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ORIGINAL ARTICLE

Quantifying abdominal wall tension in the primary repair of ventral hernias

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Abstract

Background Tension-free closure is a fundamental principle of hernia repair, yet quantitative data on fascial tension during primary ventral hernia repair and its association with outcomes remain limited. This study aimed to quantify fascial tension during primary ventral hernia repair and examine associations between closure tension and postoperative complications.

Methods This prospective observational cohort study enrolled 50 patients undergoing open ventral hernia repair with primary fascial closure without component separation at a single institution from September 2023 to May 2025. Fascial tension was measured using a sterilizable tensiometer immediately prior to closure. The primary outcome was quantitative fascial tension; secondary outcomes included associations between total closure tension, postoperative complications and use of short-term absorbable bridging mesh.

Results Among 40 patients who underwent primary closure, 97.5% were closed under supraphysiologic tension (median 8.8 lbs, IQR 5.4–19.0). At median 5.5 month follow-up, fascial tension was not significantly associated with postoperative complications including one instance of fascial dehiscence (OR = 0.97 per lb, 95% CI: 0.91–1.03, $p = 0.305$), while operative time ≥ 3 h was an independent predictor of complications (OR = 4.86, 95% CI: 1.24–22.79, $p = 0.030$). Patients who underwent bridging mesh repair ($n = 10$) demonstrated significantly higher closure tension compared to those closed primarily (median 20.3 lbs vs. 8.8 lbs, 95% CI: −18.5 to −0.25; $p = 0.035$). Total fascial tension of 11.8 lbs demonstrated good discriminatory power for predicting short-term absorbable bridging mesh use (AUC = 0.711).

Conclusions Primary fascial closure under supraphysiologic tension appears safe, with complications driven by operative complexity rather than absolute tension values. Tension greater than 11.8 lbs was associated with bridging mesh use, though whether this represents a physiologic limit or existing surgical judgment requires further study.

Keywords Primary fascial closure · Abdominal wall tension · Tensiometry · Bridging closure · Ventral hernia

Introduction

Minimizing tension is a long-established principle of successful hernia repair. Our previous work successfully established the baseline physiologic tension of the abdominal wall in patients without hernias, finding that approximately 1.94 lbs of total force is required to reestablish the linea alba during laparotomy closure [1]. Additionally, we have characterized the progressive alteration of tension on both the anterior and posterior fascial elements of various myofascial releases during posterior component separation (PCS) with transversus abdominis release (TAR) [2]. This quantification of tension at baseline and during tension-reducing techniques has provided crucial reference points for understanding abdominal wall biomechanics in ventral hernia repairs.

However, a critical knowledge gap remains regarding tension measurements in scenarios that necessitate primary fascial closure without component separation as part of a staged repair strategy. These include contaminated surgical fields, concomitant procedures that increase operative

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complexity, or cases where patient factors favor a staged approach with delayed definitive reconstruction. Our institutional preference is to achieve primary fascial closure whenever technically feasible, as this approach maintains fascial continuity and may facilitate subsequent definitive repair. Despite the intuitive concern that closing the abdomen under higher-than-baseline tension may contribute to adverse outcomes, there is a lack of quantitative data to support or refute this association. Moreover, the threshold of closure tension at which bridged repairs, component separation, or other tension-reducing techniques become necessary remains undefined.

This study aims to quantify fascial tension prior to primary closure of ventral hernias and evaluate both (1) the safety of primary closure under supraphysiologic tension and (2) tension thresholds that may predict the need for short-term absorbable bridging mesh as an alternative repair strategy.

Methods

This is a prospective, observational study designed to quantify anterior fascial tension during open ventral hernia repairs with primary closure without component separation, and to explore the associations between fascial tension at closure and postoperative complications. Following approval by the Cleveland Clinic Foundation Institutional Review Board, patients were enrolled at the Cleveland Clinic Center for Abdominal Core Health from September 2023 to May 2025. Written informed consent was obtained from all patients. Inclusion criteria were patients with midline ventral hernias who were not expected to undergo component separation for the hernia repair (i.e., primary closure due to contaminated surgical fields, concomitant procedures, or staged repairs where component separation was deferred). Study exclusion criteria included prior PCS, isolated flank hernias and mesh excision for reasons other than mesh infection (e.g. abdominal pain of unknown etiology). We planned to enroll 50 patients based on the authors' consensus and feasibility due to surgical volume at our institution. All study participants underwent ventral hernia repair with primary closure. Patient recruitment, including screening, inclusion, and exclusion, is summarized in Fig. 1. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines [3].

