Pericarditis, Bacterial

Last Updated: March 30, 2006

Synonyms and related keywords: bacterial pericarditis, purulent pericarditis, inflammation of the pericardium, bacterial infection, pericardium

**INTRODUCTION**

**Background:** Purulent pericarditis is a rare but life-threatening bacterial infection. Purulent pericarditis refers to pericardial fluid that is either culture positive regardless of appearance or purulent appearing despite, in some instances, inability to obtain a positive culture. This bacterial infection of the pericardium produces pericardial effusion that, if untreated, can lead rapidly to hemodynamic collapse, tamponade, and death. The signs of bacterial pericarditis are nonspecific; thus, a high index of suspicion is required to institute life-saving therapy. Proper treatment requires appropriate antibiotics and pericardial drainage.

**Pathophysiology:** The pericardium, which is composed of visceral and parietal layers, envelops the heart and great vessels. The pericardium provides a membrane barrier that protects the heart from infection, limits acute myocardial distension, decreases friction, and modulates ventricular interdependence. In healthy adults, the pericardial space contains approximately 20 mL of fluid, which has the appearance of a plasma ultraltrate.

Bacterial pericarditis most commonly occurs as a direct extension of an infection from an adjacent pneumonia or empyema. Alternatively, a distant infection can hematogenously seed the pericardium. Primary infection of the pericardium is rare. With inflammation, the pericardium becomes permeable to protein, and fluid accumulates between the visceral and parietal layers. Because the pericardium has a limited ability to stretch acutely, rapid accumulation of fluid leads to increased intrapericardial pressure and hemodynamic compromise.

Tamponade occurs when pericardial fluid accumulates rapidly enough or in sufficient volume to impair diastolic filling. During tamponade, all 4 cardiac chambers compete for space within the pericardium, producing increased systemic venous, pulmonary venous, and atrial pressures. Initially, an increased ejection fraction and tachycardia maintain cardiac output. When these mechanisms fail, systemic vascular resistance rises to maintain blood pressure, and the pulse pressure narrows. Any further increase in pericardial volume compromises ventricular filling, producing systemic hypotension and cardiovascular collapse. Volume and rapidity of fluid accumulation both determine whether a pericardial effusion produces tamponade.

With treatment, purulent pericarditis usually resolves without sequelae. Some patients may develop constrictive pericarditis.

**Frequency:**

- **In the US:** Bacterial pericarditis is a rare disease. Its incidence appears to be decreasing, perhaps because of earlier treatment of primary infections and availability of Haemophilus influenzae immunization.

- **Internationally:** Compared with the United States, bacterial pericarditis may occur more frequently in developing nations. This increased incidence has been associated with delay in diagnosis and treatment of serious bacterial infections, malnutrition, and overcrowding.

**Mortality/Morbidity:**
Without treatment, the mortality rate of bacterial pericarditis approaches 100%. Treatment with antibiotics and pericardial drainage decreases the mortality rate to 2-20% in modern case series. Treatment without early and adequate pericardial drainage significantly increases the risk of death. Other risk factors for increased mortality include patients presenting with tamponade or myocardial involvement, delays in diagnosis and/or institution of therapy, infection with *Staphylococcus aureus*, and malnutrition.

Constrictive pericarditis is an infrequent sequel of purulent pericarditis. Signs can develop as early as 15 days after onset of the acute illness. Pericardiectomy usually resolves the symptoms.

**Sex:** Purulent pericarditis affects both sexes nearly equally.

**Age:**

- Most cases of purulent pericarditis occur in children younger than four years.
- Infants may not present with typical or classic features. For example, in one study, no patient younger than 18 months had a friction rub.
- In infants, almost all cases of pericarditis have a bacterial etiology.

