3 Preoperative Optimization and Enhanced Recovery After Surgery Protocols in Ventral Hernia Repair

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Introduction

Many factors go into achieving success following ventral hernia repair. Besides technical factors that affect outcomes such as which repair technique, tissue plane dissected and the mesh prosthetic being implanted, there are multiple aspects of pre- and postoperative care that greatly affect outcomes. What is highly beneficial is that many of the patient-specific factors are modifiable. Therefore, with the assistance of their surgeons, patients have an opportunity to positively affect the outcomes of their own repair.

Hernia recurrence is a major indicator of the quality of the hernia repair. While extremely important, hernia recurrence may not be apparent for months, years, or even decades. In the short term, wound morbidity has a greater influence on the quality of life of the patient, as significant wound morbidity (e.g., surgical site infection [SSI]) can lead to increased visits to the emergency department, readmission to the hospital, greater time and effort within the clinic setting, or possible reoperation(s) to manage complex postoperative wound complications. Additionally, perioperative surgical site occurrences (SSOs), including SSI, seroma, wound ischemia, and dehiscence, can greatly increase the risk of recurrent hernia [1]. Therefore, it is in the best interest of the patient and surgeon to optimize all measures that promote optimal 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].

Minimally invasive surgical (MIS) techniques have been developed over the last few decades and encompass a wide breadth of surgical disciplines. While robotic-assisted procedures have been present for some time, a recent surge of hernia repairs are being performed robotically. Additionally, robotic-assisted techniques are being used for more complex hernia repairs, including component separation techniques for ventral hernias. Of the many benefits of MIS procedures, reduced wound morbidity and length of hospitalization are two of the principal advantages. With the rising popularity and use of robotic-assisted herniorrhaphy, there should be a reduction in wound complications, just as we have seen a reduction in wound complications with the utilization of laparoscopic hernia repair techniques. That said, it is still of utmost importance that we optimize our patients to ensure the highest quality hernia repair and prevent or reduce complications. This chapter will briefly review several pre- and perioperative measures that have been reported to decrease SSOs (surgical site

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occurrences) and shorten length of hospital stay. Limited robotic-specific data exist regarding enhanced recovery after surgery (ERAS) for various surgeries [3], with the bulk of ERAS literature pertaining to open as well as laparoscopic surgery optimization and complication reduction. However, much of the information is still relevant in a population requiring complex (and simple) hernia repairs performed in a minimally invasive approach such as robotics.

Preoperative Optimization

There are multiple patient factors that contribute to wound healing and should be optimized prior to surgery. Factors such as obesity, smoking, diabetes, malnutrition, and surgical site contamination are all detrimental to wound healing and can lead to infection or hernia recurrence, among other complications. Obesity and smoking have been shown to be independent risk factors for increased rate of hernia recurrence as well as SSO. Poor glycemic control in the remote preoperative period, 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 SSOs as well as hernia recurrence. Unfortunately, many of our patients had multiple 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.

Obesity

Obesity represents one of the most significant threats for the development of incisional hernias as well as recurrence following ventral hernia repair. Hernia recurrence rate increases linearly as BMI increases regardless of the technique of repair [4–6]. In our practice we have found that in patients with BMI $\geq$ 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).

A lifetime of poor eating habits and insufficient physical activity are the likely culprits for many patients, making management of obesity quite challenging. Much time is spent during clinic visits, counseling patients on methods to improve dietary habits and increase physical activity. Following weight loss strategy discussions and objective rationale for the necessity of weight loss, we will set an attainable weight loss goal (e.g. 15–30 lbs) and have the patient return to the clinic in 3–6 months for reevaluation. Having a dietary consult with a nutritionist well versed in perioperative optimization can also provide valuable information and assist with motivated patients in reaching obtainable weight loss goals. If the patient fails to lose sufficient weight, or gains weight in the interim, elective surgery is postponed and other more aggressive methods of weight loss are discussed. If attempts at medical weight loss fail, it is our practice to refer patients to our bariatric surgery colleagues for discussion for surgical weight loss. Alternatively, newer endoscopic and other minimally invasive devices have been developed to assist with weight loss. The long-term efficacy of such devices is still under investigation, but early results are encouraging.

