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Perioperative factors associated with pain following open ventral hernia repair

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Abstract

Background Effective pain control following open ventral and incisional hernia repair (VHR) impacts all aspects of patient recovery. To reduce opioid use and enhance pain management, multimodal therapy is thought to be beneficial. The purpose of this study was to identify patient characteristics associated with perioperative patient-reported pain scores.

Methods With IRB approval, surgical databases were searched for cases of open VHR performed over 3 years. Based on a retrospective chart review, modes of pain management and visual analog scale (VAS) pain scores were recorded in 12-h intervals to hospital discharge or to 8 days post-operation. Forward stepwise multivariable regression assessed the independent contribution of the perioperative factors to VAS pain scores.

Results Included in the analyses were 175 patients that underwent VHR. Average age was 55 years (+/− 12.8), and half were female (50.9%). Factors independently associated with increased preoperative VAS pain scores included preoperative opioid use, preoperative open wound, CDC Wound Class II, and prior hernia repair(s). Patients with epidural for postoperative pain had significantly decreased VAS pain scores across the time continuum. Operative factors significantly associated with increased preoperative VAS pain score included median hernia defect size, concomitantly performed procedure(s), duration of operation, and estimated blood loss. Greater preoperative VAS pain score predicted increased pain at each postoperative time point (all $p < .05$).

Conclusions Preoperative pain and opioid use are associated with increased pain postoperatively. Epidural analgesia effectively results in decreased patient-reported pain. Increased operative complexity is associated with increased preoperative pain scores.

Keywords Ventral hernia repair · Predictors of pain · Preoperative pain · Opioids · Multimodal pain management · Visual analog pain score

Repair of complex ventral hernia is known to be associated with postoperative complications. One of the more common and difficult to treat complications is pain, which is experienced in up to 80% of patients following surgery [1, 2]. Postoperative surgical site complications including sterile fluid collection, wound dehiscence, enterocutaneous fistula, and surgical site infection (SSI) [3] are known to result in hospital readmissions [4]. Other adverse events such as urinary tract infection, venous thromboembolism, and pneumonia also may complicate patient recovery [3]. Postoperative complications vary in degree of severity and most may contribute to increased pain. With the evolution of outcome-based medicine and enhanced recovery after surgery (ERAS) protocols, the emphasis on improving patient quality of life and pain has become a major objective.

The etiology of postoperative pain following ventral hernia repair (VHR) is likely multifactorial involving biological, psychosocial, and functional components [5]. Postoperative pain has been linked with implantation of mesh material

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[6], rather than the method of hernia repair, laparoscopic vs. open [7]. Larger hernia defect size, particularly greater than 100 cm^2, has been found to be predictive of increased postoperative pain [8]. Preoperative patient factors such as chronic pain (lasting > 3 months) and opioid use also have been associated with greater postoperative pain [9, 10]. However, the strongest predictor of postoperative pain is thought to be the level of preoperative pain [11]. Regardless of the etiology, the mitigation of pain is essential to patient recovery, as greater postoperative pain is associated with poorer patient-reported quality of life [12], increased risk of postoperative complications [13], progression to chronic pain [14], prolonged hospital length of stay, and readmission following VHR [15].

Current literature includes studies that identify the impact of individual operative factors on postoperative pain, such as VHR repair technique (open v. laparoscopic) or mesh implantation (biologic v. synthetic) [6, 7]. There is no study to date that examines pre-, intra-, and post-operative factors associated with postoperative pain. In an effort to understand factors associated with patient-reported pain following open VHR, our study aimed to determine the perioperative factors predictive of increased pain and to determine the effectiveness of multimodal analgesic therapy in managing postoperative pain. We examined the effects of epidural, muscle relaxants, and non-opioid analgesics on postoperative pain to determine if multimodal analgesia is as effective at managing postoperative pain as opioids. As the etiology of pain is often multifactorial and influenced by many factors, a specific aim of the study was to identify predictive factors, and drug regimens that best mitigate postoperative pain.

