

Outcomes of acute versus elective primary ventral hernia repair

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BACKGROUND:	The morbidity and mortality associated with acute primary ventral hernia repair have not been well described. We examined the rate of surgical site infection (SSI), hernia recurrence, and mortality in acute versus elective primary ventral hernia repair and identified predictors of morbidity and mortality after primary ventral hernia repair.
METHODS:	A retrospective study on all patients undergoing open primary ventral hernia repair at a single institution (2000–2010) was performed. Primary outcomes were mortality at any time, SSI, and recurrence. Survival analysis for the entire, unmatched sample was conducted. We performed a risk-adjusted analysis of outcomes using two methods as follows: (1) case matching and (2) propensity score–adjusted regression model.
RESULTS:	We identified 497 patients; 57 (11%) underwent acute primary ventral hernia repair. For the entire cohort, survival was worse for patients undergoing acute repair (log rank, 0.03). Following case matching on age, body mass index, American Society of Anesthesiologists score, and hernia size, there was no difference in mortality, SSI, or recurrence. After propensity score adjustment, acute surgery was not a predictor for mortality or SSI; however, incarcerated hernias predicted recurrence.
CONCLUSION:	After risk adjustment, acute primary ventral hernia repair was not associated with higher mortality, infection, or recurrence compared with elective repair. (<i>J Trauma Acute Care Surg.</i> 2014;76: 523–528. Copyright © 2014 by Lippincott Williams & Wilkins)
LEVEL OF EVIDENCE:	Therapeutic study, level IV.
KEY WORDS:	Acute primary ventral hernia repair; umbilical hernia repair; ventral hernia repair; mortality; survival; surgical site infection; outcomes research; general surgery; emergency hernia repair.

Acute hernia surgery has been associated with higher morbidity and mortality rates compared with elective hernia repair.^{1–3} Most studies of acute hernia surgery focus on inguinal hernia repair rather than ventral hernia repair. Of those that study ventral hernias, most have evaluated incisional hernias, and little is known about the outcomes of primary ventral hernia (PVH) repairs such as umbilical and epigastric hernias.^{4–7} In addition, existing studies often fail to provide a control for comparison^{4,6–9} or risk-adjust outcomes for acute ventral hernia repair.^{4,7,8}

Despite the paucity of literature on this procedure, PVH repairs represent a majority of ventral hernia repairs performed. It has been estimated that more than 365,000 ventral hernias are repaired annually in the United States, of which 75% are PVHs.^{10,11} The European Hernia Society (EHS) classifies ventral hernias as primary or secondary (incisional) hernias.¹² The distinction between incisional and PVHs is important because experts believe that there is a difference in the underlying pathology and outcomes in these hernia types.¹²

To better characterize the prognosis of acute PVH surgery, we reviewed our cohort of patients undergoing PVH repair at the Michael E. DeBakey Veterans Affairs Medical Center during a 10-year period. We hypothesized that acute repair of PVH was associated with worse outcomes, namely, worse mortality and higher recurrence and surgical site infection (SSI) rates compared with elective repair.

PATIENTS AND METHODS

Study Design

After approval from the Baylor College of Medicine institutional review board and the Michael E. DeBakey Veterans Affairs Medical Center Research and Development Committee, we identified all patients who underwent PVH repair at the Michael E. DeBakey Veterans Affairs Medical Center from 2000 to 2010. Patients who underwent open elective PVH repair and acute PVH repair were included in the analysis. Patients undergoing laparoscopic or concomitant (where the primary surgery was not the hernia repair, e.g., cholecystectomy and umbilical hernia repair) PVH repair were excluded.

Baseline characteristics, including demographics, body mass index (BMI), history of diabetes, chronic obstructive

pulmonary disease, coronary artery disease, peripheral vascular disease, prostate disease, tobacco use, alcohol use disorder, Model for End-Stage Liver Disease (MELD) score, American Society of Anesthesiologists (ASA) score, hernia grade, hernia size, wound class, and use of mesh repair, were abstracted from the electronic medical records. Alcohol use disorder was defined as having more than two drinks per day. Hernias were graded according to the Ventral Hernia Working Group classification and also stratified by whether or not the hernia was incarcerated.¹⁰ Hernia size was determined from operative reports or radiographic imaging if not stated in the operative report, and then grouped into small, medium, or large categories as defined by the EHS.¹²

The medical records of all patients who presented with an acute PVH repair were reviewed. Patients were classified as having a known or unknown PVH. Patients with a known prior PVH were further tracked by their surgical consultation history.