Primary fascial closure was performed by reapproximating the native linea alba with slowly absorbable monofilament suture in a figure of eight fashion, consistent across surgeons per our institutional practice. Tension measurements were obtained immediately prior to fascial closure via a previously described protocol [1, 2]. Briefly, tension on the abdominal wall was measured using a proprietary, sterilizable, spring-based tensiometer, which was fabricated and assembled by the Cleveland Clinic Foundation's Mechanical Prototyping Core. The tensiometer was calibrated, accounting for the acceleration of Earth's gravity, to measure force in pounds. To measure fascial tension, the tensiometer was hooked to a Kocher clamp that had been placed on the fascial edge, and then force was manually applied at the tensiometer handle. Tension measurements were captured when the edge of the fascia reached the midpoint of the abdomen, which was marked by a suture plumb line. The maximum force applied to the tensiometer was 15 lbs. If the clamp was at risk of disrupting the fascia as force was applied to the tensiometer or the fascia could not be reapproximated to the midline, measurements were recorded as 15 lbs. The right- and left-sided values were then summed to yield a single total closure tension per patient, and all tension values reported in this manuscript reflect this summed total.

The decision to perform a bridged repair with short-term absorbable mesh rather than primary fascial closure was made intraoperatively at the discretion of the operating surgeon when the fascial edges could not be reapproximated to the midline, or could be reapproximated only under tension judged to confer a prohibitive risk of acute dehiscence. Tensiometer measurements were obtained solely for research purposes and were not used by the surgeon at the time of this decision.

Patient characteristics and operative details were obtained from the electronic medical record, including the indication for procedure, presence of prior lateral incisions (e.g. ostomy and subcostal incisions) and use of short-term absorbable bridging mesh. The primary study outcome was tension on the anterior fascia of the abdominal wall prior to closure. Secondary study outcomes included the association of abdominal wall tension with minimum 30-day follow-up postoperative outcomes collected through July 2025 and predictive tension thresholds for complications and short-term absorbable bridging mesh use.

Statistical analysis

Statistical analyses were performed using R software (version 4.0.0, R Foundation for Statistical Computing, Vienna, Austria). Summary statistics were calculated for demographic and operative variables, with continuous variables presented as means with standard deviations or medians with interquartile ranges, and categorical variables as counts with percentages.

