

**American College of Radiology  
ACR Appropriateness Criteria®  
Sepsis**

**Variant 1:**                      **Suspected or confirmed sepsis. Cough or dyspnea or chest pain. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography chest	Usually Appropriate	⊕
CT chest with IV contrast	May Be Appropriate	⊕⊕⊕
CT chest without IV contrast	May Be Appropriate	⊕⊕⊕
MRI chest without and with IV contrast	Usually Not Appropriate	○
MRI chest without IV contrast	Usually Not Appropriate	○
CT chest without and with IV contrast	Usually Not Appropriate	⊕⊕⊕
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	⊕⊕⊕⊕

**Variant 2:**                      **Suspected or confirmed sepsis. Cough or dyspnea or chest pain. Normal or equivocal or nonspecific chest radiograph. Next imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
CT chest with IV contrast	Usually Appropriate	⊕⊕⊕
CT chest without IV contrast	Usually Appropriate	⊕⊕⊕
MRI chest without and with IV contrast	Usually Not Appropriate	○
MRI chest without IV contrast	Usually Not Appropriate	○
CT chest without and with IV contrast	Usually Not Appropriate	⊕⊕⊕
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	⊕⊕⊕⊕

**Variant 3:**                      **Suspected or confirmed sepsis. Acute abdominal pain. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
CT abdomen and pelvis with IV contrast	Usually Appropriate	⊕⊕⊕
US abdomen	May Be Appropriate	○
CT abdomen and pelvis without IV contrast	May Be Appropriate (Disagreement)	⊕⊕⊕
Radiography abdomen	Usually Not Appropriate	⊕
Fluoroscopy contrast enema	Usually Not Appropriate	⊕⊕⊕
Fluoroscopy upper GI series with small bowel follow-through	Usually Not Appropriate	⊕⊕⊕
MRI abdomen and pelvis without and with IV contrast	Usually Not Appropriate	○
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	○
Nuclear medicine scan gallbladder	Usually Not Appropriate	⊕⊕
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	⊕⊕⊕⊕
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	⊕⊕⊕⊕
WBC scan abdomen and pelvis	Usually Not Appropriate	⊕⊕⊕⊕

**Variant 4:**

**Suspected or confirmed sepsis. No specific symptoms suggestive of origin, or symptoms cannot be assessed. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography chest	Usually Appropriate	⦿
US abdomen	May Be Appropriate	○
CT abdomen and pelvis with IV contrast	May Be Appropriate	⦿⦿⦿
CT chest with IV contrast	May Be Appropriate	⦿⦿⦿
CT chest without IV contrast	May Be Appropriate	⦿⦿⦿
CT chest abdomen and pelvis with IV contrast	May Be Appropriate	⦿⦿⦿⦿
CT chest abdomen and pelvis without IV contrast	May Be Appropriate (Disagreement)	⦿⦿⦿⦿
Radiography abdomen	Usually Not Appropriate	⦿
Fluoroscopy contrast enema	Usually Not Appropriate	⦿⦿⦿
Fluoroscopy upper GI series with small bowel follow-through	Usually Not Appropriate	⦿⦿⦿
MRI abdomen and pelvis without and with IV contrast	Usually Not Appropriate	○
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	○
MRI chest without and with IV contrast	Usually Not Appropriate	○
MRI chest without IV contrast	Usually Not Appropriate	○
Nuclear medicine scan gallbladder	Usually Not Appropriate	⦿⦿
CT abdomen and pelvis without IV contrast	Usually Not Appropriate	⦿⦿⦿
CT chest without and with IV contrast	Usually Not Appropriate	⦿⦿⦿
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	⦿⦿⦿⦿
CT chest abdomen and pelvis without and with IV contrast	Usually Not Appropriate	⦿⦿⦿⦿
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	⦿⦿⦿⦿
WBC scan abdomen and pelvis	Usually Not Appropriate	⦿⦿⦿⦿

**Variant 5:**

**Suspected or confirmed sepsis. No specific symptoms suggestive of origin, or symptoms cannot be assessed. Normal or equivocal or nonspecific chest radiograph. Next imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
CT abdomen and pelvis with IV contrast	Usually Appropriate	⦿⦿⦿
US abdomen	May Be Appropriate	○
CT abdomen and pelvis without IV contrast	May Be Appropriate (Disagreement)	⦿⦿⦿
CT chest with IV contrast	May Be Appropriate	⦿⦿⦿
CT chest without IV contrast	May Be Appropriate	⦿⦿⦿
CT chest abdomen and pelvis with IV contrast	May Be Appropriate (Disagreement)	⦿⦿⦿⦿
CT chest abdomen and pelvis without IV contrast	May Be Appropriate (Disagreement)	⦿⦿⦿⦿
Radiography abdomen	Usually Not Appropriate	⦿
Fluoroscopy contrast enema	Usually Not Appropriate	⦿⦿⦿
Fluoroscopy upper GI series with small bowel follow-through	Usually Not Appropriate	⦿⦿⦿
MRI abdomen and pelvis without and with IV contrast	Usually Not Appropriate	○
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	○
MRI chest without and with IV contrast	Usually Not Appropriate	○
MRI chest without IV contrast	Usually Not Appropriate	○
Nuclear medicine scan gallbladder	Usually Not Appropriate	
CT chest without and with IV contrast	Usually Not Appropriate	⦿⦿⦿
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	⦿⦿⦿⦿
CT chest abdomen and pelvis without and with IV contrast	Usually Not Appropriate	⦿⦿⦿⦿
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	⦿⦿⦿⦿
WBC scan abdomen and pelvis	Usually Not Appropriate	⦿⦿⦿⦿

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## **Summary of Literature Review**

### **Introduction/Background**

According to the Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3), sepsis is defined as life-threatening organ dysfunction caused by a dysregulated host response to infection [1]. Therefore, what differentiates sepsis from simple infection is the presence of an aberrant host response to the underlying infection and the presence of organ dysfunction. When unexplained organ dysfunction is present, a search for possible causes of infection should commence, and radiological imaging is an integral part of this investigation.

In 2017, the global incidence of sepsis was estimated to be 48.9 million cases with 11 million sepsis-related deaths (accounting for nearly 20% of all global deaths) [2]. Within the United States, according to the Centers for Disease Control and Prevention, the incidence of sepsis is >1.7 million adults per year. Greater than 15% of Americans diagnosed with sepsis die as a result of sepsis each year, and the in-hospital mortality is >30%, exemplifying that prompt recognition and treatment is crucial. Furthermore, sepsis was shown to account for 5.2% of total United States hospital costs (>20 billion dollars) in 2011, and the incidence is only rising because of an aging population [3,4]. Risk factors for the development of sepsis overlap with risk factors for infection and include immune compromise, chronic diseases such as malignancy, certain patient demographics (infants and elderly persons, males, Black race), as well as numerous unidentified causes [5].

This ACR Appropriateness Criteria on Sepsis focuses on thoracic and abdominopelvic causes of sepsis. Other causes of sepsis such as osteomyelitis, diabetic foot infections, periprosthetic infections, and cardiovascular infections (including endocarditis and those due to implantable devices) are not addressed.