The primary outcome of interest was mortality at any time following surgery. Follow-up was determined from time of index surgery until last clinical follow-up or the date of death. Secondary outcomes included recurrence and SSI. Hernia recurrence was determined by review of clinic notes or radiographic evidence of a recurrent hernia. SSI was defined by the CDC guidelines and determined by review of the clinician notes, procedure notes, and laboratory data.^{13,14} Other postoperative outcomes were captured at 30 days and included seroma or hematoma formation, urinary tract infection, pneumonia, length of stay, and hospital readmission.

Patients were risk-adjusted using two different methods as follows: case matching and propensity score–adjusted multiple variable logistic regression.

Case Matching

Patients who presented acutely were compared in a one-to-one manner with patients who underwent elective PVH repair. Matching was based on criteria known to affect primary and secondary outcomes, including age, BMI, ASA score, and hernia size according to the EHS classification. Matching was successful for 57 patients who presented acutely and 57 patients who were repaired electively. Differences in

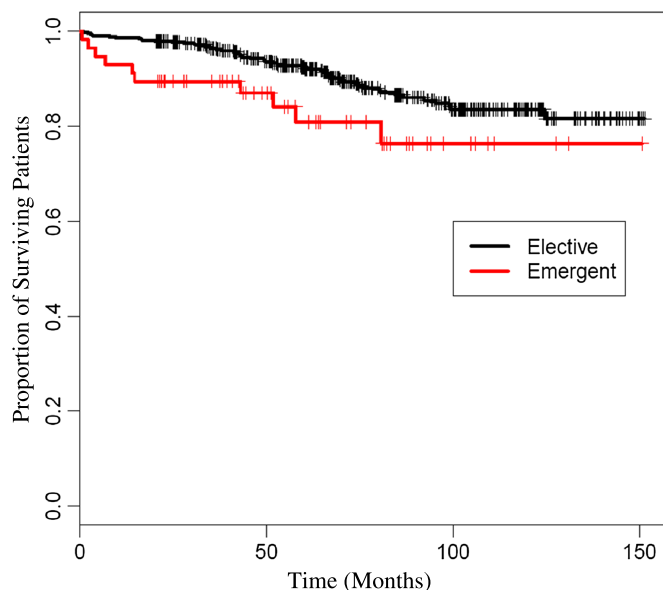


Figure 1. Proportion of surviving patients.

primary and secondary outcomes between the matched samples were analyzed using matched univariate tests. McNemar's test was used to compare categorical variables. Paired, two-tailed *t* test and Mann-Whitney U-test was used to compare parametric and nonparametric continuous variables, respectively. Statistics were generated using IBM SPSS version 19 (Armonk, NY).

Propensity Score Model

The entire cohort of patients undergoing acute and elective PVHs was assessed using a propensity score-adjusted multiple variable analysis. The propensity score for elective or acute treatment of PVH was calculated based on patient age, ASA score, history of coronary artery disease, chronic obstructive pulmonary disease, diabetes, current smoking history, alcohol abuse, and incarcerated hernia.¹⁵ A matched cohort was then identified using "full matching" in the MatchIt package in R version 2.15.0. The quality of the propensity score model was assessed using Q-Q plots and by calculating the standardized difference in baseline covariates after propensity score matching.¹⁵ A standardized difference of less than 10% or *p* < 0.05 was used to indicate adequate covariate balance. Validation of the multiple variable logistic models was performed using a 10-fold cross-validation procedure.