**History:**

- Patients are acutely ill and exhibit symptoms of sepsis. Acute purulent pericarditis in an infant is a medical emergency. Rapid evaluation, diagnosis, and treatment is essential.
  - Symptoms are often nonspecific and include fever, respiratory distress, and tachycardia out of proportion to the degree of fever.
  - Children may complain of abdominal discomfort.
- Most patients have preceding or concurrent infection that is the source of pericarditis. These infections include the following:
  - Pneumonia
  - Meningitis
  - Acute osteomyelitis
  - Acute arthritis
  - Soft tissue infections
  - Pericarditis rarely can complicate neonatal sepsis.
- Precordial chest pain is not a frequent symptom, especially in young children.
  - The pain, if present, may be sharp or dull.
  - Supine position, chest wall motion, or coughing may worsen the pain.
  - Sitting forward may relieve the pain.

**Physical:** Infants with bacterial pericarditis generally are very ill and can present with signs of severe sepsis and shock. A high index of suspicion is required.

- Tachypnea and tachycardia out of proportion to fever is characteristic of both purulent pericarditis and acute myocarditis.
- Purulent pericarditis should be suspected in any infant who appears to have sepsis and has an abnormal cardiovascular examination.
- Cardiac auscultation
  - Classic findings of pericarditis include muffled heart sounds and a friction rub.
  - A friction rub is a high-pitched scratchy sound that can occur in any combination of systole, mid diastole, and late diastole.
  - A friction rub is unlikely in the presence of a large pericardial effusion.
  - Rub may vary with patient position or the respiratory cycle, and it may be transient.
  - Infants with purulent pericarditis seldom demonstrate a rub.
Diastolic filling sounds may be heard.

- Signs of venous congestion may be present, including hepatomegaly and jugular venous distention. Jugular veins are difficult to assess in infants.

**Tamponade**

- Tamponade occurs when enough pericardial fluid accumulates to impair diastolic ventricular filling and, subsequently, cardiac output.
- Tamponade can present rapidly with hypotension, soft heart tones of poor quality, and signs of venous congestion indicating acute cardiac decompensation.
- Alternatively, tamponade can develop more insidiously, presenting a picture of right heart failure.
- Signs of tamponade include dyspnea, tachycardia, narrow pulse pressure, pulsus paradoxus, and venous congestion.

**Pulsus paradoxus**

- Pulsus paradoxus is a decrease in systolic blood pressure more than 10 mm Hg with inspiration.
- Any significant pericardial constriction produces this finding. Other causes of pulsus paradoxus include hypovolemia and either a large or small airway obstruction like with epiglottitis or asthma.

**Causes:**

- Most cases of purulent pericarditis are associated with a preexisting or concurrent infection such as pneumonia with or without empyema, meningitis, osteomyelitis, arthritis, or other soft tissue infections.
- Patients recovering from thoracic, cardiac, or esophageal surgery are at risk for purulent pericarditis.
- Purulent pericarditis has been reported in patients recovering from traumatic injury.
- The organisms that most commonly cause purulent pericarditis are *Staphylococcus aureus*, *H influenzae*, *Neisseria meningitidis*, and *Streptococcus pneumoniae*.
  - *S aureus*:
    - This is the most common organism in children, causing approximately 40% of cases.
    - Pericarditis occurs concomitantly with pneumonia with empyema and less often with acute osteomyelitis or soft tissue abscess. Rarely, pericarditis is associated with *S aureus* endocarditis.
    - Necrotizing infection and exotoxin production lead to increased incidence of shock and higher mortality risk.
    - Within the first 3 months after cardiac surgery, *S aureus* is the most common cause of purulent pericarditis.
  - *H influenzae*:
    - This is the second most common organism listed in most reported pediatric case series of purulent pericarditis, although comprehensive data since the introduction of routine immunization is lacking.
    - Infection of the upper or lower respiratory tract frequently precedes pericarditis caused by *H influenzae*. Purulent pericarditis may occur with *H influenzae* meningitis.
    - *H influenzae* produces very thick fibrinopurulent exudate.
  - *N meningitidis*:
    - Pericarditis occurs in approximately 5% of young adults with meningococccemia.
    - The clinical course is often milder than with other causes of purulent pericarditis.
    - Pericardial effusion can be detected at the onset of the illness or later in the course of the infection. Late onset effusions have a purulent appearance but are usually sterile. Whether this late appearing effusion represents an infection, hypersensitivity to an antibiotic, or an immunologic response to the primary infection is unclear.
- *S pneumoniae*: At one time, *S pneumoniae* was the leading cause of purulent pericarditis, but it has become much less common perhaps because of widespread use of antibiotics.
- Other organisms:
  - Other unusual organisms, such as gram-negative enteric bacilli and anaerobes or fungi, are rare but
should be considered in patients who are immunocompromised.