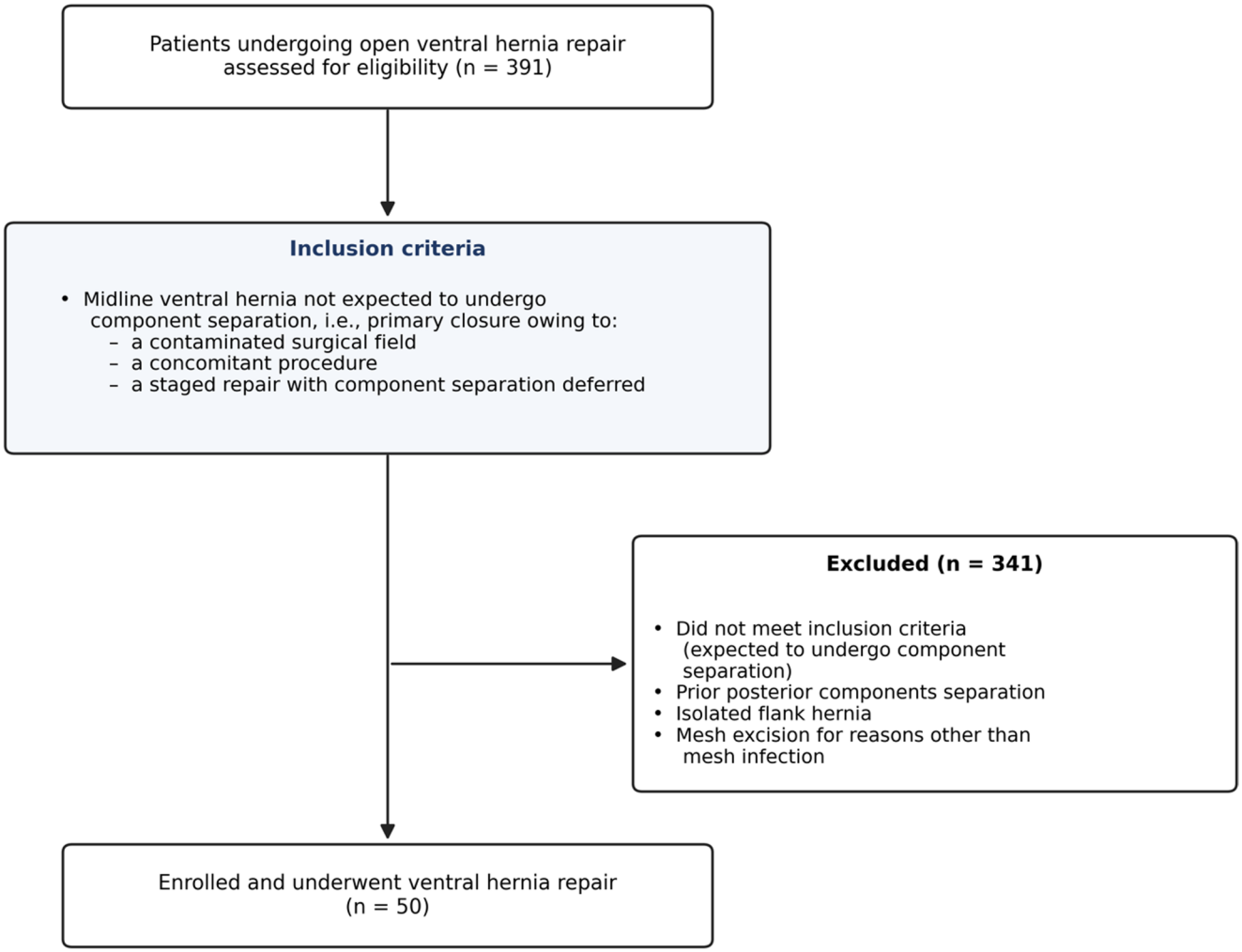


Fig. 1 Patient recruitment, inclusion and exclusion criteria

Fascial tension and complications

To explore whether fascial tension was associated with postoperative complications, patients who underwent bridged repair were excluded from the primary analysis (n = 10), resulting in a final sample size of 40 patients with primary fascial closure. Postoperative complications were defined as any of the following: fascial dehiscence, hernia recurrence, enterocutaneous fistula, wound morbidity, stroke, arrhythmia requiring cardioversion, reintubation, ileus requiring nasogastric tube placement, small bowel obstruction, intra-abdominal abscess, or acute kidney injury requiring nephrology management. Wound morbidity was defined as surgical site infection (SSI), surgical site occurrence (SSO), surgical site infections and occurrences requiring procedural intervention (SSI/O PI). SSI was defined as a superficial, deep, or organ space infection in accordance with Centers for Disease Control (CDC) definitions [4]. SSO included any SSI, 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 was defined as any SSO that required opening of the wound, wound debridement, suture excision, percutaneous drainage, or mesh removal (partial or complete).

Univariate logistic regression analysis was performed to assess the association between each predictor variable and complications, with fascial tension treated as a continuous variable. Variables with perfect separation, no variation, or fewer than 5 observations per category were excluded to ensure model stability. Variables with $p<0.10$ in univariate analysis were considered for multivariable modeling. The final multivariable model included fascial tension (primary predictor) and operative time, selected based on clinical relevance and statistical significance. Sample size adequacy was confirmed using the guideline of 10 events per predictor variable.

Receiver operating characteristic (ROC) curves were generated to evaluate the discriminatory performance of fascial tension for predicting complications, with area under the curve (AUC) calculated for predictive accuracy. Optimal probability thresholds were determined using Youden's index to identify potential cutoff values. Throughout this manuscript, 'threshold' refers to this statistically derived ROC cut-point.

Fascial tension and short-term absorbable bridging mesh use

Because patients with bridged repairs were excluded from the primary complication analysis, a separate analysis was conducted using the full dataset ($n=50$) to determine whether fascial tension could predict the use of short-term absorbable bridging mesh. Logistic regression was used to model the relationship between fascial tension and bridging repair, with ROC analysis performed to identify the optimal tension threshold for predicting when surgeons chose bridging over primary closure. Model fit was assessed using Akaike Information Criterion (AIC) and Nagelkerke pseudo-R^2. Odds ratios (ORs) with 95% confidence intervals (CIs) were reported for all variables. Statistical significance was defined as $p<0.05$.

Results

Patient characteristics

A total of 50 patients were enrolled, for a total of 100 measurements (right and left hemi-abdomen for each patient). Patient characteristics are detailed in Table 1. The median age was 61.0 years (IQR 53.2–69.0), with 31 patients (62%) being female. The median BMI was 34.8 kg/m² (IQR 30.1–41.8). The majority of presented with recurrent hernias ($n=36$, 72%) and had a prior history of abdominal wall SSI ($n=27$, 54%). The most prevalent comorbidities were hypertension ($n=37$, 74%), diabetes mellitus ($n=12$, 24%), and chronic obstructive pulmonary disease (COPD) ($n=10$, 20%). Nearly all procedures were non-emergent ($n=46$, 92%), with most patients classified as ASA class III ($n=42$, 84%), and over half the cases as wound class 4 ($n=26$, 52%). Hernia dimensions showed a median width of 13.0 cm (IQR 9.0–16.0) and length of 22.5 cm (IQR 18.2–25.8).

For the entire cohort, median follow up was 5.5 months (IQR 1.0–11.5). Complications are detailed in Table 2. A total of 25 patients experienced 42 complications, for an overall 50% complication rate per patient, with rate of 47.5% (19/40) in the primary closure group and 60.0% (6/10) in the bridged closure group, with no statistically significant difference between the groups (95% CI: −46.7% to 21.7%, $p=0.48$). The most common complication overall was wound morbidity ($n=15$ patients, 30%), followed by hernia recurrence ($n=12$ patients, 24%).

