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Delineation of factors associated with prolonged length of stay after laparoscopic ventral hernia repair leads to a clinical pathway and improves quality of care

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Abstract
Background Centers for Medicare and Medicaid Services define laparoscopic ventral hernia repair (LVHR) as outpatient procedure. We identified our institutional length of stay (LOS) to be above the National Surgical Quality Improvement Program (NSQIP) benchmark of 1 day [interquartile range (IQR) 2 days]. This study was undertaken to investigate risk factors associated with prolonged hospital stay and design an intervention to decrease median LOS.
Methods This study analyzed institutional NSQIP data on patients who underwent elective LVHR from 2006 to 2011 to define factors associated with prolonged LOS, defined as LOS $>$ 2 days. Modifiable factors identified in the initial analysis were included in a clinical care pathway to impact LOS. We repeated the NSQIP data analysis after implementation (4/2011–9/2012) to assess the effect of our intervention. Analysis was by univariate, ANOVA and logistic regression models.
Results During the pre-implementation period, 80 patients with a median age of 54 years (31–84) stayed a median of 2 days (IQR 3). On univariate analysis, factors associated with prolonged LOS included operative time, mesh size, amount of narcotics used and female gender. In multivariate analysis, operative time and narcotics used were associated with a prolonged LOS, C statistic = 0.88. Introduction of a clinical pathway focusing on non-narcotic pain relief resulted in a decrease in mean narcotic usage from 223 to 63 mg morphine equivalents/patient ($p < 0.0001$), decrease in median LOS to 1 day (IQR 2) ($p = 0.027$), in line with NSQIP benchmarks, a slight decrease in complications and a 10 % decrease in hospital cost.
Conclusion High narcotic use and long operative times are independent predictors of prolonged LOS in our patient population. Introduction of a standardized clinical care pathway designed to reduce perioperative narcotic use resulted in shorter LOS, improved quality and cost savings for patients undergoing LVHR.

Keywords Abdominal · Hernia · Pain · Quality control · Costs · Technical

The Centers for Medicare and Medicaid Services (CMS) define laparoscopic ventral hernia repair (LVHR) as an outpatient procedure. The average length of stay (LOS) reported in the literature is between 2 and 4 days [1–5]. The American College of Surgeons National Surgical Quality Improvement Program (NSQIP) benchmark data suggest the median LOS to be 1 day, interquartile range (IQR) 2 days. Past review of our institutional NSQIP data revealed our median LOS (IQR) for patients undergoing laparoscopic ventral hernia repair to be above this benchmark at 2 days [2]. We undertook this study to identify modifiable factors associated with increased LOS after LVHR at our institution. Using this information, we developed and implemented a clinical care pathway designed to decrease our average length of hospital stay. Here we show that this intervention reduced our average

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LOS by 50 % while decreasing complications and reducing hospital costs.

Methods

After institutional review board (IRB) approval, a post hoc analysis of NSQIP data from patients who underwent elective LVHR from 2006 to 2010 at our institution was performed to identify risk factors for prolonged hospital stay, defined as a stay >2 days. Age, gender, ASA (American Society of Anesthesiologists Classification), smoking history, postoperative complications were extracted. In addition, electronic medical records were reviewed for mesh size (cm^2), Visual Analog Scale (VAS) pain scores, the use of patient-controlled anesthesia and the use of narcotic pain medication calculated in morphine equivalents.

The analysis of the initial data from 2006 to 2010 identified perioperative narcotic use as a modifiable target for improvement. A group of surgeons and allied health staff met regularly to devise a standardized enhanced recovery pathway relying heavily on non-narcotic pain control. We hypothesized that a pathway focused on limiting narcotic pain medication would decrease the average LOS. The clinical pathway for LVHR maximized the use of scheduled acetaminophen and non-steroidal anti-inflammatory drugs (NSAIDS) (including pre-, intra- and postoperatively), combined with appropriate dosing of local anesthetic to the abdominal wall (e.g., 0.25 % bupivacaine 1 cc per kg/bodyweight), muscle relaxants as needed and other supportive measures (e.g., abdominal binder). In patients unable to use NSAIDS, tramadol was substituted. Oral opioids were given as needed followed by intravenous narcotics for breakthrough pain. This pathway was agreed upon by all surgeons performing LVHR at our institution, and an easily accessible order set was added to the electronic order entry software. The patients resumed diet on the same day as tolerated. Urinary catheters were removed in the operating room. The pathway was implemented in March 2011, along with resident and allied health staff education.

