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American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Rib Fractures**

Variant 1: **Adult. Suspected rib fractures from minor blunt trauma (injury confined to ribs).**

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	8	Obtain PA view.	☢
X-ray rib views	5		☢ ☢ ☢
CT chest without IV contrast	3		☢ ☢ ☢
Tc-99m bone scan whole body	2		☢ ☢ ☢
CT chest with IV contrast	1		☢ ☢ ☢
CT chest without and with IV contrast	1		☢ ☢ ☢
US chest	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Variant 2: **Adult. Suspected rib fractures after CPR.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	8		☢
X-ray rib views	5		☢ ☢ ☢
CT chest without IV contrast	5		☢ ☢ ☢
CT chest with IV contrast	2		☢ ☢ ☢
Tc-99m bone scan whole body	2		☢ ☢ ☢
US chest	2		O
CT chest without and with IV contrast	1		☢ ☢ ☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Clinical Condition: **Rib Fractures**

Variant 3: **Rib pain. Suspected stress fracture.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	7	Obtain PA view.	☢
X-ray rib views	5		☢☢☢
CT chest without IV contrast	3		☢☢☢
Tc-99m bone scan whole body	3		☢☢☢
CT chest with IV contrast	2		☢☢☢
CT chest without and with IV contrast	1		☢☢☢
US chest	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Variant 4: **Adult. Suspected pathologic rib fracture.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	8	Obtain PA view.	☢
CT chest without IV contrast	7		☢☢☢
Tc-99m bone scan whole body	7		☢☢☢
X-ray rib views	5		☢☢☢
FDG-PET/CT skull base to mid-thigh	5		☢☢☢☢
CT chest with IV contrast	2		☢☢☢
CT chest without and with IV contrast	1		☢☢☢
US chest	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

RIB FRACTURES

Expert Panel on Thoracic Imaging: Travis S. Henry, MD[1]; Jacobo Kirsch, MD[2]; Jeffrey P. Kanne, MD[3]; Jonathan H. Chung, MD[4]; Edwin F. Donnelly, MD, PhD[5]; Mark E. Ginsburg, MD[6]; Darel E. Heitkamp, MD[7]; Ella A. Kazerooni, MD[8]; Loren H. Ketai, MD[9]; Barbara L. McComb, MD[10]; J. Anthony Parker, MD, PhD[11]; James G. Ravenel, MD[12]; Carlos Santiago Restrepo, MD[13]; Anthony G. Saleh, MD[14]; Rakesh D. Shah, MD[15]; Robert M. Steiner, MD[16]; Robert D. Suh, MD[17]; Tan-Lucien H. Mohammed, MD.[18]

Summary of Literature Review

Introduction/Background

Rib fracture is the most common thoracic injury and is present in 10% of all traumatic injuries and in almost 40% of patients who sustain severe nonpenetrating trauma [1,2]. 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 [1]. Although 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 [1,2]. When isolated, rib fractures have a relatively low morbidity and mortality [2,3].

Overview of Imaging Modalities

Neither clinical examination nor radiography is ideal for the diagnosis of rib fractures. The standard posteroanterior (PA) chest radiograph is specific but not very sensitive for fractures (the supine anteroposterior [AP] radiograph is even less sensitive), and clinical examination is sensitive but not specific [2,4]. Rib detail radiographs rarely add additional information to the PA film that would change treatment. Similarly, dual-energy chest radiography with bone subtraction imaging has failed to show improved detection when compared with standard radiographs. A review of 39 patients with a total of 204 rib fractures showed no statistically significant difference in sensitivity, specificity, or level of confidence between standard images and dual-energy subtraction images [5].

Multidetector computed tomography (CT) 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 accurate means of assessing cartilage fractures, which are typically missed on radiography [1,6]. However, CT is not usually performed only to evaluate for the presence of rib fractures; rather, it is used to evaluate for other associated complications of trauma. Ultrasound (US) may also be used for depiction of rib fractures or associated costal cartilage injury in the emergency setting as described below, although it is a time-consuming examination.