Table 1 Patient demographics and operative details

Variable	All ($N=50$)
Age	61.0 [53.2–69.0]
Body Mass Index (BMI)	34.8 [30.1–41.8]
Female Sex	31 (62.0%)
Race	
White	45 (90.0%)
Black	1 (2.0%)
Multiracial	2 (4.0%)
American Indian/Alaskan	1 (2.0%)
Not Reported	1 (2.0%)
Ethnicity	
Hispanic	1 (2.0%)
Not Hispanic	47 (94.0%)
Not Reported	2 (4.0%)
Liver Failure	3 (6.0%)
Hypertension	37 (74.0%)
Diabetes	12 (24.0%)
Chronic Obstructive Pulmonary Disease (COPD)	10 (20.0%)
Congestive Heart Failure (CHF)	6 (12.0%)
Inflammatory Bowel Disease (IBD)	6 (12.0%)
Antiplatelet Use	3 (6.0%)
Anticoagulant Use	13 (26.0%)
Steroid Use	10 (20.0%)
Smoking	8 (16.0%)
Recurrent Hernia	36 (72.0%)
Abdominal wall SSI history	27 (54.0%)
Previous Lateral Incision	22 (44.0%)
Elective Case	46 (92.0%)
American Society of Anesthesiologists (ASA) Class	
2	5 (10.0%)
3	42 (84.0%)
4	3 (6.0%)
Operative Time	
0–60 min	2 (4.0%)
61–120 min	12 (24.0%)
121–180 min	12 (24.0%)
181–239 min	9 (18.0%)
≥240 min	15 (30.0%)
Wound Class	
1	5 (10.0%)
2	11 (22.0%)
3	8 (16.0%)
4	26 (52.0%)
Hernia Width (cm)	13.0 [9.0–16.0]
Hernia Length (cm)	22.5 [18.2–25.8]

Table 2 Post-operative complications

Complication	All events ($n=42$)
SSO/I	
Serous Drainage	1 (2%)
Seroma	1 (2%)
Hematoma	1 (2%)
Abscess	4 (8%)
Stitch Abscess	1 (2%)
Mesh Infection	1 (2%)
SSOPI	
Wound opened	7 (14%)
Wound dehiscence	1 (2%)
Fascial Dehiscence	2 (4%)
Enterocutaneous Fistula	1 (2%)
Hernia Recurrence	12 (24%)
Ileus (requiring nasogastric tube decompression)	1 (2%)
Small Bowel Obstruction	1 (2%)
Intra-abdominal Abscess	2 (4%)
Stroke	1 (2%)
Arrhythmia (requiring cardioversion)	2 (4%)
Pulmonary Embolism	1 (2%)
Reintubation	1 (2%)
Acute Kidney Injury (requiring nephrology management)	2 (4%)

Numbers in this table indicate number of events; individual patients may have experienced more than one complication

Among the 40 patients closed primarily, 97.5% ($n=39$) were closed under supra-physiologic tension, with a median total fascial tension of 8.8 lbs (IQR 5.4–19.0). In univariate logistic regression analyses, several variables were evaluated for association with postoperative complications. COPD was significantly associated with higher complication risk (OR = 5.41, 95% CI: 1.18–39.00, $p=0.048$), while operative time showed a marginal association (OR = 3.50 for operative time ≥ 3 h vs. ≤2 h, 95% CI: 0.97–14.78, $p=0.066$) (Table 3). We therefore constructed three logistic regression models to evaluate the robustness and independence of fascial tension as a predictor of postoperative complications: Model 1 tested the unadjusted association, Model 2 incorporated operative time as a clinically relevant covariate, and Model 3 added COPD to account for a potential confounder identified in univariate analysis (Table 4).

Across all models, fascial tension consistently demonstrated a non-significant association with complications. In univariate analysis, each 1-lb increase in fascial tension showed no significant effect on complication risk (OR = 0.97; 95% CI: 0.91–1.03; $p=0.305$). In a multivariable model adjusting for operative time, fascial tension remained non-significant (OR = 0.95; 95% CI: 0.88–1.01; $p=0.115$), whereas longer operative time (≥3 h) was independently associated with increased complication risk (OR = 4.86;

Table 3 Univariate analysis

Variable	OR	95% CI	*p*-value
Fascial tension	0.97	0.91–1.03	0.3051
Age	1.04	0.99–1.09	0.1016
BMI	1.02	0.97–1.08	0.4888
Hernia width	0.97	0.90–1.04	0.4602
Hernia length	1	0.92–1.10	0.9146
ASA Class	1.57	0.24–12.78	0.6394
Elective case	1	0.11–8.92	1
Operating Time	3.5	0.97–14.78	0.066
Wound Class	1.45	0.44–4.92	0.5451
Sex	1.19	0.38–3.77	0.7709
Race	0.64	0.08–4.20	0.6394
Ethnicity	0.79	0.15–3.26	0.7335
Liver failure	0.48	0.02–5.33	0.559
Hypertension	1.23	0.34–4.51	0.7473
Diabetes	1	0.27–3.74	1
COPD	5.41	1.18–39.00	0.0477
CHF	0.46	0.06–2.59	0.3926
IBD	0.46	0.06–2.59	0.3926
Antiplatelet Use	2.09	0.19–46.73	0.559
Anticoagulation Use	1.88	0.53–7.27	0.3369
Steroids	0.35	0.07–1.46	0.1678
Smoking History	1	0.21–4.74	1
Recurrent Hernia	2.25	0.64–8.60	0.2128
Abdominal wall SSI history	1.17	0.38–3.62	0.7767
Prior lateral incision	0.67	0.21–2.06	0.4825

