



Original Contribution

Blunt traumatic diaphragmatic injury: A diagnostic enigma with potential surgical pitfalls



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ARTICLE INFO

Article history:

Received 21 August 2016

Received in revised form 8 October 2016

Accepted 20 October 2016

ABSTRACT

Background: Blunt traumatic diaphragmatic injury (BTDI) is an uncommon injury and one which is difficult to diagnose. The objective of this study was to identify features associated with this injury.

Methods: This was a retrospective study based on records of 354 307 blunt trauma victims treated between 1998 and 2013 collected by the Israeli National Trauma Registry.

Results: BTDI was reported in 231 (0.065%) patients. Motor vehicle accidents were responsible for 84.4% of the injuries: 97 (42.0%) were reported as drivers; 54 (23.4%) were passengers; 34 (14.7%) were pedestrians hit by cars; and 10 (4.3%) were on motorcycles. There were more males than females (2.5:1) compared with blunt trauma patients without BTDI ($p < .001$). Patients with BTDI were significantly younger than blunt trauma patients without BTDI ($p < .001$). ISS was 9–14 in 5.2%, 16–24 in 16.9%, 25–75 in 77.9%. Urgent surgery was performed in 62% of the patients and 79.7% had surgery within 24 h of admission. Mortality was 26.8%. Over 40% of patients with BTDI had associated rib, pelvic and/or extremity injuries. Over 30% had associated spleen, liver and/or lung injuries. Nevertheless, less than 1% of patients with skeletal injuries and less than 2.5% with solid organ injuries overall had associated BTDI. Despite hollow viscus injury being less prevalent, up to 6% of patients with this injury had associated BTDI.

Conclusions: BTDI is infrequent following blunt trauma. Hollow viscus injuries were more predictive of BTDI than skeletal or solid organ injuries.

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1. Background

Traumatic diaphragmatic injury is rarely diagnosed, with a reported incidence that varies greatly in different series - between 0.8% and 8% [1, 2]. However, the precise incidence of Traumatic diaphragmatic injury remains unknown. Analysis of reported cases in the National Trauma Data Bank of the United States in 2012 reveals that a minority of 33% of cases of traumatic diaphragmatic injury were caused by a blunt injury with the remaining majority caused by penetrating trauma [3]. Both the

shearing forces of high-velocity traumatic injuries and the acute increase of intra-abdominal pressure caused by a direct blow to the anterior of the torso have been postulated as possible mechanisms causing blunt traumatic diaphragmatic injury (BTDI) [4].

Various imaging modalities including chest radiographs, ultrasonography, computed tomography, and magnetic resonance imaging have been used in the diagnosis of diaphragmatic rupture [5]. Computerized tomography (CT) is the modality of choice for the detection of BTDI with a variable sensitivity and specificity of 61%–87% and 72%–100%, respectively [5–8]. However, the rate of initially missed diagnoses on CT has been reported to range from 12% to 63%. Failure to diagnose BTDI may have grave results, with mortality rates of 30%–60% reported in patients presenting late with intrathoracic strangulation of a herniated viscus [9,10].

Penetrating thoraco abdominal injuries mandate exclusion of diaphragmatic injury [11,12]. However, in blunt trauma patients, BTDI can be easily missed in the absence of other indications for immediate surgery.

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The objective of this study was to identify patterns of injury that are associated with BTDI in order to identify trauma victims who require additional workup to diagnose or rule out this injury.

2. Methods

This was a retrospective cohort study of blunt trauma patients with BTDI treated from 1998 to 2013. The data was obtained from the records of the National Trauma Registry maintained by the Israel National Center for Trauma and Emergency Medicine Research, in the Gertner Institute for Epidemiology and Health Policy Research. Data recorded in this registry includes patients treated in nineteen hospitals of which six are level I trauma centers and thirteen are level II.

Patients with BTDI were identified and compared to other patients with blunt trauma. Information collected included demographic data (age, gender), clinical data (mechanism of trauma, hemodynamic instability, injury severity score, concomitant injuries, operation, and hospitalization in the ICU) and outcome (mortality). Hemodynamic instability was defined as systolic blood pressure less than 90 mmHg on admission.

Statistical analysis was performed using the SAS statistical software version 9.2 (SAS, Cary, NC). Statistical tests performed included Chi-square test and two sided Fisher's exact probability test. Mantel Haenszel chi square test was used for trend analysis. A p-value of less than 0.05 was considered statistically significant.

3. Results

The Israeli National Trauma Registry includes data on 354 307 blunt trauma victims admitted to selected Israeli hospitals between 1998 and 2013. BTDI was reported in 231 (0.065%) patients. Motor vehicle accidents including pedestrians hit by cars were responsible for 84.4% of the injuries: 97 (42.0%) were drivers; 54 (23.4%) were passengers; 34 (14.7%) were pedestrians hit by cars; and 10 (4.3%) were motorcyclists. Males outnumbered females 2.5:1. The highest incidence was in patients aged 15–29 years old accounting for 95 (41.1%) of the patients. These were followed by 49 (21.2%) patients aged 30–44. Compared to 354 076 blunt trauma victims listed in the registry, the proportions of males, patients aged 15–29 and patients aged 30–44 were higher in patients suffering from BTDI (OR 1.783 for males, $p < .001$; OR 2.964 for age 15–29, $p < .001$; OR 1.856 for age 30–44, $p < .001$).

