Management of blunt traumatic abdominal wall hernias: A Western Trauma Association multicenter study

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BACKGROUND: Blunt traumatic abdominal wall hernias (TAWH) occur in approximately 15,000 patients per year. Limited data are available to guide the timing of surgical intervention or the feasibility of nonoperative management.

METHODS: A retrospective study of patients presenting with blunt TAWH from January 2012 through December 2018 was conducted. Patient demographic, surgical, and outcomes data were collected from 20 institutions through the Western Trauma Association Multicenter Trials Committee.

RESULTS: Two hundred and eighty-one patients with TAWH were identified. One hundred and seventy-six (62.6%) patients underwent operative hernia repair, and 105 (37.4%) patients underwent nonoperative management. Of those undergoing surgical intervention, 157 (89.3%) were repaired during the index hospitalization, and 19 (10.7%) underwent delayed repair. Bowel injury was identified in 95 (33.8%) patients with the majority occurring with rectus and flank hernias (82.1%) as compared with lumbar hernias (15.8%). Overall hernia recurrence rate was 12.0% (n = 21). Nonoperative patients had a higher Injury Severity Score (24.4 vs. 19.4, $p = 0.010$), head Abbreviated Injury Scale score (1.1 vs. 0.6, $p = 0.006$), and mortality rate (11.4% vs. 4.0%, $p = 0.031$). Patients who underwent late repair had lower rates of primary fascial repair (46.4% vs. 77.1%, $p = 0.012$) and higher rates of mesh use (78.9% vs. 32.5%, $p < 0.001$). Recurrence rate was not statistically different between the late and early repair groups (15.8% vs. 11.5%, $p = 0.869$).

CONCLUSION: This report is the largest series and first multicenter study to investigate TAWHs. Bowel injury was identified in over 30% of TAWH cases indicating a significant need for immediate laparotomy. In other cases, operative management may be deferred in specific patients with other life-threatening injuries, or in stable patients with concern for bowel injury. Hernia recurrence was not different between the late and early repair groups. (*J Trauma Acute Care Surg.* 2021;91: 834–840. Copyright © 2021 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Therapeutic/care management, Level IV.

KEY WORDS: Traumatic abdominal wall hernia; blunt abdominal trauma; abdominal wall injury; hernia surgery.

Blunt force abdominal trauma can cause devastating organ and soft tissue injury. One infrequent injury pattern is a disruption of the abdominal wall musculature creating a traumatic hernia defect. First described in 1906, current epidemiological data indicate approximately 15,000 traumatic abdominal wall hernias (TAWH) occur annually, with an incidence of 0.17% to 0.9% in blunt trauma, which has limited the number of patients evaluated.[1–3] Specific injury patterns based on anatomic location such as posterolateral abdominal wall defects (lumbar hernias), lateral defects (flank hernias), or hernias caused by specific objects (i.e. handlebar hernias) have also been described leading to variations of terminology.[4–6]

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While many case reports, a few case series and meta-analyses of TAWH exist, no large multi-institutional studies are available.[2,3,7–11] Netto et al.[2] published one of the first larger case series in 2006 with 34 patients suggesting that asymptomatic TAWH found on CT scan could be managed nonoperatively. With 80 patients, Coleman et al.[8] published the largest series to date noting a high rate of associated splenic (32%) and small bowel injuries (36%).

Dennis et al.[12] described a grading scale for classifying abdominal wall injuries based on layer of the abdominal wall violated. Grades I and II were defined as a contusion of subcutaneous tissue and abdominal wall muscle hematoma respectively. A disrupted single abdominal wall muscle layer defined as Grade III with a complete disruption of all muscle layers classified as Grade IV. Grade V was defined by complete muscle disruption with herniated intra-abdominal contents. Evisceration of abdominal contents is defined as a Grade VI injury.