Table 4 Logistic regression models

		OR	95% CI	*p*-value
Model 1				
	Fascial Tension (per 1 lb)	0.97	(0.91–1.03)	0.3051
Model 2				
	Fascial Tension (per 1 lb)	0.95	(0.88–1.01)	0.1145
	Operative Time	4.86	(1.24–22.79)	0.0304
Model 3				
	Fascial Tension (per 1 lb)	0.95	(0.88–1.02)	0.1615
	Operative Time	4.66	(1.12–23.48)	0.0433
	COPD	4.91	(0.98–37.43)	0.0736

95% CI: 1.24–22.79; $p=0.030$). In the third model incorporating COPD, operative time continued to be a significant predictor (OR = 4.66; 95% CI: 1.12–23.48; $p=0.043$), and COPD was marginally associated with higher odds of complications (OR = 4.91; 95% CI: 0.98–37.43; $p=0.074$).

ROC curve analysis evaluating the predictive ability of fascial tension for complications demonstrated an area under the curve (AUC) of 0.594, indicating fair discriminatory power (Fig. 2). The optimal predicted-probability threshold was 0.544, corresponding to a total fascial tension value of 7.1 lbs, indicating that patients with tension over 7.1 lbs were more likely to have complications.

For the 10 patients who underwent bridged repair, fascial tension prior to bridged closure was significantly higher compared to those who were closed primarily (median 20.3 lbs vs. 8.8 lbs, 95% CI: −18.5 to −0.25; $p=0.035$). In multivariable logistic regression, fascial tension remained independently associated with short-term absorbable bridging mesh use after adjusting for operative time (OR = 1.15 per lb, 95% CI: 1.07–1.26, $p<0.001$). ROC curve analysis

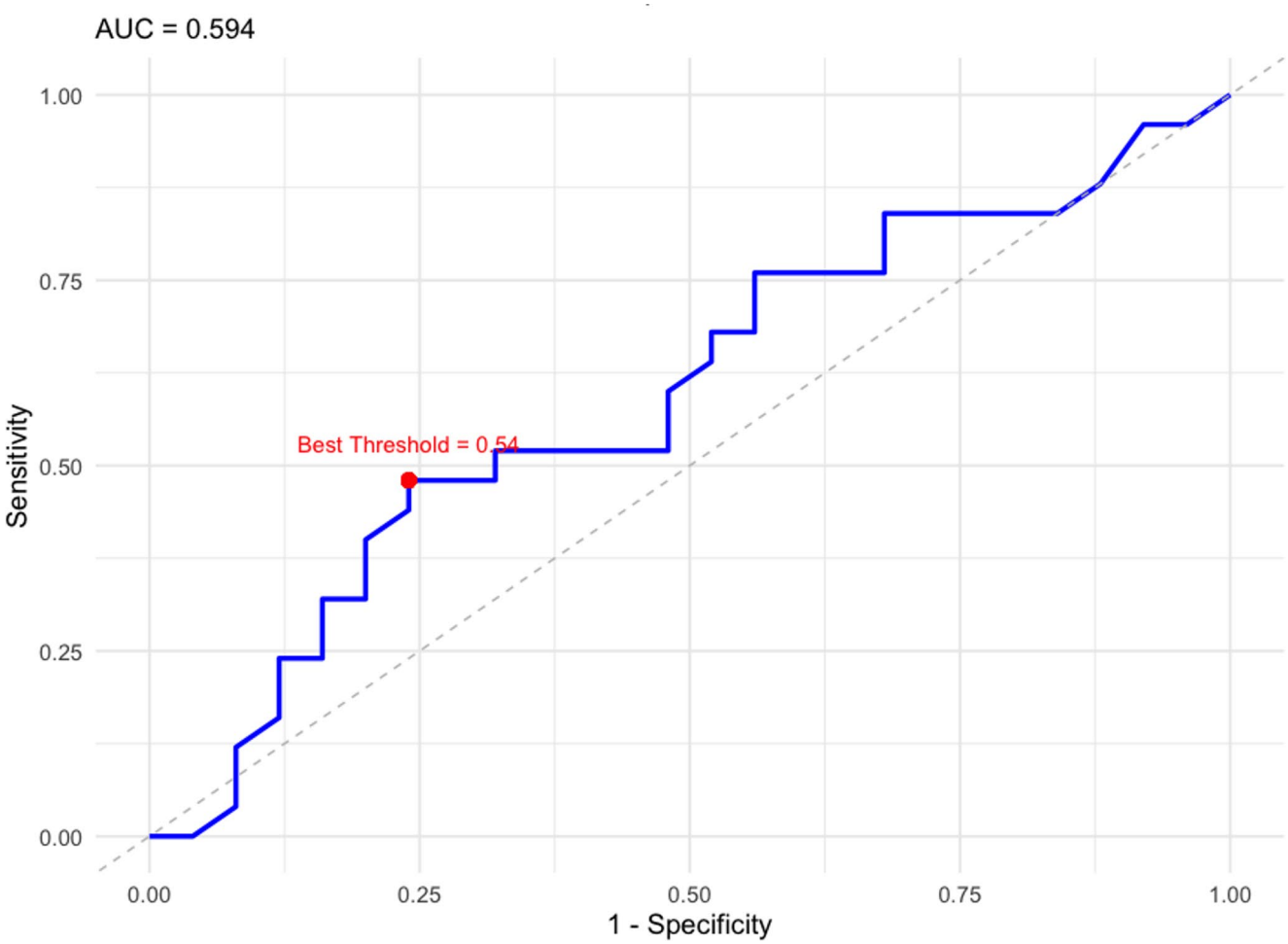


Fig. 2 Receiver operating characteristic (ROC) curve for fascial tension predicting complications

