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Drain vs no drain placement after retromuscular ventral hernia repair with mesh: an ACHQC analysis

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Abstract

Introduction Ventral hernia repair (VHR) is one of the most common procedures in the United States, and drains are used in over 50% of mesh repairs. The aim of this study is to investigate the impact of drains on surgical site occurrences (SSO) and infection (SSI) after open and minimally invasive retromuscular VHR with mesh.

Methods A retrospective review of prospectively collected data from the ACHQC was performed to include adult patients who underwent elective VHR with retromuscular mesh placement. Univariate analysis was performed comparing drain and no-drain groups. A logistic regression was performed to identify factors independently associated with increased SSO, SSI, readmission, and length of stay (LOS).

Results 6945 patients underwent elective VHR with sublay mesh. Most patients had M2 and M3 hernias in both groups (with Drain and no-drain). The median LOS was 4.7 (SD 8.3) in the drain group and 1.6 (SD 8.4) in the no-drain group ($p < 0.001$). 30-day SSI was higher in the drain group (176; 3.8% vs 25; 1.1%; $p < 0.001$). Despite lower SSO overall in the drain group (470; 10.0% vs 286; 12.7%; $p < 0.001$), SSO or SSI requiring intervention (SSOPI) was higher in the drain group (240; 5.1% vs 44; 1.9%; $p < 0.001$). Logistic regression identified diabetes (OR 1.3, CI 1.1–1.6; $p < 0.001$) and BMI (OR 1.04, CI 1.03–1.05; $p < 0.001$) as predictors of SSO, while the use of a drain was protective (OR 0.61; CI 0.5–0.8; $p < 0.001$). For SSI, logistic regression showed diabetes (OR 1.6, CI 1.2–2.3; $p = 0.004$) and open approach (OR 3.5, CI 2.1–5.9; $p < 0.001$) as predictors.

Conclusions Drain placement during retromuscular VHR with mesh was predictive of decreased postoperative SSO occurrence but associated with increased LOS. Diabetes and open approach, but not drain use, were predictors of SSI.

Keywords Ventral hernia · Retromuscular · Drain · Surgical site occurrence · Seroma · Surgical site infection

Retromuscular mesh placement in ventral hernia repair (VHR) increased over the past decade [1–3]. Placement of mesh in contact with highly vascularized muscle promotes mesh-tissue integration, improving the durability of the repair and decreasing complication rates when compared to onlay and inlay repairs [4, 5]. Recently, minimally invasive techniques have been developed and refined to accomplish this repair by developing a large retromuscular space in the abdominal wall that allows for adequate mesh overlap of the hernia defect [6–8]. However, the creation of this space may also increase the risk for seroma, hematoma, surgical site infection (SSI), and early readmission [9, 10].

Drains placed during retromuscular VHR aims to decrease the risk of seroma formation. However, there is no consensus in the literature or guidelines regarding their use. Some studies suggest that drains can increase the risk of infection [11, 12], while others demonstrate advantages in decreasing the risk of seroma formation [13, 14]. A recent meta-analysis found that retromuscular drain placement reduces seroma formation with no increased risk of infection [15].

Few studies in the literature investigated the role of drains specifically in retromuscular VHR [4, 13, 14]. The aim of this study is to investigate the drain's impact on surgical site occurrences (SSO) and infections (SSI) after open and minimally invasive retromuscular VHR with mesh.

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Methods

Data collection

The data for this study were originated from the Abdominal Core Health Quality Collaborative (ACHQC) from January 2013 to November 2022. The ACHQC is a nationwide hernia registry currently comprised of 442 participant surgeons across the United States from both academic and private institutions. Prospectively entered patient information includes demographics, preoperative information, operative details, and postoperative details with patient reported outcomes (PROs). As of early 2023, there are a total of 113,898 patients listed in the database who underwent ventral, lateral, and inguinal hernia repairs with 30-day and 1-year follow-ups.