One hundred eighty (77.9%) of the patients suffered from significant injuries resulting in ISS 25–75. Thirty nine (16.9%) had ISS in the range of 16–24 and 12 (5.2%) in the range of 9–14. This large proportion of seriously injured patients (94.8% with ISS ≥ 16) was associated with the need for urgent surgery in 61.9% of the patients, hospitalization in the ICU in 63.6% of the patients and an overall mortality of 26.8%. Causes of death in 62 patients reported in the registry were: uncontrolled hemorrhage in 15 patients; severe multitrauma in 9 patients; severe head injury in 5 patients; severe cardiac injury in 5 patients; multiple organ failure in 4 patients, severe pulmonary injury in 2 patients; severe vascular injury in one patient; severe pelvic injury in one patient; and unknown in 20 patients.

Table 1 presents the proportion of associated injuries in patients with BTDI. The most common injuries were skeletal, lung and solid abdominal organs. Less common were significant head injuries and hollow viscus abdominal organs. Though over 40% of the patients with diaphragmatic injury had associated skeletal injuries and over 30% had solid organ injuries, less than 1% and 2.5% respectively of blunt trauma patients with these injuries had associated BTDI.

The organ least injured in patients with BTDI, the stomach, proved to be the best indicator of BTDI. While only 4.3% of patients with BTDI had an associated stomach injury, 6.1% of patients with stomach injury had associated diaphragmatic injury.

Table 1
Associated injuries in 231 patients suffering from BTDI.

Organ Injured	Number of patients	% of BTDI patients with associated organ injury	% of patients with organ injury with associated BTDI	Odds Ratio ^a (95%CI)	P value
Ribs	121	52.4%	0.7%	22.4 (17.3–29.1)	<0.001
Pelvis	105	45.5%	0.9%	23.8 (18.4–30.9)	<0.001
Extremities	98	42.4%	0.1%	0.9 (0.7–1.1)	0.396
Spleen	96	41.6%	2.4%	62.7 (48.1–81.6)	<0.001
Lungs	89	38.5%	0.9%	21.6 (16.5–28.2)	<0.001
Liver	71	30.7%	2.2%	49.9 (37.7–66.2)	<0.001
Spinal Column	71	30.7%	0.4%	7.8 (5.9–10.4)	<0.001
Brain Injury	50	21.7%	0.2%	3.0 (2.2–4.1)	<0.001
Small Bowel	20	8.7%	3.3%	56.2 (35.3–89.6)	<0.001
Sternum	13	5.6%	0.4%	6.6 (3.7–11.5)	<0.001
Large Bowel	12	5.2%	4.1%	69.0 (38.1–124.8)	<0.001
Stomach	10	4.3%	6.1%	103.3 (53.8–198.5)	<0.001

^a Odds Ratio here is the ratio of the odds of BTDI occurring in patients with a specific organ injury (described in the table) to the odds of BTDI occurring in patients without this specific injury.

One hundred forty three (61.9%) patients underwent surgery for their BTDI. Fig. 1 demonstrates the timing of surgery and associated hemodynamic instability. One hundred fourteen (79.7%) patients were operated within 24 h of admission.

4. Discussion

The low incidence of BTDI and the difficulty in diagnosis makes it a challenging injury. Until recently, most of our knowledge concerning BTDI derived from descriptive articles with relatively small numbers of patients. Many of these include both penetrating and blunt trauma patients together.

In 2015, Fair et al. [3] reported their findings concerning 1240 patients with BTDI identified in the American College of Surgeons (ACS) National Trauma Data Bank (NTDB). Our findings parallel those reported in the American study. Both studies emphasize the rarity of BTDI (0.065% and 0.148% respectively). BTDI was found to be more prevalent in young males and was mostly caused by motor vehicle collisions (86.2% and 63.4% respectively). In both studies the overwhelming majority of the patients sustained severe injuries, and the mortality rate was high (26.8% and 19.8% respectively).

Our results concerning associated injuries were also similar to those observed by Fair et al. (see Table 2). Pulmonary and solid abdominal organ injuries were far more common than hollow viscus injuries in patients with BTDI. We also found that skeletal injury was one of the most common injuries associated with BTDI, in keeping with the findings reported by Reiff et al. [13].

Lopez et al. [14] reported on 124 patients with diaphragmatic injuries treated in their institution, those with BTDI had high ISS and severe concomitant injuries with mortality rate up to 17%. They found that the BTDI itself was unlikely to be the cause of early death. Rather, these authors comment that the increased mortality in BTDI patients resulted from severe associated injuries. They concluded that patients with BTDI should be evaluated for associated severe life-threatening injuries, particularly in the presence of hemorrhagic shock.

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