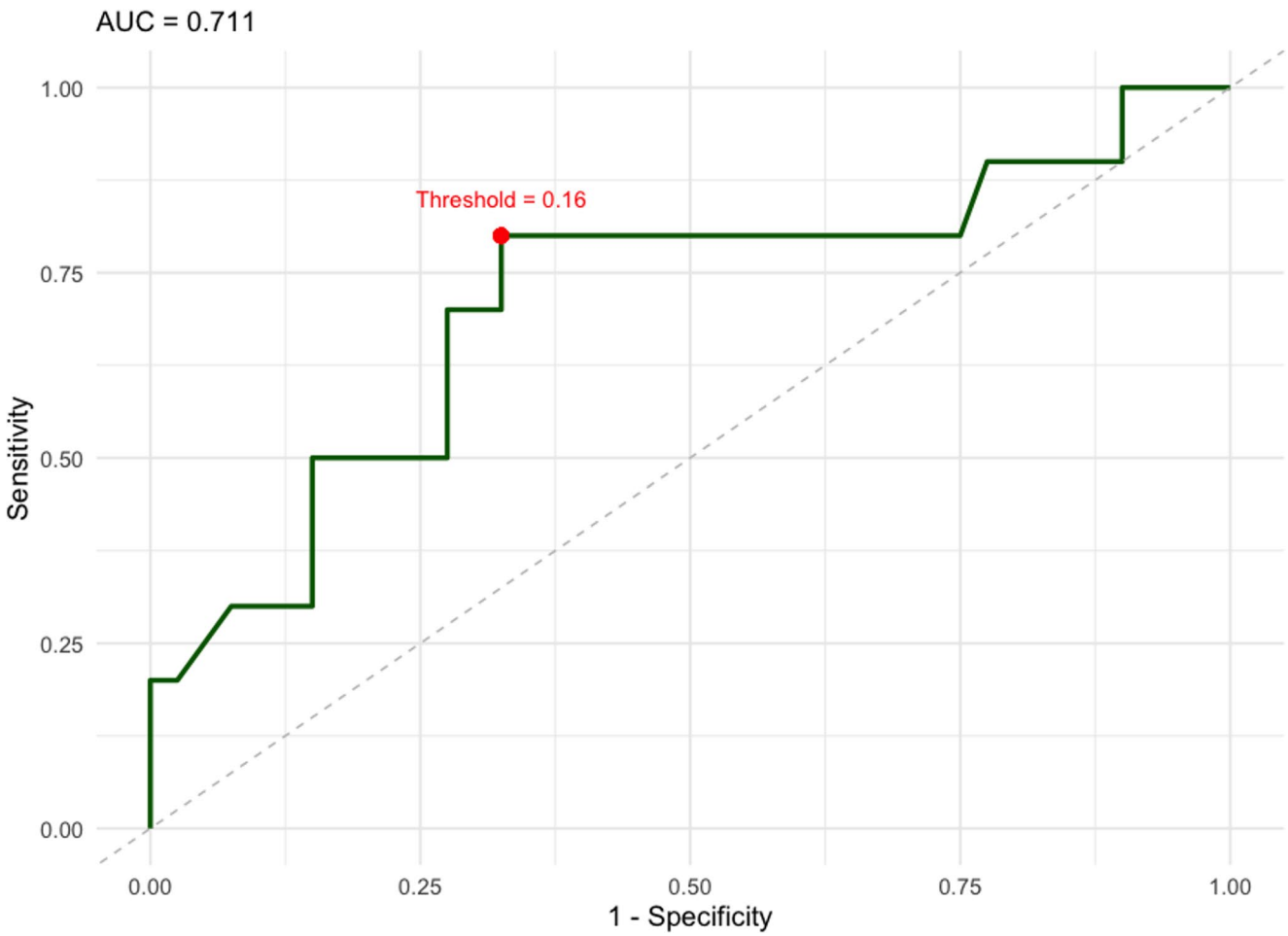


Fig. 3 Receiver operating characteristic (ROC) curve for fascial tension predicting short-term absorbable bridging mesh use

found that fascial tension had good discriminatory power for predicting short-term absorbable bridging mesh use (AUC 0.711). The optimal predicted probability threshold was 0.16, which corresponded to a fascial tension value of 11.8 lbs (Fig. 3).