Ideally, if an MIS bariatric procedure is being performed in a patient with an incisional hernia, we will wait to definitively repair the hernia until adequate weight loss has been achieved. The simplest hernia repair is performed at this time (e.g., primary fascial closure) of the bariatric procedure, saving more complex hernia repairs (e.g., component separation) until after sufficient weight loss from their bariatric procedure. Some have advocated concomitant hernia repair at the time of sleeve gastrectomy, as sleeve gastrectomy does not put the patient at the extreme nutritional risk for poor wound healing and perioperative morbidity compared to bypass procedures [7]. However, the patient is still not optimized until adequate weight loss has been achieved.

Smoking

The multiple detrimental effects of smoking are well known, with reduction of both blood and tissue oxygen tension, as well as the negative effects on collagen deposition of at the site of healing wounds [8–10]. These effects adversely influence healing of surgical wounds. Numerous animal and human models have studied the detrimental 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 along with other postoperative complications following gastrointestinal or other abdominal surgery [14]. Because complex ventral hernia repair frequently requiring a combination of prosthetics, tissue flaps, and possibly some form of concomitant gastrointestinal procedure, these studies reinforce the need for smoking cessation prior to complex hernia repair and abdominal wall reconstruction (AWR). One study looking at smoking versus cessation with nicotine patches in patient undergoing primary hernia repair, hip or knee prosthesis, or laparoscopic cholecystectomy demonstrated almost a 50% reduction in total complications in the cessation + patch group [15]. 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. 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 [16]. 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.

Because of the substantial high-quality literature demonstrating a clear correlation between active tobacco use and impaired wound healing and its sequelae, we require patients to cease all smoking activity for a minimum of 30 days preoperatively for those undergoing elective complex VHR by any method, be it open, laparoscopically or robotic [11]. While robotic-assisted and other minimally invasive techniques benefit patients with reduced wound complications, active tobacco use still adds substantial impairments to adequate wound healing. We do allow the use of nicotine patches, as the data is reasonably good indicating that nicotine is not a factor in cigarette smoke that causes problems with wound healing.

Diabetes

While glucose management is important for all stages of patient care related to hernia repair, preoperative glycemic control is essential for optimal outcomes. This is routinely measured using glycosylated hemoglobin (Hgb A1c). Studies have demonstrated reduced wound healing and increased postoperative complications in diabetic patients undergoing a variety of surgical procedures [17–19]. In elective cases, it has been shown that glucose control in the 30–60 days prior to surgery is beneficial in decreasing perioperative complications [20]. At our institution, we postpone elective hernia repair in patients with elevated Hgb A1c levels (>7.5%), with attempts at achieving a Hgb A1c goal closer to 6.5%. The patient is referred to a diabetic nurse educator or endocrinologist, and the VHR repair is rescheduled when glycemic levels are sufficiently controlled. Postoperative glycemic management is discussed later in this chapter in the Postoperative Optimization section.

Nutrition and Metabolic Control

Multiple large observational studies, over 40 randomized controlled trials (RCTs), as well as numerous meta-analyses and systematic reviews demonstrate the role that nutritional therapy plays in the ability of patients to heal and recover following surgery. Despite substantial evidence supporting the role that nutrition plays on perioperative outcomes and healing, insufficient emphasis is placed on optimizing the patient's nutritional status in the preoperative setting [21].

The concept of preoperative preparation of the patient with specific metabolic and immune active nutrients gained popularity after several landmark studies by Gianotti and colleagues [22–24]. These well-done RCT investigations demonstrated benefit in lowering perioperative complications by adding the amino acid arginine along with the omega-3 fatty acids, docosahexaenoic acid (DHA) and eicosapentaenoic 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. Similar benefit was noted in both the well-nourished and malnourished patient populations [24, 25].

Interestingly, even well-nourished patients have demonstrated benefits from nutritional metabolic and immune modulation [22, 24]. 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 and most of the other major studies 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 [22–24]. The exact mechanisms of all 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 EPA and DHA derived pro-resolving lipid compounds "Specialized Proresolving Molecules" (SPMs), and regulating bowel motility via vagal efferents [26–31]. Arginine has been reported to have a multitude of potential benefits in the surgical populations. These include improved wound healing, optimizing lymphocyte proliferation and function, and enhancing blood flow via the nitric oxide vasodilation effects [32, 33].

