Blood Stream Infections
Clinical Categories of Blood Stream Infections

• In rough order of severity, these are:
  • Bacteremia
  • Septicemia (Sepsis)
  • Severe sepsis
  • Septic shock
  • Refractory septic shock
  • Multiple-organ dysfunction syndrome
  • Death.
Introduction

• Bacteremia is the presence of viable bacteria in blood

• Bacteremia is the means by which local infections spread to distant organs.

• Hematogenous dissemination of bacteria is part of the pathophysiology of many illnesses.

• Bacteremia is typically transient rather than continuous.
• When multiple blood cultures are positive over a period of 12 hours or more, a continuous bacteremia is present.

• Continuous bacteremia suggests a severe spreading infection that has overwhelmed host defenses.

• A continuous bacteremia may originate from an intravascular site of infection, or from an early phase of a specific infection characterized by a continuous bacteremia.
Asymptomatic Bacteremia

• Bacteria enter the circulatory system via lymphatic drainage from localized sites of infection or mucosal surfaces that are subject to trauma or surgery.

• Organisms may also be introduced directly into the bloodstream by contaminated intravenous needles, catheters or infusions.

• When defense mechanisms effectively remove small numbers of organisms, clinical signs or symptoms of bacteremia may not occur.
• **Asymptomatic bacteremias** have been observed in normal individuals after:

  • Vigorous chewing
  • Dental cleaning or tooth extraction
  • Insertion of urinary bladder catheters
  • Colon surgery
  • Other manipulative procedures.
• Most cases of asymptomatic bacteremia are of no consequence; but may produce infection at a distant site.

• Artificial or damaged heart valves may be colonized by viridans streptococci during asymptomatic bacteremia induced by dental manipulations.

• Infective endocarditis is fatal if not treated, therefore, individuals with known valvular heart disease who undergo dental work or other procedures that produce asymptomatic bacteremia are given antibiotics to prevent colonization of the heart.
Symptomatic Bacteremia

• When a sufficient number of organisms are introduced into the bloodstream, an individual will develop fever, chills, rigors (shivering), and diaphoresis (sweating).

• Patients with symptomatic bacteremia usually look and feel ill.

• In recent years, the incidence of Gram-positive coccal bacteremias has increased steadily superseding Gram-negative bacillary infection which predominated for a while.
Severe Inflammatory Response Syndrome (SIRS)

• SIRS represents a widespread inflammatory response to a variety of severe clinical insults.

• It is clinically recognized by the presence of 2 or more of the following:
  – Temperature > 38°C or < 36°C
  – Heart Rate > 90/minute
  – Respiratory Rate > 20/minutes or PaCO2 < 32 mmHg
  – WBC > 12,000, < 4000 or > 10% immature forms
Sepsis

• SIRS criteria + evidence of infection, or:
  – White cells in normally sterile body fluids
  – Perforated viscus
  – Radiographic evidence of pneumonia
  – Syndrome associated with a high risk of infection
Relationship Between Sepsis and SIRS

INFECTION

BACTEREMIA

SEPSIS

SIRS

TRAUMA

BURNS
Severe Sepsis

- Sepsis criteria + evidence of organ dysfunction, including:
  - CV: Systolic BP $\leq 90$ mmHg, MAP $\leq 70$ mm Hg for at least 1 hour despite volume resuscitation, or the use of vasopressors.
  - Renal: Urine output $< 0.5$ ml/kg body weight/hr for 1 hour despite volume resuscitation.
  - Pulmonary: PaO2/FiO2 $< 250$ if other organ dysfunction present or $< 200$ if the lung is the only dysfunctional organ.
  - Hematologic: Platelet count $\leq 80K$ or decreased by 50% in 3 days.
  - Metabolic: pH $\leq 7.3$ and plasma lactate $> 1.5 \times$ upper normal.
Organ System Involvement

- Circulation
  - Hypotension, increases in microvascular permeability
- Lung
  - Pulmonary Edema, hypoxemia
- GI tract
  - Translocation of bacteria, Liver Failure
- Nervous System
  - Encephalopathy, Critical Illness Polyneuropathy
- Hematologic
  - DIC, coagulopathy
- Kidney
  - Acute Tubular Necrosis, renal failure
Sepsis/Septicemia

• "Sepsis" (in Greek putrefaction) or septicemia is a serious medical condition caused by a systemic infection leading to a severe inflammatory response (SIRS).

• Septicemia is a rapidly progressing, life-threatening infection that can arise from infections throughout the body.

• Septicemia associated with some organisms such as meningococci can lead to shock, adrenal collapse, and disseminated intravascular coagulopathy, a condition called Waterhouse – Friderichsen syndrome.
• Septicemia can begin with spiking fever and chills, rapid breathing and heart rate, the outward appearance of being seriously ill (toxic) and a feeling of impending doom.

• These symptoms rapidly progress to shock, hypothermia, falling blood pressure, confusion or other changes in mental status, and blood-clotting abnormalities evidenced by hemorrhagic lesions in the skin (petechiae and ecchymosis).
Clinical Signs of Sepsis

• Fever.
• Leukocytosis.
• Tachypnea.
• Tachycardia.
• Reduced Vascular Tone.
• Organ Dysfunction.
Severe Sepsis

• Severe sepsis is a major cause of morbidity and mortality worldwide.
  • Leading cause of death in noncoronary ICU.
  • 11\textsuperscript{th} leading cause of death overall.

• More than 750,000 cases of severe sepsis in US annually.

• In the US, more than 500 patients die of severe sepsis daily.
Severe Sepsis is Common
Severe Sepsis is deadly

- Sands, et al. 34%
- Zeni, et al. 50%
- Angus, et al. 28%

Mortality
Severe Sepsis is a Significant Healthcare Burden

- Sepsis consumes significant healthcare resources.