With its sporadic incidence, there are limited data to guide the timing and necessity of operative intervention for these injuries. Some have advocated for urgent laparotomy for all patients with TAWH due to the risk of associated bowel and other intra-abdominal injuries.[2] Hernia repair can be used at this time with or without mesh in the presence of visceral injury.[2,3,8] The optimal timing of repair has been investigated by Netto et al.[2] and Honaker and Green,[3] both noting an increased recurrence in early repairs. The decision for early repair often depends on the risk of strangulation, defect size, extent of other injuries, and overall clinical picture.[2,9,13] Other considerations, such as primary fascial closure versus the use of mesh in the acute setting, are also debated.[9,13] In the absence of other indications for laparotomy, stable patients may be considered appropriate for a trial observation.[3,14] Delayed repair may be considered after the patient has recovered from other injuries possibly with the use of minimally invasive techniques in select patients.[3,15,16]

This multicenter study was initiated to categorize the current techniques and strategies used in the management of patients with multiple traumatic injuries and TAWH defects. The primary aims of this study were to investigate the associated risk of bowel injury and compare outcomes of operative and nonoperative management of TAWH. A secondary aim was to compare complication rates in early and late repairs so that these data can guide surgeons in the management of these complex patients. We hypothesized that nonoperative management is feasible in select TAWH patients and that early repair may be attempted more frequently than previously described.

METHODS

The Western Trauma Association Multicenter Trials Committee sponsored the recruitment of 20 trauma centers for participation in a retrospective trauma registry review of patients sustaining TAWH. Study approval, as well as a waiver of consent, was obtained from the institutional review board at each participating center for collection of deidentified patient data. The trauma registry at each facility was queried for patients who sustained Grades IV to VI blunt TAWH from January 2012 through December 2018. Participating centers included 18 Level 1 and two Level 2 trauma centers across the continental United States. Patients of all ages were included in this study.

TABLE 1. Revised High-Grade Traumatic Abdominal Wall Hernia Grading Scale

Grade	Anatomic Region	Description
IV	Rectus	Complete anterior abdominal wall muscle disruption
	Flank	Complete lateral abdominal wall muscle disruption
	Lumbar	Complete posterior abdominal wall muscle disruption
V	Rectus	Anterior disruption with herniation
	Flank	Lateral disruption with herniation
	Lumbar	Posterior disruption with herniation
VI	Rectus	Anterior herniation with evisceration
	Flank	Lateral herniation with evisceration
	Lumbar	Posterior herniation with evisceration

Patients with traumatic hernias due to penetrating mechanism and those with incomplete medical records were excluded.

The grading system devised by Dennis et al.[12] described above was modified to include the anatomic region of the hernia defect (Table 1). Anterior abdominal wall hernias were termed "rectus," lateral hernias involving the internal/external obliques and transversalis muscle were termed "flank," and posterolateral hernias confined to the lumbar triangles were termed "lumbar." These designations were used to further categorize the high-grade TAWH investigated in this study.

Patients who underwent operative management of their TAWH were compared with patients who underwent nonoperative management. The primary outcomes investigated were hospital length of stay (LOS), intensive care unit (ICU) LOS, and mortality. Within the operative group, patients were stratified by early and late operative intervention, and these groups were compared in a subgroup analysis. Early repair was defined as repair during the patient's index hospitalization, and late repair was defined as repair after index hospitalization. The secondary outcomes investigated were use of mesh, surgical site infection, use of bony fixation and hernia recurrence.

A power analysis was conducted based on limited available data. With an estimated effect size of 20% and power of 0.80 it was determined that 273 patients would be needed to demonstrate a 5% difference in hernia recurrence rates comparing early vs. late repair.

Statistical analyses were performed using SPSS Statistics 27.0 software (IBM Armonk, NY). Patient groups were compared using independent t tests, χ^2 tests or Fisher's exact tests for continuous and categorical variables respectively. Mean values ± standard deviations are presented. A p value less than 0.05 was considered statistically significant.

RESULTS

Patient Population

A total of 281 patients were identified with TAWH with an average age of 38.65 ± 18.06 years and a range of 4 years to 90 years. The majority of patients were men (59.6%), White (68.7%), and insured (75.8%). Motor vehicle collision (MVC) was the most common mechanism of injury (66.2%) with motorcycle collision (9.6%), pedestrian struck (7.1%), bicycle accident (4.3%), and falls (5.7%) also causing these injuries. The mean Injury Severity Score (ISS) was 21.1 ± 14.4. The mean hospital LOS was 6.0 days with most patients being discharged

to home (58.4%). The overall mortality rate was 6.8% (n = 19). Urgent laparotomy directly from the trauma bay was performed in 155 (55.2%) patients, with 69 (30.3%) of those undergoing an initial damage-control procedure. A total of 95 (33.8%) patients underwent management of a hollow viscous injury during their primary operation. The total demographic data of the study population are displayed in Table 2.

