American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Rib Fractures**

Variant 1: **Adult: <65 years old.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	8		Min
X-ray rib views	2		Low
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Variant 2: **Adult: > 65 years old.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	8		Min
X-ray rib views	5		Low
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Variant 3: **Children.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	9		Min
X-ray rib views	8		Low
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

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Summary of Literature Review

Rib fracture is the most common thoracic injury and is thought to be present in 10% of all traumatic injuries and in almost 40% of patients who sustain severe non-penetrating trauma [1-3]. Rib fractures typically affect the fifth through ninth ribs. This may be due to the fact that the shoulder girdle affords relative protection to the upper ribs and the lower ribs are relatively mobile and may deflect before fracturing [2]. Neither clinical examination nor radiography is ideal for the diagnosis of rib fractures. While rib fractures can produce significant morbidity, the diagnosis of associated complications (such as pneumothorax, hemothorax, pulmonary contusion, atelectasis, flail chest, cardiovascular injury, and injuries to solid and hollow abdominal organs) may have a more significant clinical impact [2,3]. Radiographs are specific but not very sensitive (for undisplaced fractures), and clinical examination is sensitive but not specific [3-5].

Multidetector computed tomography (MDCT) is increasingly used as the method of choice for the radiologic evaluation of the traumatized patient. It provides an accurate assessment of fractures and associated internal injuries. CT also provides an accurage means of assessing cartilage fractures, which are typically missed on radiography [2, 6]. However, such studies result in a large number of images that must be viewed at several window settings (lung, soft tissue, bone).

Post-processing techniques such as volume rendered display may depict rib fractures with high accuracy and may provide a more time-efficient method of evaluation compared to the sequential evaluation of numerous axial images. It should be noted that 3D image processing often requires a second console or workstation [2]. Griffith et al [5] compared sonography and radiography (chest radiography plus one oblique rib radiograph) in 50 patients and found that radiographs detected only 8 of 83 (10%) of sonographically detected rib fractures and were positive in only 6 of the 39 patients who had demonstrated fractures. In this study, sonography allowed evaluation of the costochondral junction, the costal cartilage, and the ribs and was able to show non-displaced fractures. However, the procedure is time consuming, may be difficult to perform in uncooperative patients and may be limited by body habitus and the fact that retroscapular and infraclavicular portions of the rib are not accessible [5]. Kara et al [7] found rib fractures in 40.5% of 37 patients with minor blunt chest trauma and negative radiographs by using ultrasound; osseous fractures were more common in the elderly, and duration of pain was significantly longer in these patients compared to those with chondral injuries. Sonography of cartilage fractures typically demonstrates an interruption of the smooth anterior surface of the cartilage [6]. CT imaging of such fractures typically shows a low-density line through the cartilage, and surrounding calcification may be evident in old fractures [6]. In a study of 552 patients who had blunt chest trauma and resultant rib fracture (diagnosed on clinical or radiographic grounds), 93% of affected patients ultimately resumed daily activities without significant disability. The authors also evaluated the use of routine radiographic follow-up for these patients and concluded that it is not useful in the absence of clinical deterioration [3].

Certain types of rib fractures are associated with an increased incidence of various organ injuries. There is increased likelihood for injury to the adjacent subclavian and innominate vessels with displaced first and second rib fractures, but this injury can usually be suspected on clinical grounds or from the chest radiographic abnormalities [8]. Lower rib fractures are frequently associated with upper abdominal organ injury [9-11]. Multiple fractures (three or more) are associated with an increased incidence of pneumothorax, hemothorax, abdominal organ injury, and mortality [12]. However, there is no evidence that the presence, absence, or number of fractures directly influences the diagnostic approach and treatment. Suspicion based on the mechanism and severity of injury and physical examination should lead to observation or abdominal CT for verification. Schurink et al [10] reported that the negative predictive value for abdominal organ injury with lower rib fractures due to low energy impact was 100%; with lower rib fractures in the setting of a reliable negative physical examination, negative predictive value was 97%. Based on a study of 69 patients with non-threatening trauma (stable vital signs with no evidence of cardiac injury, solid or hollow viscus rupture, or fractures associated with significant blood loss), Dubinsky and Low [13] concluded that neither rib

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studies nor even chest radiographs were of clinical benefit.

Early literature stressed rib fractures (especially of the first and second ribs) as predictors for aortic injury, but several studies have demonstrated no increased likelihood of aortic injury with upper rib fractures, nor with the presence of multiple fractures [8,12,14]. In a recent study of 548 patients who underwent aortography, Lee et al [14] reported that fractures of the clavicle, sternum, scapula, and thoracic spine had no positive predictive value for aortic injury, and that rib fractures had a very weak positive predictive value (thoracic spine fractures actually had a negative predictive value for aortic injury).