Nuclear medicine bone scans are sensitive but not specific for detection of rib fracture [7]. Bone scans are most commonly used for detection of osseous involvement in systemic processes (eg, metastatic disease) and may result in false-positive diagnosis of malignancy in a patient with rib fractures, although the pattern of tracer uptake can often help differentiate the 2 processes [7]. Bone scans have limited use in distinguishing acute and subacute/chronic rib fractures as they will usually be positive within 24 hours after an injury, but the return to normal can be slow (79% by 1 year, 93% by 2 years, and 100% in 3 years) [8]. Furthermore, patients with known malignancy and benign rib fractures may exhibit false-positive findings on fluorine-18-2-fluoro-2-deoxy-D-glucose positron emission tomography (FDG-PET) studies performed 17 days to 8 weeks after injury [9].

[1]Principal Author, Emory University Hospital, Atlanta, Georgia. [2]Panel Vice-chair, Cleveland Clinic, Weston, Florida. [3]Panel Vice-chair, University of Wisconsin School of Medicine and Public Health, Madison, Wisconsin. [4]National Jewish Health, Denver, Colorado. [5]Vanderbilt University Medical Center, Nashville, Tennessee. [6]Columbia University, New York, New York, Society of Thoracic Surgeons. [7]Indiana University, Indianapolis, Indiana. [8]University of Michigan Medical Center, Ann Arbor, Michigan. [9]University of New Mexico, Albuquerque, New Mexico. [10]Mayo Clinic, Jacksonville, Florida. [11]Beth Israel Deaconess Medical Center, Boston, Massachusetts, Society of Nuclear Medicine and Molecular Imaging. [12]Medical University of South Carolina, Charleston, South Carolina. [13]University of Texas Health Science Center at San Antonio, San Antonio, Texas. [14]New York Methodist Hospital, Brooklyn, New York, The American College of Chest Physicians. [15]North Shore University Hospital, Manhasset, New York. [16]Temple University, Philadelphia, Pennsylvania. [17]Ronald Regan UCLA Medical Center, Los Angeles, California. [18]Panel Chair, University of Florida College of Medicine, Gainesville, Florida.

Reprint requests to: publications@acr.org

Discussion of Imaging Modalities by Variant

Suspected Rib Fracture after Minor Blunt Trauma (Injury Confined to Ribs)

This variant refers to rib fractures resulting from minor blunt trauma. For severe cases of trauma please refer to the ACR Appropriateness Criteria® on "Blunt Chest Trauma."

In combination with the physical examination, a standard PA chest radiograph should be the initial diagnostic test for detection of rib fractures. Despite the low sensitivity of the chest radiograph, which may miss 50% of rib fractures [2], studies suggest that failure to detect fractures does not necessarily alter patient management or outcome in uncomplicated cases. A review of 271 patients who presented to a community hospital emergency department after minor trauma showed no difference in treatment (use of pain medications, etc) between patients who did and did not have rib fractures diagnosed on physical examination or radiographs [3]. 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 [2]. The chest radiograph may detect complications that are more important than the rib fractures themselves such as pneumothorax, hemothorax, flail chest, or contusion [1,2]. Although 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, but a chest radiograph almost always shows the displaced fragments.

CT is more sensitive than radiography for the detection of rib fractures, although it is usually used for assessment of associated injuries in the setting of severe trauma. Postprocessing techniques such as volume-rendered display and multiplanar images 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. Although a recent retrospective review by Cho et al [10] revealed that at least 17% of rib fractures from blunt trauma (mostly nondisplaced or buckle fractures) were missed on CT even with coronal imaging. Multiplanar or 3-D image processing may require a second console or workstation [1].

