



## Complete Summary

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### GUIDELINE TITLE

Sinusitis--child.

### BIBLIOGRAPHIC SOURCE(S)

McAlister WH, Strain JD, Cohen HL, Fordham L, Gelfand MJ, Gunderman R, Slovis TL, Smith WL, Rodriguez W, Expert Panel on Pediatric Imaging. Sinusitis--child. [online publication]. Reston (VA): American College of Radiology (ACR); 2006. 7 p. [51 references]

### GUIDELINE STATUS

This is the current release of the guideline.

This guideline updates a previous version: McAlister WH, Parker BR, Kushner DC, Babcock DS, Cohen HL, Gelfand MJ, Hernandez RJ, Royal SA, Slovis TL, Smith WL, Strain JD, Strife JL, Kanda MB, Myer E, Decter RM, Moreland MS. Sinusitis in the pediatric population. American College of Radiology. ACR Appropriateness Criteria. Radiology 2000 Jun;215(Suppl):811-18.

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

## \*\* REGULATORY ALERT \*\*

### FDA WARNING/REGULATORY ALERT

**Note from the National Guideline Clearinghouse:** This guideline references a drug(s) for which important revised regulatory and/or warning information has been released.

- [May 23, 2007, Gadolinium-based Contrast Agents](#): The addition of a boxed warning and new warnings about the risk of nephrogenic systemic fibrosis (NSF) to the full prescribing information for all gadolinium-based contrast agents (GBCAs).

## COMPLETE SUMMARY CONTENT

\*\* REGULATORY ALERT \*\*

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## SCOPE

### **DISEASE/CONDITION(S)**

Sinusitis

### **GUIDELINE CATEGORY**

Diagnosis  
Evaluation

### **CLINICAL SPECIALTY**

Allergy and Immunology  
Family Practice  
Otolaryngology  
Pediatrics  
Radiology

### **INTENDED USERS**

Health Plans  
Hospitals  
Managed Care Organizations  
Physicians  
Utilization Management

### **GUIDELINE OBJECTIVE(S)**

To evaluate the appropriateness of initial radiologic examinations for sinusitis in the pediatric population

### **TARGET POPULATION**

Children with sinusitis

### **INTERVENTIONS AND PRACTICES CONSIDERED**

1. X-ray, paranasal sinuses
2. Computed tomography (CT)
  - Cranial, including sinuses and orbits with contrast
  - Coronal, paranasal sinuses

3. Magnetic resonance imaging (MRI), paranasal sinuses, multiple views with contrast
4. Ultrasound (US), paranasal sinuses

## **MAJOR OUTCOMES CONSIDERED**

Utility of radiologic examinations 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 recent 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 within 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 1-9, 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 the 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**

One study found that the cost of magnetic resonance imaging (MRI) was comparable to the costs of plain radiographs and computed tomography (CT), but this is not typically the case.

## **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: Sinusitis -- Child**

**Variant 1: Nasal discharge and fever <10 days' duration.**

<b>Radiologic Exam Procedure</b>	<b>Appropriateness Rating</b>	<b>Comments</b>
X-ray, paranasal sinuses	2	One to four projections. See literature review below.
CT cranial, including sinuses and orbits with contrast	2	
CT, coronal, paranasal sinuses	2	
MRI, paranasal sinuses, multiple views with contrast	2	
US, paranasal sinuses	1	A or B mode or real time.
<b><i>Appropriateness Criteria Scale</i></b> <b>1 2 3 4 5 6 7 8 9</b> <b>1 = Least appropriate 9 = Most appropriate</b>		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

**Variant 2: Purulent nasal discharge and fever >10 days' duration.**

<b>Radiologic Exam Procedure</b>	<b>Appropriateness Rating</b>	<b>Comments</b>
CT, coronal, paranasal sinuses	8	
X-ray, paranasal sinuses	3	One to four projections.
CT cranial, including sinuses and orbits with contrast	2	
MRI, paranasal sinuses, multiple views with contrast	2	
US, paranasal sinuses	1	A or B mode or real time.
<b><i>Appropriateness Criteria Scale</i></b>		

<b>Radiologic Exam Procedure</b>	<b>Appropriateness Rating</b>	<b>Comments</b>
<b>1 2 3 4 5 6 7 8 9</b> <b>1 = Least appropriate 9 = Most appropriate</b>		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

**Variant 3: Headache, no nasal discharge.**

<b>Radiologic Exam Procedure</b>	<b>Appropriateness Rating</b>	<b>Comments</b>
X-ray, paranasal sinuses	2	One to four projections.
US, paranasal sinuses	2	A or B mode or real time.
CT cranial, including sinuses and orbits with contrast	2	
CT, coronal, paranasal sinuses	2	
MRI, paranasal sinuses, multiple views with contrast	2	
<b><i>Appropriateness Criteria Scale</i></b> <b>1 2 3 4 5 6 7 8 9</b> <b>1 = Least appropriate 9 = Most appropriate</b>		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

