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Enhanced value with implementation of an ERAS protocol for ventral hernia repair

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Abstract

Background Open ventral hernia repair (VHR) is associated with postoperative complications and hospital readmissions. A comprehensive Enhanced Recovery after Surgery (ERAS) protocol for VHR contributes to improved clinical outcomes including the rapid return of bowel function and reduced infections. The purpose of this study was to compare hospital costs for patients cared for prior to ERAS implementation with patients cared for with an ERAS protocol.

Methods With IRB approval, clinical characteristics and postoperative outcomes data were obtained via retrospective review of consecutive VHR patients 2 years prior to and 14 months post ERAS implementation. Hospital cost data were obtained from the cost accounting system inclusive of index hospitalization. Clinical data and hospital costs were compared between groups.

Results Data for 178 patients (127 pre-ERAS, 51 post-ERAS) were analyzed. Preoperative and operative characteristics including gender, ASA class, comorbidities, and BMI were similar between groups. ERAS patients had faster return of bowel function ($p=0.001$) and decreased incidence of superficial surgical site infection ($p=0.003$). Hospital length of stay did not vary significantly pre and post ERAS implementation. Inpatient pharmacy costs were increased in ERAS group ($2673 vs. $1176 $p < 0.001$), but total hospital costs (14,692 vs. 15,151, $p=0.538$) were similar between groups.

Conclusions Standardization of hernia care via ERAS protocol improves clinical outcomes without impacting total costs.

Keywords Enhanced recovery · Ventral hernia repair · Hospital costs · Pharmacy costs · Surgical site infection

Ventral and incisional hernias occur commonly following abdominal operations and are associated with significant costs [1]. The costs associated with ventral hernia repair (VHR) are further increased as a result of not infrequent hospital readmissions and surgical site infections. In a tertiary care setting, VHR has been reported to be associated with significant financial losses due to costs exceeding revenue [2]. Factors contributing to these increased costs include American Society of Anesthesiologists (ASA) Class, Centers for Disease Control and Prevention (CDC) Wound Class, and postoperative complications [3]. In the US in 2006, the costs for VHR exceeded $3 billion [4]. This financial burden on the health care system and the burden to patients necessitate increased efforts to improve hernia care. Consequently, surgeons and health care systems strive to institute changes thought to improve quality of care while maintaining cost consciousness in order to provide care that is economically sustainable and clinically favorable.

Enhanced Recovery after Surgery (ERAS) protocols are evidence-based quality improvement pathways associated with improved clinical outcomes. The clinical and economic benefits of enhanced recovery after surgery (ERAS) protocols are well documented with lower costs and fewer complications achieved through standardization of care [5–10]. A meta-analysis examining outcomes after abdominal operations performed with an ERAS protocol in place revealed routine reduction in length of stay (LOS) and costs [5]. The cost benefits associated with an ERAS protocol for elective colon resection were associated with a reduction in postoperative hospital stay, duration of epidural use, and use of

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intravenous fluids leading to a significant reduction in the cost of care for patients with an ERAS protocol in place [9]. The majority of the savings in this study were attributed to the reduced length of stay and fewer postoperative complications [9]. Using an enhanced recovery after surgery (ERAS) protocol for VHR, Stearns et al. demonstrated benefits to patient outcomes including shorter duration to return of bowel function, a reduction in overall wound complications, and a reduction in superficial surgical site infection [11]. However, the cost benefits of ERAS protocols in VHR have not been previously evaluated.

Understanding costs of care associated with ERAS protocols is challenging due to variability in the calculation and reporting of costs. Additionally, many studies lack data on out-of-hospital costs and fail to assess indirect costs and no studies have evaluated the value or cost-effectiveness of an ERAS protocol for VHR. The purpose of the current study was to evaluate the clinical and financial impact of an ERAS protocol for VHR.

Methods

The University of Kentucky Institutional Review Board approved this retrospective study of clinical outcomes and cost data. The comprehensive ERAS protocol for VHR was developed with multidisciplinary input at the University of Kentucky with the goal of standardization of all aspects of patient care, from preoperative optimization through hospitalization and follow-up for patients undergoing open VHR. The ERAS for VHR protocol was initiated based upon a previously reported ERAS protocol [12, 13] and included standards for 15 aspects of care essential for patients undergoing open VHR. The primary goals of the protocol (Table 1) focused on patient optimization, prevention of postoperative complications, and faster recovery time [11].

With IRB approval, cases to be included in data analyses were obtained by review of our surgical databases.