### **Initial Imaging Definition**

Initial imaging is defined as imaging performed at the beginning of the care episode for the medical condition defined by the variant. More than one procedure can be considered usually appropriate in the initial imaging evaluation when:

- There are procedures that are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care)

OR

- There are complementary procedures (ie, more than one procedure is ordered as a set or simultaneously where each procedure provides unique clinical information to effectively manage the patient's care).

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## **Discussion of Procedures by Variant**

### **Variant 1: Suspected or confirmed sepsis. Cough or dyspnea or chest pain. Initial imaging.**

CT plays an important role in the evaluation of patients with suspected sepsis because of its high positive predictive value (PPV) [6]. When performed as either an initial or follow-up imaging study, CT often leads to a change in management [7].

#### **CT Chest With IV Contrast**

Pohlan et al [6] performed a retrospective study of 357 emergency department (ED) patients with suspected sepsis, of which 132 underwent CT scan within 72 hours of admission. The most commonly identified source of infection, which the authors refer to as septic foci, was in the chest (pneumonia) reported in 38.6% (49/127) of patients. A PPV of 81.82% (confidence interval [CI], 76.31%-86.28%) was calculated for septic foci identified by CT. However, the negative predictive value (NPV) was only 21.74% (CI, 10.73%-39.11%). Patients with suspected sepsis who received a CT within 72 hours of admission were given a final diagnosis of sepsis in 93.3% of cases (124/132). The detection of septic foci in 76.5% of CTs results in a high diagnostic yield for CT in septic ED patients, particularly in patients who are extremely ill and/or require intensive care unit (ICU) admission.

Just et al [7] performed a single-center 1 year retrospective study of all CT scans of the chest, abdomen, or both ordered in pursuit of suspected infection in surgical ICU patients. A source of infection was found in 76/144 of cases (52.8%) and resulted in a change of management in 65/144 (45%) of patients, including a change in antimicrobial regimen, surgery, and nonsurgical interventions such as placement of drainage catheters. A pathologic infectious source was found in the chest in 72% of patients who underwent chest CT. Use of intravenous (IV) contrast was not specified, and preceding diagnostic procedures including chest radiography were not recorded.

#### **CT Chest Without and With IV Contrast**

There are no data to support the use of any added value of a CT chest without IV contrast immediately before acquisition of a contrast-enhanced CT in the diagnosis of sepsis.

#### **CT Chest Without IV Contrast**

The value of chest CT is iterated above in the section labeled “CT chest with IV contrast.” In the study by Pohlan et al [6], confidence in septic focus identification was not significantly different between CT scans acquired with or without IV contrast medium ( $P = 0.432$ ). In the study by Just et al [7], use of IV contrast was not specified, but CT chest without IV contrast and with IV contrast have similar diagnostic yield in regard to pulmonary disease.

#### **FDG-PET/CT Skull Base to Mid-Thigh**

There are no data to support the use of fluorine-18-2-fluoro-2-deoxy-D-glucose (FDG)-PET/CT as an initial diagnostic imaging study in the diagnosis of sepsis.

#### **MRI Chest Without and With IV Contrast**

Although MRI can readily detect pulmonary and pleural infections, there are no data to support the use of MRI chest without and with IV contrast as an initial diagnostic imaging study in the diagnosis of sepsis.

#### **MRI Chest Without IV Contrast**

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#### **Radiography Chest**

Chest radiography is a commonly obtained study in the ED because of its portability and rapid acquisition. Additionally, it has the potential of providing valuable information as an initial screening tool for infection/pneumonia, particularly in patients with sepsis who may not be able to provide a history. Furthermore, chest radiography is commonly obtained in septic patients for evaluation of adequate placement of external devices, such as endotracheal tubes and central venous catheters, at which time radiologists can concurrently evaluate for an underlying source of infection.

Capp et al [8] performed a retrospective study of ED patients admitted to the ICU with the diagnosis of severe sepsis or septic shock over a 12 month period and evaluated the accuracy of chest radiography in the diagnosis of pneumonia. Of 1,400 patients admitted to the ICU, 170 met criteria for severe sepsis or septic shock, and 85 were diagnosed with pneumonia. The sensitivity and specificity of initial chest radiography was 58% (95% CI, 46%-68%) and 91% (95% CI, 81%-95%), respectively, for the diagnosis of pneumonia.

**Variant 2: Suspected or confirmed sepsis. Cough or dyspnea or chest pain. Normal or equivocal or nonspecific chest radiograph. Next imaging study.**

CT plays an important role in the evaluation of patients with suspected sepsis because of its high PPV [6] when performed as either an initial or follow-up imaging study and which often leads to a change in management [7]. Septic foci are most commonly detected in the chest, abdomen, or pelvis.

**CT Chest With IV Contrast**

Pohlan et al [6] performed a retrospective study of 357 ED patients with suspected sepsis, of whom 132 underwent CT scan within 72 hours of admission. The most commonly identified source of infection, which the authors refer to as septic foci, was in the chest (pneumonia) reported in 38.6% (49/127) of patients. A PPV of 81.82% (CI, 76.31%-86.28%) was calculated for septic foci identified by CT. However, the NPV was only 21.74% (CI, 10.73%-39.11%). Patients with suspected sepsis who received a CT within 72 hours of admission were given a final diagnosis of sepsis in 93.3% of cases (124/132). The detection of septic foci in 76.5% of CTs results in a high diagnostic yield for CT in septic ED patients, particularly in patients who are extremely ill and/or require ICU admission.

Just et al [7] performed a single-center 1 year retrospective study of all CT scans of the chest, abdomen, or both ordered in pursuit of suspected infection in surgical ICU patients. A source of infection was found in 76/144 of cases (52.8%) and resulted in a change of management in 65/144 (45%) of patients, including a change in antimicrobial regimen, surgery, and nonsurgical interventions such as placement of drainage catheters. A pathologic infectious source was found in the chest in 72% of patients who underwent chest CT. Use of IV contrast was not specified in this study. Furthermore, preceding diagnostic procedures including chest radiography were not recorded.

**CT Chest Without and With IV Contrast**

There are no data to support the use of any added value of a CT chest without IV contrast immediately before acquisition of a contrast-enhanced CT in the diagnosis of sepsis.

**CT Chest Without IV Contrast**

The value of chest CT is iterated above in the section labeled “CT chest with IV contrast.” In the study by Pohlan et al [6], confidence in septic focus identification was not significantly different between CT scans acquired with or without IV contrast medium ( $P = 0.432$ ). In the study by Just et al [7], use of IV contrast was not specified, but CT chest without IV contrast and with IV contrast have similar diagnostic yield in regard to pulmonary disease.

**FDG-PET/CT Skull Base to Mid-Thigh**

Tseng et al [9] performed a single-center retrospective observational study of 53 patients admitted with sepsis of unknown origin who underwent initial workup including unrevealing chest radiography followed by FDG-PET/CT within 2 weeks of sepsis diagnosis. Of these, 35/53 (66%) of patients had positive FDG-PET/CT findings and 13/53 (25%) of patients had treatment modified based on imaging results, which included surgery (9/13) and placement of drainage catheters (4/13). Although the majority of infections identified were musculoskeletal (19/53, 38%), the second most common site of infection was in the chest (13/53, 25%).

