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Rib fractures and their association With solid organ injury: higher rib fractures have greater significance for solid organ injury screening

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Abdominal screening;
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Spleen injury;
Renal injury

Abstract

BACKGROUND: The purpose of this study was to identify patients with rib injuries who were at risk for solid organ injury.

METHODS: A retrospective chart review was performed of all blunt trauma patients with rib fractures during the period from July 2007 to July 2012. Data were analyzed for association of rib fractures and solid organ injury.

RESULTS: In all, 1,103 rib fracture patients were identified; 142 patients had liver injuries with 109 (77%) associated right rib fractures. Right-sided rib fractures with highest sensitivity for liver injury were middle rib segment (5 to 8) and lower segment (9 to 12) with liver injury sensitivities of 68% and 43%, respectively ($P < .001$); 151 patients had spleen injuries with 119 (79%) associated left rib fractures. Left middle segment rib fractures and lower segment rib fractures had sensitivities of 80% and 63% for splenic injury, respectively ($P < .003$).

CONCLUSIONS: Rib fractures higher in the thoracic cage have significant association with solid organ injury. Using rib fractures from middle plus lower segments as indication for abdominal screening will significantly improve rib fracture sensitivity for identification of solid organ injury.

Blunt chest trauma is among the most common injury patterns encountered by trauma care providers in hospital emergency rooms today. Most chest wall injuries have limited clinical significance and are often treated without hospitalization. Chest injury may have significant associated injuries that can be life threatening, and severe chest trauma should be a red flag for trauma care providers not only because of possible internal thoracic injury but also potential for internal abdominal injury. Traditional teaching in trauma care asserts that lower rib fractures have an association with abdominal solid organ injury (ASOI).[1–8] The notion that lower rib fractures are

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associated with ASOI has primarily been based on anecdote and dogma without actually assessing which ribs have the highest association with ASOI. Most literature on this topic considers lower rib fractures to be the level of the eighth or ninth rib and below.[1–9]

Current Advanced Trauma Life Support guidelines suggest that patients who have been assessed to have fractures of ribs 9 to 12 should have the diagnosis of solid organ injury considered including spleen, liver, and kidneys.[8] Identification of these rib fractures on chest x-ray should guide the provider's physical examination and direct the use of ancillary diagnostic procedures such as thoracic and abdominal computed tomographic (CT) scan.

The incidence of rib fractures from blunt injury has been reported to be between 7% and 40%.[3,9,10] The incidence of associated ASOI with rib fractures has been reported between 10% and 16%[3,5–7]; however, few studies have identified specific rib fractures with associated abdominal injuries and have not grouped those rib injuries into low-, medium-, and high-level rib fractures. These past studies have concluded that lower rib fractures are associated with an increased likelihood of ASOI.[1–9] Because the liver, spleen, and kidneys reside in the area of the abdomen that is higher than what is conventionally considered the lower ribs, we hypothesized that solid abdominal organ injury has greater association with ribs located higher in the thoracic cavity. The concept that higher rib fractures have greater association with ASOI would afford trauma care providers greater sensitivity for the diagnosis of ASOI. The purpose of this study was to analyze and identify specific rib fractures and fractured rib segments that have greatest association with ASOI.

Patients and Methods

This study was a retrospective chart and radiologic review performed on blunt trauma patients older than 13 years of age who had rib fractures during the 5-year period from July 2007 to June 2012. All patients were admitted to the University of South Alabama Medical Center.

The University of South Alabama Investigational Review Board approved this study. Data with regard to demographics (age, gender, and Injury Severity Score [ISS]) were collected on all patients. All patients studied had screening chest x-rays and thoracic and abdominal CT scans. Data were collected for all individual rib fractures that were identified by chest x-ray and had CT scans of the chest and abdomen. Rib fractures were separated by laterality, individually, and by segment with superior segment (segment 1): 1st through 4th ribs, middle segment (segment 2): 5th through 8th ribs, and lower segment (segment 3): 9th through 12th ribs. Liver, spleen, and renal injuries were identified by CT scan. Interpretations of x-rays and CT scans used for study purposes were performed by board-certified radiologists. Data were analyzed for association of rib fractures and ASOI. Data analysis comparing left- and right-sided rib fractures and rib fracture segments was done by chi-square analysis. Statistical significance was defined as $P < .05$.

Results

There were 1,103 patients with rib fractures entered in the study. The average age of the study population was 36.8 years (R: 13 to 92). Seven hundred fifty-two (68%) patients were men and 351 (32%) women. The average ISS of the study population was 19.6 (R: 1 to 75). The most common mechanism of injury was motor vehicle crash (54%) followed by falls (13%), motorcycle crash (10%), pedestrian vs auto (9%), all-terrain vehicle crash (6%), and assaults (3%). There were a total of 287 (26%) patients with solid organ injuries in the study population.

Rib fractures

There were a total of 2,149 right-sided rib fractures and 2,303 left-sided rib fractures. Four hundred three (37%) patients had only right-sided rib fractures and 461 (42%) patients had only left-sided rib fractures. Two hundred thirty-nine (22%) patients had bilateral rib fractures. The breakdown of right- and left-sided rib fractures for individual ribs is described in Table 1. The distribution of rib fractures by rib segment is listed in Table 2.

Liver injuries

There were 142 (13%) liver injuries in the study population. One hundred nine (80%) liver injuries were associated with right-sided rib fractures and 77 (51%) liver injuries were associated with left-sided rib fractures ($P < .01$; Table 3). Of the 142 liver injuries, 67 (47%) had isolated right-sided rib fractures and 33 (23%) had isolated left-sided rib fractures ($P < .01$; Table 4); 42 (31%) liver injury patients had bilateral rib fractures (Table 4). The most common rib fractures associated with liver injuries were right-sided fractures of ribs 5 (44%), 6 (42%), and 7 (43%; Fig. 1). When individual ribs were considered as predictors of liver injury, no individual ribs were good predictors of liver injury relative to the other ribs with ribs 5 to 12 ranging in predictive value of 19% to 23% (Table 5).

When analyzed by right-sided rib segment with greatest association with liver injury, segment 2 had the greatest association with liver injury followed by the segment 1 (Fig. 2). Segment 3 ribs on the right side had the lowest incidence of injury when liver injuries were present (Fig. 2). Sensitivity of 43% for liver injuries was associated with fractures in segment 3 (Fig. 2) and 68% sensitivity for liver injuries and segment 2 fractures ($P < .001$; Fig. 2). Eighty-six percent sensitivity was appreciated for liver injuries with associated fractures from the combination of