One hundred and five (37.4%) patients of the 281 patients did not have repair of their TAWH. Thirty-eight (36.2%) of the 105 not undergoing repair underwent immediate abdominal exploration for other injuries. Of the 176 that underwent hernia repair intervention, 157 (89.2%) were performed early (during the patient's index hospitalization) and 19 (10.8%) were performed late (during subsequent hospitalization). Anatomically, 95 patients (33.8%) had a rectus hernia, 125 (44.4%) a flank hernia, and 58 (20.6%) had a lumbar hernia.

Comparison of Hernia Repair and Nonoperative Groups

Hernia repair (n = 176) and nonoperative (n = 105) group demographic data were then compared (Table 2). There was no difference in age (37.2 ± 18.2 vs. 41.1 ± 19.3 years, $p = 0.081$), race (68.6% vs. 66.7% white, $p = 0.527$), or sex (58.5% vs. 54.3% male, $p = 0.569$) between the two groups. Hernia repair and nonoperative patients also had a similar rate of any insurance coverage (79.0% vs. 71.2%, $p = 0.181$) and rate of MVC as mechanism of injury (63.6% vs. 70.5%, $p = 0.055$).

Figure 1 shows the significant difference in the distribution of hernia locations between the hernia repair and nonoperative groups. Patients in the nonoperative group had a significantly higher rate of lumbar hernias (38.1% vs. 10.2%, $p < 0.001$) compared with the hernia repair group which had a higher rate of rectus hernias compared with nonoperative patients (40.3% vs. 22.9%, $p = 0.004$). Of patients who had bowel injury, 31.6% were rectus hernias, 50.5% flank hernias, and 15.8% lumbar hernias. Across the total patient cohort, lumbar hernias were significantly smaller than rectus or flank hernias (5.2 ± 4.0 vs. 9.5 ± 7.1 vs. 9.4 ± 7.7 cm, $p = 0.002$).

Figure 2 demonstrates the distribution of ISS and head, face, leg, abdomen, chest, and spine Abbreviated Injury Scale (AIS) comparing hernia repair and nonoperative groups. The nonoperative group had a significantly higher ISS (24.4 ± 16.6 vs. 19.4 ± 12.7, $p = 0.010$) and AIS for the head (0.57 ± 1.1 vs. 1.1 ± 1.8, $p = 0.006$), face (0.15 ± 0.51 vs. 0.35 ± 0.80, $p = 0.023$), leg (1.34 ± 1.36 vs. 1.83 ± 1.54, $p = 0.005$), chest (1.43 ± 1.53 vs. 1.94 ± 1.81, $p = 0.011$), and spine (0.60 ± 1.02 vs. 0.90 ± 1.1, $p = 0.021$) scores. The hernia repair group had a significantly higher AIS abdomen score (2.65 ± 1.45 vs. 2.21 ± 1.44, $p = 0.015$).

No difference was found in hospital LOS (16.4 ± 16.4 vs. 14.8 ± 19.8 days, $p = 0.456$), ICU LOS (6.2 ± 9.3 vs. 5.7 ± 11.0 days, $p = 0.727$), or ventilator days (3.8 ± 8.0 vs. 4.3 ± 10.3 days, $p = 0.65$) in comparing the hernia repair and nonoperative groups (Table 2). Discharge disposition distribution was statistically different between the groups, with hernia repair patients more likely to be discharged home (63.6% vs. 50.0%, $p = 0.041$) rather than to rehabilitation or skilled nursing facilities. Hernia repair patients also had larger average hernia defect size (10.3 ± 7.7 vs. 4.9 ± 3.6 cm, $p < 0.001$). Mortality,