Kluge et al [10] performed a single-center 6 year retrospective study of critically ill patients with severe sepsis or septic shock of unknown origin. Eighteen patients underwent initial workup, including unrevealing chest radiography followed by FDG-PET/CT (without any other prior cross-sectional imaging). Of these, 14/18 (78%) of patients had positive FDG-PET/CT findings, of which 3/18 (17%) of patients were false positives, 11/18 (61%) of patients were true positives, and 6/18 (33%) of patients had treatment modified based on imaging results, which included surgery and initiation/prolongation of antibiotic therapy. There were no false negatives (100% NPV).

Brondserud et al [11] performed a single-center retrospective study of 157 patients with 165 separate episodes of bacteremia of unknown origin who had also undergone FDG-PET/CT as part of workup for infection or sepsis. FDG-PET/CT was able to detect the site of infection in 93/165 scans (56.4%). It was the first modality to identify the site of infection in 41.1% of cases, led to changes in antimicrobial therapy in 14.7% of patients, and resulted in a new infection-related diagnosis unrelated to bacteremia in 9.8% of episodes. FDG-PET/CT had a high clinical impact in 47.3% of cases and was independent of duration of preceding antimicrobial treatment as well as number of days of bacteremia.

Pijl et al [12] performed a single-center retrospective cohort study of all ICU patients with culture-proven blood stream infection over a 10 year period who had undergone FDG-PET/CT specifically to assess for source of

infection after an initial negative conventional workup. Of the 30 patients included in the study, FDG-PET/CT identified a source of infection in 70% of patients and had a sensitivity of 90.9% and a specificity of 87.5% with discharge diagnosis serving as the reference standard. The most common sources of infection found were pneumonia and septic arthritis. The overall PPV was 95.2%, and the NPV was 77.8% for identifying a focus of infection. Of the positive FDG-PET/CTs, 52% identified a new infectious focus that led to treatment modifications such as abscess drainage, removal of infected material, or change in antimicrobial therapy. FDG-PET/CT still resulted in treatment changes in an additional 14% who already had a known infectious focus.

Given that PET/CT does not provide the same degree of anatomic localization as a dedicated diagnostic dose CT, PET/CT is not considered useful as the next imaging modality after chest radiograph. Therefore, it should only be considered for use after source localization with CT has failed.

### **MRI Chest Without and With IV Contrast**

Although MRI can readily detect pulmonary and pleural infection, there are no data to support the use of MRI chest without and with IV contrast as the next diagnostic imaging study after normal, equivocal, or nonspecific chest radiography in the diagnosis of sepsis.

### **MRI Chest Without IV Contrast**

Although MRI can readily detect pulmonary and pleural infection, there are no data to support the use of MRI chest without IV contrast as the next diagnostic imaging study after normal, equivocal, or nonspecific chest radiography in the diagnosis of sepsis.

### **Variant 3: Suspected or confirmed sepsis. Acute abdominal pain. Initial imaging.**

CT plays an important role in the evaluation of patients with suspected sepsis because of its high PPV [6] when performed as either an initial or follow-up imaging study, and which often leads to a change in management [7]. Septic foci are most commonly detected in the chest, abdomen, or pelvis.

### **CT Abdomen and Pelvis With IV Contrast**

Pohlan et al [6] performed a retrospective study of 357 ED patients with suspected sepsis, of whom 132 underwent CT scan within 72 hours of admission. The second and third most commonly identified septic foci were in the abdomen, 22.0% (28/127 patients), and pelvis/genitourinary tract 20.5% (26/127 patients). A PPV of 81.82% (CI, 76.31%-86.28%) was calculated for septic foci identified by CT. However, the NPV was only 21.74% (CI, 10.73%-39.11%). Patients with suspected sepsis who received a CT within 72 hours of admission were given a final diagnosis of sepsis in 93.3% of cases (124/132). The detection of septic foci in 76.5% of CTs results in a high diagnostic yield for CT in septic ED patients, particularly in patients who are extremely ill and/or require ICU admission.

Just et al [7] performed a single-center 1 year retrospective study of all CT scans of the chest and/or abdomen ordered in pursuit of suspected infection in surgical ICU patients. A source of infection was found in 76/144 of cases (52.8%) and resulted in a change of management in 65/144 (45%) of patients, including a change in antimicrobial regimen, surgery, and nonsurgical interventions such as placement of drainage catheters. A pathologic infectious source was found in up to 44% of patients who underwent abdominal CT (exact breakdown not provided). Use of IV contrast was not specified in this study. Furthermore, preceding diagnostic procedures such as abdominal radiography were not recorded.

Hoddick et al [13] performed a prospective study of 12 patients with urosepsis who were evaluated with both ultrasound (US) and CT. Of these, 6/12 patients had renal abscesses, of whom 6/6 (100%) of the patients were identified on both US and contrast-enhanced CT. One patient had multiple perirenal abscesses, and another patient had a gas-forming perinephric abscess that were both missed by US but seen on CT.

### **CT Abdomen and Pelvis Without and With IV Contrast**

There are no data to support the use of any added value of a CT abdomen and pelvis without IV contrast immediately before acquisition of a contrast-enhanced CT in the diagnosis of sepsis.

### **CT Abdomen and Pelvis Without IV Contrast**

The value of abdomen and pelvis CT is iterated above in the section above labeled “CT abdomen and pelvis with IV contrast.” In the study by Pohlan et al [6], confidence in focus identification was not significantly different between CT scans acquired with or without IV contrast medium ( $P = .432$ ). In the study by Just et al [7], the use of IV contrast was not specified. Per expert opinion, CT abdomen and pelvis without IV contrast is not equivalent to

CT abdomen and pelvis with IV contrast but may be useful in specific clinical situations such as urosepsis from suspected obstructing renal calculi or ureteral calculi.

### **FDG-PET/CT Skull Base to Mid-Thigh**

There are no data to support the use of FDG-PET/CT as an initial diagnostic imaging study in the diagnosis of sepsis.

### **Fluoroscopy Contrast Enema**

There are no data to support the use of fluoroscopy contrast enema as an initial diagnostic imaging study in the diagnosis of sepsis.

### **Fluoroscopy Upper GI Series with Small Bowel Follow-Through**

There are no data to support the use of fluoroscopy upper gastrointestinal (GI) series with small bowel follow-through as an initial diagnostic imaging study in the diagnosis of sepsis.

### **MRI Abdomen and Pelvis Without and With IV Contrast**

There are no data to support the use of MRI abdomen and pelvis without and with IV contrast as an initial diagnostic imaging study in the diagnosis of sepsis. The majority of patients with sepsis are too unstable to undergo a relatively long imaging procedure, especially with the availability of alternate imaging modalities that are shorter and easier to obtain. However, in certain situations, such as targeting a specific source of clinically suspected infection, MRI has been shown to be useful.

Given that perianal sepsis occurs in up to 10% of neutropenic patients, Ashkar et al [14] performed a retrospective review of neutropenic patients from hematologic malignancy who were given the diagnosis of perianal sepsis. Of the 19 included patients, 9 patients underwent pelvic MRI without and with IV contrast. Of these, 88% (8/9) of the patients were found to have a focal collection compatible with a perianal abscess. This resulted in intraoperative drainage of the fluid collection in 6 patients, of whom 80% (5/6) of patients were confirmed to have a purulent draining cavity intraoperatively; 20% (1/6) of the patients was deemed to be a false-positive result.