National Surgical Quality Improvement Program data analysis was repeated after the implementation of this pathway (from November 4, 2011 to December 9, 2012) and compared the earlier results. In addition, data from the NSQIP database were used for benchmarking.

Statistical analysis was performed by univariate analysis, ANOVA and logistic regression models. To allow for appropriate modeling, age was grouped by decades, and body mass index (BMI) was grouped in increments of 5 kg/m^2. Significance was set at $p < 0.05$.

Results

A total of 132 patients underwent laparoscopic hernia repair and were captured in the NSQIP database from April 2006 to September 2012, 80 patients before and 52 patients after the intervention. Prior to the intervention (2006–2010), no clinical care pathway was in use. The technical components of the hernia repair were similar for all surgeons throughout the study. Prior to the implementation of the pathway, univariate analysis revealed that factors significantly associated with LOS > 2 days included operative time, mesh size, ASA, amount of narcotic pain medication used and female gender (Table 1). Age and BMI were not significantly associated with prolonged hospital stay. In the multiple variable model of data prior to pathway implementation, operative time and amount of narcotic pain medication used were associated with a prolonged hospital stay, C statistic = 0.88. During that time, 64 % of patients received patient-controlled anesthesia (PCA). The mean amount of morphine equivalent units received during the hospital stay was 226 ± 238 mg. The mean length of stay was 2.9 days (±2.9; range 0–14 days, median 2, IQR 3), and 44 % of patients stayed longer than 2 days (Fig. 1). During the 30-day follow-up by the trained nurse abstractors, one patient had a postoperative ileus; no wound infection was encountered. No additional complications were reported.

Following the implementation of the pathway, repeat analysis was performed for 52 patients captured in the NSQIP database from April 2011 to September 2012. Patient characteristics and procedural complexity as measured by operative time and implanted mesh size were similar to the pre-implementation period. Our intervention successfully decreased the average dose of narcotics per patient from 223 mg morphine equivalents pre-implementation to 63 mg after implementation ($p < 0.0001$). This decreased the average LOS by half ($p = 0.027$) and was now in line with national benchmarks as captured in the NSQIP data. Concurrently, fewer complications were noted, but this was not statistically significant given the small sample size (Table 2). Compared to pre-implementation, an administratively significant cost savings of 10 % were realized after the pathway was implemented.

Discussion

Ventral hernia is a common problem, and the operative approaches for repair vary substantially. Laparoscopic ventral hernia repair is one available option with a lower risk of postoperative complications compared to open hernia repair [1–4]. In addition, the technique is relatively

Table 1 Association of variables with extended length of hospital stay, >2 days versus ≤2 days

	Univariate		Multiple variable	
	OR[a] (95 % CI)	*p* value	OR (95 % CI)	*p* value
Operative time, per 15 min	1.4 (1.2–1.6)	<0.001	1.2 (1.1–1.5)	0.005
Mesh size, per 100 cm^2	1.4 (1.1–1.8)	0.01	–	
Narcotics med, per 100 units	4.0 (1.9–8.6)	<0.001	2.6 (1.1–6.2)	0.03
Female gender	2.8 (1.02–7.6)	0.046	–	
BMI[b], per 5 units	1.4 (0.98–1.9)	0.07	–	
Age, per 10 years	1.2 (0.8–1.7)	0.35	–	
ASA[c] = 3 versus 1 or 2	2.9 (1.04–8.1)	0.04	–	

[a] Odds ratio

[b] Body mass index

[c] American Society of Anesthesiologists Classification

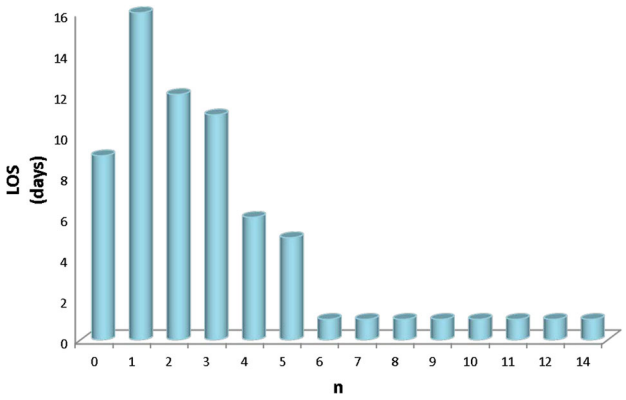

Fig. 1 Number of patients (*n*) with a given length of stay (days) after laparoscopic ventral hernia repair