Population, comparison groups, and baseline variables

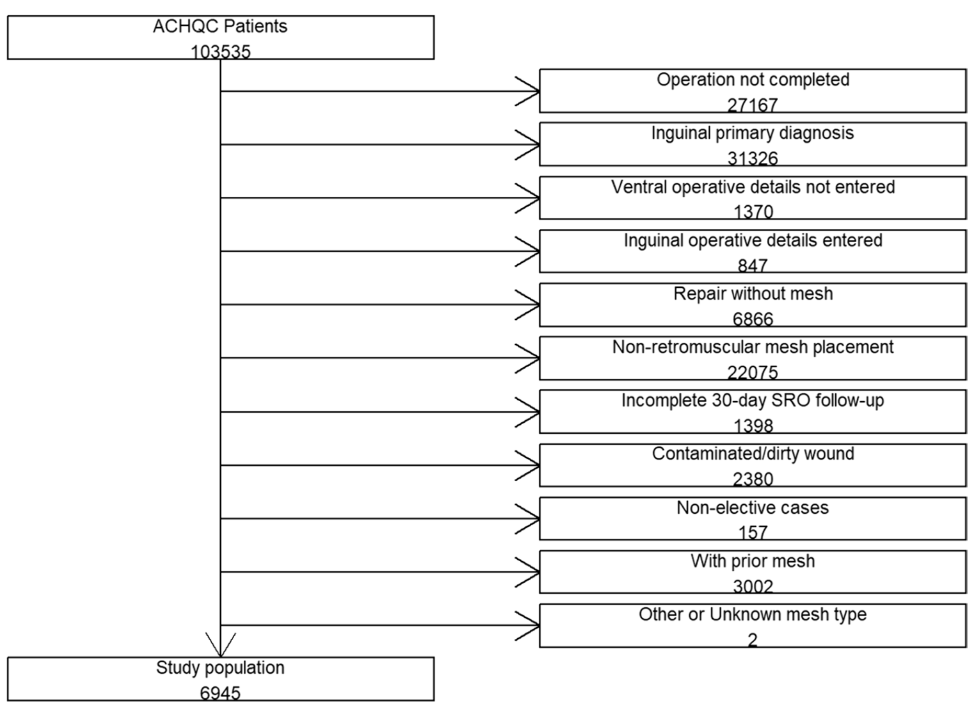
The objective of this study is to investigate the impact of drain placement on SSO and SSI after open and minimally invasive retromuscular VHR with mesh. We selected all elective open, laparoscopic, and robotic-assisted VHR s with retromuscular mesh placement in the ACHQC (Fig. 1). We excluded patients with concomitant inguinal hernia repairs, repairs in contaminated and dirty fields (CDC Class III and IV), repairs with no mesh, or patients with prior mesh. We also excluded patients who had no 30-day follow-up data. Drain usage was collected in the ACHQC database, and patients were categorized as with or without drain accordingly.

Baseline characteristics assessed were age, gender, race, BMI, diabetes, hypertension, chronic obstructive pulmonary disease, anti-platelet medications, ASA class, European Hernia Society hernia classification midline component, hernia size, hernia length, hernia width, current smoker within 1 month, number of meshed used, fixation type, myofascial release (transversus abdominis) performed, and mesh type. 0.1% patients had no assigned ASA class. They were combined with patients with ASA class = 4 to facilitate modeling. Hernia size was calculated based on hernia length and hernia width with the following formula: $\frac{\text{length}}{2} \times \frac{\text{width}}{2} \times \pi$.

Outcomes

The primary outcomes of this study are wound morbidities after VHR. SSO, SSI, surgical site occurrence requiring procedural intervention (SSOPI), and seroma are of particular interest. *Surgical site infection* is defined as infections occurring up to 30 days after surgery and affecting either the incision or deep tissue at the operation site [16]. SSO includes any SSI, as well as wound cellulitis, nonhealing incisional wound, fascial disruption, skin or soft tissue ischemia, skin or soft tissue necrosis, wound serous or purulent drainage, stitch abscess, seroma, hematoma, infected or exposed mesh, or development of an enterocutaneous fistula. SSOPI is defined as any SSO that requires wound opening, wound debridement, suture excision, percutaneous drainage, and

Fig. 1 Flowchart with inclusion criteria



partial or complete mesh removal. Secondary outcomes were length of stay (LOS) and readmission at 30 days after surgery.

Statistical analysis

Categorical variables were presented as frequency and percentage and compared across groups using Pearson Chi-squared tests or Fisher exact tests, and continuous variables were presented as the median and interquartile range (IQR) and compared across groups using Wilcoxon rank sum tests. We dichotomized the LOS using the median before the regression analysis. Multivariable logistic models were built to evaluate independent factors associated with endpoints adjusting for all baseline characteristics except for hernia width and length, because they correlated with hernia size. Odds ratios with a 95% confidence interval were reported. A p value < 0.05 was considered statistically significant. All statistical analysis was performed using R Statistical Software, version 4.2.3 (R Foundation for Statistical Computing).