The increased sensitivity of CT for the detection of rib fractures does not necessarily alter the management or clinical outcomes of patients without associated injuries. Kea et al [11] reported that CT detected rib fractures in 66 of 589 patients (11%) who had initial chest radiographs interpreted as normal at a level I trauma center, but none of the rib fractures were considered of major clinical significance. The presence and number of rib fractures do carry prognostic significance, and detection of rib fractures may be indicated under certain circumstances. An outcomes analysis by Livingston et al [12] reviewed 388 patients with rib fractures who underwent both chest radiography (AP, supine) and chest CT and correlated the presence of rib fractures with pulmonary morbidity and mortality. They reported that although rib fractures were detected on only 46% of patients' initial chest radiographs, the presence of rib fractures and/or underlying parenchymal abnormality on radiography was associated with increased pulmonary morbidity (odds ratio, 3.8) compared with fractures only detected by CT.

Rib fractures are associated with pulmonary complications including atelectasis, impaired clearance of secretions, pneumonia, and adult respiratory distress syndrome [2,13,14]. Increased number of rib fractures has been shown to directly correlate with increasing morbidity and mortality, and this effect is greater in patients 65 or older, many of whom have additional comorbid conditions that contribute to poor cardiopulmonary reserve [2,13-15]. Treatment of rib fractures is generally aimed at pain control and avoidance of respiratory distress and intubation, but the presence of multiple rib fractures, in an elderly patient especially, may warrant transfer from a community hospital to tertiary care center [2,13-15].

Patients with rib fractures from a high-energy mechanism or with a high clinical suspicion of intrathoracic or intra-abdominal injury may warrant further evaluation such as contrast-enhanced CT, whereas a low-energy injury or normal physical examination may obviate further testing. Dubinsky and Low [16] studied 69 patients with nonthreatening trauma (stable vital signs with no evidence of cardiac injury, solid or hollow viscus rupture, or fractures associated with significant blood loss) and found that neither rib studies nor chest radiographs were of clinical benefit in this scenario, but they concluded that clinical evidence of a complicated injury such as pneumothorax, hemothorax, or flail chest may warrant further evaluation.

Similarly, Schurink et al [17] studied patients with lower rib fractures (ribs 7–12) and found that the negative predictive value of a negative physical examination for abdominal injury due to low-energy impact was 100%, but in patients with multiple injuries lower rib fractures were associated with abdominal organ injury in 67% of patients. Matthes et al [18] found no association between right-sided lower rib fractures in 55 trauma patients with hepatic injury when matched with 55 trauma patients without hepatic injury (there was a slight negative association of hepatic laceration with left-sided fractures) but ultimately concluded that the absence of rib fractures could not rule out hepatic injury. Thus, in patients with multiple injuries and lower rib fractures, contrast-enhanced CT might be indicated even in the setting of a normal clinical examination.

Several studies have demonstrated a high prevalence of radiographically-detected rib fractures in patients with aortic injury, although the positive predictive value is low. In a large prospective multicenter trial involving 50 trauma centers in North America, Fabian et al [19] reported multiple rib fractures in 46% of 274 patients with blunt aortic injury. Mirvis et al [20] found fractures of ribs 1–4 in 18% of 41 patients with traumatic aortic injury proved by angiography but a positive predictive value of only 20%–21%. Lee et al [21] studied 548 patients who underwent angiography to evaluate for aortic injury and concluded that rib fractures were the only type of thoracic skeletal injury that had a higher incidence in patients with aortic injury (58%) versus those without aortic injury (43%), but the positive predictive value was only 14.8%. This has also been shown at autopsy, where Williams et al [22] retrospectively reviewed 530 motor vehicle fatalities. In 90 victims, 105 aortic injuries were found, and 78% had multiple rib fractures, including 42% with fractures of the first rib.

There is some evidence that rib fractures detected with CT (given the increased sensitivity) may not be associated with an increased risk of aortic injury. A review of 185 patients with rib fractures detected on spine CT found no association between presence of first-rib or second-rib fracture and the incidence of aortic injury on subsequent CT [23], however ribs 3–12 were not assessed. Increased likelihood of injury to the adjacent subclavian and innominate vessels has been reported with displaced first-rib and second-rib fractures, but this injury can usually be suspected on clinical grounds or from a chest radiograph [24].

