ROLE OF THE TRAUMA-ROOM CHEST X-RAY FILM IN ASSESSING THE PATIENT WITH SEVERE BLUNT TRAUMATIC INJURY

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OBJECTIVES: To examine the accuracy of standard trauma-room chest x-ray films in assessing blunt abdominal trauma and to determine the significance of missed injuries under these circumstances.

DESIGN: A retrospective review.

SETTING: A regional trauma unit in a tertiary-care institution.

PATIENTS: Multiply injured trauma patients admitted between January 1988 and December 1990 who died within 24 hours of injury and in whom an autopsy was done.

INTERVENTION: Standard radiography of the chest.

MAIN OUTCOME MEASURES: Chest injuries diagnosed and recorded by the trauma room team from standard anteroposterior x-ray films compared with the findings at autopsy and with review of the films by a staff radiologist initially having no knowledge of the injuries and later, if injuries remained undetected, having knowledge of the autopsy findings.

RESULTS: Thirty-seven patients met the study criteria, and their cases were reviewed. In 11 cases, significant injuries were noted at autopsy and not by the trauma-room team, and in 7 cases these injuries were also missed by the reviewing radiologist. Injuries missed by the team were: multiple rib fractures (11 cases), sternal fractures (3 cases), diaphragmatic tear (2 cases) and intimal aortic tear (1 case). In five cases, chest tubes were not inserted despite the presence (undiagnosed) of multiple rib fractures and need for intubation and positive-pressure ventilation.

CONCLUSIONS: Significant blunt abdominal trauma, potentially requiring operative management or chest-tube insertion, may be missed on the initial anteroposterior chest x-ray film. Caution must therefore be exercised in interpreting these films in the trauma resuscitation room.
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itial management of the patient with serious injuries due to blunt trauma will, in part, be guided by injuries detected on the initial antero-posterior (AP) chest x-ray film. Although other investigations are available to diagnose or rule out thoracic injury (e.g., computed tomography, angiography, magnetic resonance imaging and pleuroscopy), resuscitation in most cases of blunt chest injury will be determined by clinical assessment and standard radiography. Previous studies have documented missed injuries in the multiply injured patient and the limitations of chest radiography for the non-critically injured patient.

This retrospective review was undertaken to determine the role of the admission AP chest x-ray in assessing a group of seriously injured blunt trauma patients who died within 24 hours of admission to the trauma unit and who underwent autopsy.

PATIENTS AND METHODS

The Regional Trauma Unit at Sunnymount Health Science Centre is a level I trauma unit, currently assessing over 600 seriously injured patients annually. More than 92% of injuries are the result of blunt trauma. The hospital does not routinely assess patients under 16 years of age. (They are selectively diverted to a level I pediatric trauma unit.) Trauma patients are assessed by a trauma team, directed by a trauma-team leader and comprising residents from anesthesia, general and orthopedic surgery and neurosurgery.

Fifty percent of patients are referred after initial assessment and treatment at primary hospitals; 90% of them are referred from within a catchment area of 180 km. The remaining patients are transported directly to our unit from the greater metropolitan Toronto region (population 2.3 million).

The records of patients admitted between Jan. 1, 1988, and Dec. 31, 1989, with blunt trauma, who died within 24 hours, for whom an admission AP chest x-ray film was available and in whom an autopsy was performed, were reviewed, because it was less likely that time, treatment or complications would have influenced chest findings at autopsy.

Data were prospectively collected on all trauma admissions. Trauma records were reviewed to determine chest injuries diagnosed and recorded by the trauma team, based on clinical and radiographic interpretation at the time of admission. During the study period, AP chest x-rays films were obtained with a standard x-ray generator with a ceiling-mounted free-floating x-ray tube requiring manual exposure control and tube–image receptor alignment. Cases in which further investigation or surgery may have influenced the diagnosis of chest injuries were excluded. The performance of closed-chest cardiopulmonary resuscitation (CPR) (recognized as potentially causing thoracic trauma) after admission chest radiography was noted.