Discussion

This prospective, observational cohort study represents the first quantitative assessment of fascial tension during primary ventral hernia repair and its association with postoperative complications. Our analysis revealed that 97.5% of patients who underwent primary closure were closed under supraphysiologic tension (8.8 lbs, IQR 5.4–19.0), yet closure tension was not independently associated with postoperative complications across multiple analytical models. Notably, fascial tension demonstrated reasonable discriminatory power for predicting surgeon decision-making, with a statistically derived threshold of 11.8 lbs prompting the use of bridging repair (AUC = 0.711). Furthermore, longer operative time was independently associated with increased complications. While this study provides the first objective data to quantify fascial tension during primary ventral hernia repair, these findings should be considered exploratory and hypothesis-generating rather than definitive due to several methodological considerations that limit definitive conclusions.

The importance of minimizing tension in hernia repair has become a fundamental tenet of surgical practice, originating from Irving Lichtenstein's pioneering work in inguinal hernia surgery that demonstrated significantly reduced recurrence rates compared to traditional tension-based repairs [5–7]. While this principle has been widely adopted and held as surgical dogma across essentially all hernia repairs, its application to ventral hernia surgery remains less clearly defined. Moreover, existing literature predominantly addresses tension as a subjective, qualitative assessment rather than quantitative measurement. While the role of quantitative tension in ventral hernia outcomes remains incompletely understood, emerging evidence is beginning to provide more insights [1, 2, 8–11].

Previous work from our group established that baseline physiologic tension measures approximately 1.94 lbs, consistent with earlier investigations [1, 11]. Employing the same equipment and methodology in the current study, we observed that the majority of patients who underwent primary fascial closure of ventral hernias experienced tension levels exceeding this physiologic baseline (8.8 lbs total, IQR 5.4–19.0). This finding aligns with our current understanding of the pathophysiologic changes that occur with hernia formation, including fascial edge retraction and fibrosis, decreased abdominal wall compliance, and the chronic adaptation of the abdominal cavity to reduced intraabdominal volume, that logically warrant greater force to achieve closure compared to native tissues [12, 13].

While our findings validate that successful primary closure of ventral hernias often requires accepting supraphysiologic tension levels, we also identified that the degree of tension above physiologic baseline was not associated with worse outcomes. Instead, operative time, which likely serves as a proxy for both patient and case complexity, was more strongly associated with complications, consistent with prior large database studies [14, 15]. Indeed, patient and surgical complexity has previously been shown to predict the use of bridging repairs, which in turn are associated with higher rates of complications [16, 17]. In our cohort, complication rates were higher in bridged patients compared to those closed primarily (60.0% [6/10]) vs. 47.5% [19/40]), though this difference did not reach statistical significance (95% CI: −46.7%, 21.7%, p = 0.48), likely due to limited sample size. In a similar study investigating the relationship between tension and complications after transversus abdominis release (TAR), fascial tension was not associated with SSI, SSO, readmission, ileus or bleeding requiring transfusion [18]. Taken together, these findings suggest that when primary closure is achieved, complications are more closely associated with overall complexity encompassing both patient and operative factors rather than with the absolute measure of closure tension itself.

For the 10 patients who underwent bridged repair using short-term absorbable mesh without primary fascial closure, fascial tension measured prior to bridging was significantly higher compared to those who were closed primarily (median 20.3 lbs vs. 8.8 lbs, 95% CI: −18.5 to −0.25; p = 0.035). The statistically derived threshold of 11.8 lbs for predicting short-term absorbable bridging mesh use demonstrated good discriminatory power (AUC 0.711), though the underlying physiologic rationale for this cut-point remains unclear. While we cannot definitively explain why this specific tension value represents a clinical decision point, it appears to reflect surgeon judgment regarding acceptable tension limits, possibly driven by concerns about fascial dehiscence when tension exceeds this level. Due to the relatively low number of recurrences (n = 8) and fascial dehiscence (n = 1) in the non-bridged group, we were unable to perform robust statistical analysis to examine the relationship between tension and these important outcomes.

The practical applicability of these findings warrants careful consideration and addresses what we believe is a critical knowledge gap in ventral hernia repair. While we identified a statistically derived tension value (11.8 lbs) above which surgeons in our practice chose bridging repair over primary closure, it remains unclear whether this threshold represents a true physiologic limit beyond which primary closure becomes unsafe, or simply reflects our current clinical judgment patterns. Notably, the widely-held surgical belief that higher tension directly causes more complications may require reexamination in light of these data. Given the low event rate for mechanical failures in the primary closure group, we cannot definitively determine causality between tension and fascial dehiscence. Therefore, while these data support the safety of our current practice of primary closure under high tension in staged repairs, they do not yet provide sufficient evidence to prospectively use tension measurements as the primary determinant of repair strategy. Instead, patient complexity and operative factors appear to be more important predictors of outcomes than absolute tension values in this cohort.