- **Aspergillus pericarditis** arises as a result of pulmonary infection in patients who are immunocompromised. Patients have a very poor prognosis. Therapy includes long-term amphotericin B or itraconazole. Successful therapy relies on recovery of adequate immune function.

- **Mycoplasma pneumoniae** pericarditis is associated with pulmonary disease. The effusion responds to erythromycin.

### DIFFERENTIALS

- Cardiomyopathy, Dilated
- Endocarditis, Bacterial
- Endocarditis, Fungal
- Glycogen-Storage Disease Type I
- Glycogen-Storage Disease Type II
- Heart Failure, Congestive
- Hypothyroidism
- Kawasaki Disease
- Mixed Connective Tissue Disease
- Myocarditis, Nonviral
- Myocarditis, Viral
- Pericardial Effusion, Malignant
- Pericarditis, Constrictive
- Pericarditis, Viral
- Postpericardiotomy Syndrome
- Rheumatic Fever
- Rheumatic Heart Disease

### Other Problems to be Considered:

**Diseases associated with pericardial effusion and tamponade**
- Infectious pericarditis (fungal pericarditis)
- Malignancy
- Autoimmune disorders
- Connective tissue diseases (see Mixed Connective Tissue Disease, Undifferentiated Connective Tissue Disease)
- End-stage renal disease (uremic pericarditis)
- Chest trauma (see Penetrating Chest Trauma, Blunt Chest Trauma)
- Extravasation from central venous catheter

### WORKUP

#### Lab Studies:

- **CBC**
  - CBC usually shows leukocytosis with predominance of immature polymorphonuclear leukocytes.
  - Lymphocytosis suggests viral or idiopathic etiology.
- **Blood culture**: Results are positive in more than one half of patients with bacterial pericarditis.
- **Erythrocyte sedimentation rate (ESR)** and other acute phase reactants are elevated with purulent pericarditis.

#### Imaging Studies:

- **Chest radiography**
  - A rapidly enlarging cardiac silhouette with a water-bottle appearance without accompanying increase in pulmonary vascular markings strongly suggests a pericardial effusion.
  - Consider purulent pericarditis in an infant or child with sepsis and cardiomegaly.
- **Echocardiography**
  - Echocardiography is the imaging modality of choice for rapid accurate identification of a pericardial effusion and its size and distribution.
  - By 2-dimensional echocardiography, pericardial fluid appears as an "echo-free" space. With small effusions, fluid first appears posteriorly in the dependent portion of the pericardial sack. With larger effusions, fluid is found both anterior and posterior to the heart.
  - Echogenic material may be observed in the pericardial fluid and may represent adhesions, clots, or fibrinous material.
  - Multiple echocardiographic indicators of cardiac tamponade exist, but none are completely sensitive or specific. The
Echocardiogram must be considered in relation to the clinical picture when making the diagnosis of tamponade.

- Common criteria of tamponade on echocardiograph include right atrium (RA) collapse at end diastole that continues into systole, right ventricle (RV) compression during diastole (especially with expiration), and marked respiratory variation in transvalvular flow velocities by Doppler echocardiogram. Reversal of systemic venous return flow can occur during diastole.

- Echocardiography is useful in guiding pericardiocentesis. Visualizing the tip of the needle is helpful because echographic artifacts arising from the shaft of the needle may mislead the operator to the actual location of the needle tip. If needle position is uncertain, 5 mL (or less) of agitated saline may be injected for a contrast echocardiogram.