Another area of metabolic manipulation of growing interest is preoperative carbohydrate-loading [34]. This metabolic strategy utilizes an isotonic carbohydrate solution given 3 h preoperatively to alter stress metabolism and decrease insulin resistance [35]. 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 at the time of surgery. Soop et al. [36], Fearon et al. [37], and more recently Awad [38, 39] have demonstrated the beneficial effects of carbo-loading in several animal and clinical studies reporting primarily benefits in insulin resistance. Caution with direct cause and effect conclusions here is needed as most large human 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 [34]. 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 [36, 37].

Peri- and Postoperative Care

Surgical Site Infection

Attention to SSIs plays an important role with far-reaching ramifications for hernia repairs. SSI rates are noted to be higher for hernia repairs compared to other clean non-hernia surgeries [40]. Traditionally, if a permanent synthetic mesh was implanted at the time of hernia repair and it becomes infected, the ability to sterilize the mesh and completely eradicate the infection without removing the mesh was essentially zero. Synthetic mesh salvage rates following mesh related wound infections are reported between 10 and 70% and depend on the type of mesh involved. The bacterial 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, 41]. PTFE-based meshes remain the most difficult and virtually impossible to clear of infection, followed by multi-filament polyester, while macroporous polypropylene yields the best chance of salvage [41, 42]. In addition, infected mesh is associated with costly and serious morbidity including prolonged wound management, enterocutaneous fistulae as well as recurrent hernia. These complications can be quite severe and expose the patient to significant morbidity, mortality, and significant additional cost of care [42].

Skin Preparation and Decolonization Protocols

Proper disinfection of the surgical site with the use of skin preparations has been well elucidated. Multiple major trials have been published which essentially show equality with either an iodine or chlorhexidine skin prep as long as alcohol is included [43–45].

Hair trimming at the time of surgery has been the standard of care for several years, with the notion that clippers rather than razor be used to clear the surgical site hair [46]. Surgical site barriers and skin sealants have not been studied well in ventral hernia repair. The data on these products are 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. That said, the use of iodine-impregnated sealant drapes can be beneficial from a draping standpoint, allowing wide draping and sealing at various edges of the sterile field. Also, the use of preoperative showers with antiseptic soaps to decrease SSIs has been inconsistent [47–49]. Showering with antiseptic agents such as chlorhexidine or Betadine, when compared to showering with soap, has not shown significant benefit in lowering SSI, and may alter the normal protective skin flora (microbiome) [50].

The nares are the most common site for colonization of *Staphylococcus aureus*. As such, nasal clearance of *S. aureus* in the preoperative setting 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* in 2010. They reported a 42% decrease in *S. aureus* postoperative infections in the treated group [51]. Other studies have been carried out in orthopedic joint replacement or spine surgery, as hardware infection has devastating and costly consequences. In our practice we favor treating high-risk patient populations instead of random methicillin-resistant *S. aureus* (MRSA) nasal screening. High-risk patients include 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. These patients are treated with a protocol combining mupirocin ointment applied in each nostril twice daily along with chlorhexidine showers once daily for 5 days prior to the date of surgery. A povidone-iodine based preparation has recently been released and may offer a single treatment option [52].

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 [53]. 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 within 30 min prior to incision [54]. 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. Regarding the use of postoperative antibiotics, several well-done randomized trials have shown no benefit of dosing prophylactic antibiotics after the skin has been closed [53, 55–58]. These outcomes have been similar across several surgical disciplines. One challenge with regard to antibiotic dosing is in the obese population. In a recent large survey, only 66% of patients received prophylactic dosing to reach adequate serum levels when BMI was over 30 [59]. 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 [53]. Additionally, because of increased risk of methicillin-*sensitive S. aureus* (MSSA) wound infection when vancomycin is used [60], we routinely use both cefazolin in addition to vancomycin for prophylaxis in patients with high risk for MRSA infection. This ensures adequate coverage of both MSSA and MRSA, especially in the setting of a mesh prosthetic implant; this is also discussed in the ASHP therapeutic guidelines [53].

