The persistent diagnostic challenge of thoracoabdominal stab wounds

Regan J. Berg, MD, Efstathios Karamanos, MD, Kenji Inaba, MD, Obi Okoye, MD, Pedro G. Teixeira, MD, *and* **Demetrios Demetriades, MD, PhD,** *Los Angeles, California*

BACKGROUND: Penetrating thoracoabdominal trauma, with potential injury to two anatomic cavities, significantly challenges surgical management, yet this injury pattern has not been reviewed across a large patient series.

METHODS: The trauma registry of a major level 1 center was queried for all adult patients admitted with thoracoabdominal stab wounds between January 1996 and December 2011.

RESULTS: The study identified 617 patients; 11% arrived hypotensive (systolic blood pressure < 90 mm Hg), 6.5% had Glasgow Coma Scale (GCS) score less than 8, and 3.6% were in cardiac arrest. Of those arriving alive, 350 (59%) of 595 underwent surgery (88% laparotomy, 3% thoracotomy, and 9% both procedures). Nontherapeutic laparotomy was performed on 12.3% of these patients. Cardiac injury occurred in 71% (29 of 41) of the patients arriving alive undergoing thoracotomy. Among this group, only 1 (2.4%) of 41 had a major thoracic vessel or aortic injury without cardiac trauma. Diaphragmatic injury (DI) occurred in 224 (38%) of 595, with 72 (32.1%) of these 224 demonstrating no computed tomographic evidence of DI. Either hollow viscus injury or DI occurred in 50%. Only 36.8% of liver, 58% of spleen, and 29.8% of kidney injuries required surgical repair. The need for dual-cavitary intervention was associated with a precipitous increase in patient mortality.

CONCLUSION: Patients with thoracoabdominal stab wounds present considerable clinical challenges due to high surgical need, high occult DI incidence, persistently high rates of negative laparotomy, and significant mortality with dual-cavitary intervention. Many patients with solid-organ injuries do not require intervention. High incidence of hollow viscus injury and DI ultimately limits nonoperative management. Laparoscopy is necessary to exclude occult DI. In unstable patients, determination of which anatomic cavity to explore primarily requires exclusion of cardiac injury. In those with equivocal clinical or ultrasonographic evidence of cardiac trauma, laparotomy, with transdiaphragmatic pericardial window, if a causative abdominal injury is not immediately apparent, seems the most effective strategy. (*J Trauma Acute Care Surg*. 2014;76: 418–423. Copyright © 2014 by Lippincott Williams & Wilkins)

LEVEL OF EVIDENCE: Epidemiologic study, level III.

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Concomitant penetrating trauma to both the chest and the abdomen has been described as a situation of "double jeopardy" owing to the inherent difficulty of managing potential injury to two anatomic cavities.[1] Assessment of these patients may be confounded by misleading chest tube outputs, unreliable examination findings in those with diaphragmatic injuries (DIs), and the pressures of decision making in the face of clinical instability.[2–4] Despite recognized clinical complexity, optimal management strategies are uncertain for this population because the frequency and nature of operative interventions, amenability to nonoperative management (NOM), and subsequent outcomes remain incompletely described. Even in high-volume centers, the management strategies for diagnostic evaluation and surgical sequencing are debated, and this injury pattern's relative rarity has hindered the large-scale study that might contribute to optimal management.

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From the Division of Trauma Surgery and Surgical Critical Care, Los Angeles County Medical Center–University of Southern California, Los Angeles, California.
Address for reprints: Demetrios Demetriades, MD, PhD, Division of Trauma Surgery and Surgical Critical Care, LAC+USC Medical Center, 2051 Marengo St, Inpatient Tower–Room C5L100, Los Angeles, CA, 90033; email: demetria@usc.edu.