A flail chest can usually be diagnosed at physical examination. It is conceivable that in a heavy patient, a flail chest could be missed by clinical examination. However, a chest radiograph almost always shows the displaced fragments [9].

Lederer et al [15] showed that rib fractures are underreported on radiography performed following cardiopulmonary resuscitation (CPR). These fractures are more common on the left side and are more numerous in the elderly. The diagnosis of such fractures on CPR survivors is important. Approximately half of CPR survivors with rib fractures experience complications, and the presence of rib fractures in these patients may impair ventilation and compromise recovery. It should be noted that many of these patients are examined with portable supine radiography, which may contribute to underdiagnosis.

The presence and number of rib fractures do carry prognostic significance, and detection of rib fractures in children and adults may be indicated under certain circumstances. Rib fractures are associated with pulmonary dysfunction (atelectasis, shunting, impairment of clearance of secretions, pneumonia, and adult respiratory distress syndrome). Treatment of rib fractures is aimed at pain control and avoidance of respiratory distress and intubation [3]. Mortality is increased in patients with three or more fractures, particularly the elderly as they may have additional comorbid conditions that contribute to poor cardiopulmonary reserve (65 years or age or older) [3,9,12,16]. The diagnosis of multiple fractures in an elderly patient may warrant his/her transfer from a community hospital to a tertiary care center [12,16].

Children younger than 14 years of age have more compliant rib cages than adults. The presence of rib fracture(s) therefore indicates that the child's chest has sustained significant trauma [17-19]. Such fractures frequently occur at the costovertebral and costochondral junctions and may be difficult to identify on standard chest and rib radiographs [18,19]. Garcia et al [17] reported 14 deaths in 33 children with more than one rib fracture. Although thoracic injury accounted for only 1.6% of 2,080 injuries in their study, it led to 25% of the deaths.

Rib fractures may account for 5% to 27% of all skeletal injuries in abused children. In this population, rib fractures may be diagnosed during the evaluation of infants who present for a variety of complaints unrelated to rib fractures such as respiratory problems, seizures, and mental status changes. Although rib fractures are uncommon in infants, they frequently indicate abuse and are thought to result from anterior-posterior chest compression associated with shaking. Thus, the majority are located in the posterior rib near the costovertebral junction, although the mechanism of injury may also result in lateral and anterior rib fractures [20,21]. First rib fractures in infants are considered virtually diagnostic of abuse [21]. It should be noted that posterior rib fractures may occur as a result of birth trauma and that rib fractures unassociated with non-accidental trauma (NAT) may occur in very low birth weight infants, premature infants and infants with disease processes that cause increased bone fragility such as osteogenesis imperfecta and rickets, but are extremely rare in the setting of CPR [20].

Barsness et al reported a strong association between rib fractures and NAT in children under the three years of age with a high positive predictive value of a rib fracture as an indication of NAT, particularly when other causes of fracture are excluded based on history and clinical exam. The study suffers from errors in statistical analysis but highlights the importance of skeletal imaging in the diagnosis of NAT in children under the age of three [22,23]. In patients with suspected NAT, bone scintigraphy may complement radiography in the recognition of fractures undetected by radiography [24].

Radiographically occult nondisplaced ("stress") rib fractures may result from severe coughing. Nuclear scintigraphy and chest CT may be employed to diagnose these injuries. While scintigraphic findings are nonspecific, CT may demonstrate the fracture, fracture-related osteosclerosis or osteolysis, or callus formation. More importantly, metastatic of primary neoplasia may be successfully excluded [25-28].

Nuclear medicine skeletal scintigraphy may result in false-positive diagnosis of malignancy in patients with rib fractures [29]. In addition, patients with known malignancy and benign rib fractures may exhibit false-positive findings on FDG-PET studies performed 17 days to 8 weeks after injury [30].

Summary

In summary, it is usually unnecessary to perform dedicated rib radiography (in addition to chest radiography) for the diagnosis of fractures in adults, because CT is almost always used to evaluate potential organ injury in patients with significant chest and upper abdominal trauma. Although the diagnosis of multiple fractures has prognostic implications, there is no evidence that performing rib studies is beneficial (as opposed to performing other diagnostic procedures to evaluate the presence or absence of internal organ injury). An exception is the evaluation of a child in whom abuse is suspected; extended examination is warranted because of the high association of certain rib fractures with abuse and the difficulty of identifying such fractures with standard chest radiography. In these cases, scintigraphy may be useful as a complementary imaging study for diagnosing fractures not detected by radiography. Another possible exception is to establish the diagnosis of multiple fractures in the elderly if such information is to be used clinically to determine the need for tertiary or intensive care. A recent study suggests that sonography is much more sensitive than radiography for situations in which identification of rib fractures is clinically important [3]. CT, skeletal scintigraphy and ultrasound may be helpful in evaluating selected patients with occult "stress" fractures and in evaluating selected CPR survivors.

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