### **MRI Abdomen and Pelvis Without IV Contrast**

There are no data to support the use of MRI abdomen and pelvis without IV contrast as an initial diagnostic imaging study in the diagnosis of sepsis.

### **Nuclear Medicine Scan Gallbladder**

There are no data to support the use of nuclear medicine scan gallbladder as an initial diagnostic imaging study in the diagnosis of sepsis.

### **Radiography Abdomen**

Although abdominal radiography is portable and rapidly acquired, it rarely provides a definitive diagnosis in the setting of sepsis. It may provide information that increases the probability of an abdominal source such as pneumoperitoneum, but these findings would likely be suspected by physical examination and necessitate further evaluation with CT or US regardless [15,16].

### **US Abdomen**

Abdominal/pelvic US is often chosen as the initial imaging modality in patients of child-bearing age in the evaluation of suspected intraabdominal sepsis. Potential diagnoses responsible for sepsis in this setting can be divided into gynecological causes (such as endometritis, salpingitis, oophoritis, tubo-ovarian abscess, pelvic peritonitis) and nongynecological causes (such as acute appendicitis, diverticulitis, ileitis/colitis, epiploic appendagitis, and urological causes), which can be assessed to varying degrees on US [17]. In the setting of urosepsis, US is often considered the first imaging modality of choice in part because of its portability and rapid acquisition [15,16]. Based on recent studies, there is potential value in employment of artificial intelligence techniques to enhance the value of abdominal US in the setting of sepsis, but this discussion is beyond the scope of this topic.

Sorenson et al [18] performed a retrospective review of 221 patients with first-time bacteremia suspected to be urosepsis. Of these, 116/221 (52%) of the patients underwent further evaluation with either abdominal US or abdomen/pelvis CT. Major abnormalities were found in 37/115 (32%) of patients and most commonly included pyonephrosis and renal calculi. Of these, 15/115 (13%) of the patients underwent urological intervention as a result of imaging findings. Follow-up of the 105 patients who did not undergo initial imaging revealed that 10/105 (9.5%)



of the patients were readmitted the following year with urosepsis; of these patients, imaging by US or CT was indicated for 6/10, and a major abnormality was detected in 3/6 imaged patients.

Hoddick et al [13] performed a prospective study of 12 patients with urosepsis who were evaluated with both US and CT. Of these, 6/12 patients had renal abscesses, of whom 6/6 (100%) of the patients were identified on both US and contrast-enhanced CT. One patient had multiple perirenal abscesses, and another patient had a gas-forming perinephric abscess that were both missed by US but seen on CT.

### **WBC Scan Abdomen and Pelvis**

There are no data to support the use of white blood cell (WBC) scan abdomen and pelvis as an initial diagnostic imaging study added in the diagnosis of sepsis.

### **Variant 4: Suspected or confirmed sepsis. No specific symptoms suggestive of origin, or symptoms cannot be assessed. Initial imaging.**

CT plays an important role in the evaluation of patients with suspected sepsis because of its high PPV [6] when performed as either an initial or follow-up imaging study, which often leads to a change in management [7]. Septic foci are most commonly detected in the chest, abdomen, or pelvis. Of note, transthoracic echocardiography, which plays an important role in the diagnosis of infective endocarditis and associated sepsis, is not addressed in this appropriateness criteria owing to the scope of the topic and that this imaging examination is typically performed outside of radiology.

### **CT Abdomen and Pelvis With IV Contrast**

Pohlan et al [6] performed a retrospective study of 357 ED patients with suspected sepsis, of whom 132 underwent CT scan within 72 hours of admission. The second and third most commonly identified septic foci were in the abdomen, 22.0% (28/127 patients), and pelvis/genitourinary tract 20.5% (26/127 patients). A PPV of 81.82% (CI, 76.31%-86.28%) was calculated for septic foci identified by CT. However, the NPV was only 21.74% (CI, 10.73%-39.11%). Patients with suspected sepsis who received a CT within 72 hours of admission were given a final diagnosis of sepsis in 93.3% of cases (124/132). The detection of septic foci in 76.5% of CTs results in a high diagnostic yield for CT in septic ED patients, particularly in patients who are extremely ill and/or require ICU admission.

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### **CT Abdomen and Pelvis Without and With IV Contrast**

There are no data to support the use of any added value of a CT abdomen and pelvis without IV contrast immediately before acquisition of a contrast-enhanced CT in the diagnosis of sepsis.

### **CT Abdomen and Pelvis Without IV Contrast**

The value of abdomen and pelvis CT is iterated above in the section above labeled “CT abdomen and pelvis with IV contrast.” In the study by Pohlan et al [6], confidence in focus identification was not significantly different between CT scans acquired with or without IV contrast medium ( $P = .432$ ). In the study by Just et al [7], the use of IV contrast was not specified. Per expert opinion, CT abdomen and pelvis without IV contrast is not equivalent to CT abdomen and pelvis with IV contrast, and this procedure is usually not appropriate in this clinical scenario of no symptoms suggestive of origin.

### **CT Chest, Abdomen, and Pelvis With IV Contrast**

Pohlan et al [6] performed a retrospective study of 357 ED patients with suspected sepsis, of whom 132 underwent CT scan within 72 hours of admission. The most commonly identified source of infection, which the authors refer to as septic foci, was in the chest (pneumonia) reported in 38.6% (49/127) of patients. The second and third most commonly identified septic foci were in the abdomen, 22.0% (28/127 patients), and pelvis/genitourinary tract, 20.5% (26/127 patients). A PPV of 81.82% (CI, 76.31%-86.28%) was calculated for septic foci identified by CT. However, the NPV was only 21.74% (CI, 10.73%-39.11%). Patients with suspected sepsis who received a CT within 72 hours of admission were given a final diagnosis of sepsis in 93.3% of cases (124/132). The detection of

septic foci in 76.5% of CTs results in a high diagnostic yield for CT in septic ED patients, particularly in patients who are extremely ill and/or require ICU admission.

Just et al [7] performed a single-center 1 year retrospective study of all CT scans of the chest, abdomen, or both ordered in pursuit of suspected infection in surgical ICU patients. A source of infection was found in 76/144 of cases (52.8%) and resulted in a change of management in 65/144 (45%) of patients, including a change in antimicrobial regimen, surgery, and nonsurgical interventions such as placement of drainage catheters. A pathologic infectious source was found in the chest in 72% of patients who underwent chest CT. A pathologic infectious source was found in up to 44% of patients who underwent abdominal CT (exact breakdown not provided). Use of IV contrast was not specified in this study. Furthermore, preceding diagnostic procedures including chest radiography were not recorded.

#### **CT Chest, Abdomen, and Pelvis Without and With IV Contrast**

There are no data to support the use of any added value of a CT chest, abdomen, and pelvis without IV contrast immediately before acquisition of a contrast-enhanced CT in the diagnosis of sepsis.