Methods

After obtaining IRB approval, surgical databases at the University of Kentucky were searched for consecutive open VHR cases (initial or recurrent) performed by one surgeon over 3 years (August 2013 through September 2016). Cases in which planned ostomy reversals were done in combination with VHR were excluded. Cases of only one surgeon were included in order to ensure that the surgical decision-making, surgical technique, and postoperative care would be highly similar across cases in this study.

Conducted as a retrospective review of hospital and ambulatory electronic medical records, preoperative patient characteristics including age, gender, body mass index, smoking status at time of surgery scheduling (defined as non-smoker, former smoker, active smoker), history of common comorbidities (diabetes, chronic obstructive pulmonary disease, cancer, coronary artery disease, and/or hypertension), American Society of Anesthesiologists' (ASA) Class, and preoperative opioid use for each case were recorded. Preoperative opioid use was defined as having one or more opioid (including synthetic and non-synthetic) prescriptions filled within 1 year prior to operation date. Additional details about preoperative opioid use were not available in the electronic record review. Whether or not a patient had a previous hernia repair, previous abdominal wall infection, previous mesh infection, and/or an open wound on the abdomen at the time of surgery also were recorded. Operative details obtained from the medical records included duration of the procedure, estimated blood loss, Centers for Disease Control and Prevention (CDC) Wound Class, whether or not component separation was performed, and the mesh type, size, and location.

Patient-reported pain scores and methods of pain management were recorded from electronic medical records in 12-h intervals to hospital discharge or up to 8 days post-operation. Patient-reported pain scores had been measured pre- and postoperatively using the visual analog scale (VAS) ranging from 0 to 10 (0 = no pain, 10 = severe pain) and entered into the electronic medical record. For study purposes, the average pain score was recorded at each time interval, as described by Hawker et al. [16] The method of postoperative pain management was divided into four categories: epidural, opioid analgesic, non-opioid analgesic, and muscle relaxant, with method recorded at each time interval into the respective category. Multimodal pain management involving minimization of opioid use, which is intricately involved in hastened bowel recovery, included epidural pain control, intravenous transitioning to oral non-narcotic analgesics, and muscle relaxants. Epidural use (bupivacaine, bupivacaine + hydromorphone, other, or none) was documented up to the catheter cap time; postoperative opioids that were documented included fentanyl, hydromorphone, morphine, oxycodone, hydrocodone/ acetaminophen, meperidine, or none; non-opioid analgesics that were documented included acetaminophen, ibuprofen, ketorolac, gabapentin, pregabalin, lidocaine, bupivacaine, or none; and muscle relaxants that were documented included baclofen, cyclobenzaprine, clonazepam, or none. The route of administration (patient-controlled analgesia, intravenous, or oral) was recorded for each medication. Contraindications to any of the modes of pain management including pertinent medication allergies, kidney disease, prior surgery, or patient refusal were recorded.

Pain scores were reported as mean (standard deviation). We analyzed relationships between pain scores at the various time points with patient and operative characteristics using Spearman's Rho Correlations for continuous variables and t tests for differences in group means. Significance was set at $p < .05$ for all tests. Forward stepwise multivariable regression (p for entry < .05; exit > .10) was used to assess the independent contribution to VAS pain scores. All

statistical calculations were performed using SPSS® version 23 (IBM® Corp., Armonk NY).

Results

Over the course of the 3-year time period, 175 patients who were admitted for a minimum of 24 h and had at least two documented postoperative pain scores after their transfer from the post-anesthesia care unit to the surgical inpatient floor underwent open VHR and were included in the analyses. Average patient age was 55 years (SD = 13 years), and 51 percent of the patients were female. The mean preoperative VAS pain score was 2.6 (± 3.2) and 63 percent had preoperative opioid use (Table 1). No significant associations or differences were found between pain scores at any time point with gender, ASA class, body mass index (BMI), smoking status, or comorbidities. Patient preoperative characteristics and significant associations with postoperative pain scores are presented in Table 2. The highest mean pain score was documented during the 0–11 h postoperative time period (5.1 ± 2.8) (Fig. 1). Increasing patient age was associated with decreased pain scores across pre- and postoperative time periods (Table 2). Pain scores preoperatively and at each postoperative time period were significantly increased for patients with preoperative opioid use ($p < .01$). Similarly, greater preoperative pain scores were associated with increased postoperative pain at 0–11 h ($p < .001$), 60–71 h ($p < .05$) , and 84–95 h ($p < .01$) time periods. As greater than 90% of the patients were discharged by postoperative day 8, further recordings of pain scores for patients with prolonged hospitalizations were not included in the study database.