Institutional review board

This study was approved by our Institutional Review Board (IRB) Number #2022-13807.

Results

Patient characteristics

The ACHQC database identified 6945 patients who underwent elective VHR with sublay mesh (Fig. 1). We divided the patients into two groups: 4687 patients with drains and 2258 patients without drains. Demographic and descriptive data are shown in Table 1. The mean age was 58.3 (SD 12.6) years in patients with drains vs 57.1 (SD 13.5) years in the no-drain group ($p < 0.001$). There was no difference in mean BMI between the groups [32.1 kg/m^2 (SD 6.5) in the drain group vs 32.4 kg/m^2 (SD 6.9) in the no-drain group ($p = 0.697$)]. Smoking was higher in the no drain group ($n = 223$; 10%) vs ($n = 391$; 8.4%) in the drain group ($p = 0.039$) and DM was higher in the drain group (20.6%) vs (18.6%) in the no-drain group ($p = 0.062$) (Table 1).

Hernia characteristics

Most patients had M2 and M3 hernias (according to the EHS classification) in both groups. Mean defect area was 177 (SD 151) cm^2 in the drain group vs 53.9 (SD 59.8) cm^2 in the no-drain group ($p < 0.001$). The drain group had more patients with 2 meshes (248; 5.3%) when compared with the no-drain group (40; 1.8%) ($p < 0.001$) (Table 2).

Perioperative outcomes

The surgical approach was open in the group with drain in 3946 (84.2%) vs 701 (31%) in the no-drain group ($p < 0.001$). Component separation, such as TAR, was also higher in the drain group (3115; 66.5%) vs the no-drain group (526; 23.3%) ($p < 0.001$). In most cases, the permanent synthetic mesh was used in both groups, and resorbable synthetic mesh use was higher in the drain group (Table 2).

The median LOS was 4.7 days (IQR 2–6) in the drain group and 1.6 days (IQR 0–2) in the no-drain group ($p < 0.001$) (Table 2). The readmission rate was higher in the drain group ($n = 285$; 6.1% vs $n = 76$; 3.4%; $p < 0.001$). 30-day SSI was higher in the drain group (176; 3.8% vs 25; 1.1%; $p < 0.001$). Despite lower SSO overall in the drain group (47; 10% vs 286; 12.7%; $p < 0.001$), SSO requiring intervention (SSOPI) was higher (240; 5.1% vs 44; 1.9%; $p < 0.001$). Seroma was higher in the no-drain group ($n = 235$; 10.4%) vs 171 (3.6%) patients in the drain group ($p < 0.001$) (Table 2).

Multivariate analysis

A multivariate model was built to evaluate independent factors associated with wound morbidity (SSO, SSI, LOS, SSOPI and seroma). Regarding LOS, logistic regression demonstrated drain use (OR 2.8, CI 2.31–3.738; $p < 0.001$), open approach (OR 7.28, CI 6.05–8.79; $p < 0.001$) and TAR (OR 2.3, 95% CI 1.94–2.62; $p < 0.001$) were strongly associated with longer LOS (Table 3). Regarding 30-day readmissions, drain use was not associated with readmissions in 30 days after surgery (OR 1.08; 95% CI 0.8–1.52; $p = 0.663$) (Table 3). Drain was not associated with SSI (OR 1.37; 95% CI 0.83–2.32; $p = 0.227$). All variables included in the model are listed in Table 4. Logistic regression identified diabetes (OR 1.3, CI 1.1–1.57; $p = 0.005$, and COPD (OR 1.35, 95% CI 1.02–1.8; $p = 0.005$) as predictors of SSO, while use of a drain was protective (OR 0.61; 95% CI 0.5–0.8; $p < 0.001$) (Table 5). Finally, drain use was associated with preventing seroma formation at 30 days (OR 0.34; 95% CI 0.25–0.45; $p < 0.001$). Surprisingly, the open approach was associated with lower seroma formation (OR 0.71; 95% CI 0.54–0.93; $p = 0.013$) (Table 6).