Table 1 Key care components of ERAS for VHR protocol

No.	Key element	Specific recommendations
1.	Preoperative risk stratification/counseling	• Weight optimization, smoking cessation, Hemoglobin A1c ≤ 8.0%, Preoperative counseling by surgical and nursing staff
2.	Preoperative bowel preparation	• Avoidance of bowel preparation
3.	Prophylaxis against thromboembolism	• Sequential compression system (SCD) peri- and postoperatively • Pharmacological prophylaxis with heparin or low-molecular-weight heparin preoperatively and continued until the time of discharge
4.	Methicillin-resistant *Staphylococcus Aureus* (MRSA) prophylaxis	• Chlorhexidine shower once daily × 5 days and morning of surgery • Intranasal mupirocin ointment bid × 5 days preoperatively
5.	Nutritional preparation	• Impact AR, 3 servings for 5 days preoperatively
6.	Preoperative fasting and carbohydrate treatment	• Preoperative oral carbohydrate loading with Gatorade 400 mL to be taken by patients 4 h before arrival time for surgery • In diabetic patients, preoperative oral carbohydrate loading with G2 (Gatorade Low-Calorie Hydration) 400 mL taken at midnight
7.	Perioperative fluid management	• In the normovolemic patient, blood pressure should be maintained using vasopressors to avoid fluid overload • Postoperative intravenous fluids minimized to maintain normovolemia and avoid fluid excess • Discontinue intravenous fluids at the earliest opportunity • Enteral route for fluids postoperatively as early as possible
8.	Postoperative nausea and vomiting	• Multimodal approach
9.	Nasogastric intubation	• Nasogastric tubes inserted during surgery to be removed before reversal of anesthesia
10.	Urinary drainage	• Remove bladder catheter per hospital protocol after 1–2 days
11.	Prevention of intraoperative hypothermia	• Warming device such as forced-air heating blankets and warmed intravenous fluids should be routinely used to keep body temperature > 36° C. Monitor temperature to avoid hyperpyrexia
12.	Multimodal pain management	• Multimodal therapy (Epidural with hydromorphone and bupivacaine, scheduled acetaminophen (IV transitioning to po), ketorolac transitioning to ibuprofen; muscle relaxants, oxycodone prn only after discontinuation of epidural)
13.	Acceleration of intestinal recovery	• Alvimopan preoperatively and bid until bowel function for patients not taking chronic opioids • Clear liquids early with advancement to regular diet
14.	Early mobilization	• Early and regular ambulation
15.	Postoperative glucose control	• Judicious use of insulin to maintain blood glucose as low as feasible

Consecutive cases of open VHR (Current Procedural Terminology [CPT©] codes 49560—repair initial incisional or ventral hernia; reducible; 49561—repair initial incisional or ventral hernia; incarcerated or strangulated; 49565—repair recurrent incisional or ventral hernia; reducible; or 49566—repair recurrent incisional or ventral hernia; incarcerated or strangulated with/without 49568—implantation of mesh or other prosthesis or open incisional or ventral hernia repair; and 15734—muscle, myocutaneous, or fasciocutaneous flap; trunk) performed by one surgeon at our institution for 2 years prior to ERAS protocol implementation and for 14 months with ERAS protocol in place were included. Cases with planned bowel resection or stoma reversal were excluded; procedures in which there was an unplanned enterotomy or bowel resection were included. Perioperative clinical data obtained from medical record review included patient age, gender, prior surgical history, the specific procedure(s) performed, comorbidities, smoking status, body mass index (BMI), American Society of Anesthesiologists' classification, operative information, length of hospital stay, incidence of postoperative complication, hospital readmission, and emergency room or outpatient office visits. Clinical outcomes were recorded to 30 days postoperatively.

Hospital cost data were obtained from the hospital accounting system (Allscripts EPSi Version 7.5 FP2, Chicago, IL) and were matched to the cases identified from the surgical database review. Costs were reported in US dollars. Hospital costs were categorized as operating room, floor, intensive care unit, diagnostics, ancillary services, emergency room, and pharmacy costs. Pharmacy costs were further sub-categorized. Differences between periods (pre-ERAS, post-ERAS) in median costs by category were calculated using Mann–Whitney U tests. Multivariable analysis of floor costs was performed versus log-transformed costs. Statistical analyses were performed using SPSS®, Version 23 (IBM® Corp., Armonk, NY). Significance was defined as $p < 0.05$.