standardized among surgeons; thus, it is easier to compare for analysis and intervention than the many approaches to open ventral hernia repair [6–9]. With decreasing reimbursement for surgical procedures, including for ventral hernia repair, there is an increasing pressure to minimize hospital costs. One factor that significantly contributes to cost is the length of hospital stay [10]. Enhanced recovery pathways have proven to decrease LOS [11]. LVHR incurs higher intraoperative costs; however, the overall cost is usually reported lower than for open hernia repair, mainly due to decreased hospital stay [12, 13]. Understanding the factors that contribute to prolonged hospital stay for patients undergoing LVHR is important to reduce procedural cost, improve patient satisfaction and lower complication rates [11, 14]. Several previous studies have examined the effect of patient and procedural characteristics on hospital stay after LVHR [15, 16]. These studies demonstrate that more complex procedures associated with long operative duration due to the lysis of adhesions or large hernia defects are associated with prolonged LOS. In our analysis, we used operative time and mesh size as markers of procedural complexity. The previous studies did not, however, examine narcotic dosage with respect to LOS. The use of narcotics is one of the few potentially modifiable factors and thus a target for intervention.

To investigate the factors contributing to prolonged hospital stay at our institution, we used an institutional NSQIP dataset as it benefits from standardized and audited prospective data collection with a reliable 30-day follow-up. NSQIP is used by more than 500 hospitals nationwide and therefore easily transferrable to other centers. While this is a high-quality dataset with excellent follow-up, the limitation of using the NSQIP data is that it does not span the entire institutional case volume over the time period, rather a 10–15 % random sample. In this study, we could not expand our dataset to use the nationwide NSQIP sample due to the need for electronic medical record review to obtain mesh size used and narcotic pain medication administered. We regarded operative time as a proxy for operative complexity as extensive adhesiolysis for patients with incisional and/or incarcerated hernia, and intestine will usually lead to increased operative time. A key component of our clinical pathway was a standardized postoperative order set designed to minimize narcotic use.

Clinical pathways have been shown to reduce hospital stay and improve outcomes after surgical procedures [17–19]. Similar to these studies, our clinical pathway was effective and resulted in a marked reduction in narcotic use after LVHR, a 50 % reduction in hospital stay and 10 % cost savings. A limitation of this study is the small sample size. While it may be premature to draw definitive conclusions about the role of narcotic usage and length of hospital stay in all LVHR from this small study, our post-intervention group provides an internal validation of our results and shows that modifying this factor in our patients reduces hospital stay after ventral hernia repair.

Table 2 Comparison of pre- and post-intervention variables

	Pre-intervention		Post-intervention		*p* value*
	NSQIP[a] overall	Institution (4/06–3/11)	NSQIP overall	Institution (4/11–9/12)	
N	12,781	80	11,048	52	–
BMI[b], kg/m^2 median (range)	33.2	32.5 (22.5–66.5)	33.3	32.0 (22.6–63.2)	0.76
Age, median (years) (range)	N/A	54 (31–84)	N/A	58 (24–83)	0.71
ASA[c], median (range)	N/A	2 (1–3)	N/A	2 (1–3)	0.45
Operative time, mean (min.) (range)	N/A	135 (38–306)	109	131 (36–315)	0.59
Mesh size, mean (cm^2) (range)	N/A	315 (0–952)	N/A	277 (16–884)	0.196
Narcotic use (mg morphine equivalent) (range)	N/A	223 (27–1290)	N/A	63 (15–311)	<0.0001
LOS[d] days (median) (IQR[e])	1 (2)	2 (3)	1 (2)	1 (2)	0.027
30-day F/U	92 %	90 %	92 %	85 %	–
30 day postoperative occurrences	4.2 %	3.8 %	3.6 %	1.9 %	NS

[a] National Surgical Quality Improvement Program

[b] Body mass index

[c] American Society of Anesthesiologists Classification

[d] Length of stay

[e] Interquartile range

* *p* value listed refers to comparisons between pre- and post-intervention groups

Conclusions

Long operative times and high-dose narcotics are independent risk factors that prolong hospital stay in patients with LVHR. This study shows that careful review of quality databases combined with standardized practices and electronic order sets can result in improved outcomes for patients and cost savings without undue burden on physicians or nurses.

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