TABLE 2. Patient Demographic Data Stratified by Hernia Repair

Variable	All Patients (N = 281)	Hernia Repair (n = 176)	Nonoperative (n = 105)	*p*
Age	38.65 ± 18.06	37.20 ± 17.15	41.09 ± 19.31	0.081
Sex (male)	160 (56.9%)	103 (58.5%)	57 (54.3%)	0.569
Race (White)	193 (68.7%)	123 (68.6%)	70 (66.7%)	0.527
BMI	30.0 ± 7.67	29.40 ± 7.13	31.82 ± 8.32	**0.012**
Smoking	78 (27.8%)	53 (30.3%)	25 (24.0%)	0.324
Hypertension	62 (22.4%)	37 (21.1%)	26 (25.0%)	0.534
COPD	6 (2.1%)	3 (1.7%)	3 (2.9%)	0.674
Insurance	213 (75.8%)	139 (79.0%)	74 (71.2%)	0.181
MOI (MVC)	186 (66.2%)	112 (63.6%)	74 (70.5%)	0.055
ISS	21.22 ± 14.40	19.41 ± 12.66	24.37 ± 16.61	**0.010**
Hospital LOS	15.82 ± 17.70	16.43 ± 16.36	14.80 ± 19.78	0.456
ICU LOS	6.04 ± 9.93	6.20 ± 9.26	5.77 ± 11.00	0.727
Ventilator days	3.94 ± 8.89	3.75 ± 7.96	4.26 ± 10.31	0.645
Mortality	19 (6.8%)	7 (4.0%)	12 (11.4%)	**0.031**
Discharge status:				
Home	164 (58.4%)	112 (63.6%)	52 (50.0%)	**0.041**
Rehab	73 (26.0%)	42 (23.9%)	31 (29.8%)	
SNF	24 (8.5%)	15 (8.5%)	9 (8.7%)	
Morgue	19 (6.8%)	7 (4.0%)	12 (11.5%)	
Defect size (cm)	8.37 ± 6.99	10.29 ± 7.68	4.94 ± 3.57	**<0.001**
Immediate Laparotomy	155 (55.2%)	117 (66.5%)	38 (36.2%)	**<0.001**
Damage control	69 (30.3%)	59 (35.3%)	10 (16.4%)	**0.010**
Bowel resection	95 (33.8%)	75 (44.4%)	20 (32.8%)	0.154

Statistically significant *p* values are in bold emphasis.
BMI, body mass index; COPD, chronic obstructive pulmonary disease; MOI, mechanism of injury, SNF, skilled nursing facility.

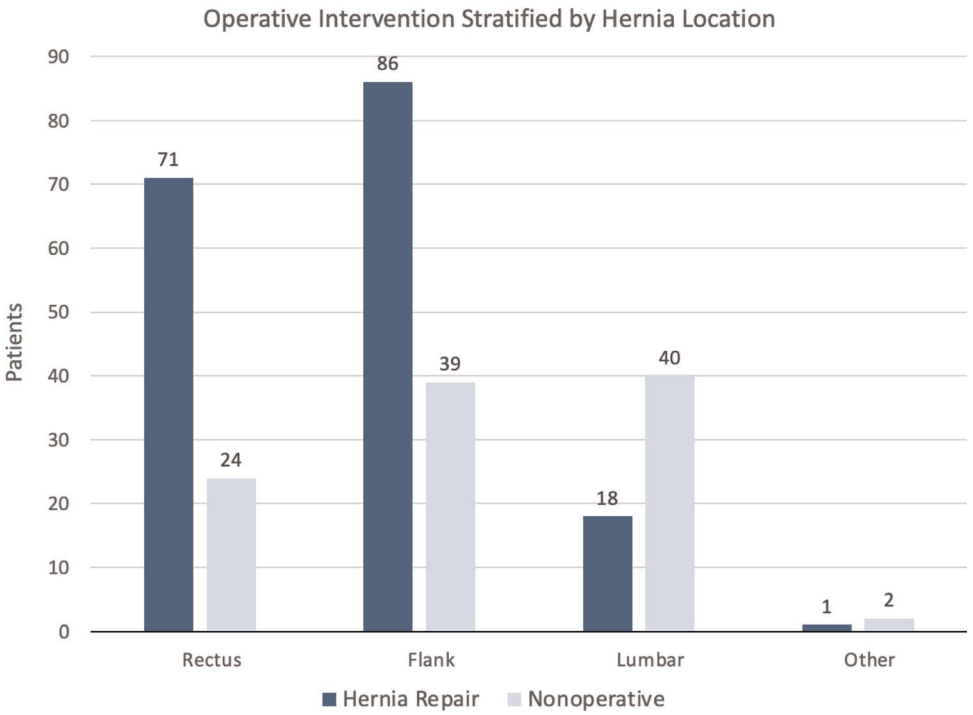

Figure 1. Comparison of traumatic abdominal wall hernia location in hernia repair and nonoperative groups.

however, was significantly lower in the hernia repair group (4.0% vs. 11.4%, $p = 0.031$).