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Previous reviews of penetrating thoracoabdominal injury have focused on specific anatomic regions[5,6] and mechanisms,[7,8] primarily addressed surgical sequencing,[1,9] or featured very small numbers of patients.[10–12] In addition, firearm and nonfirearm trauma demonstrate fundamental differences in weapon kinetics, the nature and extent of resultant injuries, and the amenability to NOM, distinctions that are lost when these two mechanisms are examined together. The current review examines injury patterns, operative procedures, and outcomes in all patients with thoracoabdominal stab wounds (SWs) admitted to the Los Angeles County and University of Southern California Medical Center (LAC+USC) over 16 years in an attempt to determine potentially advantageous management strategies for this challenging population.

PATIENTS AND METHODS

Following institutional board review, all patients with concomitant SWs to both the chest and the abdomen admitted to LAC+USC between January 1996 and November 2011 were reviewed. To best capture the population of interest to clinicians, enrollment thoracoabdominal injury was defined as the presence of two or more nonsuperficial, penetrating external wounds, involving both the thorax and the abdomen, regardless of subsequent registry-coded injury severity. Demographics,

TABLE 1. Population Demographics and Admission Physiologic Variables

	Total (n = 617)	Patients Alive on Admission (n = 595)
Demographics and vitals on admission		
Age, median (range), y	29 (2–87)	29 (2–87)
Age ≥ 55 y, n (%)	18/617 (2.9)	17/595 (2.9)
Male, n (%)	564/617 (91.4)	544/595 (91.4)
Hypotension, SBP ≤ 90 mmHg, n (%)	68/617 (11.0)	46/595 (7.7)
Heart rate > 120 beats/min, n (%)	100/617 (16.2)	98/565 (16.5)
GCS score ≤ 8, n (%)	40/617 (6.5)	19/595 (3.2)
Cardiac arrest on admission, n (%)	22/617 (3.6)	0
Injury severity		
ISS < 15, n (%)	385/617 (62.4)	381/595 (64.0)
ISS, 15–24, n (%)	144/617 (23.3)	141/595 (23.7)
ISS ≥ 25, n (%)	88/617 (14.3)	73/595 (12.3)
Head AIS score > 2, n (%)	32/617 (5.2)	28/595 (4.7)
Extremity AIS score > 2, n (%)	35/617 (5.7)	35/595 (5.9)
Chest and abdomen AIS score > 2, n (%)	182/617 (29.5)	173/595 (29.1)

Severe head injury defined as the presence of intracranial pathology or head AIS score of 3 or greater.

initial physiologic parameters, mechanism, injury distribution, operative procedures, need for massive transfusion (MT), mortality, and intensive care unit and hospital length of stay (LOS) were abstracted from the institutional trauma registry. Medical record review obtained missing registry data.

The total population and the subgroup arriving alive were analyzed. Management strategies (no surgical procedure, tube thoracostomy alone, laparotomy alone, thoracotomy alone, or thoracotomy and laparotomy) were tabulated. "Thoracotomy" included both lateral thoracic incisions and median sternotomy. Resuscitative thoracotomy (RT) was defined as an emergent procedure for immediate hemodynamic decompensation or cardiac arrest, performed outside the operating room. The distribution of chest and abdominal injuries was tabulated and examined across the total population as well as the subgroup arriving alive. Injuries in those arriving alive were then examined by management strategy. The diagnosis and management of DI was examined separately.

Significant outcomes, LOS, mortality, and the need for MTs were described for the total population as well as the subgroup arriving alive. Mortality was also described according to need for, and type of, operative procedure.

Bivariate analysis of patient demographics, injury patterns, and management interventions was performed in the subgroup arriving alive to identify differences between those who did and did not survive to discharge. All discordant factors at $p < 0.2$ on the bivariate analysis were included in a stepwise logistic regression model, to identify independent mortality predictors.

Continuous variables were reported as mean (SD) and occasionally dichotomized using clinically relevant cutoff points as follows: age (≥55 years vs. <55 years), admission systolic blood pressure (SBP) (<90 mm Hg vs. ≥90 mm Hg), Glasgow Coma Scale (GCS) score (≤8 vs. >8), and Injury Severity Score (ISS) (≥25 vs. <25). Categorical variables were reported as a proportion or percentage of the total population. Continuous variables were compared using unpaired t or Mann-Whitney U-tests. All analyses were performed using SPSS for Windows, version 17 (Chicago, IL).