Discussion

This study is the first large-scale study to evaluate the drain use in both open and minimally invasive retromuscular VHR with mesh. Using the ACHQC database, we found that drain

Table 1 Sociodemographic characteristics, hernia characteristics and perioperative outcomes

	With drain ($N=4687$)	No drain ($N=2258$)	p value
Mean age (SD)	58.3 (12.6)	57.1 (13.5)	< 0.001
Gender			
Female	2458 (52.4%)	1181 (52.3%)	0.933
Male	2229 (47.6%)	1077 (47.7%)	
Race			< 0.001
White, not of Hispanic origin	4040 (86.8%)	1801 (80.3%)	
Black, not of Hispanic origin	360 (7.7%)	257 (11.5%)	
Hispanic	162 (3.5%)	149 (6.6%)	
Mean BMI (SD)	32.1 (6.5)	32.4 (6.9)	0.697
Diabetes mellitus	965 (20.6%)	421 (18.6%)	0.062
Hypertension	2569 (54.8%)	1135 (50.3%)	< 0.001
COPD	345 (7.4%)	149 (6.6%)	0.26
Antiplatelets medication	643 (13.7%)	296 (13.1%)	0.51
ASA Class			< 0.001
1	105(2.2%)	123 (5.4%)	
2	1479 (31.6%)	1013 (44.9%)	
3	2988 (63.8%)	1083 (48%)	
4	114 (2.4%)	38 (1.7%)	
Hernia classification			
M1—subxiphoidal	1194 (25.5%)	209 (9.3%)	< 0.001
M2—epigastric	3412 (72.9%)	1311 (58.1%)	< 0.001
M3—umbilical	3894 (83.2%)	1757 (77.8%)	< 0.001
M4—infraumbilical	2910 (62.2%)	744 (33.0%)	< 0.001
M5—suprapubic	915 (19.5%)	187 (8.3%)	< 0.001
No midline component	200 (4.3%)	144 (6.4%)	< 0.001
Mean size of defect (SD)	177 (151)	53.9 (59.8)	< 0.001
Mean hernia length (SD)	17.1 (7.10)	9.61 (6.51)	< 0.001
Mean hernia width (SD)	11.6 (6.15)	5.78 (3.29)	< 0.001
Current smoker	391 (8.4%)	223 (10.0%)	0.039
Number of meshes used			
One mesh	4439 (94.7%)	2218 (98.2%)	< 0.001
Two meshes	248 (5.3%)	40 (1.8%)	
Mesh fixation			
Suture	3208 (68.5%)	944 (41.8%)	< 0.001
Tacks	202 (4.3%)	144 (6.4%)	< 0.001
Adhesives	267 (5.7%)	225 (10.0%)	< 0.001
Surgical approach			
MIS	740 (15.8%)	1557 (69.0%)	< 0.001
Open	3946 (84.2%)	701 (31.0%)	
TAR procedure	3115 (66.5%)	526 (23.3%)	< 0.001
Mesh type			
Biological tissue-derived	60 (1.3%)	7 (0.3%)	< 0.001
Permanent synthetic	4419 (94.3%)	2222 (98.4%)	
Resorbable synthetic	208 (4.4%)	29 (1.3%)	

use is associated with longer LOS but is not independently associated with increased risk for SSI, SSO, or readmission. Furthermore, drain was a protective factor against SSO and seroma formation specifically. These findings are corroborated by other published studies with smaller samples.

A previous study by Krpata and colleagues using the same database in 2017 only investigated the use of drains after open retromuscular repair [14]. The authors performed Propensity Score Matching (PSM) of 300 patients and also found, using a logistic regression model, retromuscular

Table 2 Postoperative outcomes

	With drain ($N=4761$)	No drain ($N=2343$)	*p* value
Mean length of stay (SD)	4.69 (8.33)	1.57 (8.43)	< 0.001
Readmission	285 (6.1%)	79 (3.37%)	< 0.001
SSO or SSI requiring procedural intervention	240 (5.1%)	44 (1.9%)	< 0.001
Surgical site infection or occurrence	591 (12.6%)	300 (13.3%)	0.452
SSI	176 (3.8%)	25 (1.1%)	< 0.001
SSO	470 (10.0%)	286 (12.7%)	0.001
Seroma	171 (3.6%)	235 (10.4%)	< 0.001

SD standard deviation, *SSO* surgical site occurrence, *SSI* surgical site infection