#### **CT Chest, Abdomen, and Pelvis Without IV Contrast**

The value of CT chest, abdomen, and pelvis is iterated above in the section above labeled “CT chest, abdomen, and pelvis with IV contrast.” In the study by Pohlen et al [6], confidence in focus identification was not significantly different between CT scans acquired with or without IV contrast medium ( $P = .432$ ). In the study by Just et al [7], use of IV contrast was not specified. Per expert opinion, this procedure is typically not useful in this clinical scenario but may be appropriate because patients with sepsis often present with or develop acute renal failure and therefore fall outside of the parameters of the appropriateness criteria. However, based on expert opinion, CT chest abdomen pelvis without IV contrast is less likely to detect a source of infection than one performed with IV contrast and would therefore not be appropriate as first-line examination in a patient with nonlocalized symptoms.

#### **CT Chest With IV Contrast**

Pohlen et al [6] in a retrospective study of 357 ED patients with suspected sepsis, of whom 132 underwent CT scan within 72 hours of admission, the most commonly identified source of infection, which the authors refer to as septic foci, was in the chest (pneumonia) reported in 38.6% (49/127) of patients. A PPV of 81.82% (CI 76.31%-86.28%) was calculated for a septic focus identified by CT. However, the NPV was only 21.74% (CI 10.73%-39.11%). Patients with suspected sepsis who received a CT within 72 hours of admission were given a final diagnosis of sepsis in 93.3% of cases (124/132). The detection of septic foci in 76.5% of CTs results in a high diagnostic yield for CT in septic ED patients, particularly in patients who are extremely ill and/or require ICU admission.

Just et al [7] performed a single-center 1 year retrospective study of all CT scans of the chest and/or abdomen ordered in pursuit of suspected infection in surgical ICU patients. A source of infection was found in 76/144 of cases (52.8%) and resulted in a change of management in 65/144 (45%) of patients, including a change in antimicrobial regimen, surgery, and nonsurgical interventions such as placement of drainage catheters. A pathologic infectious source was found in the chest in 72% of patients who underwent chest CT. Use of IV contrast was not specified in this study. Furthermore, preceding diagnostic procedures including chest radiography were not recorded.

#### **CT Chest Without and With IV Contrast**

There are no data to support the use of any added value of a CT chest without IV contrast immediately before acquisition of a contrast-enhanced CT in the diagnosis of sepsis.

#### **CT Chest Without IV Contrast**

The value of chest CT is iterated above in the section above labeled “CT chest with IV contrast.” In the study by Pohlen et al [6], confidence in focus identification was not significantly different between CT scans acquired with or without IV contrast medium ( $P = .432$ ). In the study by Just et al [7], the use of IV contrast was not specified, but CT chest without IV contrast and with IV contrast have similar diagnostic yield in regard to pulmonary disease.

#### **FDG-PET/CT Skull Base to Mid-Thigh**

There are no data to support the use of FDG-PET/CT as an initial diagnostic imaging study in the diagnosis of sepsis.

#### **Fluoroscopy Contrast Enema**

There are no data to support the use of fluoroscopy contrast enema as an initial diagnostic imaging study in the diagnosis of sepsis.

### **Fluoroscopy Upper GI Series with Small Bowel Follow-Through**

There are no data to support the use of fluoroscopy upper GI series with small bowel follow-through as an initial diagnostic imaging study in the diagnosis of sepsis.

### **MRI Abdomen and Pelvis Without and With IV Contrast**

There are no data to support the use of MRI abdomen and pelvis without and with IV contrast as an initial diagnostic imaging study in the diagnosis of sepsis. The majority of patients with sepsis are too unstable to undergo a relatively long imaging procedure, especially with the availability of alternate imaging modalities that are shorter and easier to obtain. However, in certain situations, such as targeting a specific source of clinically suspected infection, MRI has been shown to be useful.

Given that perianal sepsis occurs in up to 10% of neutropenic patients, Ashkar et al [14] performed a retrospective review of neutropenic patients from hematologic malignancy who were given the diagnosis of perianal sepsis. Of the 19 included patients, 9 patients underwent pelvic MRI without and with IV contrast. Of these, 88% (8/9) of the patients were found to have a focal collection compatible with a perianal abscess. This resulted in intraoperative drainage of the fluid collection in 6 patients, of whom 80% (5/6) of patients were confirmed to have a purulent draining cavity intraoperatively; 20% (1/6) of the patients was deemed to be a false-positive result.

### **MRI Abdomen and Pelvis Without IV Contrast**

There are no data to support the use of MRI abdomen and pelvis without IV contrast as an initial diagnostic imaging study in the diagnosis of sepsis.

### **MRI Chest Without and With IV Contrast**

Although MRI can readily detect pulmonary and pleural infection, there are no data to support the use of MRI chest without and with IV contrast as an initial diagnostic imaging study in the diagnosis of sepsis.

### **MRI Chest Without IV Contrast**

Although MRI can readily detect pulmonary and pleural infection, there are no data to support the use of MRI chest without IV contrast as an initial diagnostic imaging study in the diagnosis of sepsis.

### **Nuclear Medicine Scan Gallbladder**

There are no data to support the use of nuclear medicine scan gallbladder as an initial diagnostic imaging study in the diagnosis of sepsis.

### **Radiography Abdomen**

Although abdominal radiography is portable and rapidly acquired (which is of obvious benefit for a suspected or confirmed septic patient), it rarely provides a definitive diagnosis in the setting of sepsis. It may provide information that increases the probability of an abdominal source such as pneumoperitoneum, but these findings would be suspected by physical examination and would still necessitate further evaluation with CT or US regardless [15,16].

### **Radiography Chest**

Chest radiography is a commonly obtained study in the ED because of its portability and rapid acquisition. Additionally, it has the potential of providing valuable information as an initial screening tool for pneumonia, particularly in patients with sepsis who may not be able to provide a history. Furthermore, chest radiography is commonly obtained in septic patients for the evaluation of adequate placement of external devices such as endotracheal tubes and central venous catheters at which time radiologists can concurrently evaluate for an underlying source of infection.

Capp et al [8] performed a retrospective study of ED patients admitted to the ICU with the diagnosis of severe sepsis or septic shock over a 12 month period and evaluated the accuracy of chest radiography in the diagnosis of pneumonia. Of 1,400 patients admitted to the ICU, 170 met criteria for severe sepsis or septic shock, and 85 were diagnosed with pneumonia. The sensitivity and specificity of initial chest radiography was 58% (95% CI, 46%-68%) and 91% (95% CI, 81%-95%), respectively, for the diagnosis of pneumonia.

### **US Abdomen**

Abdominal/pelvic US is often chosen as the initial imaging modality in patients of child-bearing age in the evaluation of suspected intraabdominal sepsis. Potential diagnoses responsible for sepsis in this setting can be divided into gynecological causes (such as endometritis, salpingitis, oophoritis, tubo-ovarian abscess, pelvic peritonitis) and nongynecological causes (such as acute appendicitis, diverticulitis, ileitis/colitis, epiploic appendagitis, and urological causes), which can be assessed to varying degrees on US [17]. In the setting of

urosepsis, US is often considered the first imaging modality of choice in part because of its portability and rapid acquisition (which is of obvious benefit for a suspected or confirmed septic patient) [15,16]. Based on recent studies, there is potential value in employment of artificial intelligence techniques to enhance the value of abdominal US in the setting of sepsis, but this discussion is beyond the scope of this topic.