TABLE 1. Overall Mortality Based on Acuity of PVH Repair

	Hernia-Related Death(s)	Death Within			Total Deaths	<i>p</i>
		0–30 d	31–90 d	91–365 d		
Acute surgery (n = 57)	1	1	1	7	9 (16%)	0.02
Elective surgery (n = 440)	1	1	2	26	30 (7%)	

TABLE 2. Baseline Characteristics for Matched Cohort

	Elective (n = 57)	Acute (n = 57)	<i>p</i>
Patient characteristics			
Age, mean (SD)	54.5 (10.7)	54.4 (12.1)	0.95*
White race	43 (71.9%)	39 (68.4%)	0.40
Male	57 (100%)	54 (94.7%)	0.24
BMI, mean (SD)	32.8 (5.9)	33.1 (9.9)	0.86*
Chronic obstructive pulmonary disease	7 (12.3%)	8 (14.0%)	0.78
Coronary artery disease	12 (21.1%)	8 (14.0%)	0.33
Peripheral vascular disease	2 (3.5%)	2 (3.5%)	1.00
Benign prostate hypertrophy	7 (6.1%)	4 (7.0%)	0.53
Diabetes mellitus, total	18 (31.6%)	16 (28.1%)	0.68
Diabetes mellitus, insulin dependent	2 (3.5%)	4 (7.0%)	0.68
Hemoglobin A1C, mean (SD)	6.4 (1.3)	7.1 (1.3)	0.17*
Current smoker	29 (50.9%)	27 (47.4%)	0.71
Alcohol abuse	9 (15.8%)	10 (17.5%)	0.80
ASA			0.53
1	0 (0%)	1 (1.8%)	
2	11 (21.1%)	11 (19.3%)	
3	34 (59.6%)	28 (49.1%)	
4	12 (21.1%)	16 (28.1%)	
Hernia characteristics			
Grade			—
1	4 (7.0%)	14 (24.6%)	
2	53 (93.0%)	35 (61.4%)	
3	0 (0%)	8 (14.0%)	
4	0 (0%)	0 (0%)	
Incarcerated	7 (12.3%)	49 (87.5%)	<0.01
Hernia size**			0.26
Small	18 (36.0%)	12 (27.3%)	
Medium	25 (50.0%)	20 (45.5%)	
Large	7 (14.0%)	12 (27.3%)	
Hernia diameter, mean (SD), cm	2.3 (1.7)	2.5 (1.9)	0.92
Operative details			
Wound class			—
1	57 (100.0%)	39 (68.4%)	
2	0 (0%)	8 (14.0%)	
3	0 (0%)	9 (15.8%)	
4	0 (0%)	1 (1.8%)	
Mesh repair	24 (42.1%)	17 (29.8%)	0.17

*Two-tailed paired *t* test.

**Defined by the EHS: small, less than 2 cm; medium, 2 cm to 3.9 cm; large, 4 cm or greater.

Survival Curve

Difference in survival was analyzed for the entire, unmatched cohort using the Kaplan-Meier method and tested using log-rank analysis.

RESULTS

Study Characteristics

A total of 497 patients with PVH who underwent surgical repair were identified during the study period; of these, 57 (11%) underwent acute PVH repair and 440 (89%) had

TABLE 3. Early and Late Outcomes for Matched Cohort

	Elective (n = 57)	Acute (n = 57)	p
Early outcomes (<30 d)			
SSI	12 (21.1%)	19 (33.3%)	0.14
Superficial	11 (19.3%)	17 (29.8%)	0.19
Deep	3 (5.3%)	2 (3.5%)	0.65
Organ/space	0 (0%)	4 (7.0%)	0.04
Seroma	5 (8.8%)	1 (1.8%)	0.09
Hematoma	1 (1.8%)	5 (8.8%)	0.09
Urinary tract infection	0 (0%)	6 (10.5%)	0.03
Pneumonia	0 (0%)	6 (10.5%)	0.03
Length of stay, day, mean (SD)	1.2 (4.4)	5.7 (5.8)	<0.01
30-d readmission	13 (22.8%)	18 (31.6%)	0.29
Late outcomes (>30 d)			
Hernia recurrence	8 (14%)	17 (29.8%)	0.07
Bowel obstruction	2 (3.5%)	4 (7.0%)	0.68
Reoperation, all	9 (15.8%)	13 (22.8%)	0.48
Death	8 (14.0%)	9 (15.8%)	1.00
Follow-up months, median (interquartile range)	71.5 (33.4)	52.9 (33.3)	0.01