RESULTS

During the 16-year study period, 617 patients sustained penetrating thoracoabdominal injury from SWs, for whom complete registry and chart records were available. The vast majority (91.4%, 564 of 617) were male, with only 2.9% older than 55 years. Overall, 11% presented hypotensive (SBP < 90 mm Hg), 16.2% presented tachycardic (heart rate > 120 beats/min), and 6.5% presented with a GCS score of less than 8. A small minority (22 of 617, 3.6%) presented in cardiac arrest. Demographics, overall injury severity, and incidence of concomitant head or extremity injury did not differ significantly between those arriving alive and the total population (Table 1).

Table 2 summarizes the management strategies. Overall, 250 (40.5%) of the 617 did not require any operative procedure. Tube thoracostomy, as the only intervention, was performed in 7.6%. Laparotomy was the most common surgical intervention, as a sole procedure in 56.2% (325 of 617) and in conjunction with a thoracotomy in an additional 6.0% (37 of 617). Overall, nontherapeutic operation was performed in 12.4% (43 of 347) of the patients undergoing laparotomy or in 7 % (43 of 617) of the total study population. The majority of these, 83.7% (36 of 43), occurred when patients underwent emergent surgery, without directive advanced radiologic assessment. Only 9.7% (60 of 617) of all patients underwent thoracotomy. RT accounted for 25 (41.7%) of 60 of these procedures. Lung parenchymal and cardiac were the most common thoracic injuries overall, occurring in 6.2% (38 of 617) and 6.6% (41 of 617), respectively (Table 3). Thoracic aortic injury occurred in only 5 (0.8%) of 617 of the total population. In the subgroup arriving alive, the incidence of cardiac, thoracic aortic, and major thoracic injuries decreased to 4.9% (29 of 595), 0.2% (1 of 595), and 1.3% (8 of 595), respectively. Cardiac injury was the most common injury present in those undergoing thoracotomy, whether alone (7 of 9, 77.8%) or with laparotomy (22 of 32, 68.8%)

TABLE 2. Operative Management by Patient Group

	All Patients (n = 617)	Arriving Alive (n = 595)
No thoracotomy or laparotomy	247/617 (40.0%)	245/595 (41.2%)
Chest thoracostomy only	47/617 (7.6%)	46/595 (7.7%)
Thoracotomies (total)	60/617 (9.7%)	41/595 (6.9%)
RT	25/617 (4.1%)	8/595 (1.3%)
Followed by laparotomy	9/617 (1.5%)	4/595 (0.7%)
OR thoracotomy	35/617 (5.7%)	33/595 (5.5%)
With laparotomy	30/617 (4.9%)	28/595 (4.7%)
Laparotomies (total)	349/617 (56.6%)	341/595 (57.3%)
Nontherapeutic laparotomies	43/349 (12.3%)	43/341 (12.6%)
Laparotomy only	325/617 (52.7%)	323/595 (54.3%)
Thoracotomy and laparotomy	39/617 (6.3%)	32/595 (5.4%)
Excluding RT	30/617 (4.9%)	28/595 (4.7%)

TABLE 3. Specific Thoracic and Abdominal Injuries in the Total Population and in Patients Arriving Alive