While hernia characteristics and operative details, such as prior hernia repair and performance of concomitant procedure, were predictive of increased preoperative pain scores ($p < .01$), only the preoperative presence of an open wound on the abdomen was predictive of increased postoperative pain ($p < .01$), and this was only during the immediate postoperative time point (Table 2). Patients with CDC Wound Class I had lower mean preoperative pain scores than average for all patients (2.2 ± 2.9 vs. 2.6 ± 3.2), but the difference did not reach statistical significance (Table 3). However, patients with CDC Wound Class II had significantly increased mean preoperative pain

Table 1 Preoperative VHR patient characteristics

Patient characteristic	Incidence
Age, mean year ± SD	55.1 ± 12.8
Female sex, %	50.9
BMI, kg/m^2, %	
< 30	34.3
30–39.9	54.9
40+	10.9
ASA class, %	
I–II	34.8
III	62.9
IV	2.3
Smoking status, %	
Never	45.1
Former	44.6
Current	10.3
HTN, %	62.9
Diabetes, %	25.7
COPD, %	9.1
CAD, %	13.7
Preoperative opioid use, %	63
Preoperative VAS pain score (0–10), mean ± SD	2.6 ± 3.2

Table 2 Patient and operative characteristics with significant associations with postoperative VAS patient-reported pain scores

Variable		Preop VAS	0–11 h Postop	60–71 h Postop	84–95 h Postop
Number of scores recorded		151	159	138	118
Mean ± SD	Incidence	2.6 ± 3.2	5.1 ± 2.8	3.9 ± 2.5	4.0 ± 2.6
Rho correlation with VAS pain score					
Age, years	55.1 ± 12.8	− .25**	− .25**	− .32***	− .39***
Preoperative VAS	2.6 ± 3.2	1.00	.41***	.21*	.33**
Operative duration, minutes	193 ± 63	.26***	.16*		
Difference in Mean VAS pain score (95% CI)					
Female sex, %	50.9%		− 1.0 (− 1.9 to − 0.1)*		
Hypertension, %	62.9%				− 1.5 (− 2.5 to − 0.6)**
Preoperative opioid use	63%	1.6 (0.6–2.6)**	1.3 (0.4 to 2.2)**	1.4 (0.5–2.2)**	1.3 (0.3 to 2.2)**
Preoperative open wound	8.6%	2.6 (0.9–4.2)**	2.3** (0.8 to 3.9)		

Spearman's Rho correlations or difference in means (95% CI)