Comparison of Early and Late Hernia Repair Groups

Table 3 demonstrates the surgical data for the total hernia repair cohort and compares the early and late repair groups. Bowel injury was treated in 41.3% (n = 95) of the hernia operation patients. A primary fascial repair was performed in 130 (73.9%) patients and mesh was used in 66 (37.5%) patients. Bone fixation of tissue or mesh to the iliac crest was performed in 41 (23.3%) hernia repair patients.

The time to repair was significantly different between the early and late groups (1.7 ± 2.98 vs. 377.3 ± 429.5 days, $p = 0.001$). Patients who underwent early hernia repair had higher rates of primary fascial closure (77.1% vs. 46.4%, $p = 0.012$) and lower rates of mesh utilization (32.5% vs.

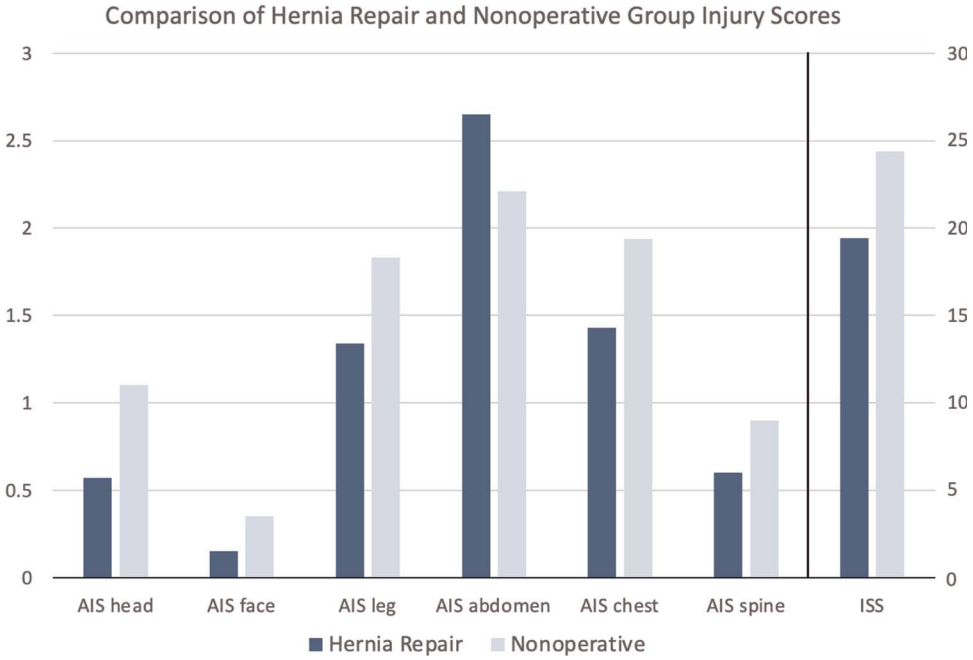

Figure 2. Injury scores in hernia repair and nonoperative groups.

TABLE 3. Hernia Repair Patient Demographic, Operative, and Outcome Data Stratified by Operative Timing

