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Comparison of computed tomography and chest radiography in the detection of rib fractures in abused infants

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ABSTRACT

Purpose: Chest radiographs (CXR) are the standard method for evaluating rib fractures in abused infants. Computed tomography (CT) is a sensitive method to detect rib fractures. The purpose of this study was to compare CT and CXR in the evaluation of rib fractures in abused infants.
Methods: This retrospective study included all 12 abused infants identified from 1999 to 2004 who had rib fractures and both CXR and CT (8 abdomen CTs, 4 chest CTs). CT exams had been performed for clinical indications, and were obtained within one day of the CXR. Studies were reviewed by two pediatric radiologists to determine the number, locations, and approximate ages of the rib fractures. A total of 225 ribs were completely (192) or partially (33) seen by CT, and the matched ribs on CXR were used for the analysis.
Results: The mean patient age was 2.5 months (1.2–5.6), with seven females and five males. While 131 fractures were visualized by CT, only 79 were seen by CXR ($p < .001$). One patient had fractures only seen by CT. There were significantly ($p < .05$) more early subacute (24 vs. 4), subacute (47 vs. 26), and old fractures (4 vs. 0) seen by CT than by CXR. Anterior (42 vs. 11), anterolateral (21 vs. 12), posterolateral (9 vs. 3) and posterior (39 vs. 24) fractures were better seen by CT than by CXR ($p < .01$). Bilateral fractures were detected more often by CT (11) than by CXR (6).
Conclusions: While this study group is small, these findings suggest that CT is better than CXR in visualizing rib fractures in abused infants.

Introduction

Rib fractures are relatively uncommon in infants and children under 3 years of age (Barsness et al., 2003) and may result from either direct trauma to the chest, from anterior-posterior compression of the thorax, or from bone fragility states (Bulloch et al., 2000). Because of the plasticity of the pediatric skeleton, rib fractures are unusual even in severe accidental trauma and are rare after vigorous cardiopulmonary resuscitation (Bush, Jones, Cohle, & Johnson, 1996; Feldman & Brewer, 1984; Maguire et al., 2006; Spevak, Kleinman, Belanger, Primack, & Richmond, 1994). In fact, most rib fractures in infants are caused by non-accidental trauma. Several recent studies (Barsness et al., 2003; Bulloch et al., 2000; Cadzow & Armstrong, 2000) have reported that rib fractures in infants resulted from child abuse in more than 80% of cases.

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Currently, the standard imaging method for evaluating rib fractures in abused infants is the chest radiograph (CXR) (Kemp et al., 2006; Sane et al., 2000; Slovis et al., 2000). As rib fractures may be incomplete, non-displaced, superimposed over other bony structures or oriented obliquely with respect to the X-ray beam, they may be difficult to see (Kleinman, Marks, Adams, & Blackbourne, 1988). To increase detection of these fractures, oblique views (Ingram, Connell, Hay, Strain, & Mackenzie, 2000), bone scintigraphy (Mandelstam, Cook, Fitzgerald, & Ditchfield, 2003; Smith, Gilday, Ash, & Green, 1980) or follow-up chest radiographs after 2 weeks (Kleinman, Nimkin et al., 1996; Zimmerman, Makoroff, Care, Thomas, & Shapiro, 2005) have been suggested.

Chest computed tomography (CT) is known to be accurate in the diagnosis of rib fractures in trauma in adults (Alkadhi, Wildermuth, Marincek, & Boehm, 2004; Chan & Hiorns, 1996,) and children (Renton, Kincaid, & Ehrlich, 2003). However, to date, no studies have been reported comparing chest radiography and computed tomography in the diagnosis of rib fractures in abused infants. The purpose of this study was to compare CXR and chest CT in the diagnosis of rib fractures in abused infants less than 1 year of age. Our hypothesis is that chest CT would be more sensitive than CXR in the diagnosis of rib fractures in abused infants.

Methods

This observational retrospective study was approved by the University of California, Davis Medical Center (UCDMC) Institutional Review Board. Study subjects were obtained from a comprehensive search of the medical record database for child abuse cases admitted at UCDMC over a 5 year time period from 1999 to 2004. The study group included all infants less than 12 months of age who had confirmed non-accidental trauma and who had both of the following: (1) a two-view (frontal and lateral) chest radiograph (CXR) and a computed tomography (CT) scan of either the abdomen or chest obtained at clinical presentation; and (2) documentation of at least one rib fracture by either method. Both the CXR and CT were performed within 1 day of each other on all patients. The medical records were reviewed for demographic data including gender, age at presentation, and other injuries at admission. Two pediatric radiologists blinded to the patient name separately reviewed the two-view chest radiographs and the CT scans. The result of the CXR was not utilized in the review of the CT, nor vice versa. The following information was determined by consensus between the two radiologists: (1) number of ribs viewed; and for each individual rib (2) the presence or absence of rib fracture(s); (3) the location of rib fracture(s) along the rib (anterior, anterolateral, lateral, posterolateral, or posterior); and (4) the fracture age (acute, early subacute, subacute, late subacute, old (Islam et al., 2000)). Acute fractures were defined as those with sharp margins and no periosteal reaction. Early subacute fractures were defined as those with blurring of the fracture margins, and very early periosteal reaction. Subacute fractures had well-developed periosteal reaction, and/or early callus formation. Late subacute fractures demonstrated well-developed callus and near complete resolution of the fracture line. Old fractures demonstrated mature callus, non-visualization of fracture lines, and bony remodeling.

Statistical analysis

Data were entered into an Access database and analyzed in SPSS (11.0) for Windows. Descriptive statistics were conducted on child demographics, number of ribs visualized, number of ribs fractured, and other child abuse injuries. To determine significant differences in fracture outcome between radiography and CT, χ^2 analysis was conducted.

Results

There were 12 patients in this study: 7 females and 5 males, with a mean age of 2.5 months (range 1.2–5.6) (Table 1). While all 12 children had CXR, CTs were performed based on clinical indication, and included 8 abdominal CTs and 4 chest CTs. A total of 225 ribs were visualized by CT: 192 were seen totally (along their entire arc) and in 33 only a part of the rib

Table 1
Patient demographic data

Patient	Gender	Age (months)	CT type	Other findings (besides rib fractures)
#1	M	2.5	Abdominal	SDH; skull fracture; liver laceration
#2	M	4.8	Abdominal	ICH; cystic encephalomalacia
#3	F	1.6	Abdominal	SDH; bilateral cerebral infarcts
#4	M	1.3	Abdominal	Retinal hemorrhage; SAH; neuro-respiratory failure
#5	F	2.2	Abdominal	Skull fracture; SDH; retinal hemorrhages
#6	F	1.3	Chest	Subconjunctival hemorrhages
#7	M	1.8	Chest	Retinal hemorrhages; ICH; pleural effusion
#8	F	1.9	Abdominal	SDH; retinal hemorrhages; skull fracture
#9	F	4.3	Chest	Skull fracture; cerebral edema; retinal hemorrhages
#10	F	1.2	Abdominal	SDH; ICH; right humerus fracture; left tibial fracture.
#11	F	1.6	Abdominal	SDH; encephalomalacia; left femur fracture; retinal hemorrhages
#12	M	5.6	Chest	None

ICH, intracranial hemorrhage; SAH, subarachnoid hemorrhage; SDH, subdural hematoma.