Sorenson et al [18] performed a retrospective review of 221 patients with first-time bacteremia suspected to be urosepsis. Of these, 116/221 (52%) of the patients underwent further evaluation with either abdominal US or abdomen/pelvis CT. Major abnormalities were found in 37/115 (32%) of the patients and most commonly included pyonephrosis and renal calculi. Of these, 15/115 (13%) of the patients underwent urological intervention as a result of imaging findings. Follow-up of the 105 patients who did not undergo initial imaging revealed that 10/105 (9.5%) of the patients were readmitted the following year with urosepsis; of these patients, imaging by US or CT was indicated for 6/10, and a major abnormality was detected in 3/6 imaged patients.

Hoddick et al [13] performed a prospective study of 12 patients with urosepsis who were evaluated with both US and CT. Of these, 6/12 patients had renal abscesses, of whom 6/6 (100%) of the patients were identified on both US and contrast-enhanced CT. One patient had multiple perirenal abscesses, and another patient had a gas-forming perinephric abscess that were both missed by US but seen on CT.

### **WBC Scan Abdomen and Pelvis**

There are no data to support the use of WBC scan abdomen and pelvis as an initial diagnostic imaging study in the diagnosis of sepsis.

**Variant 5: Suspected or confirmed sepsis. No specific symptoms suggestive of origin, or symptoms cannot be assessed. Normal or equivocal or nonspecific chest radiograph. Next imaging study.**

CT plays an important role in the evaluation of patients with suspected sepsis because of its high PPV [6] when performed as either an initial or follow-up imaging study, which often leads to a change in management [7]. Septic foci are most commonly detected in the chest, abdomen, or pelvis. Of note, transthoracic echocardiography, which plays an important role in the diagnosis of infective endocarditis and associated sepsis, is not addressed in this appropriateness criteria owing to the scope of the topic and that this imaging examination is typically performed outside of radiology.

### **CT Abdomen and Pelvis With IV Contrast**

Pohlan et al [6] in a retrospective study of 357 ED patients with suspected sepsis, of whom 132 underwent CT scan within 72 hours of admission, the second and third most commonly identified septic foci were in the abdomen, 22.0% (28/127 patients), and pelvis/genitourinary tract, 20.5% (26/127 patients). A PPV of 81.82% (CI 76.31%-86.28%) was calculated for a septic focus identified by CT. However, the NPV was only 21.74% (CI 10.73%-39.11%). Patients with suspected sepsis who received a CT within 72 hours of admission were given a final diagnosis of sepsis in 93.3% of cases. The detection of septic foci in 76.5% of CTs results in a high diagnostic yield for CT in septic ED patients, particularly in patients who are extremely ill and/or require ICU admission.

Just et al [7] performed a single-center 1 year retrospective study of all CT scans of the chest, abdomen, or both ordered in pursuit of suspected infection in surgical ICU patients. A source of infection was found in 76/144 of cases (52.8%) and resulted in a change of management in 65/144 (45%) of patients, including a change in antimicrobial regimen, surgery, and nonsurgical interventions such as placement of drainage catheters. A pathologic infectious source was found in up to 44% of patients who underwent abdominal CT (exact breakdown not provided). Use of IV contrast was not specified in this study. Furthermore, preceding diagnostic procedures including chest radiography were not recorded.

Hoddick et al [13] performed a prospective study of 12 patients with urosepsis who were evaluated with both US and CT. Of these, 6/12 patients had renal abscesses, of whom 6/6 (100%) of patients were identified on both US and contrast-enhanced CT. One patient had multiple perirenal abscesses, and another patient had a gas-forming perinephric abscess that were both missed by US but seen on CT.

### **CT Abdomen and Pelvis Without and With IV Contrast**

There are no data to support the use of any added value of a CT abdomen and pelvis without IV contrast immediately before acquisition of a contrast-enhanced CT in the diagnosis of sepsis.

### **CT Abdomen and Pelvis Without IV Contrast**

The value of abdomen and pelvis CT is iterated above in the section above labeled “CT abdomen and pelvis with IV contrast.” In the study by Pohlan et al [6], confidence in focus identification was not significantly different between CT scans acquired with or without IV contrast medium ( $P = .432$ ). In the study by Just et al [7], the use of IV contrast was not specified. Per expert opinion, CT abdomen and pelvis without IV contrast is not equivalent to CT abdomen and pelvis with IV contrast but may be useful in specific clinical situations such as urosepsis from suspected obstructing renal calculi or ureteral calculi.

### **CT Chest, Abdomen, and Pelvis With IV Contrast**

Pohlan et al [6] performed a retrospective study of 357 ED patients with suspected sepsis, of whom 132 underwent CT scan within 72 hours of admission. The most commonly identified source of infection, which the authors refer to as septic foci, was in the chest (pneumonia) reported in 38.6% (49/127) of patients. The second and third most commonly identified septic foci were in the abdomen, 22.0% (28/127 patients), and pelvis/genitourinary tract, 20.5% (26/127 patients). A PPV of 81.82% (CI, 76.31%-86.28%) was calculated for septic foci identified by CT. However, the NPV was only 21.74% (CI, 10.73%-39.11%). Patients with suspected sepsis who received a CT within 72 hours of admission were given a final diagnosis of sepsis in 93.3% of cases (124/132). The detection of septic foci in 76.5% of CTs results in a high diagnostic yield for CT in septic ED patients, particularly in patients who are extremely ill and/or require ICU admission.

Just et al [7] performed a single-center 1 year retrospective study of all CT scans of the chest, abdomen, or both ordered in pursuit of suspected infection in surgical ICU patients. A source of infection was found in 76/144 of cases (52.8%) and resulted in a change of management in 65/144 (45%) of patients, including a change in antimicrobial regimen, surgery, and nonsurgical interventions such as placement of drainage catheters. A pathologic infectious source was found in the chest in 72% of patients who underwent chest CT. A pathologic infectious source was found in up to 44% of patients who underwent abdominal CT (exact breakdown not provided). Use of IV contrast was not specified in this study. Furthermore, preceding diagnostic procedures including chest radiography were not recorded.

### **CT Chest, Abdomen, and Pelvis Without and With IV Contrast**

There are no data to support the use of any added value of a CT chest, abdomen, and pelvis without IV contrast immediately before acquisition of a contrast-enhanced CT in the diagnosis of sepsis.

### **CT Chest, Abdomen, and Pelvis Without IV Contrast**

The value of CT chest, abdomen, and pelvis is iterated above in the section above labeled “CT chest, abdomen, and pelvis with IV contrast.” In the study by Pohlan et al [6], confidence in focus identification was not significantly different between CT scans acquired with or without IV contrast medium ( $P = .432$ ). In the study by Just et al [7], the use of IV contrast was not specified. Per expert opinion, this procedure may be appropriate in this clinical scenario because patients with sepsis often present with or develop acute renal failure and therefore fall outside of the parameters of the appropriateness criteria. However, based on expert opinion, CT chest abdomen pelvis without IV contrast is less likely to detect a source of infection than one performed with IV contrast and would therefore not be appropriate as a next line examination in a patient with nonlocalized symptoms.

