use of antibiotics being a major source for AAD and *Clostridium difficile* diarrhea [98, 99]. Numerous recent prospective trials have shown that

Table 27.1 Perioperative interventions for ventral hernia repair

Solid data to support intervention	Awaiting greater confirmation of data
Obesity and weight management • Sufficient weight loss necessary, however, no consensus on target BMI	Bowel preparation
Smoking cessation—30+ days pre-op	Patient warming
Diabetes management and perioperative glucose control • Pre-op Hgb A1c <7.0 • Post-op blood sugar 120–160 mg/dL	Hyper-oxygenation
Nutrition and metabolic control • Pre- and post-op supplements • Consider specific nutrients (arginine, ω-3 fatty acids)	Carbohydrate loading
Alcohol-containing skin prep	Prehabilitation
Antibiotic prophylaxis • Choice of antibiotic—1st generation cephalosporin for most • Vancomycin in high-risk groups • Duration—should stop when wound closed and all sutures placed • Duration—for redosing, consider $t^{1/2}$ of specific antibiotic; refer to ASHP and/or hospital guidelines	Antibiotic-impregnated sutures

appropriate selection and supplementation of probiotics (live viable bacteria when given in adequate amounts showing benefit in the host) are safe and can significantly decrease both AAD and *C. difficile* diarrhea [98–100].

It is valuable to mention that several other factors can be addressed in the intraoperative period and postoperative period that can optimize patient outcome and minimize SSO but are beyond the scope of this chapter. One concept that is rapidly gaining traction in major surgery is the idea that preoperative routine scheduled physical activity program, so-called "prehabilitation," can decrease length of stay and decrease total complications associated with major surgery [101].

27.4 Conclusion

There are multiple factors that affect postoperative outcomes following ventral hernia repair. Optimizing the patient preoperatively including smoking cessation, glucose control, and nutritional support can all be achieved over a relatively short time (1–5 weeks). Obesity, however, is a major threat to this high-risk group that takes months for patients to lose significant weight, be it with diet and exercise or even following a bariatric operation. If the surgeon has the luxury of waiting (minimally or asymptomatic hernia), he or she should wait until the patient has lost considerable weight to maximize outcomes. Unfortunately, for those hernias which are highly symptomatic or with threatened bowel, the surgeon may not have the advantage of waiting. Various segments of the patient's surgical journey should be addressed and optimized when possible (Table 27.1). These preoperative and perioperative interventions have been shown to be safe and even cost effective in most cases. The interventions performed in the immediate perioperative period, including appropriate choice and timing of prophylactic antibiotics, metabolic preparation with specific nutrients and/or carbohydrate-loading, choice of alcohol-containing skin preps, and preoperative decolonization of *Staph aureus* from the nostrils and skin, are reasonable interventions which, when implemented, should minimize peri- and postoperative morbidity.

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