*$p < .05$; **$p < .01$; ***$p < .001$

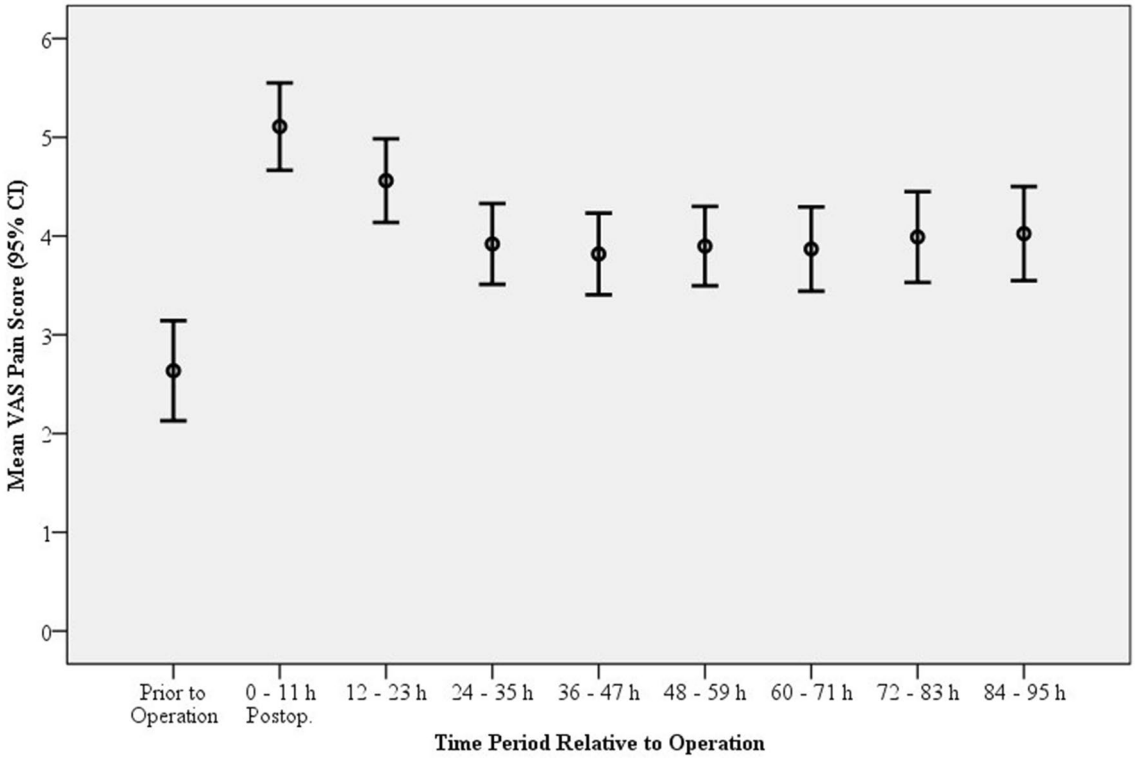

Fig. 1 Mean preoperative and postoperative VAS pain scores (95% CI)

Table 3 Hernia and operative characteristics associated with preoperative pain scores

Variable	Incidence	Difference in (95% CI), or correlation with, Preop VAS
Preoperative opioid use	63%	1.6 (0.6–2.6)**
Prior hernia repair	54.3%	1.3 (0.3–2.3)**
# of previous repairs, median (IQR)	1 (0–1)	.22**
Previous infected mesh, %	14.3%	
Previous abdominal wall infection, %	31.4%	
Preoperative open wound	8.6%	2.6 (0.9–4.2)**
Median defect size, cm^2 (IQR)	136 (76–240)	.18*
Concomitant procedure, %	32.6%	1.1 (0.1–2.1)*
Component separation, %	90.9%	1.3
Mesh type used		
Only synthetic	45.7%	
Any biologic, no bioresorbable	9.7%	
Any bioresorbable	44.0%	
Wound Class		
Clean, %	80.5%	2.2 ± 2.9
Clean/contaminated, %	5.7%	5.1 ± 3.2**
Contaminated, %	6.9%	3.6 ± 3.8
Dirty/infected, %	6.9%	4.0 ± 3.4*
Operative duration, minutes	193 ± 63	.26***
Estimated blood loss, mL	159 ± 95	.23**

*$p < .05$; **$p < .01$; ***$p < .001$

score (5.1 ± 3.2, $p < .01$). Operative factors including hernia defect size, operative duration, and estimated blood loss were associated with increased preoperative pain, but not postoperative pain (Table 4).

The method of postoperative pain management, including epidural, opioid, non-opioid analgesia, and/or muscle relaxant use was individually assessed for contribution to patient-reported pain. Epidural use for postoperative pain control was associated with significantly decreased pain scores ($p < .05$), while use of muscle relaxants and opioids were associated with significantly increased pain scores during each postoperative time point of interest ($p < .05$). Use of non-narcotic pain medication was not associated with significantly decreased or increased pain scores (Table 5).