### **CT Chest With IV Contrast**

Pohlan et al [6] in a retrospective study of 357 ED patients with suspected sepsis, of whom 132 underwent CT scan within 72 hours of admission, the most commonly identified source of infection, which the authors refer to as septic foci, was in the chest (pneumonia) reported in 38.6% (49/127) of patients. A PPV of 81.82% (CI 76.31%-86.28%) was calculated for a septic focus identified by CT. However, the NPV was only 21.74% (CI 10.73%-39.11%). Patients with suspected sepsis who received a CT within 72 hours of admission were given a final diagnosis of sepsis in 93.3% of cases (124/132). The detection of septic foci in 76.5% of CTs results in a high diagnostic yield for CT in septic ED patients, particularly in patients who are extremely ill and/or require ICU admission.

Just et al [7] performed a single-center 1 year retrospective study of all CT scans of the chest, abdomen, or both ordered in pursuit of suspected infection in surgical ICU patients. A source of infection was found in 76/144 of cases (52.8%) and resulted in a change of management in 65/144 (45%) of patients, including a change in antimicrobial regimen, surgery, and nonsurgical interventions such as placement of drainage catheters. A pathologic infectious source was found in the chest in 72% of patients who underwent chest CT. Use of IV contrast was not specified in this study. Furthermore, preceding diagnostic procedures including chest radiography were not recorded.

### **CT Chest Without and With IV Contrast**

There are no data to support the use of any added value of a CT chest without IV contrast immediately before acquisition of a contrast-enhanced CT in the diagnosis of sepsis.

### **CT Chest Without IV Contrast**

The value of chest CT is iterated above in the section above labeled “CT chest with IV contrast.” In the study by Pohlen et al [6], confidence in focus identification was not significantly different between CT scans acquired with or without IV contrast medium ( $P = 0.432$ ). In the study by Just et al [7], the use of IV contrast was not specified, but CT chest without IV contrast and with IV contrast have similar diagnostic yield in regard to pulmonary disease.

### **FDG-PET/CT Skull Base to Mid-Thigh**

Tseng et al [9] performed a single-center retrospective observational study of 53 patients admitted with sepsis of unknown origin who underwent initial workup including unrevealing chest radiography followed by FDG-PET/CT within 2 weeks of sepsis diagnosis. Of these, 35/53 (66%) of the patients had positive FDG-PET/CT findings, and 13/53 (25%) of the patients had treatment modified based on imaging results, which included surgery (9/13) and placement of drainage catheters (4/13). Although the majority of infections identified were musculoskeletal (19/53, 38%), the second most common site of infection was in the chest (13/53, 25%). The presence of liver cirrhosis was the only variable significantly associated with the likelihood of negative PET data ( $P = .005$ ).

Kluge et al [10] performed a single-center 6 year retrospective study of critically ill patients with severe sepsis or septic shock of unknown origin. Eighteen patients underwent initial workup, including unrevealing chest radiography followed by FDG-PET/CT (without any other prior cross-sectional imaging). Of these, 14/18 (78%) of the patients had positive FDG-PET/CT findings, of whom 3/18 (17%) of the patients were false positives, 11/18 (61%) of the patients were true positives, and 6/18 (33%) of the patients had treatment modified based on imaging results, which included surgery and initiation/prolongation of antibiotic therapy. There were no false negatives (100% NPV).

Brondserud et al [11] performed a single-center retrospective study of 157 patients with 165 separate episodes of bacteremia of unknown origin who had also undergone FDG-PET/CT as part of the workup for infection or sepsis. FDG-PET/CT was able to detect the site of infection in 93/165 scans (56.4%). It was the first modality to identify the site of infection in 41.1% of cases, led to changes in antimicrobial therapy in 14.7% of patients, and resulted in a new infection-related diagnosis unrelated to bacteremia in 9.8% of episodes. FDG-PET/CT had a high clinical impact in 47.3% of cases and was independent of the duration of the preceding antimicrobial treatment as well as the number of days of bacteremia.

Pijl et al [12] performed a single-center retrospective cohort study of all ICU patients with culture-proven blood stream infection over a 10 year period who had undergone FDG-PET/CT specifically to assess for source of infection after an initial negative conventional workup. Of the 30 patients included in the study, FDG-PET/CT identified a source of infection in 70% of patients and had a sensitivity of 90.9% and a specificity of 87.5% with discharge diagnosis serving as the reference standard. The most common sources of infection found were pneumonia and septic arthritis. The overall PPV was 95.2%, and NPV was 77.8% for identifying a focus of infection. Of the positive FDG-PET/CTs, 52% identified a new infectious focus that led to treatment modifications such as abscess drainage, removal of infected material, or change in antimicrobial therapy. FDG-PET/CT still resulted in treatment changes in an additional 14% who already had a known infectious focus.

Given that PET/CT does not provide the same degree of anatomic localization as a dedicated diagnostic dose CT, PET/CT is not considered useful as the next imaging modality after chest radiograph. Therefore, it should only be considered for use after source localization with CT has failed.

### **Fluoroscopy Contrast Enema**

There are no data to support the use of fluoroscopy contrast enema without contrast as a diagnostic imaging study in the diagnosis of sepsis.

### **Fluoroscopy Upper GI Series with Small Bowel Follow-Through**

There are no data to support the use of upper GI series with small bowel follow-through as a diagnostic imaging study in the diagnosis of sepsis.

### **MRI Abdomen and Pelvis Without and With IV Contrast**

There are no data to support the use of MRI abdomen and pelvis without and with IV contrast as the next diagnostic imaging study after normal, equivocal, or nonspecific chest radiography in the diagnosis of sepsis. The majority of

patients with sepsis are too unstable to undergo a relatively long imaging procedure especially with the availability of alternate imaging modalities that are shorter and easier to obtain. However, in certain situations such as targeting a specific source of clinically suspected infection, MRI has been shown to be useful.

Given that perianal sepsis occurs in up to 10% of neutropenic patients, Ashkar et al [14] performed a retrospective review of neutropenic patients from hematologic malignancy who were given the diagnosis of perianal sepsis. Of the 19 included patients, 9 patients underwent pelvic MRI without and with IV contrast. Of these, 88% (8/9) of the patients were found to have a focal collection compatible with a perianal abscess. This resulted in intraoperative drainage of the fluid collection in 6 patients, of whom 80% (5/6) of patients were confirmed to have a purulent draining cavity intraoperatively; 20% (1/6) of the patients was deemed to be a false-positive result.

#### **MRI Abdomen and Pelvis Without IV Contrast**

There are no data to support the use of MRI abdomen and pelvis without IV contrast as a diagnostic imaging study in the diagnosis of sepsis.

#### **MRI Chest Without and With IV Contrast**

Although MRI can readily detect pulmonary and pleural infection, there are no data to support the use of MRI chest without and with IV contrast as the next diagnostic imaging study after normal, equivocal, or nonspecific chest radiography in the diagnosis of sepsis.

#### **MRI Chest Without IV Contrast**

Although MRI can readily detect pulmonary and pleural infection, there are no data to support the use of MRI chest without IV contrast as the next diagnostic imaging study after normal, equivocal, or nonspecific chest radiography in the diagnosis of sepsis.

#### **Nuclear Medicine Scan Gallbladder**

There are no data to support the use of nuclear medicine scan gallbladder as a diagnostic imaging study in the diagnosis of sepsis.