Several articles have noted that US can detect fractures not seen on conventional radiographs [4,6,25]. Griffith et al [4] compared sonography and radiography (chest radiography plus one oblique rib radiograph) in 50 patients and found that radiographs detected only 8 of 83 (10%) 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 nondisplaced fractures. Kara et al [25] found rib fractures in 40.5% of 37 patients with minor blunt chest trauma and negative radiographs by using US; osseous fractures were more common in the elderly, and duration of pain was significantly longer in these patients compared to those with chondral injuries [4,6,25]. However, Hurley et al [26] found US to be only marginally superior to conventional radiographs, and its routine use was not indicated due to the lengthy time of the examination, averaging 13 minutes in this series, and patient discomfort from the pressure of the US probe, particularly since identification of the fracture was unlikely to impact patient care.

Suspected Rib Fractures After Cardiopulmonary Resuscitation

Multiple studies [27,28] have shown that rib fractures are underreported on radiography performed following cardiopulmonary resuscitation (CPR). In a retrospective analysis of 40 patients who survived CPR, Kim et al [28] reported that CT detected rib fractures in 26 patients (65%), whereas AP chest radiography detected fractures in only 10 of the patients. These fractures are more commonly anterior, on the left side, and are more numerous in the elderly. The diagnosis of such fractures in CPR survivors may be important since 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.

Suspected "Stress" Rib Fractures

Stress fractures are uncommon in the ribs but can result from repetitive contraction of chest wall muscles or the diaphragm at the point that it attaches to the ribs. This is most commonly caused by chronic cough (especially in women) but has also been reported in athletes who perform repetitive motion (eg, weightlifters, pitchers, and rowers) [29]. Nuclear scintigraphy and chest CT may be used to diagnose these injuries. Although scintigraphic findings are nonspecific, CT may demonstrate the fracture, fracture-related osteosclerosis or osteolysis, or callus formation. More importantly, metastatic or primary neoplasia may be successfully excluded [30-32].

Suspected Pathologic Fracture

Pathologic fractures may result from metabolic disorders or neoplasm, including primary bone tumor, metastatic disease of intrathoracic or extrathoracic primary, hematologic malignancy (eg, multiple myeloma, lymphoma), or direct extension of a tumor in the thorax. A PA chest radiograph may be sufficient for diagnosis of a pathologic fracture (or provide clues to an underlying diagnosis), but further evaluation using such modalities as CT, bone scan, or FDG-PET may be necessary to further characterize a lesion detected on radiography or to search for radiographically occult lesions [33,34]. For further evaluation of pathologic fractures from metastatic disease, please see the ACR Appropriateness Criteria® on "Metastatic Bone Disease."

Summary

- It is usually unnecessary to perform dedicated rib radiography (in addition to chest radiography) for the diagnosis of rib fractures in adults after minor trauma.
- Although the diagnosis of multiple fractures has prognostic implications, there is no evidence that performing dedicated rib studies, CT, or bone scintigraphy is beneficial, except in the setting where such evaluation is necessary for establishing further care or other investigations (eg, elder abuse, legal documentation).
- CT, skeletal scintigraphy, and US may be helpful in evaluating selected patients with occult "stress" fractures and in evaluating selected CPR survivors or in situations in which identifying a rib fracture is deemed to be clinically important.

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document.

Relative Radiation Level Designations		
Relative Radiation Level*	**Adult Effective Dose Estimate Range**	**Pediatric Effective Dose Estimate Range**
O	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢ ☢	0.1-1 mSv	0.03-0.3 mSv
☢ ☢ ☢	1-10 mSv	0.3-3 mSv
☢ ☢ ☢ ☢	10-30 mSv	3-10 mSv
☢ ☢ ☢ ☢ ☢	30-100 mSv	10-30 mSv

*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies".

Supporting Documents

For additional information on the Appropriateness Criteria methodology and other supporting documents go to www.acr.org/ac.

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