Results

Cost and clinical data were analyzed for 178 cases (127 pre-ERAS, 51 post-ERAS). Preoperative characteristics including gender, ASA class, comorbidities, number of prior hernia repairs, and BMI category were similar between groups (Table 2). CDC Wound Class, operative duration, hernia defect size, and estimated blood loss also were similar between groups ($p > 0.05$). The post- and pre-ERAS

Table 2 Patient preoperative characteristics in historical controls and applied ERAS protocol groups

Characteristic	Historical control (n = 127)	ERAS protocol applied (n = 51)	p Value†
Median age, years (IQR)	55 (46–64)	57 (47–67)	ns
Female, %	50	51	ns
ASA class > II, %	68	61	ns
Diabetes, %	28	20	ns
COPD, %	9	8	ns
Hypertension, %	65	61	ns
Smoking status, %			ns
Never smoked	45	45	
Former smoker	43	47	
Current smoker	12	8	
BMI, kg/m^2, %			ns
< 30	31	43	
30–39	56	53	
≥ 40	13	4	
Number of prior hernia repairs, %			ns
0	43	57	
1	40	22	
2+	17	21	
Previous infected mesh, %	16.5	9.8	ns
Preoperative open wound, %	11.0	5.9	ns
Previous abdominal wall infection, %	33.1	31.4	ns

SD standard deviation, *IQR* interquartile range, 25th–75th percentiles, *ns* Not Significant

†χ^2 or Fisher's exact test for group proportions; Mann–Whitney U test for continuous variables

cohorts varied in that synthetic mesh was more frequently implanted in patients in the ERAS cohort (67%) compared to the historical controls (36%) ($p < 0.001$), and 69% of patients in the post-ERAS group required component separation, compared to 42% patients in the pre-ERAS cohort ($p = 0.001$) (Table 3). Median hospital length of stay was 5 days (IQR: 4–7) for historical controls and 4 days (IQR: 4–6) for ERAS cohort ($p = 0.33$), whereas the time to return to bowel function was significantly decreased in the ERAS cohort [control: 4 (IQR: 3–5), ERAS: 3 (IQR: 2–4) ($p = 0.001$)]. Percentage of overall surgical site occurrences was 33% in the control patients versus 16% in the ERAS patients ($p = 0.03$). Surgical site occurrences included infected seroma, seroma requiring drainage, superficial surgical site infection, and deep surgical site infection. The percentage of patients with superficial surgical site infection was 25% in the control cases versus 6% in the ERAS cases ($p = 0.003$). Percentage of patients requiring 30-day hospital readmission was similar between groups ($p = 0.64$) (Table 4).

Median index hospitalization costs for the pre-ERAS cohort were $15,151 (IQR: $10,662–23,928) compared to $14,692 (IQR: 12,320–23,403) for the patients cared for with ERAS protocol implemented (Table 5). Median pharmacy costs were significantly greater for ERAS cases than pre-ERAS cases (+ $1497, $p < 0.001$) (Table 5). Specifically, costs for alvimopan, analgesics, pharmacy labor and supply, and anesthetics were significantly increased in the ERAS cases compared to the pre-ERAS cases (Table 6).

After adjusting for concomitant procedures, complex repairs, separation of components, prior hernia repairs, and

Table 3 Patient intraoperative characteristics in historical controls and applied ERAS protocol groups

Characteristic	Historical control (n = 127)	ERAS protocol applied (n = 51)	p Value[†]
Wound class, %			ns
I-Clean	80	78	
II-Clean/contaminated	4	9	
III-Contaminated	6	8	
IV-Dirty/infected	10	4	
Mesh type, %			< .001
Synthetic	36	67	
Biologic	15	0	
Bioresorbable	49	33	
Concomitant procedure, %	31	39	ns
Component separation technique, %	42	69	.001
Complex ventral hernia repair, %	52	75	.007
Median operative duration, min (IQR)	185 (148–232)	191 (143–236)	ns
Median EBL, cm^3 (IQR)	150 (100–200)	100 (50–213)	ns
Median defect size, cm^2 (IQR)	135 (77–240)	180 (64–270)	ns
Median mesh Size, cm^2 (IQR)	600 (410–800)	918 (511–1144)	< .001

SD standard deviation, *IQR* interquartile range, 25th–75th percentiles, *ns* not significant

[†]χ^2 or Fisher's exact test for group proportions; Mann–Whitney U test for continuous variables

Table 4 30-Day postoperative clinical outcomes in historical controls and applied ERAS protocol groups

Characteristic	Historical control (n = 127)	ERAS protocol applied (n = 51)	p Value[†]
Median length of hospital stay, days (IQR)	5 (4–7)	4 (4–6)	ns
Return of bowel function, median days (IQR)	4 (3–5)	3 (2–4)	.001
Wound complication, n (%)	42 (33%)	8 (16%)	.026
Infected seroma or seroma requiring drainage, n (%)	11 (9%)	3 (6%)	ns
Superficial SSI, n (%)	32 (25%)	3 (6%)	.003
Deep SSI, n (%)	3 (2%)	1 (2%)	ns
Non-wound complication, n (%)	19 (15%)	4 (8%)	ns
Readmission, n (%)	19 (15%)	6 (12%)	ns