Variables	Hernia Repair (n = 176)	Early (n = 157)	Late (n = 19)	*p*
Time to repair (d)	42.49 ± 181.16	1.72 ± 2.98	377.26 ± 429.49	**0.001**
Defect size (cm)	10.29 ± 7.68	10.38 ± 7.80	9.53 ± 6.82	0.696
Immediate laparotomy	117 (66.5%)	108 (68.8%)	9 (47.4%)	0.107
Damage control	59 (35.3%)	53 (34.6%)	6 (42.9%)	0.746
Repair at first laparotomy	113 (66.9%)	110 (71.4%)	3 (20.0%)	**<0.001**
Bowel resection	75 (44.4%)	69 (44.8%)	*6 (40.0%)	0.932
Contamination	57 (28.4%)	43 (27.9%)	5 (33.3%)	0.886
Primary repair	130 (73.9%)	121 (77.1%)	9 (46.4%)	**0.012**
Mesh placement	66 (37.5%)	51 (32.5%)	15 (78.9%)	**<0.001**
Incision:				
Midline	120 (68.6%)	113 (72.4%)	7 (36.8%)	**0.013**
Flank	30 (17.1%)	22 (14.1%)	8 (42.1%)	
Posterior	2 (1.1%)	2 (1.3%)	0 (0.0%)	
Other	23 (13.1%)	19 (12.2%)	4 (21.1%)	
Approach				
Open	158 (90.3%)	145 (92.9%)	13 (68.4%)	**<0.001**
Laparoscopic	14 (8.0%)	11 (7.1%)	3 (21.4%)	
Robotic	3 (1.7%)	0 (0.0%)	3 (15.8%)	
Bone fixation	41 (23.3%)	37 (23.6%)	4 (21.1%)	1.000
Hernia location				
Rectus	71 (40.3%)	67 (42.7%)	4 (21.1%)	0.184
Flank	86 (48.9%)	75 (47.8%)	11 (57.9%)	
Lumbar	18 (10.2%)	14 (8.9%)	4 (21.1%)	
Other	1 (0.6%)	1 (0.6%)	0 (0.0%)	
Recurrence	21 (12.0%)	18 (11.5%)	3 (15.8%)	0.869
Mesh infection	1 (1.1%)	1 (1.4%)	0 (0.0%)	1.000
SSI	26 (14.9%)	23 (14.7%)	3 (15.8%)	1.000
Hospital LOS	16.43 ± 16.36	16.57 ± 16.65	15.32 ± 14.08	0.745
ICU LOS	6.20 ± 9.26	6.08 ± 9.01	7.16 ± 10.79	0.634
Ventilator days	3.75 ± 7.96	3.58 ± 7.65	5.16 ± 10.33	0.416
Mortality	7 (4.0%)	7 (4.5%)	0 (0.0%)	1.000

Statistically significant *p* values are in bold emphasis.
*Five of these patients underwent immediate laparotomy.
SSI, surgical site infection,

78.9%, $p < 0.001$). Early operative patients were also more likely to undergo an open surgery (92.9% vs. 68.4%, $p < 0.001$). Eleven (7.1%) patients in the early repair group were repaired laparoscopically, all performed on hospital day 0 or 1. Mesh reinforcement was used in 29 (16.4%) patients who also underwent bowel resection, with no mesh infections.

The outcome data comparing early and late hernia repair groups are shown in Table 3. No difference was found between the early and late groups in rates of hernia recurrence (11.5% vs. 15.8%, $p = 0.869$), mesh infection (1.4% vs. 0.0%, $p = 1.000$), or surgical site infection (14.7% vs. 15.8%, $p = 0.001$). In addition, there was no difference in hospital LOS (16.6 ± 16.7 vs. 15.3 ± 14.1 days, $p = 0.745$), ICU LOS (6.1 ± 9.0 vs. 7.2 ± 10.8, $p = 0.634$), or mortality (4.5% vs. 0.0%, $p = 1.000$).

DISCUSSION

While numerous single-center studies of TAWHs exist, the relative rarity of these injuries in blunt trauma has limited comprehensive evaluation of the subject.[3,8,12] This study spanning 7 years describes 281 patients with TAWH from 20 trauma centers across the United States. The results reflect a diverse management approach in a complex patient population with a multitude of other injuries and care priorities. Bowel injury was identified in over one third of TAWH patients. Nonoperative management was pursued in 37.3% of patients. No difference was seen in the rate of hernia recurrence, surgical site infection, or mortality for early hernia repair compared with late hernia repair.

Traditional management of TAWH has called for mandatory abdominal exploration due to risk of associated bowel injury, with a reported incidence of bowel injury ranging from 18% to 60% (Table 4).[2,3,8] Chow et al.[14] reported a 60% incidence of bowel injury in a single center case series of 15 patients identified over 14 years. The remaining five relevant studies totaling 221 patients report incidences of bowel injury ranging from 18% to 36%, similar to the reported incidence of 33.8% in this study. Excluding the one outlier study, the risk of bowel injury associated with TAWH is approximately one patient in three. As such, vigilant evaluation of TAWH patients should occur with a bias toward immediate operative evaluation if any concerns for bowel injury exist.