an elective PVH repair. A total of 177 patients had PVH repair with mesh; of these, 17 were acute hernia repairs and 160 were elective hernia repairs. Overall survival was worse among patients who underwent acute PVH repair (log rank, 0.03) (Fig. 1). Patients undergoing acute repair had higher rates of mortality (16% vs. 7%, $p = 0.02$), recurrence (30% vs. 6%, $p < 0.01$), and SSI (33% vs. 13%, $p < 0.01$). There were two hernia-related deaths that occurred within 30 days after surgery (Table 1). One patient with severe chronic obstructive pulmonary disease required acute hernia repair; his postoperative course was complicated by respiratory distress and reintubation, and the patient succumbed to cardiac arrest and respiratory failure 19 days after surgery. Another patient underwent elective hernia repair and had an uneventful hospital course. However, the patient experienced new episodes of fainting spells after his hernia repair and expired 24 days after surgery—his exact cause of death remains unknown since the patient was not readmitted to the institution. The most common known cause of death was caused by cancer ($n = 8$) or end-stage liver disease ($n = 7$).

TABLE 4. Propensity Score Adjusted Multivariate Logistic Regression

	Odds Ratio	95% Confidence Interval	p
Mortality			
ASA score	1.79	2.98–12.10	<0.01
Recurrence			
Incarcerated hernia	3.77	1.96–7.26	<0.01
SSI			
BMI	1.11	1.06–1.17	<0.01
Readmission			
Incarcerated hernia	1.85	1.06–3.25	0.03

TABLE 5. Clinical Course Before Acute Presentation (n = 57)

Known hernia before acute episode*	36 (63%)
Referred for surgical evaluation	16 (44%)
No referral for surgical evaluation	20 (56%)
No documented hernia before acute presentation	21 (37%)

*Either as documented previously in electronic medical record or reported by patient.

Outcomes After Case Matching

Fifty-seven patients who underwent acute PVH repair were case-matched to 57 patients who underwent elective PVH repair. There were no significant differences in baseline patient characteristics between the matched samples, except that patients undergoing acute surgery demonstrated a higher (but expected) rate of incarcerated hernia compared with patients who underwent elective repair ($p < 0.01$) (Table 2). All elective PVH repairs were classified as clean cases (wound Class 1).

There was no difference in the rate of death, recurrence, or SSI between the two groups (Table 3). However, patients undergoing acute PVH repair were more likely to have an organ/space infection (7.0% vs. 0%, $p = 0.04$). Other post-operative complications such as urinary tract infection and pneumonia were more common among patients who underwent acute PVH repair. Hospital length of stay was approximately 4 days longer for patients undergoing acute surgery ($p < 0.01$). Median follow-up was 52.9 months for acute cases and 71.5 months for elective cases.

Outcomes After Propensity Score Adjustment

Propensity score matching of the overall cohort normalized the covariates differences between the two groups (acute or elective PVH repair) with Q-Q plots more closely approximating the $x = y$ plot after matching. Analysis of the standardized differences showed that only age and ASA score remained different after propensity score matching. However, the mean age among unmatched and matched samples were similar (51.7 vs. 54.3); likewise, mean ASA scores between the two groups were also remarkably similar (2.8 vs. 2.9). Statistical difference in the standardized score may persist because there are a few patients who underwent acute surgery at the extremes of age and comorbidity. Acute surgery was not a predictor for death, recurrence, or SSI after propensity score adjustment (Table 4).

TABLE 6. Clinical Course of Patient Referred for Surgical Evaluation (n = 16)

Completed surgical evaluation (n = 10)	
Surgery scheduled	1 (10%)
Surgery not recommended	3 (30%)
Medical/imaging workup pending	2 (20%)
Patient declined surgery	2 (20%)
Lost to follow-up after surgical evaluation	2 (20%)
Did not complete surgical evaluation (n = 6)	
Acute presentation	2 (33%)
Lost to follow-up	2 (33%)
Appointment never scheduled	2 (33%)

However, incarcerated hernia was the sole independent predictor of hernia recurrence, and incarcerated hernia repairs were highly correlated with acute surgery. SSI was only correlated with elevated BMI, while mortality was associated with elevated ASA score.