SSI surgical site infection, *IQR* interquartile range, 25th–75th percentiles, *ns* not significant

[†]χ^2 or Fisher's exact test for group proportions; Mann–Whitney U test for continuous variables

Table 5 Hospital cost comparison for pre-ERAS versus post-ERAS cohorts, in US Dollars

Cost category	Pre-ERAS	Post-ERAS	Difference in medians	Difference *p* value
Total hospital costs	15,151 (10,662–23,928)	14,692 (12,320–23,403)	−459	ns
Ancillary services	23 (0–371)	120 (0–466)	97	ns
Diagnostics	276 (136–681)	247 (124–797)	−29	ns
Emergency room	0 (0–0)	0 (0–0)	0	ns
Floor	3302 (1984–4470)	3031 (2273–3788)	−271	ns
Intensive care unit	0 (0–2566)	0 (0–0)	0	ns
Operating room	7601 (6002–17,904)	8194 (6452–13,968)	593	ns
Pharmacy	1176 (841–1582)	2673 (2068–3185)	1497	<.001

ns Not significant

Table 6 Pharmacy costs for pre-ERAS versus post-ERAS cohorts, in US Dollars

Median costs (IQR)	Pre-ERAS	Post-ERAS	Difference	Difference *p* value
No. of cases	127	51		
% with Epidural tray charged	49.6%	47.1%	−2.5%	ns
Total pharmacy costs, (IQR)	1176 (841–1582)	2673 (2068–3185)	1497	<.001
Alvimopan	0 (0–0)	928 (449–1326)	928	<.001
Pain management	141 (63–243)	648 (432–796)	507	<.001
Pharmacy—labor and supplies	363 (280–538)	557 (383–730)	194	<.001
Anesthesia	106 (82–137)	129 (103–197)	23	.004
Antibiotics	6 (3–15)	9 (4–14)	3	ns
Daily medications	21 (6–72)	10 (4–59)	−11	ns
Deep vein thrombosis prophylaxis	44 (33–66)	38 (29–49)	−6	ns
Intravenous fluids	197 (123–315)	215 (109–278)	18	ns
Other hospital pharmacy costs	106 (69–167)	91 (66–197)	−15	ns

ns Not significant

incidence of malignancy, the estimated change in floor costs associated with the ERAS protocol was −$745 (95% CI −1538 to +48, $p = .066$). The adjustment variables chosen included all preoperative and intraoperative variables that differed between the groups at $p < .20$ and would not have been influenced by the ERAS protocol itself.

Discussion

Healthcare delivery continues to evolve with a focus upon improved value, predicated upon the relationship between costs and clinical outcomes. In the US, physician payments are increasingly linked to both quality and cost metrics encouraging providers to focus upon these metrics in order to avoid financial penalties.

Ventral hernia repair is a common general surgical procedure associated with a high incidence of both surgical site infections and hospital readmission [14]. As a result, efforts to improve outcomes have the potential to improve value (defined as the ratio of quality/cost). Accordingly, it is the overall ratio of quality to cost that will enhance or detract from the value of the healthcare delivery. While simplistically improved quality and reduced costs are desirable, the value of more costly healthcare that improves outcomes may be more difficult to measure and appreciate.

Long-term hernia recurrence rates up to 40% have been reported for primary repairs of ventral hernias, and patients with recurrent ventral hernias are two to three times more likely to experience complications including surgical site infection (SSI) and further recurrence compared to first-time ventral hernia repairs [15]. Combined, these factors are major drivers of care costs and may be responsible for hernia referrals to tertiary medical centers. Accordingly, tertiary care centers likely deal with a disproportionate number of patients with complex ventral hernia requiring complex and costly care.

In 2006 alone, 348,000 VHRs were performed in the United States at a cost exceeding 3 billion dollars [4]. Although the majority of hernia repairs are successful, any hernia recurrence further increases costs. The vicious cycle of hernia recurrences has been well described; patients who develop postoperative complications experience higher rates of hernia recurrence which increases subsequent rates of both surgical site infections and recurrence [16]. This vicious cycle results in higher rates of both recurrence and reoperation for each successive hernia repair. Recurrent hernia repair results in greater hospital financial loss ($1730 more) compared to initial repair [16]. This increase in net loss was related to the increase in the number of complications seen with recurrent hernia repair.