TABLE 4. Studies Investigating Traumatic Abdominal Wall Hernias

Author (Year)	Patients	Bowel Injury	Nonoperative	*Early Repair	*Late Repair	Primary Repair	Mesh Repair	Recurrence
Harrell (2021)	281	95/281 (33.8%)	105/281 (37.4%)	157/281 (55.9%)	19/281 (6.7%)	130/176 (73.9%)	66/176 (37.5%)	21/176 (12.0%)
Chow (2020)[14]	15	9/15 (60.0%)	0/15 (0.0%)	14/15 (93.0%)	1/15 (7.0%)	5/15 (32.0%)	11/15 (68.0%)	4/15 (26.7%)
Pardhan (2016)[10]	44	8/44 (18.2%)	3/44 (7.0%)	37/44 (84.1%)	4/44 (9.1%)	—	5/41 (12.0%)	3/41 (7.3%)
Coleman (2015)[8]	80	29/80 (36.0%)	57/80 (71.3%)	18/80 (22.5%)	5/80 (6.3%)	16/23 (69.6%)	7/23 (30.4%)	6/23 (26.1%)
Honaker (2014)[3]	38	— 20.0%	8/38 (21.1%)	27/38 (71.1%)	3/38 (7.9%)	19/30 (63.3%)	11/30 (36.6%)	3/30 (10.0%)
Bender (2008)[7]	25	6/25 (24.0%)	3/25 (12.0%)	11/25 (44.0%)	11/25 (44.0%)	—	18/22 (81.8%)	3/22 (13.6%)
Netto (2006)[2]	34	12/34 (35.0%)	19/34 (55.8%)	13/34 (38.2%)	2/34 (5.9%)	—	—	3/15 (20.0%)
Average	74	32.4%	29.2%	58.4%	12.4%	59.8%	44.4%	16.5%

*Varied definition among studies.

The decision when to repair TAWHs is difficult as patients often have concomitant injuries and may not be in a physiologic state to undergo surgery or optimize healing. Nearly two thirds of the 281 total patients underwent repair of their TAWH, with 10% of those performed after the initial hospitalization. Over one third of patients not receiving hernia repair underwent immediate exploration for other injuries leaving 24% of the total study population that underwent completely nonoperative management of their TAWH. Similar to the present results, Coleman et al.[8] reported 35 patients that underwent urgent abdominal exploration with 12 (34%) patients not receiving hernia repair at the time of laparotomy. Of the 38 patients undergoing laparotomy without hernia repair in this study, 25% underwent damage-control laparotomy and just over 50% of patients had bowel injury indicating that there was some other concern at the time of surgery that likely influenced the decision not to repair the hernia. Furthermore, 27 (70%) of these patients had either flank or lumbar hernias which often require fixation of tissue or mesh to the iliac crest which can be another deterrent to hernia repair in a patient with visceral edema, shock, widespread bowel contamination, or other critical injuries.

In many cases, the decision for nonoperative management of TAWH is based on the patient's physiologic status and overall injury burden, including traumatic brain injury, which were both higher in the nonoperative group as evidenced by higher ISS and head AIS score. Mortality was also higher in the nonoperative cohort, suggesting that while nonoperative management is feasible in patients with isolated TAWH, it may be preferred in other patients with other more critical injuries best managed nonoperatively (Fig. 2).

Two observations are apparent in the 67 patients that underwent complete nonoperative management of their TAWH. The first is the size of the hernia defect which was almost 6 cm larger in the operative group. Secondly, the nonoperative group had more patients with lumbar hernias that less commonly had herniated bowel or associated bowel injury. The smaller size and reduced incidence of bowel injury suggests the treatment of lumbar hernias may be different from flank and rectus hernias. Indeed, only 15.8% of patients in this study with bowel injury had a lumber hernia, while 82.1% of patients with bowel injury had a rectus or flank hernia. Modifying the high-grade hernia grading scale is useful in further categorizing TAWH and the associated risk of bowel injury by anatomic location (Table 1).[12]

Early versus late repair of TAWH had varied definitions in the literature.[3,7,9,17] For this study, early was defined as during the patient's initial hospitalization with late repair sometime after discharge. The early repair patients were repaired within 48 hours on average, while the average timing for the late groups was more than 1 year after the patient's initial injury. More than three fourths of patients in the late repair group had mesh placed compared with less than one third of the early hernia repair patients, likely because of the decreased concern about contamination from other injuries or increase in the size of the hernia over time requiring the use of mesh. However, interestingly, the only mesh infection reported occurred in the early group, and this patient did not have any associated bowel injury. Also, of note, 41 (23.3%) patients required tissue or mesh fixation to bone to accomplish repair of their TAWH. No difference in bone fixation

rates was found between the early and late hernia repair groups. Overall, the patient outcomes, such as hospital LOS, ICU LOS, ventilator days, and mortality, were not different between the early and late groups. The overall hernia recurrence rate was 12%, similar to previously published literature (Table 4).[3,7,10] These findings suggest that early repairs may be safer than previously thought and should not dissuade surgeons from an attempt at the time of laparotomy, even if the laparotomy was for a separate indication.