Clinical Course Before Acute Presentation

Thirty-six patients (63%) who presented acutely for PVH repair had previously recognized hernias (Table 5). Of these, 20 (56%) were never referred for surgical evaluation. Among those who were seen by a surgeon, three did not undergo elective repair owing to severe comorbidities; two patients declined surgery (Table 6). Operative repair was scheduled in one case. Six patients (38%) referred to a surgeon did not complete surgical evaluation owing to loss to follow-up, emergent presentation, or an appointment that was never scheduled.

DISCUSSION

Overall, 11% of the study population undergoing PVH repairs required acute surgery. While it appeared that these patients had worse outcomes, after adjusting for potential confounders using two different methodologies, acute surgery did not seem to be an independent risk factor for mortality, recurrence, or SSI. Rather, the severity of the patient's comorbidity burden was a significant predictor for death, and presence of an incarcerated hernia was an important independent predictor for hernia recurrence. While incarcerated hernias were highly correlated with acute surgery, it was not universal—88% of acute cases had incarcerated hernias, compared with 12% of elective cases. Similar to other studies, we found that BMI was associated with SSI.^{16,17}

Currently, there is a paucity of risk-adjusted, controlled studies evaluating the outcomes of acute PVH repairs. Despite these limitations, experts have concluded that acute ventral hernia repairs are associated with worse outcomes.^{4,6–8} In contrast, our study notes that after risk adjustment and controlling for potential confounders, the outcomes following acute PVH repair were not significantly different from that of elective surgery. An explanation may be that patients undergoing acute PVH repair are more likely to be high-risk patients; thus, potential differences were suppressed after case matching. This is supported by our multivariate analysis where surrogate indicators of high-risk patients, such as elevated ASA score, were found to be independent predictors. Moreover, we remarked upon recurrence rate in the case-matched cohort—30% among acute cases versus 14% in elective cases—which seems to be a substantial difference but not statistically significant owing to the smaller sample size. This may be a Type II error; given the reported rates of recurrences, a prospective randomized trial would need to include a total of 232 patients.

Compared with groin hernias (6.1%) and incisional hernias (4.3%), PVH seems to have a higher rate of requiring acute surgery (11%).^{2,5} Recently, some investigators have explored the role of watchful waiting, in particular for groin hernias, but the use of conservative management for PVH remains unclear since the rate of acute presentation may be

higher among PVHs.¹⁸ To study the natural history of PVHs, a large untreated patient population would be required with long-term follow-up for several years; such a study design would be challenging to achieve in our current environment. Instead, retrospective studies, such as the current study, may be necessary to better understand this pathology.

Alternatively, failure to diagnose or refer patients with PVH may account for a part of the higher rate of presenting acutely with a PVH. In our cohort, 37% of patients presenting emergently had no documentation of a PVH in the medical records. However, of those who had a documented hernia, more than half were never referred to a surgeon before their acute presentation. Our findings are similar to that of other studies where a majority of groin hernias were undiagnosed and/or untreated before presenting acutely.² This suggests a need for improved collaboration with primary care providers to heighten vigilance for identifying and referring patients with hernias.

Limitations

There are several limitations to our study. First, the sample size of acute PVH repairs was small and vulnerable to a Type II error. However, our cohort remains one of the largest studies available evaluating acute PVH repairs. Given a larger sample size, many of the borderline differences may have become statistically significant. Second, this study was performed at a tertiary care referral Veterans Affairs hospital with a predominately older, high-risk, and male patient population. Therefore, extrapolation of these results to other patient populations must be approached with caution.

CONCLUSION

In summary, high-risk patients are at an increased risk for acute hernia surgery. While acute surgery is associated with worse outcomes compared with elective surgery, these differences are largely related to patient comorbidity rather than the emergency nature of the procedure. Efforts should be made to improve the coordination of care and promote optimization of patients' comorbidities in anticipation for elective hernia repair.

DISCLOSURE

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