For patients with active wound infections, chronic draining sinuses, infected mesh, enterocutaneous or enteroatmospheric fistulae, and so on, our primary goal is removal of all foreign bodies and niduses of infection. Prior to definitive hernia repair the goal is removal of all infected meshes and other foreign bodies (e.g., suture material), debridement all infected and poor integrity tissue, and perform any necessary gastrointestinal resections with anastomoses, as indicated. 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 native tissue or absorbable 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 [61].

Postoperative Blood Glucose Management

The immediate postoperative period is a critical period with regard to glucose management. Hyperglycemia has been shown to alter chemotaxis, phagocytosis, and oxidative burst which can prevent the early optimal killing of bacteria which entered the wound during surgery [62]. Therefore, meticulous glycemic control is vital within the first 24 h of the postoperative period to maximize neutrophil activity. Multiple large randomized clinical trials have confirmed the target blood glucose level in the immediate perioperative period appears optimal in the 120–160 mg/dL range [63–66].

Multimodal Pain Control

Adequate pain control remains a challenging entity following hernia repair. This holds true for minimally invasive approaches including laparoscopy and robotic-assisted repairs, along with their open repair counterpart. Because of the innervation of the abdominal wall, defect closure and trans-fascial suturing all play roles in postoperative pain. That said, because robotic-assisted surgery allows for improved intracorporeal suturing, with less transabdominal suturing, there is potential for reduced pain compared to standard laparoscopy. While narcotics represent a common component of multimodal approaches, their use is lessened when combined with an array of non-opiates in an effort to reduce the deleterious effects of opiates such as constipation, sedation, and respiratory depression. The principal components of our postoperative multimodal pain regimen include an immediate-acting narcotic such as hydromorphone or oxycodone, acetaminophen, along with gabapentin. Other agents, including antispasmodics may be added but are less routine. The multimodal approach should be tailored to the degree of hernia repair, as more complex repairs (e.g., robotic TAR or flank hernia repairs) will likely require greater breadth of analgesics. Conversely, simpler umbilical hernia repairs may only require one or two analgesic agents.

Commonly, patients are given an opiate-based analgesic for immediate pain relief. Patients undergoing same-day surgery can be discharged with oral oxycodone, hydromorphone, or hydrocodone. However, patients that are admitted are routinely given a hydromorphone patient-controlled analgesia (PCA) pump for narcotic-assisted analgesia. Once a patient is tolerating a diet, we transition to oral oxycodone or hydromorphone as needed for breakthrough pain. Acetaminophen is routinely given as well to aid in analgesia, as there is lack of side effects seen with opiates such as sedation, respiratory depression, and ileus, and no concern of bleeding or impaired renal function seen with nonsteroidal anti-inflammatory drugs (NSAIDs) [13]. However, because acetaminophen is primarily metabolized in the liver, its use should be cautioned in patients with hepatic dysfunction. These benefits result in decreased postoperative pain while significantly reducing opioid consumption. While the precise mechanism of acetaminophen remains unknown, it appears to have a central analgesic effect on multiple target pathways [67]. For those that are unable to receive oral medications, IV acetaminophen can be very helpful. However, IV acetaminophen is expensive, and many hospital pharmacies will require documentation stating a patient's inability to accept oral or rectal acetaminophen before allowing IV infusion. Principal benefits of IV acetaminophen include rapid onset and high peak concentration compared to equivalent oral and rectal doses, along with its ability to be used in patients without adequate bowel function. Because of its safety profile when dosed appropriately, patients will routinely be discharged with acetaminophen as a primary analgesic.

Another useful analgesic for patients admitted following hernia repair is gabapentin, which serves as an adjunct for postoperative pain control at the neuronal level, with mechanisms of action on calcium channels and GABA receptors [68–70]. Multiple randomized controlled trials (RCTs) have demonstrated the benefits of pain control as well as reduced opioid use without the side effect profile of opiates [70–74]. While some patients experience sedative effects from gabapentin, this effect is less frequent than opiates, though monitoring for sedation with the use of multiple analgesics is necessary. For our pain pathway, we routinely provide oral gabapentin (300 mg TID) immediately postoperatively until the day of discharge. Rarely, patients are prescribed gabapentin upon discharge, and this is typically reserved for patients with known chronic pain syndromes or if significant lateral wall dissection was performed.