Table 4 Summary of significant relationships between preoperative Visual Analog Scale (VAS) pain score and other variables

Continuous variable	Rho correlation with Preop VAS
Age, years	−.25**
# Previous repairs	.22**
Defect size, cm^2	.18*
Operative duration, min	.26***
EBL, mL	.23**
Preoperative pain	
Categorical variables	Mean increase in Preop. VAS
Preoperative opioid use	+1.6**
Prior hernia repair	+1.3**
Preoperative open wound	+2.6**
Concomitant procedure	+1.1*
Clean/contaminated vs. clean Wound Class	+5.1**
Dirty/infected wound	+4.0*

*$p < .05$; **$p < .01$; ***$p < .001$

Discussion

As our study and previous studies have shown [11, 13], preoperative pain status is predictive of postoperative pain. Many attribute this phenomenon to the psychological component of pain, which may include patient anxiety, depression, and overall preoperative expectations of pain [17]. This very well may play a role in postoperative pain; yet, we show a more tangible component to preoperative pain status. Increased preoperative pain in the current study was associated with longer operative duration, greater estimated blood loss, and larger hernia defect size, all indicators of increased surgical complexity. This is important to patient management following VHR, as these variables are known to be associated with postoperative complications such as SSI. Our findings suggest that patient preoperative pain status is associated with operative complexity and should not be ignored.

Advanced age was associated with lower patient-reported pain at all pre- and postoperative time points, suggesting that age may be protective of pain. There are many factors that likely contribute to this finding, including differences in how pain is perceived, greater pain tolerance with aging, and the overall decline of pain-transmitting C and Adelta peripheral nerve fibers that occurs with age [18]. Yet this is not a new finding, with Ip et al. showing that age is negatively correlated with analgesic consumption and postoperative pain intensity [19]. While difficult to explain, it sheds light on the management of pain in elderly patients, suggesting that patients over the age of 55 can have adequate pain control with fewer medications, especially opioids.

Traditional management of postoperative pain has relied on opioid administration as the gold standard, but the current role of opioids in pain management has come into question. According to the CDC, the number of opioids prescribed to patients for pain relief has quadrupled since 2000 [20]; yet, there has not been an overall change in patient-reported pain [21, 22]. Re-thinking prescribing practices, including the minimization of opioids in postoperative pain management,

Table 5 Postoperative pain regimen and associations with pain scores

Variable	0–11 h Postop	60–71 h	84–95 h
No. recorded	159	138	118
Mean ± SD	5.1 ± 2.8	3.9 ± 2.5	4.0 ± 2.6
Difference in mean VAS (95% CI) associated with pain control regimen			
Opioids during period	1.4 (0.5 to 2.3)**	1.4 (0.5 to 2.3)**	2.3 (1.2 to 3.3)***
Epidural during period	−1.1 (−1.9 to −0.2)*	−1.1 (−1.9 to −0.2)*	−1.2 (−2.1 to −0.5)*
Muscle relaxant during period	1.2 (0.1 to 2.5)*	1.2 (0.1 to 2.4)*	1.2 (0.1 to 2.4)*
Other pain medications during period	0.6 (−0.3 to 1.5)	0.5 (−0.4 to 1.3)	−0.5 (−1.4 to 0.5)

*$p < .05$; **$p < .01$; ***$p < .001$

is a necessary step in addressing the opioid epidemic and its adverse effects on American communities.

Multimodal analgesic regimens have been shown to be as effective at treating pain as opioids. Multimodal analgesia comprised of epidural (i.e., bupivacaine), muscle relaxants (i.e., baclofen, cyclobenzaprine, and clonazepam), and non-opioid analgesics (i.e., acetaminophen, non-steroidal anti-inflammatory drugs, gabapentin, and lidocaine) with the minimization of opioids is increasingly becoming the standard of care in treating postoperative pain [23]. The effectiveness of multimodal analgesia in treating pain has been debated; however, as some believe that a multimodal approach is not as effective as opioid-reliant methods. Recent studies have shed light on this dilemma and have found no clinical difference in pain reduction among treatments with multimodal analgesia vs. those with opioid and analgesia combinations [24]. Multimodal analgesia is also a mainstay of many ERAS protocols and is likely a contributing factor to shorter hospital lengths of stay, reductions in complication rates and cost, and better pain control [25]. Non-opioid therapy is now preferred for the treatment of chronic pain as well, as a CDC guideline shows the increasing contribution of opioids to opioid use disorder, overdose, and other adverse events [26]. Together, these findings highlight the efficacy of multimodal analgesia as an alternative to opioids in the management of pain.