Thoracic injuries diagnosed at autopsy were compared with those noted by the trauma team. The admission chest x-ray films were subsequently reviewed (as part of this study) by a staff radiologist, blinded to the patients’ injuries but aware that a review was being undertaken, to assess the role of the admission chest x-ray films. If injuries were not detected by the radiologist during this initial review, x-rays were later presented with the radiologist informed of all diagnosed injuries to determine if any missed injuries could be detected in retrospect.

RESULTS

Of the 917 trauma patients assessed during the study period, 37 met the study criteria (blunt trauma, an admission AP chest x-ray film and no further investigations or surgery, death within 24 hours of admission and autopsy findings available for review).

In 26 (70%) of the 37 cases, there was no discrepancy between injuries diagnosed by the trauma-room team and those found at autopsy. In 11 cases (Table I), chest injuries were missed by the trauma team; in 7 of these cases, injuries were also missed by the reviewing radiologist. Because some chest injuries were noted clinically and not at autopsy (pneumothorax or flail segment), chest injuries diagnosed were considered to be those diagnosed by the trauma-room team.
### Table I

Thoracic Injuries Missed by Trauma Team in 11 Patients With Severe Blunt Trauma

<table>
<thead>
<tr>
<th>Case no.</th>
<th>Mechanism of injury</th>
<th>Injuries diagnosed by trauma team or at autopsy</th>
<th>Injuries not diagnosed by trauma team</th>
<th>Chest tubes inserted</th>
<th>Cause of death according to coroner</th>
<th>Closed chest CPR</th>
<th>Time from arrival to death, h</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pedestrian</td>
<td>Intimal aortic tear, B hematomes, R diaphragmatic tear, # L ribs 1–7, R ribs 2, 6, 7</td>
<td>Intimal aortic tear, # L rib 1–3, R rib 2</td>
<td>Bilaterally</td>
<td>Multiple #s, internal injuries</td>
<td>Yes</td>
<td>5.5</td>
</tr>
<tr>
<td>2</td>
<td>Bicycle</td>
<td>L pulmonary contusion, B hematomes, # L ribs 1–6 with flail segment</td>
<td># L ribs 1, 2</td>
<td>None</td>
<td>Bilaterally</td>
<td>Multiple #s, internal injuries</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>Motor vehicle</td>
<td># L ribs 2–4, R ribs 2–5</td>
<td># L ribs 2–4, R ribs 2–5</td>
<td>Bilaterally</td>
<td>Hypovolemic shock, multiple injuries with pelvic #</td>
<td>No</td>
<td>9.45</td>
</tr>
<tr>
<td>4</td>
<td>Pedestrian</td>
<td>B apical hematomas, R diaphragmatic tear, # L ribs 1–7, R ribs 2, 6, 7</td>
<td>R diaphragmatic tear, # L rib 6, 7</td>
<td>Bilaterally</td>
<td>Exanguination from retroperitoneal hematoma</td>
<td>No</td>
<td>4.55</td>
</tr>
<tr>
<td>5</td>
<td>Motor vehicle</td>
<td>R pulmonary contusion, R flail segment, # L ribs 1–6, R ribs 1–9</td>
<td># L ribs 1–6, R ribs 1–2</td>
<td>None</td>
<td>Bilaterally</td>
<td>Massive trauma</td>
<td>Yes</td>
</tr>
<tr>
<td>6</td>
<td>Motorcycle</td>
<td>R pulmonary contusion, R flail segment, # L ribs 4–6, 10, R ribs 2–7</td>
<td># L ribs 4–6, 10</td>
<td>None</td>
<td>Right only</td>
<td>Massive closed head injury</td>
<td>No</td>
</tr>
<tr>
<td>7</td>
<td>Motor vehicle</td>
<td>L diaphragmatic tear, B hematomes, # L rib 6, R ribs 7, 8</td>
<td>L diaphragmatic tear, # L rib 6, R ribs 7, 8</td>
<td>Bilaterally</td>
<td>Multiple #s, pulmonary hemorrhage</td>
<td>Yes</td>
<td>1.4</td>
</tr>
<tr>
<td>8</td>
<td>Pedestrian</td>
<td>R pulmonary contusion, R pneumothorax, R flail segment, # L ribs 3–8, R ribs 2–12, # sternum</td>
<td># L ribs 3–8, R ribs 9–12 (# sternum)</td>
<td>Right only</td>
<td>Multiple injuries</td>
<td>No</td>
<td>16</td>
</tr>
<tr>
<td>9</td>
<td>Motor vehicle</td>
<td># L ribs 1–3, R ribs 7, 8, # sternum</td>
<td># L ribs 1–5, R ribs 1–8 (# sternum)</td>
<td>None</td>
<td>Multiple injuries</td>
<td>No</td>
<td>1.45</td>
</tr>
<tr>
<td>10</td>
<td>Motor vehicle</td>
<td>Aortic tear, L. pneumothorax, R hematomes, # L ribs 6, 9, R ribs 3–3, 6–9</td>
<td># L ribs 6–9, R ribs 2, 3, 6–9</td>
<td>Bilaterally</td>
<td>Exanguination, aortic tear</td>
<td>No</td>
<td>0.45</td>
</tr>
<tr>
<td>11</td>
<td>Motor vehicle</td>
<td># L ribs 3–6, R ribs 2–4, # sternum</td>
<td># L ribs 3–6 (# sternum)</td>
<td>None (# sternum)</td>
<td>Right only</td>
<td>Massive closed head injury</td>
<td>No</td>
</tr>
</tbody>
</table>