#### **Radiography Abdomen**

Although abdominal radiography is portable and rapidly acquired (which is of obvious benefit for a suspected or confirmed septic patient), it rarely provides a definitive diagnosis in the setting of sepsis. It may provide information that increases the probability of an abdominal source such as pneumoperitoneum, but these findings would be either suspected by physical examination or at least partially visualized on chest radiography and would still necessitate further evaluation with CT or US regardless [15,16].

#### **US Abdomen**

Abdominal/pelvic US is often chosen as an imaging modality in patients of child-bearing age in the evaluation of suspected intraabdominal sepsis. Potential diagnoses responsible for sepsis in this setting can be divided into gynecological causes (such as endometritis, salpingitis, oophoritis, tubo-ovarian abscess, pelvic peritonitis) and nongynecological causes (such as acute appendicitis, diverticulitis, ileitis/colitis, epiploic appendagitis, and urological causes), which can be assessed to varying degrees on US [17]. In the setting of urosepsis, US is often useful as the first imaging modality of choice, in part because of its portability and rapid acquisition, which is of obvious benefit for a suspected or confirmed septic patient [15,16]. Based on recent studies, there is potential value in employment of artificial intelligence techniques to enhance the value of abdominal US in the setting of sepsis, but this discussion is beyond the scope of this topic.

Sorenson et al [18] performed a retrospective review of 221 patients with first-time bacteremia suspected to be urosepsis. Of these, 116/221 (52%) of the patients underwent further evaluation with either abdominal US or abdomen/pelvis CT. Major abnormalities were found in 37/115 (32%) of patients and most commonly included pyonephrosis and renal calculi. Of these, 15/115 (13%) of the patients underwent urological intervention as a result of imaging findings. Follow-up of 105 patients who did not undergo initial imaging revealed that 10/105 (9.5%) of the patients were readmitted the following year with urosepsis; of these patients, imaging by US or CT was indicated for 6/10, and a major abnormality was detected in 3/6 imaged patients.

Hoddick et al [13] in a prospective study of 12 patients with urosepsis who were evaluated with both US and CT. Of these, 6/12 of the patients had renal abscesses, of whom 6/6 (100%) of the patients were identified on both US and contrast-enhanced CT. One patient had multiple perirenal abscesses, and another patient had a gas-forming perinephric abscess that were both missed by US but seen on CT.

## WBC Scan Abdomen and Pelvis

When initial cross-sectional imaging is inconclusive in determining the origin of sepsis, radiolabeled WBC scans may be useful as a subsequent imaging study in providing diagnostic information. There is a relative paucity of recent literature regarding the usefulness of WBC scans in the setting of sepsis, and the majority of studies were performed before the routine use of SPECT/CT, which improves the accuracy of radiolabeled WBC scans by co-registering scintigraphic and CT data [19].

Carter et al [20] performed a retrospective review on the usefulness of Indium-111-tagged WBC scan and US in 45 patients with suspected intraabdominal sepsis but without localizing abdominal signs, of whom 22 were ultimately determined to have intraabdominal abscesses. Indium-111-tagged WBC scan correctly identified the intraabdominal abscess in 21/22 patients (sensitivity 95%) and incorrectly predicted abscesses in 2 patients (specificity 91%). All patients had a concurrent US performed and Indium-111-tagged WBC scan was shown to be more sensitive but less specific (US sensitivity was 45% and specificity was 100%).

Baba et al [21] performed a retrospective review of the 45 Indium-111-tagged WBC scans that were performed in the aforementioned study by Carter et al in order to evaluate the usefulness of having performed these examinations. Of these, 34/45 (76%) of the studies were determined to be helpful in furthering patient management, even though only half (50%) of the 34 studies were positive, and 8/45 (18%) were considered to be unhelpful in furthering patient management, and 3/45 (6%) were considering to be misleading and led to inappropriate treatment from study results.

Uslu et al [22] performed a prospective study involving 15 women with clinically suspected pyogenic pelvic inflammatory disease who underwent Tc-99m-HMPAO (hexamethylpropyleneamine oxime)-tagged WBC scan. All patients had previously undergone another study by either US or CT before the WBC scan. Tc-99m-HMPAO-tagged WBC correctly identified pyogenic pelvic inflammatory disease in all 5 surgically confirmed cases (sensitivity 100%) and incorrectly reported pyogenic pelvic inflammatory disease in 1/10 surgically confirmed negative cases (specificity 90%).

Given that the above-mentioned studies are from older literature before the routine use of cross-sectional CT studies, WBC scans are no longer considered useful as the next imaging modality after chest radiograph, given that a WBC scan cannot provide exact anatomic localization in the manner comparable to a CT scan. Therefore, it should only be used after source localization with CT has failed.

## Summary of Recommendations

- **Variant 1:** Radiography chest is usually appropriate for the initial imaging of patients with suspected or confirmed sepsis, cough or dyspnea or chest pain.
- **Variant 2:** CT chest with IV contrast or CT chest without IV contrast is usually appropriate as the next imaging study for patients with suspected or confirmed sepsis, cough or dyspnea or chest pain after normal or equivocal or nonspecific chest radiography. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).
- **Variant 3:** CT abdomen and pelvis with IV contrast is usually appropriate for the initial imaging of patients with suspected or confirmed sepsis with acute abdominal pain. The panel did not agree on recommending CT abdomen and pelvis without IV contrast for patients with this clinical scenario. There is insufficient medical literature to conclude whether or not these patients would benefit from this modality. Imaging with CT abdomen and pelvis without IV contrast in this patient population is controversial but may be appropriate.
- **Variant 4:** Radiography chest is usually appropriate for the initial imaging of patients with suspected or confirmed sepsis with no specific symptoms suggestive of origin or whose symptoms cannot be assessed. The panel did not agree on recommending CT chest abdomen and pelvis without IV contrast for patients with this clinical scenario. There is insufficient medical literature to conclude whether or not these patients would benefit from this modality. Imaging with CT chest abdomen and pelvis without IV contrast in this patient population is controversial but may be appropriate, for instance in patients with significant renal insufficiency.
- **Variant 5:** CT abdomen and pelvis with IV contrast is usually appropriate as the next imaging study for patients with suspected or confirmed sepsis with no specific symptoms suggestive of origin or whose symptoms cannot be assessed after normal or equivocal or nonspecific chest radiography. The panel did not agree on recommending CT chest abdomen and pelvis with IV contrast because there was discrepancy on whether this



examination is usually appropriate or may be appropriate as the next imaging study. The panel did not agree on recommending CT abdomen and pelvis without IV contrast or CT chest abdomen and pelvis without IV contrast as the next imaging study for this clinical scenario. There is insufficient medical literature to conclude whether or not these patients would benefit from these modalities. Imaging with the mentioned examinations in this patient population is controversial but may be appropriate.

### Supporting Documents

The evidence table, literature search, and appendix for this topic are available at <https://acsearch.acr.org/list>. The appendix includes the strength of evidence assessment and the final rating round tabulations for each recommendation.

For additional information on the Appropriateness Criteria methodology and other supporting documents go to [www.acr.org/ac](http://www.acr.org/ac).

### Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

### 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, because of both 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 with 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 [23].

Relative Radiation Level Designations		
Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
○	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.”		

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The 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 examinations 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 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.