**Variant 4: Recurrent or persistent clinical sinusitis.**

<b>Radiologic Exam Procedure</b>	<b>Appropriateness Rating</b>	<b>Comments</b>
CT, coronal, paranasal sinuses	8	
X-ray, paranasal sinuses	2	One to four projections.
CT cranial, including sinuses and orbits with contrast	2	

<b>Radiologic Exam Procedure</b>	<b>Appropriateness Rating</b>	<b>Comments</b>
MRI, paranasal sinuses, multiple views with contrast	2	
US, paranasal sinuses	1	A or B mode or real time.
<b><i>Appropriateness Criteria Scale</i></b> <b>1 2 3 4 5 6 7 8 9</b> <b>1 = Least appropriate 9 = Most appropriate</b>		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

**Variant 5: Poorly responding asthma or history of atopia with persistent nasal discharge.**

<b>Radiologic Exam Procedure</b>	<b>Appropriateness Rating</b>	<b>Comments</b>
CT, coronal, paranasal sinuses	6	
X-ray, paranasal sinuses	2	
CT cranial, including sinuses and orbits with contrast	2	
MRI, paranasal sinuses, multiple views with contrast	2	
US, paranasal sinuses	1	A or B mode or real time.
<b><i>Appropriateness Criteria Scale</i></b> <b>1 2 3 4 5 6 7 8 9</b> <b>1 = Least appropriate 9 = Most appropriate</b>		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

**Variant 6: Preoperative evaluation for functional endoscopic sinus surgery.**

<b>Radiologic Exam Procedure</b>	<b>Appropriateness Rating</b>	<b>Comments</b>
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<b>Radiologic Exam Procedure</b>	<b>Appropriateness Rating</b>	<b>Comments</b>
CT, coronal, paranasal sinuses	9	
X-ray, paranasal sinuses	2	One to four projections.
CT cranial, including sinuses and orbits with contrast	2	
MRI, paranasal sinuses, multiple views with contrast	2	
US, paranasal sinuses	1	A or B mode or real time.
<b><i>Appropriateness Criteria Scale</i></b> <b>1 2 3 4 5 6 7 8 9</b> <b>1 = Least appropriate 9 = Most appropriate</b>		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

**Variant 7: Suspected complication of sinusitis (e.g., orbital cellulitis).**

<b>Radiologic Exam Procedure</b>	<b>Appropriateness Rating</b>	<b>Comments</b>
CT cranial, including sinuses and orbits with contrast	9	
CT, coronal, paranasal sinuses	4	Use IV contrast material.
X-ray, paranasal sinuses	2	One to four projections.
MRI, paranasal sinuses, multiple views with contrast	2	For problem solving and suspected intracranial disease involvement.
US, paranasal sinuses	1	A or B mode or real time.
<b><i>Appropriateness Criteria Scale</i></b> <b>1 2 3 4 5 6 7 8 9</b> <b>1 = Least appropriate 9 = Most appropriate</b>		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

**VARIANT 8: Complex sinus disease; rule out fungal sinusitis.**

<b>Radiologic Exam Procedure</b>	<b>Appropriateness Rating</b>	<b>Comments</b>
CT cranial, including sinuses and orbits with contrast	9	
MRI, paranasal sinuses, multiple views with contrast	9	
CT, coronal, paranasal sinuses	4	Use IV contrast material.
X-ray, paranasal sinuses	2	One to four projections.
US, paranasal sinuses	1	A or B mode or real time.
<p><b><i>Appropriateness Criteria Scale</i></b>  <b>1 2 3 4 5 6 7 8 9</b>  <b>1 = Least appropriate 9 = Most appropriate</b></p>		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Sinusitis is a common problem in the pediatric population. The underlying factors that may lead to sinusitis in children include nasal airway obstruction, immunodeficiencies, alterations in the mucosa of the sinuses and nasal passageways, ciliary dysfunction, and underlying conditions such as cystic fibrosis, allergic rhinitis, and immotile cilia syndrome. The growing number of children in day care centers has led to an increase in upper respiratory infections, which usually precede acute sinusitis. Recognition of the importance of sinus disease in children has been stimulated by the realization that sinus disease can have a negative impact on chronic pulmonary disease and is often a major complication of primary and acquired immunodeficiencies, the incidence and recognition of which are increasing. Not to be overlooked is the social and economic importance of sinusitis—parents often missing work to care for their children.