Table 3 Logistic regression for length of stay and readmissions at 30 days

	OR	95% (CI)	*p* value
Logistic regression for LOS			
Drain	2.8	2.31–3.38	< 0.001
Diabetes mellitus	1.09	0.92–1.28	0.316
Size of defect	1.00	1.00–1.01	< 0.001
Current smoker	0.73	0.58–0.92	0.007
Two meshes	1.09	0.80–1.49	0.573
Open approach	7.28	6.05–8.79	< 0.001
TAR	2.25	1.94–2.62	< 0.001
Permanent synthetic mesh	0.74	0.41–1.32	0.316
Resorbable synthetic mesh	0.68	0.35–1.29	0.240
Age	1.00	1.00–1.01	0.261
BMI	1.00	0.99–1.01	0.996
COPD	1.36	1.06–1.76	0.017
Logistic regression for 30-day readmission			
Drain	1.08	0.77–1.52	0.663
Male	0.83	0.66–1.04	0.104
Diabetes mellitus	1.30	1.00–1.69	0048
Size of defect	1	1.00–1.00	0.577
Current smoker	1.35	0.94–1.91	0.094
Two meshes	0.91	0.52–1.50	0.738
Open approach	1.55	1.14–2.11	0.005
TAR	1.09	0.83–1.43	0.530
Permanent synthetic mesh	0.81	0.35–2.36	0.660
Resorbable synthetic mesh	1.01	0.37–3.26	0.985
Age	0.99	0.98–1.00	0.206
BMI	1.00	0.99–1.02	0.684

LOS length of stay, *TAR* transversus abdominis release, *BMI* body mass index, *COPD* chronic obstructive pulmonary disease, *CI* confidence interval, *OR* odds ratio

drains were not associated with SSI (OR, 1.30; 95% CI 0.33–5.21) or SSOPI (OR, 0.94; 95% CI 0.29–3.01) and patients were less likely to develop SSO (OR, 0.33; 95% CI 0.14–0.78). In addition, they found that seroma formation was higher in patients that did not have drains (8.0 vs 1.0%; $p < 0.01$). A more recent study by Miller et al. using the same database but only patients who underwent

Table 4 Logistic regression for SSI at 30 days after surgery

Logistic regression for 30-day SSI	OR	95% CI	*p* value
Drain	1.37	0.83–2.32	0.227
Male	0.91	0.67–1.23	0.529
Diabetes mellitus	1.63	1.16–2.27	0.004
Size of defect	1	1.00–1.00	0.988
Current smoker	1.32	0.80–2.07	0.259
Two meshes	1.83	1.03–3.04	0.028
Open approach	3.47	2.11–5.95	< 0.001
TAR	1.75	1.21–2.55	0.003
Permanent synthetic mesh	0.80	0.29–3.32	0.706
Resorbable synthetic mesh	0.50	0.11–2.61	0.373
Age	0.99	0.98–1.01	0.346
BMI	1.03	1.01 – 1.05	0.007

LOS length of stay, *TAR* transversus abdominis release, *BMI* body mass index, *COPD* chronic obstructive pulmonary disease, *CI* confidence interval, *OR* odds ratio

Table 5 Logistic regression for SSO at 30 days

Logistic regression for 30-day SSO	OR	95% (CI)	*p* value
Drain	0.61	0.49–0.76	< 0.001
Male	0.98	0.83–1.16	0.822
Diabetes mellitus	1.30	1.08–1.57	0.005
Size of defect	1	1.00–1.00	0.009
Current smoker	1.26	0.97–1.62	0.081
Two meshes	1.18	0.81–1.69	0.370
Open approach	1.11	0.90–1.37	0.338
TAR	0.89	0.73–1.08	0.235
Permanent synthetic mesh	0.58	0.31–1.20	0.113
Resorbable synthetic mesh	0.47	0.20–1.11	0.077
Age	1	0.99–1.01	0.240
BMI	1.04	1.03–1.05	< 0.001

LOS length of stay, *TAR* transversus abdominis release, *BMI* body mass index, *COPD* chronic obstructive pulmonary disease, *CI* confidence interval, *OR* odds ratio

Table 6 Logistic regression for seroma at 30 days

Logistic regression for seroma	OR	95% CI	p value
Drain	0.34	0.25–0.45	< 0.001
Male	0.95	0.76–1.19	0.673
Diabetes mellitus	1.06	0.82–1.37	0.646
Size of defect	1	1–1	0.279
Current smoker	1.24	0.88–1.72	0.205
Two meshes	1.27	0.73–2.07	0.370
Open approach	0.71	0.54–0.93	0.013
TAR	0.96	0.73–1.24	0.736
Permanent synthetic mesh	0.88	0.32–3.65	0.829
Resorbable synthetic mesh	0.81	0.22–3.91	0.773
Age	1	0.99–1.01	0.620
BMI	1.04	1.02–1.05	< 0.001