	All Patients (n = 617), n (%)	Total Alive on Admission (n = 595), n (%)	No Thoracotomy or Laparotomy (n = 245), n (%)	Thoracotomy Only (n = 9), n (%)	Laparotomy Only (n = 309), n (%)	Thoracotomy and Laparotomy (n = 32), n (%)
Chest						
Cardiac trauma	41/617 (6.6)	29/595 (4.9)	0	7/9 (77.8)	0	22/32 (68.8)
Thoracic vascular injury	39/617 (6.3)	15/595 (2.5)	2/245 (0.8)	1/9 (11.1)	6/309 (1.9)	6/32 (18.8)
Thoracic aorta	5/617 (0.8)	1/595 (0.2)	0	1/9 (11.1)	0	0
Major thoracic vessel	27/617 (4.4)	8/595 (1.3)	0	0	0	6/32 (18.8)
Nonspecific vascular injury	7/617 (1.1)	6/595 (1.0)	2/245 (0.8)	0	6/309 (1.9)	0
Lung injuries	38/617 (6.2)	28/595 (4.7)	5/245 (2.0)	1/9 (11.1)	13/309 (4.2)	9/32 (28.1)
Abdomen						
Solid organs	322/617 (52.2)	310/595 (52.1)	94/245 (38.4)	4/9 (44.4)	205/309 (66.4)	23/32 (71.9)
Liver	172/617 (27.9)	165/595 (27.7)	64/245 (26.1)	3/9 (33.3)	85/309 (27.5)	13/32 (40.6)
Spleen	102/617 (16.5)	100/595 (16.8)	15/245 (6.1)	1/9 (11.1)	79/309 (25.6)	5/32 (15.6)
Kidney	48/617 (7.8)	47/595 (7.9)	14/245 (5.7)	0	29/309 (9.4)	4/32 (12.5)
Pancreas	16/617 (2.6)	16/595 (2.7)	1/245 (0.4)	0	12/309 (3.9)	3/32 (9.4)
Hollow viscus	197/617 (31.9)	191/595 (32.1)	0	0	175/309 (56.6)	16/32 (50.0)
Stomach injury	74/617 (12.0)	71/595 (11.9)	0	0	65/309 (21.0)	6/32 (18.8)
Small bowel injury	62/617 (10.0)	60/595 (10.1)	0	0	55/309 (17.8)	5/32 (15.6)
Large bowel injury	61/617 (9.9)	60/595 (10.1)	0	0	55/309 (17.8)	5/32 (15.6)
Bladder injury	1/617 (0.2)	1/595 (0.2)	0	0	1/309 (0.3)	0
Named vessel	29/617 (4.7)	27/595 (4.5)	3/245 (1.2)	1/9 (11.1)	19/309 (6.1)	4/32 (12.5)
Diaphragm	233/671 (37.8)	224/595 (37.6)	24/245 (9.8)	3/9 (33.3)	184/309 (59.5)	13/32 (40.6)
Diaphragmatic or HVI	309/617 (50.1)	298/595 (50.1)	24/245 (9.8)	3/9 (33.3)	249/309 (80.6)	22/32 (68.9)

(Table 3). Examination of the subgroup of patients who arrived alive and subsequently underwent thoracotomy revealed that 12 (29.3%) of 41 had thoracotomy for resuscitation after hemodynamic deterioration in the absence of a significant intrathoracic pathology or had minimally significant injury (such as trauma to the lung parenchyma). Isolated cardiac injury occurred in 23 (56.1%) of 41. Cardiac injury in combination with major thoracic vessel or thoracic aortic injury occurred in an additional 6 (14.7%) of 41. Only 1 (2.4%) of 41 had an injury to a major thoracic vessel or the thoracic aorta in the absence of cardiac injury.

Although thoracic injury incidence differed between the total population and those arriving alive, the distribution of abdominal injuries was similar (Table 3). Solid organ injury occurred in 52.2% of the total population (322 of 617). The liver was the most frequently injured (27.9%, 172 of 617), followed by the spleen (16.5%, 102 of 617) and kidney (7.8%, 48 of 617). Hollow viscus injury (HVI) occurred in 31.9% (197 of 617) of the population and was nearly equally divided among gastric (74 of 617, 12%), small bowel (62 of 617, 10%), and large bowel (61 of 617, 9.9%) injury. HVI was found at laparotomy in more than half of those patients undergoing this procedure, alone (175 of 309, 56.6%) or with thoracotomy (16 of 32, 50%).