This study evaluated not only clinical outcomes but also hospital costs. As a result of implementation of an ERAS protocol, wound complications were reduced approximately 50% and surgical site infections were reduced nearly 75% without any incremental increase in costs. Implementation of an ERAS protocol involved a multidisciplinary approach centered upon evidence-based guidelines demonstrated to improve hernia repair outcomes. This study is not able to isolate any single variable responsible for the improved outcomes but instead evaluates the totality of the ERAS protocol upon outcomes and cost. Standardization of preoperative criteria and metrics that include diabetes optimization, smoking cessation, weight loss, and bacterial decolonization has systematically altered patient selection for elective hernia repair. However, intraoperative measures to maintain normothermia, prevent hyperglycemia, and maintain euvolemia also contribute to the benefits of ERAS. Similarly, streamlining postoperative care aims to reduce variability, thus reducing complications and control costs. While we were not able to reduce costs through the implementation of ERAS, the implementation was successful in that it was done without increasing costs, while improving quality, thus improving the value of the healthcare delivered. Future efforts to maintain the gains in improved clinical outcomes associate with the ERAS protocol, while subsequently reducing costs represent our next initiative. Understanding the individual metrics responsible for the costs of the hernia care delivered is essential to these subsequent cost-saving efforts.

Hospital floor costs were not reduced in this study, suggesting that additional refinements in the ERAS protocol are necessary to drive down cost. This study did not demonstrate a reduction in hospital length of stay, which represents a significant component of overall costs. Although speculative, we feel that the multimodal pain management component of the protocol, which utilizes epidural analgesia, may contribute to the increased length of stay. Although utilized prior to the ERAS implementation, routine epidural catheter use was implemented with the ERAS protocol. Our practice has been to utilize the epidural catheter for a minimum of 48 h with removal between 48 and 72 h following the operation. While we believe this provides enhanced pain relief, the presence of the epidural for this period of time precludes earlier discharge and may negatively impact our ability to discharge patients from the hospital earlier than postoperative day 3. Nevertheless, there is a reason to be hopeful that the protocol will continue to reduce cost over time. In New Zealand, Sammour et al. reported that after the first few patients, the cost of ERAS implementation began to become significantly offset [9]. Our sample size of 127 pre- and 51 post-ERAS patients may not be able to differentiate the differences between groups fully. In a meta-analysis reported by Lee et al., a significant reduction in medical costs was reported in all included studies [6].

In comparing our pre- and post-ERAS cohorts, another important consideration is that our post-ERAS cohorts were more complex, underwent more frequent component separation procedures, and had larger meshes implanted. Despite similar patient characteristics during the study periods, there was more frequent utilization of biologic mesh in the pre-ERAS group, whereas synthetic mesh utilized more frequently in the post-ERAS group. As a result, this study is not able to discern whether the favorable improvements in patient outcomes are related to a change in mesh selection. Nevertheless, improved clinical outcomes were realized while maintaining cost neutrality following implementation of the ERAS protocol. As our experience with ERAS grows, we are optimistic that we will be able to realize cost savings in the future.

In the current healthcare climate, there has been greater attention directed toward the cost of care and movement away from the fee-for-service payment models with a shift to value-based care and bundled payments. These initiatives have the goal of improving the quality of care and reducing cost. While these changes are important, bundled care payment models need to address variability in patient complexity. Standardization is intended to reduce the variation in cost of care between patients—which may decrease the cost of care for patients with increased complexity and comorbidities. However, a drawback may be an increase in the cost for low complexity patients. This reduction in variability may minimize negative outliers (high cost, long length of stay, increased complications) at the expense of positive outliers (low cost, short length of stay). Other studies in colorectal surgery point to reduction in length of stay as a significant contributor to the reduction in the cost of care with an ERAS protocol [6, 9, 10]. Reducing length of stay not only represents savings in fixed costs but also the opportunity cost associated with the ability to accommodate additional patients, thus increasing throughput. In a healthcare environment with fixed resources, the ability to provide high-quality care to the greatest number of patients at the lowest cost offers the greatest value to a population. Standardization of hernia care through ERAS protocols represents and effective method to enhance value.

Conclusions

Implementation of an enhanced recovery protocol for ventral hernia repair is associated with improved value. Clinical outcomes are improved following implementation of an ERAS hernia program without change in total costs. The increased pharmacy costs in ERAS hernia patients are offset by a collective reduction in expense throughout the hospital stay, resulting in budget neutrality. Future efforts aim to reduce costs while maintaining the improvements in clinical outcomes.

Compliance with ethical standards

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