Although physicians vary in their understanding and ability to diagnose sinusitis clinically, a number of publications have detailed the signs and symptoms of acute, recurrent, and chronic sinusitis. The findings of sinusitis, especially chronic recurrent sinusitis, are nonspecific. The most common signs and symptoms of acute sinusitis are upper respiratory infection with cough and purulent nasal drainage persisting beyond 10 days. Infants and children with acute sinusitis almost always have purulent nasal discharge with acute sinusitis. Also considered is the patient who has severe symptoms and signs, including a temperature greater than 102 degrees F (39 degrees C) and a purulent nasal discharge present concurrently for at least 3 to 4 consecutive days in an ill child. Acute sinusitis is a clinical diagnosis which may not require imaging, especially in children less than 6

years of age. In patients with chronic sinusitis or rhinosinusitis with symptoms lasting more than 90 days, one must consider the possibility that they are associated with or secondary to asthma, gastroesophageal reflux, cystic fibrosis, or allergic rhinitis. Allergic patients have a higher incidence and more severe disease seen on computed tomography (CT) examinations of the sinuses. The same is true for asthma patients. The precise role of imaging for the diagnosis and management of chronic or recurrent sinusitis, is unclear, including the CT classifications of disease staging, and will therefore not be included in the clinical condition variants.

Two main controversies surround imaging of sinusitis in the pediatric population. The first concerns the use of plain radiographs versus coronal CT scans. Although they are less costly and more widely available, plain radiographs both underdiagnose and overdiagnose soft tissue changes in the paranasal sinuses. In addition, the Caldwell projection does not localize ethmoid disease, and the Waters projection does not show ethmoid involvement. Demonstration and localization of disease are essential for endoscopic sinus surgery; therefore, plain radiographs cannot be used as a guide for this procedure. Lateral sinus radiographs are of little value in patients under 4 years of age. Coronal sinus CT is the recommended examination for imaging persistent or chronic sinusitis in patients of any age, because it accurately depicts the sinus anatomy, including soft tissue changes, anatomic variations, the ostiomeatal complex, and complications, especially those involving the orbit or intracranial structures. The fourth view, the submentovertex, does not contribute to the depiction of soft tissue changes in the paranasal sinuses.

An even greater controversy in imaging pediatric sinusitis is the high incidence of soft tissue findings noted on plain radiographs, CT, or magnetic resonance imaging (MRI) examinations found in patients who have no clinical evidence of sinus disease but who have undergone these examinations for other reasons. Incidences of 33%-50% have been reported. The common cold acutely produces mucosal abnormalities in sinuses, including the ostiomeatal area and nasal passageways, in the majority of adults. This incidence is even higher in infants and children and, indeed, was 97% in a study involving infants who had a cold in the two weeks preceding cranial CT done for other reasons. Another study demonstrated an 88% incidence of soft tissue changes in sinuses associated with viral respiratory infections. However, acute viral rhinosinusitis does predispose the patient to acute bacterial sinusitis. MRI studies have also shown that soft tissue changes in sinuses can last months following an acute infection. Soft tissue abnormalities on CT scans are dynamic and can change from day to day. Clinical correlation with imaging findings is critical for accurate evaluation of these findings.

If suspicion exists for complications of sinusitis such as preseptal or postseptal cellulitis, subperiosteal abscess, orbital cellulitis or abscess, cavernous sinus thrombosis, osteomyelitis of the frontal bone, subdural empyema, epidural or brain abscess, meningitis, brain infarction, or myotic aneurysm, then cranial CT including the brain and sinuses is indicated. MRI with gadolinium is especially useful if intracranial involvement is suspected.

MRI of the paranasal sinuses beautifully shows mucosal thickening, differentiates mucosal thickening from sinus secretions, and is not associated with ionizing

radiation, but it is not feasible as a primary imaging modality for pediatric sinusitis because of its higher costs, its limited availability, frequent need for sedation in infants and children, and the lack of bony detail of the ostiomeatal complex felt to be a major factor in sinusitis. MRI of the sinuses can play a role in evaluating the complications of sinusitis, such as fungal involvement of the sinuses and intracranial extension, as well as in excluding tumor in patients with opacified sinuses. In one study the cost of MRI was comparable to the costs of plain radiographs and CT, but this is not typically the case.

Conventional tomography of the sinuses and nuclear medicine studies are rarely indicated. Control studies using ultrasound of the sinuses have shown that this modality lacks sufficient sensitivity and specificity and is not recommended.

Plain radiographs of the sinuses may be useful for confirming soft tissue findings in patients with clinical sinusitis, but they have very low specificity. They can be used on patients with headaches in whom the diagnosis of sinusitis is considered to be a clinical possibility. Plain radiographs of the sinuses can assist in excluding sinus disease when the clinical manifestations are unclear.