B = bilateral; R = right; L = left; # = fracture; CPR = cardiopulmonary resuscitation
and those found at autopsy. It is evident that the most frequent injuries missed by the trauma-room team or radiologist were multiple rib fractures (11 for the team), frequently bilateral (8 for the team). In 5 of 11 cases, chest tubes were not inserted bilaterally despite the need for positive-pressure ventilation and the presence (undiagnosed) of multiple rib fractures. Sternal fractures are presented in parentheses in Table I as this injury would not be expected to be diagnosed on an AP chest x-ray film. Examples of four cases are presented in Figs. 1 to 4.

The causes of death were those determined by the coroner after investigation. On review of all available records, including the autopsy findings, there were no cases in which missed injuries were considered responsible for or contributory to death. In four cases, closed-chest CPR was performed and could have resulted in further injury after admission radiography. In two of these four cases, however, all injuries noted at autopsy were detected by the radiologist on the admission chest x-ray film, leaving the potential influence of CPR to two cases (cases 1 and 7 in Table I).

The seven cases in which some injuries were not detected by the reporting radiologist were subsequently re-presented to the radiologist with a full description of all injuries diagnosed by the trauma-room team or at autopsy. In two of them (case 4 — right second rib fracture, case 10 — right second and third rib fractures), the radiologist agreed that, in retrospect, the evidence was there. In the remaining five cases and for the other “missed” injuries in cases 4 and 10, it was the opinion of the radiologist that there was no evidence of the injuries on the radiographs.

**DISCUSSION**

This review demonstrates that a single AP admission chest x-ray film may not be relied upon, even in combination with clinical assessment, to accurately diagnose all potentially significant chest injuries. Although none of the undetected thoracic injuries in this study were thought to have contributed directly to a patient’s death, the potential exists for some of these missed injuries (e.g., ruptured hemidiaphragm, multiple rib fractures) to cause increased morbidity or death. It is common practice in our institution to insert chest tubes prophylactically when multiple rib fractures are diagnosed in seriously injured patients who required intubation and positive-pressure ventilation, because these patients are at high risk of having underlying pulmonary parenchymal injury. In six of the cases presented (two cases with ruptured diaphragm and five with multiple rib fractures), the management might have changed if injuries have been detected clinically or on the chest radiograph.