Other Tests:

- Electrocardiography
  - Most patients exhibit at least 1 ECG abnormality. ECG abnormalities depend on the amount of effusion and the presence of superficial myocardial injury. A normal ECG does not exclude the diagnosis of acute pericarditis. Typical findings include ST segment elevation and low voltage QRS complexes.
  - Pericardial fluid can produce low voltage QRS complexes because of a dampening effect of the fluid between the chest wall and myocardium.
  - Most patients have ST elevation (usually in leads I, II, V5, and V6).
  - Electrical alternans (ie, changes in the P, QRS, and T wave voltages) is very specific, although not sensitive for large pericardial effusions. Electrical alternans results from the heart swinging in a large effusion.
  - Four classic stages of ECG changes are described in acute pericarditis; however, many patients will not exhibit all 4 stages. The stages are as follows:
    1. ST segment elevation and PR segment may be depressed.
    2. ST segment still is elevated but returning to baseline with decreased T wave amplitude. PR segment is depressed.
    3. ST segment returns to normal with T wave inversion (may be incomplete in some cases).
    4. ECG normalization occurs. T wave changes may persist and do not necessarily indicate active disease.

Procedures:

- Pericardiocentesis
  - Definitive diagnosis of purulent pericarditis requires direct examination of pericardial fluid.
  - Pericardiocentesis is safest when performed in a controlled environment, such as the catheterization laboratory or ICU.
  - ECG, blood pressure, and oximetry monitoring is necessary.
  - The procedure is associated with morbidity and should be performed or supervised by an experienced physician.
  - Sedation is desirable unless the patient is unconscious or extremely unstable. Pericardiocentesis in a struggling patient is dangerous.
  - Some operators prefer to use ECG monitoring of needle advancement by clipping the V1 lead to the needle. This technique is cumbersome and is not often employed. If visualization is desired, echocardiography or fluoroscopy guidance is preferred.
  - A pericardial pigtail catheter may be placed using a modified Seldinger technique. The use of a pigtail catheter reduces the risk of dislodgment and myocardial puncture. Additionally, the pigtail catheter may be left in place to provide continuous and potentially definitive pericardial drainage.
  - During pericardiocentesis, bloody fluid often is obtained that may be blood from a myocardial puncture or bloody pericardial fluid. Pericardial fluid fails to clot and has a hematocrit that is much lower than the patient's hematocrit.
  - Potential complications of pericardiocentesis include arrhythmias, laceration of coronary arteries with subsequent hemopericardium and tamponade, pneumothorax, and myocardial perforation.
  - Careful handling of pericardial fluid is required to properly identify etiologic agents for pericardial effusion.
  - Culture fluid for aerobic and anaerobic organisms, fungi, miliary tuberculosis, and viruses.
  - Approximately 50-60% of patients with purulent pericarditis have positive pericardial fluid cultures.
  - Antigen detection tests can be helpful in patients who have received antibiotics.
  - If malignancy is suspected, other studies include cell count and differential, Gram stain, and cytology.
  - The effusion of purulent pericarditis usually has a high WBC with predominately polymorphonuclear cells.
  - Viral pericarditis produces a lymphocytic picture. Protein and lactate dehydrogenase (LDH) often are sent, although both usually are elevated in most types of pericarditis.
Medical Care: Proper treatment of life-threatening illness requires proper antimicrobial therapy, pericardial decompression and drainage, and intensive supportive care.

- **Antibiotics**
  - Until a definitive agent is identified, empiric therapy includes antibiotics to treat both *S. aureus* and gram-negative bacilli.
  - Initial antibiotics should include a combination of penicillinase-resistant penicillin and third-generation cephalosporin.
  - In areas of high antibiotic resistance, consider the use of vancomycin and a third-generation cephalosporin.
  - Include an aminoglycoside if the patient is postoperative from cardiac surgery, is immunocompromised, or has a genitourinary coinfection.
  - Duration of therapy is empiric but generally continues for 3-4 weeks with an antibiotic specific to the organism isolated.