DI occurred in 37.6% (224 of 595) of those arriving alive and was found in 57.8% (197 of 341) of all patients undergoing laparotomy. A small number (27 of 224, 12.1%) found to have DI on computed tomographic (CT) scan did not undergo repair, owing to a right-sided or very posterior lesion or patient preference. Of patients with DI, 42.9% (96 of 224) were clinically unstable and had the diagnosis made at an emergent operation. Of the 128 (57.1%) of 224 who arrived clinically stable, 56 (43.8%) of 128 had diagnosis of DI suggested by CT scan. Laparoscopy confirmed the diagnosis in 17 (30.4%) of 56 of this group, while an additional 19 (33.9%) of 56 underwent laparotomy. A third of clinically stable patients found to have DI (72 of 224, 32.1%) had no CT suggestion of this injury. In this group, laparoscopy provided diagnosis in 34 (47.2%) of 72. Overall, diagnostic laparoscopy was performed in 51 (22.8%) of 224 of all patients found to have DI who arrived clinically stable. DI was successfully repaired laparoscopically in 36 (70.6%) of 51 of these patients, the remainder being converted to laparotomy owing to technical challenge or additional injury. Overall, half of all patients arriving alive (298 of 595, 50.1%) were found to have either HVI or DI.

A significant percentage of those with penetrating solid organ injury did not require operative solid organ repair. Only 60 (36.8%) of 163 of liver injuries required an operative liver procedure. Only 58% (58 of 100) of splenic injuries and 29.8% (14 of 47) of renal injuries required repair or removal. Although these numbers reflect the percentage of patients undergoing an operative procedure on the respective solid organ, the number of patients having laparotomy was higher. In total, 58.9% (96 of 163) of the patients with liver, 84% (84 of 100) with splenic, and 70.2% (33 of 47) with renal injury underwent laparotomy, either for exploration or associated injury.

Clinical outcomes for the entire population and for those arriving alive, stratified by patient management, are summarized in Table 4. Mortality in patients undergoing RT was 92%. Overall mortality among patients arriving alive was 3.5%. In this group, all patients not requiring surgery survived. In those requiring an operation, mortality was lowest in those undergoing laparotomy alone (9 of 323, 2.8%) but greatly increased with dual-cavitary intervention (5 of 12, 41.7%). Of those presenting alive with cardiac injury, 25 (86%) of 29 survived

TABLE 4. Clinical Outcomes in the Entire Population and by Operative Subgroup in Those Arriving Alive

	Survival, n (%)	MTs, n (%)	Intensive Care Unit LOS, Mean ± SEM	Hospital LOS, Mean ± SEM
All patients (n = 617)	578/617 (88.3)	72/617 (11.7)	2.2 ± 0.3	9.1 ± 1.5
All patients having RT (n = 25)	2/25 (8.0)	14/25 (56.0)	1.0 ± 0.5	1.6 ± 0.7
Patients arriving alive (n = 595)	574/595 (96.5)	62/595 (10.4)	2.2 ± 0.3	9.3 ± 1.5
No thoracotomy or laparotomy (n = 248)	248/248 (100.0)	1/248 (0.4)	0.4 ± 0.1	3.6 ± 0.3
Thoracotomy only (n = 8)	4/8 (50.0)	3/8 (37.5)	5.4 ± 4.1	7.9 ± 4.5
RT (n = 4)	0/4 (100.0)	2/4 (50.0)	0.3 ± 0.3	0.5 ± 0.3
OR thoracotomy (n = 4)	4/4 (100.0)	1/4 (25.0)	10.5 ± 7.9	15.3 ± 7.7
Laparotomy only (n = 323)	314/323 (97.2)	45/323 (13.9)	2.9 ± 0.4	13.3 ± 2.8
Thoracotomy and laparotomy (n = 30)	8/16 (50.0)	13/16 (81.3)	15.0 ± 6.4	18.6 ± 6.6
Excluding resuscitative thoracotomy (n = 26)	7/12 (58.3)	9/12 (75.0)	19.2 ± 8.3	23.5 ± 8.4

to discharge. Multivariate analysis identified five factors independently associated with mortality in patients arriving alive (Table 5).