Of the numerous patient and operative factors examined in the current study, only preoperative pain status and preoperative opioid use were significantly associated with greater postoperative pain across multiple time points following VHR. Our study reveals that optimal pain management should begin in the preoperative period and should be tailored to the individual. The notion that preoperative pain predicts greater postoperative pain is not new, with previous studies [11, 13] noting that preoperative pain is a consistent risk factor not only for VHR, but for other operations such as limb amputation, breast surgery, hysterectomy, and thoracotomy [13]. Instead, the challenge is in predicting which patients will experience greater postoperative pain. This is especially important, as greater postoperative pain requires more treatment [21] and is associated with poorer patient-reported quality of life [12] and prolonged hospital lengths of stay [15]. Current guidelines on managing postoperative pain by the American Pain Society confirms these findings, as they recommend that clinicians do a thorough preoperative assessment of medical and psychiatric comorbidities, medications, substance abuse, and previous postoperative treatment regimens before an operation [27]. By screening for and managing patient pain preoperatively, we can aim to effectively reduce postoperative pain following VHR.

Mode of pain management was found in the current study to influence postoperative pain following VHR. The use of epidural resulted in decreased pain, while muscle relaxant and opioid use were not associated with decreased patient-reported pain. Our study sheds light on the effectiveness of epidural analgesia, as recent studies have reached conflicting conclusions on its utility for postoperative pain following VHR. Prabhu et al. found significantly higher pain scores, increased hospital length of stay, and increased risk of postoperative complications in patients receiving epidural compared to controls [28], while other studies have shown that epidural analgesia effectively mitigates postoperative pain [29]. The current study showed a decrease in postoperative pain associated with epidural analgesia. It must be noted, however, that patients receiving epidural also had significantly lower preoperative pain than the mean VAS pain score. As we found preoperative pain to be predictive of postoperative pain, the effectiveness of epidural analgesia may be confounded by lower preoperative pain. Nonetheless, epidural analgesia did not result in greater postoperative pain, which previously had been reported [28].

Interestingly, there was no significant effect of analgesics or opioids on postoperative pain, indicating that multimodal analgesia is as effective as opioid analgesia at managing pain following VHR. This suggests that patient pain can be managed with multimodal analgesia instead of relying on opioids for the same outcome, reducing the potential for addiction, abuse, and unwanted side effects such as prolonged ileus that complicate postoperative recovery.

The primary limitation of the current study was that it was a retrospective review of hernia repair performed by a single surgeon at one institution, making the results prone to selection bias and less generalizable to the overall US population. The VAS pain score is a validated method for measuring and quantifying pain; yet, pain is a subjective feeling and difficult to measure, as everyone experiences it differently. This makes it harder to standardize pain levels for a particular operation, as they may vary dramatically between two individuals. We found statistically significant reductions and increases in VAS pain scores but do not know how these data will translate clinically. What does a +/− 1 difference in pain look like in a pre- or postoperative patient? A better understanding of how VAS pain scores translate to the clinical setting is needed.

Conclusions

Increased preoperative patient-reported pain scores and preoperative opioid use were predictive of increased pain scores following VHR. Increased preoperative pain scores also were associated with increased operative complexity measured by operative duration, hernia defect size, and EBL. These findings correspond with prior studies [9, 10] and highlight an aspect of VHR that may be improved upon and controlled by the surgeon: preoperative pain optimization.

While surgeons may not be able to control patient and operative complexity, modification of preoperative pain may lead to decreased postoperative pain and resultant improved clinical outcomes. Further study would be needed to determine the effects of treatment of preoperative pain and elimination of preoperative opioid use in patients undergoing VHR.

Compliance with ethical standards

Disclosures Walker Ueland, Margaret Plymale, and Daniel Davenport declare no conflicts of interest. John Scott Roth declares conflict of interest not directly related to the submitted work: grants, personal fees, and other from Bard; grants, personal fees, and other from Acelity; and grants from Miromatrix.

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