Coronal CT scans are the gold standard for diagnosing soft tissue findings in the sinuses. However, the high incidence of soft tissue abnormalities in the sinuses of infants and children with intercurrent or recent upper respiratory tract infections necessitates the correlation of clinical and imaging findings. In addition, the incidence on CT of anatomic sinus variations, Haller cells, concha bullosa, and so forth, along with the distribution of diseases within the sinuses is similar in asymptomatic infants and children, such as those with recurrent sinusitis.

Coronal CT scans should be obtained before functional endoscopic sinus surgery (FESS) as they provide a road map for surgery. Controversies certainly exist not only about imaging for suspected sinusitis but also regarding management of the disease—antibiotic therapy, duration of therapy, adjunct therapies, role of FESS, etc. A randomized placebo controlled study of clinically diagnosed acute uncomplicated sinusitis showed no clinical benefit from antibiotic therapy. There is poor concordance between clinical signs and symptoms and the imaging and clinical results of FESS.

Recommendations are as follows:

1. The diagnosis of acute and chronic sinusitis should be made clinically, not on the basis of imaging findings alone.
2. When acute sinusitis is diagnosed and appropriately treated, no imaging studies are indicated if full clinical resolution occurs.
3. Patients with acute sinusitis persisting after 10 days of appropriate therapy, or with chronic sinusitis, and in whom imaging evaluation is desired, should undergo coronal CT scans of the sinuses regardless of their age.
4. The use of plain radiographs in evaluating of sinusitis should be discouraged unless exceptional circumstances warrant it. If plain radiographs are performed, only Waters and Caldwell views are recommended for patients younger than 4 years of age; for older patients, a lateral view is obtained. The lateral view should be performed with cross-table technique if the Waters view cannot be obtained with the patient upright.

5. Cranial CT with contrast, to include the sinuses, is indicated for suspected complications of bacterial sinusitis.

### **Abbreviations**

- CT, computed tomography
- IV, intravenous
- MRI, magnetic resonance imaging
- US, ultrasound

### **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 diagnosis of sinusitis in the pediatric population

### **POTENTIAL HARMS**

High incidence of soft tissue findings noted on plain radiographs, computed tomography (CT), and magnetic resonance imaging (MRI) examinations in patients who have no clinical evidence of sinus disease. Clinical correlation with imaging findings is critical for accurate evaluation of these findings.

## **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 radiologists, radiation oncologists, 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)

McAlister WH, Strain JD, Cohen HL, Fordham L, Gelfand MJ, Gunderman R, Slovis TL, Smith WL, Rodriguez W, Expert Panel on Pediatric Imaging. Sinusitis--child. [online publication]. Reston (VA): American College of Radiology (ACR); 2006. 7 p. [51 references]

### ADAPTATION

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

### DATE RELEASED

1995 (revised 2006)

## **GUIDELINE DEVELOPER(S)**

American College of Radiology - Medical Specialty Society

## **SOURCE(S) OF FUNDING**

The 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 Pediatric Imaging

## **COMPOSITION OF GROUP THAT AUTHORED THE GUIDELINE**

*Panel Members:* William H. McAlister, MD; John D. Strain, MD; Harris L. Cohen, MD; Lynn Fordham, MD; Michael J. Gelfand, MD; Richard Gunderman, MD, PhD; Thomas L. Slovis, MD; Wilbur L. Smith, MD; William Rodriguez, MD

## **FINANCIAL DISCLOSURES/CONFLICTS OF INTEREST**

Not stated

## **GUIDELINE STATUS**

This is the current release of the guideline.

This guideline updates a previous version: McAlister WH, Parker BR, Kushner DC, Babcock DS, Cohen HL, Gelfand MJ, Hernandez RJ, Royal SA, Slovis TL, Smith WL, Strain JD, Strife JL, Kanda MB, Myer E, Decter RM, Moreland MS. Sinusitis in the pediatric population. American College of Radiology. ACR Appropriateness Criteria. Radiology 2000 Jun;215(Suppl):811-18.

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**

This summary was completed by ECRI on March 25, 1999. The information was verified by the guideline developer on September 9, 1999. The summary was updated on February 12, 2002. The information was verified again by the guideline developer on March 25, 2002. This summary was updated by ECRI on August 17, 2006. This summary was updated by ECRI Institute on May 17, 2007 following the U.S. Food and Drug Administration (FDA) advisory on Gadolinium-based contrast agents. This summary was updated by ECRI Institute on June 20, 2007 following the U.S. Food and Drug Administration (FDA) advisory on gadolinium-based contrast agents.

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