DISCUSSION

Management of penetrating throacoabdominal injury is a widely recognized clinical challenge, yet injury patterns, management strategies, and clinical outcomes remain undescribed across a large population. Clinical application of the literature is also complicated by published studies' frequent combination of firearm and nonfirearm trauma, obscuring the qualitatively different impact of these mechanisms on injuries, management strategies, and outcomes. Our study identified 617 patients with penetrating thoracoabdominal SWs over 16 years. A third (182 of 617, 29.5%) experienced at least moderate injury (Abbreviated Injury Scale [AIS] score > 2) to both anatomic cavities. To our knowledge, this is the largest, most complete review of penetrating thoracoabdominal SWs to date.

The incidence of operative intervention and suitability for selective NOM of truncal SWs were established by two landmark prospective series. Demetriades[13] determined operative intervention necessary in only 14% of 543 patients with thoracic SWs. In a series of 651 anterior abdominal SWs, 43.4% did not require operation.[14] These findings have echoed across subsequent retrospective and prospective series, with thoracic penetrating injury requiring operative intervention (beyond tube thoracostomy) in 10% to 15%[15–17] and abdominal SW intervention rates ranging from 32% to 46%.[18–20]

Determining which anatomic cavity to open is the surgical decision at the heart of double jeopardy. Correct sequencing of cavitary intervention is essential to the management of unstable patients, and missequencing rates of 23% to 44% are reported.[1,8,9] Our series illustrates that, in patients presenting alive, exclusion of cardiac injury (present in 29 of 41 or 70.7% of all patients undergoing thoracotomy) is the primary consideration underlying this dilemma. Injury to a major thoracic vessel or the thoracic aorta in the absence of cardiac injury occurred in only 1 (2.4%) of 41 of patients undergoing thoracotomy. Cardiac injury is therefore the primary determinant of who requires an urgent therapeutic thoracotomy.

Surgeon-performed ultrasound has a reported close to 100% sensitivity and specificity for penetrating cardiac injury, and increased use of this modality, now common in North American trauma centers, should improve surgical sequencing in these patients.[21,22] To date, the impact of this technology on the operative management of this population has not been evaluated. Given the significant morbidity of a missed cardiac injury, previous authors (without access to this technology) have advocated for sternotomy or thoracotomy as the initial incision in hypotensive patients with thoracoabdominal SWs.[8] This strategy would be associated with unacceptably high rates of negative exploration and delayed injury recognition based on the patterns observed in our population. Cardiac ultrasound, along with trauma bay chest radiography to identify those patients who may experience decompression of tamponade into the pleural space, should be the initial evaluation of these patients. A negative Focused Assessment with Sonography for Trauma (FAST) finding alone does not always rule out cardiac trauma and may be a potentially dangerous pitfall in a small percentage of patients because this technology's sensitivity can be compromised by both decompression of tamponade into the mediastinal or pleural spaces and concomitant pathology such a pneumothorax.[23] In cases where this technology is not available or the FAST results are equivocal, sequencing of operative intervention depends on clinical grounds alone. Our series suggests that the most efficacious approach for an unstable patient arriving alive without clear clinical or ultrasonographic evidence of cardiac injury is emergent laparotomy, followed by rapid transdiaphragmatic pericardial window if a causative injury is not immediately apparent.

