# Complete Summary

## GUIDELINE TITLE

Rib fractures.

## BIBLIOGRAPHIC SOURCE(S)

Rosado de Christenson ML, Davis SD, Goodman PC, Haramati LB, Khan A, Leung AN, McLoud TC, Rozenshtein A, White CS, Kaiser LR, Expert Panel on Thoracic Imaging. Rib fractures. [online publication]. Reston (VA): American College of Radiology (ACR); 2005. 5 p. [30 references]

## GUIDELINE STATUS

This is the current release of the guideline.

This guideline updates a previous version: Westcott J, Davis SD, Fleishon H, Gefter WB, Henschke CI, McLoud TC, Pugatch RD, Sostman HD, Tocino I, White CS, Yankelevitz D, Bode FR, Goodman N. Rib fractures. American College of Radiology. ACR Appropriateness Criteria. Radiology. 2000 Jun;215 Suppl:637-9.

The appropriateness criteria are reviewed annually and updated by the panels as needed, depending on introduction of new and highly significant scientific evidence.

## COMPLETE SUMMARY CONTENT

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## SCOPE

### DISEASE/CONDITION(S)

Rib fractures

### GUIDELINE CATEGORY

Diagnosis
Evaluation

### CLINICAL SPECIALTY

Emergency Medicine
Family Practice
Internal Medicine
Pediatrics
Pulmonary Medicine
Radiology

### INTENDED USERS

Health Plans
Hospitals
Managed Care Organizations
Physicians
Utilization Management

### GUIDELINE OBJECTIVE(S)

To evaluate the appropriateness of initial radiologic examinations for patients with possible rib fractures

### TARGET POPULATION

Patients with possible rib fractures

### INTERVENTIONS AND PRACTICES CONSIDERED

X-ray (chest or rib views)

### MAJOR OUTCOMES CONSIDERED

Utility of radiologic examination in differential diagnosis

## METHODOLOGY

### METHODS USED TO COLLECT/SELECT EVIDENCE

Searches of Electronic Databases

### DESCRIPTION OF METHODS USED TO COLLECT/SELECT THE EVIDENCE

The guideline developer performed literature searches of peer-reviewed medical journals, and the major applicable articles were identified and collected.

### NUMBER OF SOURCE DOCUMENTS

The total number of source documents identified as the result of the literature search is not known.

## METHODS USED TO ASSESS THE QUALITY AND STRENGTH OF THE EVIDENCE

Weighting According to a Rating Scheme (Scheme Not Given)

## RATING SCHEME FOR THE STRENGTH OF THE EVIDENCE

Not stated

## METHODS USED TO ANALYZE THE EVIDENCE

Systematic Review with Evidence Tables

## DESCRIPTION OF THE METHODS USED TO ANALYZE THE EVIDENCE

One or two topic leaders with in a panel assume the responsibility of developing an evidence table for each clinical condition, based on analysis of the current literature. These tables serve as a basis for developing a narrative specific to each clinical condition.

## METHODS USED TO FORMULATE THE RECOMMENDATIONS

Expert Consensus (Delphi)

## DESCRIPTION OF METHODS USED TO FORMULATE THE RECOMMENDATIONS

Since data available from existing scientific studies are usually insufficient for meta-analysis, broad-based consensus techniques are needed for reaching agreement in the formulation of the appropriateness criteria. The American College of Radiology (ACR) Appropriateness Criteria panels use a modified Delphi technique to arrive at consensus. Serial surveys are conducted by distributing questionnaires to consolidate expert opinions within each panel. These questionnaires are distributed to the participants along with the evidence table and narrative as developed by the topic leader(s). Questionnaires are completed by the participants in their own professional setting without influence of the other members. Voting is conducted using a scoring system from 1 to 9, indicating the least to the most appropriate imaging examination or therapeutic procedure. The survey results are collected, tabulated in anonymous fashion, and redistributed after each round. A maximum of three rounds is conducted and opinions are unified to the highest degree possible. Eighty percent agreement is considered a consensus. This modified Delphi technique enables individual, unbiased expression, is economical, easy to understand, and relatively simple to conduct.