Had our analysis demonstrated that primary fascial closure under high tension was associated with increased complications, this might have prompted reconsideration of our clinical threshold for bridging repairs and potentially informed future studies examining optimal tension limits for primary closure. However, given the observed absence of increased complications with high-tension fascial closure in these staged scenarios, our current practice approach of prioritizing primary closure appears, on short-term follow-up, both safe and reasonable. This finding is particularly relevant for surgeons managing contaminated fields or complex cases where staged approaches are necessary. Future work should focus on validating these tension cut-points that could serve as valuable adjuncts for intraoperative decision-making, particularly in borderline cases where tension measurements fall near these values and surgical judgment alone may be insufficient to determine optimal repair strategy.

While this work represents early-stage investigation, these preliminary findings suggest that quantitative tension measurements may prove clinically useful with continued research and validation. From a practical standpoint the measurement is feasible: it uses a sterilizable, spring-based device coupled to a standard surgical clamp, adds less than a minute to the operation, and requires only a midline reference point. Rather than serving as absolute complication predictors, these measurements appear most valuable

as adjuncts to determine repair feasibility, helping identify when primary closure can be safely achieved versus when bridging techniques should be employed to avoid excessive tension. Notably, surgeons are likely already applying this reasoning intuitively based on clinical experience; however, quantitative tension measurements may offer an additional objective tool to supplement intraoperative decision-making processes. In its current form, however, the device remains a research prototype and the thresholds reported here are not yet validated. Realistic adoption will require a commercially available instrument and validation of these thresholds across diverse patient cohorts before clinical implementation, along with prospective confirmation that tension-guided decisions improve outcomes and better characterize the clinical utility of quantitative tension measurement in ventral hernia repair.

This study has several important limitations. First, the limited sample size of our cohort has insufficient statistical power to draw definitive conclusions about tension-outcome relationships, rendering these findings as hypothesis-generating and exploratory in nature. Second, the tension measurement methodology has inherent subjectivity in manual force application, and the 15 lb maximum measurement cutoff likely underestimated true values in high-tension cases, potentially masking associations with complications. Third, while the composite outcome definition including several complications (fascial dehiscence, hernia recurrence, wound morbidity, stroke, arrhythmia, ileus, etc.) provided adequate event rates for analysis, many complications are potentially unrelated to fascial tension, which may have diluted hernia-specific signals and reflected patient comorbidities rather than tension-related effects. Importantly, the median 5.5-month follow-up may be insufficient to capture late hernia recurrences, which can occur years post-repair and represent a primary tension-related outcome of interest. Long-term follow-up will be critical to characterize the incidence and timeline of hernia formation as a function of both closure tension and repair technique (primary versus bridged closure), as this represents the most clinically relevant outcome for evaluating the success of different tension thresholds and repair strategies. Future studies should focus on hernia-specific complications and employ longer follow-up periods in larger cohorts to better isolate tension-related outcomes and provide adequate power for more definitive conclusions. Additionally, refinement of tension measurement methodology to capture maximum thresholds beyond 15 lbs and exploration of alternative thresholds may further clarify the potential role of quantitative tension assessment in clinical decision-making. Although fascial closure was performed using a consistent institutional technique—slowly absorbable monofilament suture placed in a figure-of-eight fashion—suture-to-wound length ratios were not recorded. Because this ratio can influence how tension is distributed along the closure, its omission further limits interpretation of the absolute tension values reported here. Finally, formal inter-operator reliability of the tensiometry technique was not assessed in this cohort. Though we adhered to a standardized protocol for obtaining tension measurements, prospective assessment of inter-rater reliability is warranted and should be included in future studies.

Conclusion

This study provides the first quantitative assessment of fascial tension during primary ventral hernia repair, demonstrating two key findings: (1) primary closure under supraphysiologic tension (median 8.8 lbs) appears safe, with complications more closely associated with operative complexity than absolute tension values, and (2) fascial tensions exceeding 11.8 lbs were associated with surgeon decision to use bridging mesh rather than primary closure. Importantly, these preliminary findings suggest that the widely-held belief that higher tension directly causes more complications may require further examination, as patient complexity and operative factors appear to be more important predictors of outcomes than absolute tension values in this cohort. However, the clinical significance of the 11.8 lb threshold remains uncertain as it may represent either a physiologic limit for safe closure or merely reflect current surgical judgment patterns. Given the limited sample size and low event rates for tension-specific complications (one fascial dehiscence), these exploratory findings require validation in larger, multi-institutional studies specifically powered to detect mechanical failures before quantitative tension measurements can be prospectively incorporated into clinical decision-making algorithms for ventral hernia repair.

The ROC curve demonstrates the discriminatory ability of fascial tension to predict postoperative complications, with an area under the curve (AUC) of 0.594, indicating limited predictive performance. The optimal threshold identified by Youden's index was 0.54, corresponding to the red point shown, which balances sensitivity and specificity and corresponds to a total fascial tension of 7.1 lbs.

Receiver operating characteristic (ROC) curve evaluating the ability of fascial tension to predict the need for short-term absorbable bridging mesh. The area under the curve (AUC) was 0.711, indicating fair discrimination. The optimal threshold, identified at 0.16 (red point), balanced sensitivity and specificity for predicting bridging mesh use, which corresponds to a total fascial tension of 11.8 lbs.

Declarations

Competing interests The authors declare that they have no competing interests.

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