- **Pericardial drainage**
  - Although needle pericardiocentesis may be life saving in tamponade and confirming the diagnosis, it rarely provides complete and long-lasting resolution of the effusion.
  - Avoid repeated attempts at needle pericardiocentesis because they are associated with increased morbidity rates.
  - Open surgical drainage has been used in most cases of purulent pericarditis.
  - Continuous drainage using specialized pericardial catheters and echographic monitoring has had reported success in treating bacterial pericarditis. However, the pericardial fluid may be too thick or loculated to be drained adequately by a catheter.
  - Delay in adequate pericardial drainage is associated with increased mortality rates.

- **Supportive care**
  - Almost all patients require intensive supportive care.
  - In patients with tamponade, supportive therapies are of little or no benefit until emergent pericardial drainage is performed.
  - Drugs that depress the heart rate, produce vasodilatation, or decrease intravascular volume are contraindicated because they further compromise cardiac output. Do not administer digoxin to an infant with purulent pericarditis who shows signs of congestive heart failure.
  - Application of positive pressure mechanical ventilation and positive end-expiratory pressure (PEEP) must be performed carefully because the increased intrathoracic pressure can lead to lethal falls in ventricular preload and worsened shock.
  - Although systolic function of the heart may not be depressed, inotropic agents may be required to treat hypotension that persists after pericardial drainage.
  - Plasma volume expansion is helpful in maintaining cardiac output.

Surgical Care:

- **Pericardial drainage**
  - If pericardiocentesis is unsuccessful in resolving tamponade, emergent surgical drainage is indicated.
  - Surgical drainage is indicated in most patients after the acute emergency resolves.
  - Delay in adequate pericardial drainage is associated with increased mortality rates.
  - A variety of surgical procedures have been employed to provide adequate pericardial drainage, and optimal approach is controversial. Techniques for drainage include placement of a large bore subxiphoid drainage tube (with or without irrigation), creation of a pericardial window and placement of a drain, or pericardiectomy.
  - Proponents of pericardiectomy argue that thick clots and fibrin will not be removed through a tube and that it prevents the possibility of late pericardial constriction and recurrent tamponade.

- **Pericardiectomy**: Late pericardiectomy may be required in the rare patient who develops constrictive pericarditis as a complication of the infection.

Consultations:

- Critical care medicine: Most patients with bacterial pericarditis present with severe hemodynamic compromise. Patients should be referred to specialists proficient in the use of vasoactive agents and mechanical ventilation.
- Cardiology: Patients with cardiomegaly and cardiovascular compromise require cardiology consultation and echocardiography to rule out myocardial or pericardial disease.
- Cardiovascular surgery: Emergent consultation with a cardiovascular surgeon is warranted in patients who have incomplete
resolution of pericardial tamponade despite pericardiocentesis. Consultation should be considered in patients with recurrent effusions or constrictive pericarditis.

**Activity:** No activity restrictions are required in patients who have recovered from bacterial pericarditis.

**Drug Category:** *Antibiotic agents* -- Empiric antimicrobial therapy must be comprehensive and should cover all likely pathogens in the context of the clinical setting. Initial empiric coverage requires a combination of a penicillinase-resistant penicillin and third-generation cephalosporin. In areas of high antibiotic resistance, substitute vancomycin for the penicillin antibiotic.