If consensus cannot be reached by this Delphi technique, the panel is convened and group consensus techniques are utilized. The strengths and weaknesses of each test or procedure are discussed and consensus reached whenever possible.

If "No consensus" appears in the rating column, reasons for this decision are added to the comment sections.

## RATING SCHEME FOR THE STRENGTH OF THE RECOMMENDATIONS

Not applicable

## COST ANALYSIS

A formal cost analysis was not performed and published cost analyses were not reviewed.

## METHOD OF GUIDELINE VALIDATION

Internal Peer Review

## DESCRIPTION OF METHOD OF GUIDELINE VALIDATION

Criteria developed by the Expert Panels are reviewed by the American College of Radiology (ACR) Committee on Appropriateness Criteria.

# RECOMMENDATIONS

## MAJOR RECOMMENDATIONS

ACR Appropriateness Criteria®

Clinical Condition: Injury, Possible Rib Fracture

Variant 1: Adult: <65 years old.

| Radiologic Exam Procedure | Appropriateness Rating | Comments |
|---|---|---|
| X-ray, chest | 8 | |
| X-ray, rib views | 2 | |
| Appropriateness Criteria Scale<br>1 2 3 4 5 6 7 8 9<br>1 = Least appropriate 9 = Most appropriate | | |

Variant 2

| Radiologic Exam Procedure | Appropriateness Rating | Comments |
|---|---|---|
| X-ray, chest | 8 | |

| Radiologic Exam Procedure | Appropriateness Rating | Comments |
|---|---|---|
| X-ray, rib views | 5 | |
| Appropriateness Criteria Scale<br>1 2 3 4 5 6 7 8 9<br>1 = Least appropriate 9 = Most appropriate | | |

Variant 3: Children.

| Radiologic Exam Procedure | Appropriateness Rating | Comments |
|---|---|---|
| X-ray, chest | 9 | |
| X-ray, rib views | 8 | |
| Appropriateness Criteria Scale<br>1 2 3 4 5 6 7 8 9<br>1 = Least appropriate 9 = Most appropriate | | |

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. 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. 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. Radiographs are specific but not very sensitive (for undisplaced fractures), and clinical examination is sensitive but not specific.

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. Computed tomography (CT) also provides an accurate means of assessing cartilage fractures, which are typically missed on radiography. 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. One study 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. Another study 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. CT imaging of such fractures typically shows a low-density line through the cartilage, and surrounding calcification may be evident in old fractures. 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.

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. Lower rib fractures are frequently associated with upper abdominal organ injury. Multiple fractures (three or more) are associated with an increased incidence of pneumothorax, hemothorax, abdominal organ injury, and mortality. 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. One study 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), the authors concluded that neither rib 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. In a recent study of 548 patients who underwent aortography, the authors 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.

One study 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, adult respiratory distress syndrome). Treatment of rib fractures is aimed at pain control and avoidance of respiratory distress and intubation. 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). The diagnosis of multiple fractures in an elderly patient may warrant his/her transfer from a community hospital to a tertiary care center.

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. Such fractures frequently occur at the costovertebral and costochondral junctions and may be difficult to identify on standard chest and rib radiographs. One study 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. First rib fractures in infants are considered virtually diagnostic of abuse. 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. One study 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. In patients with suspected NAT, bone scintigraphy may complement radiography in the recognition of fractures undetected by radiography.

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.

Nuclear medicine skeletal scintigraphy may result in false-positive diagnosis of malignancy in patients with rib fractures. In addition, patients with known malignancy and benign rib fractures may exhibit false-positive findings on fluorodeoxyglucose-positron emission tomography (FDG-PET) studies performed 17 days to 8 weeks after injury.

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. CT, skeletal scintigraphy and ultrasound may be helpful in evaluating selected patients with occult "stress" fractures and in evaluating selected CPR survivors.

### CLINICAL ALGORITHM(S)

Algorithms were not developed from criteria guidelines.