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**FIG. 1.** Case 1. Injuries undetected by trauma team and radiologist initially were: intimal aortic tear, fractures of left ribs 1 to 3 and fracture of right rib 2. Usual radiographic signs of aortic injury, apart from possible widening of mediastinum are not obvious on this film. No further injuries were detected when film was re-presented to radiologist.

**FIG. 2.** Case 3. Injuries undetected by trauma team and radiologist initially were: fractures of left ribs 2 to 4 and right ribs 2 to 5. Film does not clearly show these fractures. No further injuries were detected when film was re-presented to radiologist.
The quality of chest film will obviously affect the interpretation. All chest x-ray films in this study were performed with a ceiling-mounted free-floating x-ray tube. In January 1990, a new unit was installed in our trauma room, an integration of a dedicated ceiling-mounted radiographic C-arm device and x-ray generator with automatic exposure control, collimation and fixed tube–image receptor alignment. This appeared to result in a qualitatively improved image. The period of study was chosen to eliminate the confounding variable of different x-ray equipment and to more closely approximate results available in many other trauma units and emergency departments. We intend to compare the results obtained in this study with those obtained from this superior imaging equipment.

From a review of the trauma-room chest x-ray films, it appears that several factors may contribute to the incidence of missed injuries, not the least of which are poor technique and poor quality of the films. For example, all of the ribs may not be included in the film or the film may be taken during a poor inspiration. Our review did not allow us to estimate the degree to which such factors affected the accuracy of the chest radiograph. The introduction of new equipment should improve the quality and the accuracy of chest films obtained in our trauma room. Clearly, other measures, such as improving the radiology training of the trauma team and the availability of radiology staff in the trauma room, will enhance the accuracy of diagnosis. Conceivably, with present-day technology, the service of a staff radiologist could also be provided through electronic computer transfer of images.

Previous studies have reported missed injuries at the time of a multiply injured patient’s initial assessment.\(^1\) Multiple causes have been postulated for missing injuries during initial assessment, including misinterpretation of initial radiographs.\(^2\)\(^,\)\(^3\) During the period of this study, the chest x-ray films of trauma patients were routinely reviewed by a radiologist, but at least 24 hours after admission. In an attempt to eliminate the variable of different radiologists interpreting the admission chest film, all films were presented to one radiologist with a special interest in chest radiography. Since the radiologist was aware that a review was being undertaken, it is difficult for us to determine the additional value of radiologist versus trauma-team interpretations. We have, however, changed our policy in this regard and, in an effort to improve x-ray interpretation,\(^4\) all films are now reviewed by a staff or resident radiologist before the patient leaves the trauma resuscitation room. Our data still reflect the common situation in trauma rooms where the expertise of a staff radiologist is not always immediately available.

When a seriously injured blunt trauma patient with chest injury presents in extremis to our trauma unit, bilateral chest tubes will often be inserted before the chest x-ray film is obtained. When time and clinical condition permit, a chest film is obtained and the insertion of chest tubes is

FIG. 3. Case 4. Injuries undetected by trauma team were: right diaphragmatic tear, fractures of left ribs 1 to 7 and fracture of right rib 2. Injuries undetected by radiologist initially were: right diaphragmatic tear, fractures of left ribs 3 to 6 and fracture of right rib 2. When film was re-presented to radiologist fracture of right rib 2 was diagnosed. Of note is that tip of endotracheal tube is very close to carina. No radiographic signs of diaphragmatic rupture were evident on this trauma-room chest film.

FIG. 4. Case 9. Injuries undetected by trauma team were: fractures of left ribs 1 to 5 and right ribs 1 to 8 (sternal fracture). Injuries undetected by radiologist initially were: fractures of left ribs 3 to 5 and right ribs 1 to 8 (sternal fracture). No further injuries were detected when film was re-presented to radiologist.
guided by the radiographic findings. With respect to the prophylactic insertion of chest tubes when multiple rib fractures are diagnosed, we emphasize that it would be prudent, based on the results of this review, to consider the potential for undiagnosed injury and proceed with further investigation(s) or, if the patient is in extremis, with the prophylactic insertion of chest tubes.

References