<table>
<thead>
<tr>
<th>Drug Name</th>
<th>Oxacillin (Bactocill, Prostaphlin) -- Bactericidal antibiotic that inhibits cell wall synthesis. Used in the treatment of infections caused by penicillinase-producing staphylococci. May be used to initiate therapy when a staphylococcal infection is suspected.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult Dose</td>
<td>2 g IV q6h</td>
</tr>
<tr>
<td>Pediatric Dose</td>
<td>200 mg/kg/d IV divided q6h; not to exceed adult dose</td>
</tr>
<tr>
<td>Contraindications</td>
<td>Documented hypersensitivity</td>
</tr>
<tr>
<td>Interactions</td>
<td>Oxacillin decreases effects of contraceptives and tetracycline; administered concomitantly with disulfiram and probenecid, may increase oxacillin levels; effect of anticoagulants increase when large IV doses of oxacillin given</td>
</tr>
<tr>
<td>Pregnancy</td>
<td>B - Usually safe but benefits must outweigh the risks.</td>
</tr>
<tr>
<td>Precautions</td>
<td>Use with caution in patients with hypersensitivity to cephalosporins or severe renal impairment; adjust dosage in patients with renal failure</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Drug Name</th>
<th>Methicillin (Staphcillin) -- Bactericidal antibiotic that inhibits cell wall synthesis. Used in the treatment of infections caused by penicillinase-producing staphylococci. May be used to initiate therapy when a staphylococcal infection is suspected.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult Dose</td>
<td>2 g IV q6h</td>
</tr>
<tr>
<td>Pediatric Dose</td>
<td>200-400 mg/kg/d IV divided q6h; not to exceed adult dose</td>
</tr>
<tr>
<td>Contraindications</td>
<td>Documented hypersensitivity</td>
</tr>
<tr>
<td>Interactions</td>
<td>Methicillin may decrease effects of contraceptives and tetracycline; administered concomitantly with disulfiram and probenecid may increase methicillin levels</td>
</tr>
<tr>
<td>Pregnancy</td>
<td>B - Usually safe but benefits must outweigh the risks.</td>
</tr>
<tr>
<td>Precautions</td>
<td>Use with caution in patients with hypersensitivity to cephalosporins or severe renal impairment; adjust dosage in patients with renal failure</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Drug Name</th>
<th>Nafcillin (Nafcil, Unipen, Nailpen) -- Bactericidal antibiotic that inhibits cell wall synthesis. Used in the treatment of infections caused by penicillinase-producing staphylococci. May be used to initiate therapy when a staphylococcal infection is suspected.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult Dose</td>
<td>2 g IV q6h</td>
</tr>
<tr>
<td>Pediatric Dose</td>
<td>200 mg/kg/d IV divided q6h; not to exceed adult dose</td>
</tr>
<tr>
<td>Contraindications</td>
<td>Documented hypersensitivity</td>
</tr>
<tr>
<td>Interactions</td>
<td>Associated with warfarin resistance when administered concurrently; effects may decrease with bacteriostatic action of tetracycline derivatives; may increase hepatic metabolism of cyclosporine; probenecid inhibits nafcillin elimination</td>
</tr>
<tr>
<td>Pregnancy</td>
<td>B - Usually safe but benefits must outweigh the risks.</td>
</tr>
<tr>
<td>Precautions</td>
<td>Use extravasation precautions; adjust dosage in severe renal and/or hepatic impairments; caution with hypersensitivity to cephalosporins</td>
</tr>
</tbody>
</table>
**Vancomycin** (Lyphocin, Vancocin, Vancoled) -- Indicated for patients with suspected or known infection with resistant organisms. To avoid toxicity, assay vancomycin trough levels 30 min before fourth dose. Use CrCl to adjust dose in patients diagnosed with renal impairment.

<table>
<thead>
<tr>
<th>Drug Name</th>
<th>Adult Dose</th>
<th>Pediatric Dose</th>
<th>Contraindications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vancomycin</td>
<td>500 mg IV q6h</td>
<td>60 mg/kg/d IV divided q6h; not to exceed 4 g/d</td>
<td>Documented hypersensitivity; previous hearing loss</td>
</tr>
</tbody>
</table>

**Interactions**
- Erythema, histaminelike flushing and anaphylactic reactions may occur when administered with anesthetic agents; coadministration with other nephrotoxic or ototoxic drug (eg, aminoglycosides, cisplatin, loop diuretics) increases risk of toxicity; enhanced effect of neuromuscular blockade when coadministered with nondepolarizing muscle relaxants

**Pregnancy**
- C - Safety for use during pregnancy has not been established.

**Precautions**
- Caution in renal dysfunction (adjust dose) or myelosuppression; red man syndrome is caused by too rapid IV infusion (dose given over a few min) but rarely happens when dose given as 2-h infusion

---

**Cefotaxime** (Clafortan) -- Arrests bacterial cell wall synthesis, which, in turn, inhibits bacterial growth. Third-generation cephalosporin with gram-negative spectrum. Lower efficacy against gram-positive organisms.