## EVIDENCE SUPPORTING THE RECOMMENDATIONS

### TYPE OF EVIDENCE SUPPORTING THE RECOMMENDATIONS

The recommendations are based on analysis of the current literature and expert panel consensus.

## BENEFITS/HARMS OF IMPLEMENTING THE GUIDELINE RECOMMENDATIONS

### POTENTIAL BENEFITS

Selection of appropriate radiologic imaging procedures for evaluation of patients with possible rib fractures

### POTENTIAL HARMS

Not stated

## QUALIFYING STATEMENTS

### QUALIFYING STATEMENTS

An American College of Radiology (ACR) Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologist, radiation oncologist, and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those exams generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the U.S. Food and Drug Administration (FDA) have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.

## IMPLEMENTATION OF THE GUIDELINE

### DESCRIPTION OF IMPLEMENTATION STRATEGY

An implementation strategy was not provided.

### IMPLEMENTATION TOOLS

Personal Digital Assistant (PDA) Downloads

For information about availability, see the "Availability of Companion Documents" and "Patient Resources" fields below.

## INSTITUTE OF MEDICINE (IOM) NATIONAL HEALTHCARE QUALITY REPORT CATEGORIES

### IOM CARE NEED

Getting Better

### IOM DOMAIN

Effectiveness

## IDENTIFYING INFORMATION AND AVAILABILITY

### BIBLIOGRAPHIC SOURCE(S)

Rosado de Christenson ML, Davis SD, Goodman PC, Haramati LB, Khan A, Leung AN, McLoud TC, Rozenshtein A, White CS, Kaiser LR, Expert Panel on Thoracic Imaging. Rib fractures. [online publication]. Reston (VA): American College of Radiology (ACR); 2005. 5 p. [30 references]

### ADAPTATION

Not applicable: The guideline was not adapted from another source.

### DATE RELEASED

1995 (revised 2005)

### GUIDELINE DEVELOPER(S)

American College of Radiology - Medical Specialty Society

### SOURCE(S) OF FUNDING

American College of Radiology (ACR) provided the funding and the resources for these ACR Appropriateness Criteria®.

### GUIDELINE COMMITTEE

Committee on Appropriateness Criteria, Expert Panel on Thoracic Imaging

### COMPOSITION OF GROUP THAT AUTHORED THE GUIDELINE

Panel Members: Melissa L. Rosado de Christenson, MD (Review Author); Sheila D. Davis, MD (Panel Chair); Philip C. Goodman, MD; Linda B. Haramati, MD; Arfa Khan, MD; Ann N. Leung, MD; Theresa C. McLoud, MD; Anna Rozenshtein, MD; Charles S. White, MD; Larry R. Kaiser, MD

### FINANCIAL DISCLOSURES/CONFLICTS OF INTEREST

Not stated

### GUIDELINE STATUS

This is the current release of the guideline.

This guideline updates a previous version: Westcott J, Davis SD, Fleishon H, Gefter WB, Henschke CI, McLoud TC, Pugatch RD, Sostman HD, Tocino I, White CS, Yankelevitz D, Bode FR, Goodman N. Rib fractures. American College of Radiology. ACR Appropriateness Criteria. Radiology. 2000 Jun;215 Suppl:637-9.

The appropriateness criteria are reviewed annually and updated by the panels as needed, depending on introduction of new and highly significant scientific evidence.

## GUIDELINE AVAILABILITY

Electronic copies: Available in Portable Document Format (PDF) from the American College of Radiology (ACR) Web site.

ACR Appropriateness Criteria® Anytime, Anywhere™ (PDA application). Available from the ACR Web site.

Print copies: Available from the American College of Radiology, 1891 Preston White Drive, Reston, VA 20191. Telephone: (703) 648-8900.

## AVAILABILITY OF COMPANION DOCUMENTS

The following is available:

- ACR Appropriateness Criteria®. Background and development. Reston (VA): American College of Radiology; 2 p. Electronic copies: Available in Portable Document Format (PDF) from the American College of Radiology (ACR) Web site.

## PATIENT RESOURCES

None available

## NGC STATUS

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