Negative or nontherapeutic cavitary investigation is also a recognized pitfall associated with the double jeopardy of

TABLE 5. Independent Predictors of Mortality for Patients Arriving Alive

Variable	Adjusted Odds Ratio (95% Confidence Interval)	*p*	Cumulative R^2
GCS score ≤ 8	111.4 (20.0–620.2)	<0.001	0.286
ISS > 25	9.8 (2.5–38.6)	0.001	0.450
Dual-cavity exploration	17.6 (3.8–81.0)	<0.001	0.502
Renal injury	14.3 (3.0–67.6)	0.001	0.546
Thoracotomy	28.2 (3.5–225.9)	0.002	0.598

Other variables in the model: age greater than 55 years, head AIS score greater than 3, extremities AIS score greater than 3, hypotension on admission, need for MT, cardiac injury, injury to the thoracic aorta, lung injury, abdominal solid organ injury, liver injury, splenic injury, injury to major vessels of the abdomen, pancreatic injury, and DI.

thoracoabdominal trauma. Nontherapeutic laparotomy is associated with complication rates as high as 20%.[24,25] A 16-year retrospective review of anterior abdominal SWs from our institution reported a decrease in negative laparotomy rate from 21.3% to 8.6% over that period.[26] The overall rate of nontherapeutic laparotomies in this population was 12.4%. The vast majority of nontherapeutic explorations occurred in patients undergoing emergent surgery. Our population's frequency of negative explorations did not change significantly over time, highlighting the persistent diagnostic difficulty of these patients.

A third (32%) of the patients in this series had HVI, and more than a third (37%) had DI. Half of this population had either DI or HVI, these two injuries driving the need for abdominal exploration and limiting the expansion of NOM in this population. Previous prospective studies of patients with left-sided thoracoabdominal trauma from our institution documented overall DI rates of 32%[27] and rates of occult DI as high as 26%.[28] Other studies' rates of occult injury in thoracoabdominal SWs range from 17% to 23%.[29–31] At LAC+USC, clinically stable SW patients without radiologic evidence of DI or other injury mandating laparotomy are observed for an interval of 12 hours for the development of peritoneal findings.[32] Laparotomy is performed if the patient deteriorates, and diagnostic laparoscopy is offered to stable patients, with the potential for left-sided injury, to rule out DI.

Although the patterns of diaphragmatic, abdominal solid, and hollow organ trauma were similar in both groups, patients arriving alive had lesser incidence of cardiac, major thoracic vascular, and thoracic aortic trauma, reflecting these injuries' contribution to on-scene mortality.[33,34] For patients arriving alive, cardiac trauma was the most commonly found pathology at thoracotomy, occurring in more than three quarters of patients having thoracotomy alone and in more than two thirds of those also having a laparotomy. Survival in those arriving alive with cardiac injury was 86%. Previous series of patients arriving alive with cardiac SWs have reported mortality rates from 13.5% to 16%, and our findings are consistent with this literature.[4,15,16,35]

As previously reported, dual-cavitary intervention greatly increases mortality, indicating the tremendous injury burden and surgical challenge inherent with trauma to two anatomic cavities. Hirshberg et al., in the first study to refer to penetrating thoracoabdominal trauma as a situation of double jeopardy, reported 41% mortality. Our findings reaffirm the persistent diagnostic complexity and high morbidity of this injury pattern.

The current article is, to our knowledge, the largest and most rigorous review of thoracoabdominal SWs to date. Within the limitations of any retrospective study, a number of conclusions are evident. This population manifests high surgical need, primarily driven by intra-abdominal injury. Although solid organ injury can often be managed without operation, high incidence of DI and HVI ultimately limits opportunity for NOM. In stable patients, laparoscopy remains essential for the identification of occult DI. In unstable patients, correct sequencing of cavitary intervention, depending primarily on exclusion of cardiac injury, is paramount. For those patients arriving alive who manifest ongoing hemodynamic instability but equivocal clinical and ultrasonographic evidence of cardiac injury, initial laparotomy, followed by transdiaphragmatic pericardial window if no causative injury is found, is likely the most efficacious strategy.

AUTHORSHIP

R.J.B., D.D., and K.I. were involved in the study conception, data interpretation, manuscript preparation and critical review and revision of the manuscript. P.G.T. was involved in data interpretation, manuscript preparation and revision of the manuscript. E.K. was a study coordinator and involved in data collection, statistical analysis and revision of the manuscript. O.O. was a study coordinator and involved in data collection and revision of the manuscript.

DISCLOSURE

The authors declare no conflicts of interest.

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