<table>
<thead>
<tr>
<th>Drug Name</th>
<th>Adult Dose</th>
<th>Pediatric Dose</th>
<th>Contraindications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cefotaxime</td>
<td>2.5 g IV q6h</td>
<td>200 mg/kg/d IV divided q6h; not to exceed adult dose</td>
<td>Documented hypersensitivity</td>
</tr>
</tbody>
</table>

**Interactions**
- Probenecid may increase cefotaxime levels; coadministration with furosemide and aminoglycosides may increase nephrotoxicity

**Pregnancy**
- B - Usually safe but benefits must outweigh the risks.

**Precautions**
- Caution with history of hypersensitivity to penicillin, impaired renal function (adjust dose), or colitis

---

**Ceftriaxone** (Rocephin) -- Third-generation cephalosporin with broad-spectrum gram-negative activity; lower efficacy against gram-positive organisms; higher efficacy against resistant organisms. Arrests bacterial growth by binding to one or more penicillin binding proteins.

<table>
<thead>
<tr>
<th>Drug Name</th>
<th>Adult Dose</th>
<th>Pediatric Dose</th>
<th>Contraindications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceftriaxone</td>
<td>4 g/d IV divided q12-24h</td>
<td>75 mg/kg/d IV divided q12-24h; not to exceed adult dose</td>
<td>Documented hypersensitivity; hyperbilirubinemic neonates, especially premature neonates</td>
</tr>
</tbody>
</table>

**Interactions**
- Probenecid may increase ceftriaxone levels; coadministration with furosemide and aminoglycosides may increase nephrotoxicity

**Pregnancy**
- B - Usually safe but benefits must outweigh the risks.

**Precautions**
- Use with caution in patients with gallbladder, biliary, liver, or pancreatic disease; use with caution in patients with a history of colitis or penicillin hypersensitivity; adjust dose in severe renal insufficiency (high doses may cause CNS toxicity)

---

**Gentamicin** (Garamycin) -- Aminoglycoside antibiotic for gram-negative coverage. Dosing regimens are numerous; adjust dose based on CrCl and changes in volume of distribution. To avoid toxicity, assay trough levels 30 min before fourth dose and peak levels 30-60 min following.

<table>
<thead>
<tr>
<th>Drug Name</th>
<th>Adult Dose</th>
<th>Pediatric Dose</th>
<th>Contraindications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gentamicin</td>
<td>3-6 mg/kg/d IV qd or divided q8-12h</td>
<td>2-2.5 mg/kg IV q8h</td>
<td>Documented hypersensitivity; non–dialysis dependent renal insufficiency</td>
</tr>
</tbody>
</table>

**Interactions**
- Coadministration with other aminoglycosides, cephalosporins, penicillins, and amphotericin B may increase nephrotoxicity; because aminoglycosides enhance effects of neuromuscular blocking agents prolonged respiratory depression may occur; coadministration with loop diuretics may increase auditory toxicity of aminoglycosides; possible irreversible hearing loss of varying degrees may occur (monitor regularly)

**Pregnancy**
- C - Safety for use during pregnancy has not been established.

**Precautions**
- Narrow therapeutic index (not intended for long-term therapy); caution in renal failure (not on dialysis), myasthenia gravis, hypocalcemia, and conditions that depress neuromuscular transmission; adjust dose in renal impairment

### Further Inpatient Care:
- Almost all patients have critical illness and require admission to an ICU.
Further Outpatient Care:

- Once the patient has recovered from the acute infection, follow-up with a cardiologist is recommended to monitor for the development of constrictive pericarditis.

Transfer:

- Critically ill patients with suspected purulent pericarditis require transfer to a tertiary pediatric center with cardiac, cardiac surgical, and critical care medicine expertise. Bacterial pericarditis is a life-threatening disease requiring a full complement of pediatric subspecialty care.
- Do not delay treatment of a critically ill infant in shock. Every hospital with echocardiographic capability should have someone who can perform an emergency pericardiocentesis.