More than 90% of early repairs were performed open, compared with 68% of late repairs. Delayed repairs were frequently performed with laparoscopic or robotic techniques often with mesh reinforcement, similar to nontraumatic hernias. Novitsky[16] described a series of 14 patients who underwent laparoscopic repair of a traumatic flank hernia with suture passer-assisted primary fascial closure and intra-abdominal mesh reinforcement. Alternatively, Ferris et al.[15] described a case of laparoscopic bridging mesh repair affixed with tacks and transfascial sutures. While most delayed hernia repairs in this study were performed, open (68.4%), laparoscopic (15.8%), and robotic (15.8%) techniques were used. Others have advocated for a laparoscopic approach during the index hospitalization, and 11 patients in this study underwent an early laparoscopic repair of their TAWH, all performed on hospital Day 0 or 1.[18] This early laparoscopic approach should be carried out with caution in the acutely injured patient because of the potential for coexisting injury, contamination, inability to tolerate insufflation, and so on. While Honaker and Green[3] and Netto et al.[2] noted a decreased recurrence and complication rate with a delayed repair, there was no difference in this report.

This study is limited by its retrospective nature, and although 20 centers contributed data, this represents only a small sample of trauma centers and surgical practices across the United States. Definitions and trauma registry recording practices also vary across centers. A significant limitation is that the late repair group had a small number of patients which diminished our statistical power, limits the validity of our initial power analysis, and may introduce significant selection bias. Because of concerns about the lack of follow-up, the reported recurrence rates may underestimate actual recurrence rates and we do not know the fate of patients not undergoing early repair if they had their hernia repaired at another facility after discharge. Data describing specifics of the type of mesh and method of fixation were not available. The data also do not distinguish between small bowel and colon injuries and do not include seat belt injury information. Large, prospective studies are needed to better guide the treatment of these complex injuries.

This study represents the largest and only multicenter report to date describing the management of TAWHs. Bowel injury occurred in just over one third of patients with TAWH and one quarter of patients were treated totally nonoperatively. Nonoperative patients were overall more injured, and observation of a TAWH may be appropriate when other injuries take precedent, and there is no concern for bowel injury. When comparing early versus late repairs, patients who underwent early hernia repair were more likely to have a primary tissue repair and less likely to have mesh placed, whereas there was no difference in the rate of hernia recurrence. Early repair of TAWH appears to be safe with low complication and recurrence rates.

AUTHORSHIP

K.N.H. and R.A.M. contributed to the study concept and design. K.N.H., A.D.G., R.M.A., J.K.R., W.R.U., J.D.S., S.R.T., M.D.T., M.N., B.W.T., S.A.A., A.LR., M.C.S., M.J.C., B.R.C., B.S.K., M.A.dM., M.J.L., J.M.C., J.M.H., K.L.L., D.C.C., C.R.F., R.C.P., D.B., M.T.K., H.B.A., P.O.U., G.D.S., A.N.H., W.L.B., K.B.S., G.M., O.M., J.N., N.S., S.L.M., and R.A.M. contributed to the acquisition of data. K.N.H. and R.A.M. contributed to the statistical analysis and interpretation of the data. K.N.H. and R.A.M. contributed to the drafting of the article. K.N.H., A.D.G., R.M.A., J.K.R., W.R.U., J.D.S., S.R.T., M.D.T., M.N., B.W.T., S.A.A., A.LR., M.C.S., M.J.C., B.R.C., B.S.K., M.A.dM., M.J.L., J.M.C., J.M.H., K.L.L., D.C.C., C.R.F., R.C.P., M.T.K., H.B.A., P.O.U., G.D.S., A.N.H., W.L.B., K.B.S., G.M., O.M., J.N., N.S., S.L.M., and R.A.M. contributed to the critical revision of the article for intellectual content.

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DISCLOSURE

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