Another medication of usefulness following abdominal wall hernia repair is diazepam. While typically thought as an anxiolytic, we administer diazepam as a postoperative muscle relaxant. There is limited literature regarding the use of diazepam for postoperative pain control in hernia repair, though studies do support the use in a multimodal fashion with narcotics [75, 76]. Because significant abdominal wall dissection can result in muscle spasm, diazepam's antispasmodic properties can be a useful component, especially if trans-fascial fixation or numerous tacks are utilized. Diazepam is initiated on postoperative day 1 or 2, allowing for evaluation of sedation with other multimodal medications. 2–5 mg of diazepam is scheduled every 6 h around the clock for the first 48 postoperative hours, excluding elderly patients over 65 years old and all patients with a history of obstructive sleep apnea. Caution must be used with diazepam, as an added sedative effect can be seen with patients sensitive to sedatives, prompting strict holding parameters for any signs of somnolence or lethargy. Because of the sedative effects and greater addictive profile of benzodiazepines, we routinely exclude diazepam as a discharge medication.

While oral and intravenous analgesics represent the mainstay of a multimodal pain regimen, local-regional blockade is a useful adjunct for ventral hernia repair. Transversus abdominis plane (TAP) blocks have gained greater popularity given its blockade of intercostal, subcostal, ilioinguinal, and iliohypogastric nerves (T6-L1) [77, 78]. TAP blocks employ local anesthetic infusion between the internal oblique and transversus abdominis muscles and are performed either via ultrasound-guidance, indirect visualization laparoscopically/robotically, or direct visualization of the planes if performing a transversus abdominis release (TAR). TAP blocks have shown to reduce postoperative pain, overall narcotic usage, length of stay, as well as reduction of opioid-specific side effects [79–83]. If available, long-acting liposomal bupivacaine can provide up to 72 h of local anesthetic blockade, though many hospital pharmacies restrict their use due to high cost compared to standard bupivacaine.

Other analgesics are being utilized by surgical and anesthesia teams to help alleviate peri- and postoperative pain following ventral hernia repair. NSAIDS are a useful adjunct, but should be used in caution with elderly patients given the risk of postoperative kidney injury. Therefore, NSAIDS are reserved for non-elderly patients, with only a short duration in the postoperative setting. Given the opiate crisis that is more publicly apparent, a reduction in narcotic use is favored. Therefore, multimodal pain regimens will no doubt change in the upcoming years, and patients should be tailored for their own personal analgesic needs in the postoperative setting.

Early Enteral Feeding

No longer do we keep our patients *nil* per os (NPO) for extended periods of time awaiting return of bowel function. Multiple studies have demonstrated success with tolerance to early enteral feeding, in addition to multiple metabolic benefits, all while reducing postoperative ileus and decreasing length of hospitalization [84–87]. For our early recovery pathway, patients receive unlimited clear liquids with the addition of a clear liquid protein supplement on postoperative day #1, then are advanced to a regular diet on postoperative day #2. Antiemetics are provided for patients on an as needed basis. However, most patients tolerate this rapid progression without deleterious sequelae. The exceptions are for patients that required significant adhesiolysis and/or bowel resection; such patients are at higher risk for ileus development. Therefore, any significant nausea and emesis prompt nasogastric tube decompression and holding enteral feeds.

Conclusion

As discussed above, many factors influence the outcomes following ventral hernia repair. Optimizing the patient in the preoperative setting, including smoking cessation, appropriate weight loss, and diabetes control, among others, can greatly impact success after ventral hernia repair. While most preoperative optimization studies pertain to open repairs, it is still of great benefit to maximize outcomes for patients undergoing minimally invasive approaches such as robotic-assisted ventral hernia repair. As we accrue more data from robotic-assisted surgeries, there will no doubt be advancements in patient outcomes as we combine the positive returns of preoperative optimization with the benefits of minimally invasive surgeries.

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