Deterrence/Prevention:

- Pericarditis often is preceded by other severe bacterial infections such as pneumonia with empyema. Proper treatment of those infections will prevent some cases of pericarditis.
- Immunization against *H influenzae* has led to dramatic decreases in the incidence of invasive *H influenzae* disease, including pericarditis.

Complications:

- Acutely, serial ECGs may indicate the presence of occult arrhythmia, suggesting additional myocardial involvement.
- Most patients recover without significant complications.
- Constrictive pericarditis
  - Constrictive pericarditis is a rare complication. Acute constriction has been reported as early as 8 days but generally develops within weeks of diagnosis.
  - Patient symptoms include increased systemic venous pressure, weight gain, hepatomegaly, dyspnea, and decreased urine output. Presence of continued heart failure without a large cardiac silhouette suggests constriction.
  - After recovery from the acute infection, patients should have follow-up with a cardiologist to monitor for the development of constrictive pericarditis. Once identified, pericardiectomy is indicated.

Prognosis:

- Bacterial pericarditis is a life-threatening infection with a high mortality rate unless timely therapy with antibiotics and pericardial drainage is instituted. Despite optimal therapy, the mortality rate can be as high as 20%.
- Patients who survive the acute infection generally do well, without long-term sequelae. Patients infrequently develop constrictive pericarditis requiring pericardiectomy.

Patient Education:

- The following items should be disguised with patients and/or their families:
  - Bacterial pericarditis is a life threatening disease.
  - Proper treatment includes a prolonged course of antibiotics and drainage of the pericardium.
  - If the patient survives, prognosis is good.
  - If symptoms suggestive of congestive heart failure develop after treatment (eg, dyspnea, fatigue, weight gain), the patient should seek evaluation for possible constrictive pericarditis.

Medical/Legal Pitfalls:

- Bacterial pericarditis is a life-threatening illness that requires proper antibiotics and adequate pericardial drainage. The signs and symptoms are often nonspecific and subtle; thus, a high index of suspicion is required. Consider the diagnosis in any infant or young child with septic shock and abnormal cardiovascular physical findings.


**Kocheril AG, Luttmann C, Sadanianz A:** Pneumococcal pericarditis successfully treated with catheter drainage and intravenous antibiotics. Cathet Cardiovasc Diagn 1991 Dec; 24(4): 286-7


**Sinzobahamvya N, Ikegu MO:** Purulent pericarditis. Arch Dis Child 1987 Jul; 62(7): 696-9


**Zahn EM, Houde C, Benson L, Freedom RM:** Percutaneous pericardial catheter drainage in childhood. Am J Cardiol 1992 Sep 1; 70(6): 678-80

**NOTE:**

Medicine is a constantly changing science and not all therapies are clearly established. New research changes drug and treatment therapies daily. The authors, editors, and publisher of this journal have used their best efforts to provide information that is up-to-date and accurate and is generally accepted within medical standards at the time of publication. However, as medical science is constantly changing and human error is always possible, the authors, editors, and publisher, or any other party involved with the publication of this article do not warrant the information in this article is accurate or complete, nor are they responsible for omissions or errors in the article or for the results of using this information. The reader should confirm the information in this article from other sources prior to use. In particular, all drug doses, indications, and contraindications should be confirmed in the package insert. FULL DISCLAIMER
Privacy Policy Changes

Important Announcement:
WebMD, Inc. ("WebMD Health"), a leader in online health information services to the medical professional community has acquired eMedicine. This acquisition was completed January 18, 2006. As we become more fully integrated, eMedicine users are now eligible to utilize the services available to physicians through WebMD Health's professional portals, including Medscape.com, theheart.org and Medsite.com. Your eMedicine account information will now be accessible to WebMD Health where it will be maintained in accordance with the WebMD Professional Services Privacy Policy. Click here to view the WebMD Professional Services Privacy Policy.

If you desire to remove your account information from WebMD Health, please send an email to PrivacyPolicyNotice@emedicine.com.