LOS length of stay, *TAR* transversus abdominis release, *BMI* body mass index, *COPD* chronic obstructive pulmonary disease, *CI* confidence interval, *OR* odds ratio

robotic retromuscular VHR showed that patients with drains had fewer seromas and drain placement lowered the risk of an SSO compared to no drain placement (OR 0.32, CI 0.21–0.47; $p < 0.0001$) [13]. They also showed that the LOS was longer for patients with drains (2.0 days [IQR 1.0; 3.0] vs 1.0 days [IQR 1.0; 2.0], respectively; $p < 0.0001$). We similarly found that patients with drains had a mean LOS of 4.7 days (SD 8.3) vs 1.6 (SD 8.3) days for those without ($p < 0.001$).

Due to a lack of scientific evidence or definitive consensus guidelines, drain use is primarily driven by individual surgeon preference and experience. This may result in a selection bias favoring the use of drains in more complex cases [17]. In this study, the drain group had more complex hernias and higher rates of component separation when compared with the no-drain group. Patients with bigger and more complex hernias are more likely to need component separation, such as TAR, to reconstitute the linea alba [18–22]. In this study, patients who had TAR had a higher risk of infection. Furthermore, the open approach was associated with a higher risk of SSI, 30-day readmission, and longer LOS.

A retrospective study published by Arora et al. using the Abdominal Wall Reconstruction Surgical Collaborative (AWRSC) registry evaluated the use of drains in 120 patients who underwent enhanced-view totally extraperitoneal (eTEP) retromuscular repairs [4]. Like our findings, they noted longer LOS with the drain use, found no significant difference regarding SSO or SSI, and their drain group had a higher risk of SSOPI.

Willemin and colleagues published the only randomized clinical trial with 144 patients who underwent open retromuscular incisional hernia repair. They found no difference between the groups in the fluid collection at 30 days (60.3% vs 62%) and fewer surgical complications and wound dehiscence in the drain group [23]. In their study, the prophylactic drainage in open incisional retromuscular hernia repair did not reduce the rate of postoperative seroma.

Systematic reviews and meta-analysis

A recent meta-analysis by Marcolin et al. (2023) included only three observational studies and one randomized clinical trial with 1724 patients [15]. The authors found that drain placement was associated with decreased seroma formation (OR 0.34; 95% CI 0.12–0.96; $p = 0.04$). However, there was no difference in SSI, SSO, and SSOPI. Important limitations of this study are the low number of studies included, only one of which was a randomized controlled trial, and differences in how seroma is evaluated between studies (retromuscular or subcutaneous) despite the drain being placed in the retromuscular space. As more retrospective and prospective studies are published, future meta-analysis can be performed to better understand the role of drains in the retromuscular space.

Novelty of this study

This study uses a national database with surgeons from all parts of the country. It reinforces the findings of other retrospective studies with smaller sample sizes and the most recent meta-analysis that showed advantages of using drains to decrease the risk of seroma formation with no increased risk of infection. In addition, this study is the first to evaluate drains in open and minimally invasive approach repairs using permanent and resorbable synthetic meshes.

Limitations and strength of this study

This study has several limitations. It is a retrospective study with prospective data entered by the surgeons who input their data into the ACHQC database. This may lead to recall bias. Second, a performance bias might be present as dedicated abdominal wall repair surgeons are more likely to participate in data collection. Another important limitation is that the ACHQC database does not collect drain removal timing or antibiotic use duration. Finally, the data are collected through voluntary self-reporting, so there may be selection bias if participating surgeons input only some of their cases. The strength of this study lies in our large sample size ($N = 7104$) and the multivariate analysis to identify independent factors associated with wound morbidity after retromuscular repairs. Using multivariate analysis allowed for the interpretation of odds ratios of individual events while controlling for other covariates.

Conclusion

Drain placement during retromuscular VHR with mesh was predictive of decreased postoperative SSO occurrence but associated with increased LOS. Diabetes and open approach, but not drain use, were predictors of SSI.

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Declarations

Disclosures Diego L Lima, Raquel Nogueira, Xinyan Zheng, Shannon Keisling, and Prashanth Sreeramoju have no conflicts of interest or financial ties to disclose.

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