- In a study of Patients who contract nosocomial infections, develop sepsis and survive:
  - ICU stay prolonged an additional 8 days.
  - Additional costs incurred were $40,890/patient.

- Estimated annual healthcare costs due to severe sepsis in U.S. exceed $16 billion.
Septic shock

• “Septic shock” is a serious medical condition causing such effects as multiple organ failure and death in response to infection and sepsis.

• Its most common victims are children and the elderly as well as immunocompromised individuals.

• Septic shock kills about 50% of its victims.

• Septic shock occurs in approximately 40 percent of patients with Gram-negative bacillary bacteremia and 5 percent of patients with Gram-positive bacteremia.
The septic shock syndrome consists of a fall in systemic arterial blood pressure with a resultant decreased effective blood flow to vital organs.

Septic shock patients frequently develop renal and pulmonary insufficiency and coma as part of a generalized metabolic failure caused by inadequate blood flow.

In septic shock, there is sepsis with hypotension despite adequate resuscitation along with the presence of perfusion abnormalities which may include, but are not limited to lactic acidosis, oliguria, or an acute alteration in mental status.

Toxins may cause direct tissue damage, and may lead to low blood pressure and poor organ function. They also produce a vigorous inflammatory response which contributes to septic shock.
Clinical Signs of Septic Shock

- Myocardial Depression.
- Altered Vasculature.
- Altered Organ Perfusion.
- Imbalance of O2 delivery and Consumption.
- Metabolic (Lactic) Acidosis.
Clinical Signs of Septic Shock

- Hemodynamic Alterations
  - Hyperdynamic State ("Warm Shock")
    - Tachycardia.
    - Elevated or normal cardiac output.
    - Decreased systemic vascular resistance.
  - Hypodynamic State ("Cold Shock")
    - Low cardiac output.
Multiorgan dysfunction syndrome

- "Multiple organ dysfunction syndrome" (MODS) is an altered organ function in an acutely ill patient requiring medical intervention to maintain homeostasis.

- MODS is the progressive impairment of two or more organ systems from an uncontrolled inflammatory response to a severe illness or injury.

- Sepsis and septic shock are the most common causes of MODS, with MODS being the end stage.

- Organ dysfunction or organ failure may be the first clinical sign of sepsis, and no organ system is immune to the consequences of the inflammatory excesses of sepsis.
Risk Factors

• Most patients who develop sepsis and septic shock have underlying circumstances that interfere with the local or systemic host defense mechanisms.

• The most common disease states predisposing to sepsis are malignancies, diabetes mellitus, chronic liver disease, chronic renal failure, and the use of immunosuppressive agents.

• In addition, sepsis also is a common complication after major surgery, trauma, and extensive burns.
Risk factors for severe sepsis and septic shock

- Extremes of age (<10 y and >70 y)
- Primary diseases
  - Liver cirrhosis
  - Alcoholism
  - Diabetes mellitus
  - Cardiopulmonary diseases
  - Solid malignancy
  - Hematologic malignancy
- Immunosuppression
  - Neutropenia
  - Immunosuppressive therapy
  - Corticosteroid therapy
  - Intravenous drug abuse
  - Complement deficiencies
  - Asplenia
- Major surgery, trauma, and burns

- Invasive procedures
  - Catheters
  - Intravascular devices
  - Prosthetic devices
  - Hemodialysis and peritoneal dialysis catheters
  - Endotracheal tubes

- Prior antibiotic treatment

- Prolonged hospitalization

- Other factors - Childbirth, abortion, and malnutrition
Microorganisms

• Prior to the introduction of antibiotics in clinical practice, gram-positive bacteria were the principal organisms causing sepsis.

• Gram-negative bacteria then became the key pathogens causing severe sepsis and septic shock for few decades.

• Currently, Gram positive bacteria predominate as a cause of nosocomial blood stream infection being responsible for about 65% of cases.

• Fungal and viral infections can also be the cause of sepsis.
Origin of infection

• In most patients with sepsis, a source of infection can be identified, with the exception of patients who are immunocompromised with neutropenia, where an obvious source of infection often is not found.

• Respiratory tract infections and abdomopelvic infections are the most frequent causes of sepsis, followed by urinary tract and soft tissue infections.

• The use of intravascular devices is a notorious cause of nosocomially-acquired sepsis.

• Multiple sites of infection may occur.
Where’s the infection?

- Abdomen: 15%
- Culture Negative: 20%
- Lung: 47%
- Urine: 10%
- Other: 8%
- Culture: 20%
Lower respiratory tract infections are the cause of septic shock in more than 45% of patients. The following are common pathogens:

- *Streptococcus pneumoniae*
- *Klebsiella pneumoniae*
- *Staphylococcus aureus*
- *Escherichia coli*
- *Legionella species*
- *Haemophilus species*
- *Anaerobes*
- *Gram-negative bacteria*
- *Fungi*
GI tract infections are the cause of septic shock in 15% all patients, and the following are the common pathogens:

- *E coli*
- *Streptococcus faecalis*
- *Bacteroides fragilis*
- *Acinetobacter species*
- *Pseudomonas species*
- *Enterobacter species*
- *Salmonella species*
Urinary tract infections are the cause of septic shock in about 10% of patients, and the following are the common pathogens:

- *E coli*
- *Proteus species*
- *Klebsiella species*
- *Pseudomonas species*
- *Enterobacter species*
- *Enterococcus species*
- *Serratia species*
- **Soft tissue infections** are the cause of septic shock in 15% of patients, and the following are the common pathogens:

- *staphylococcus aureus*
- *Staphylococcus epidermidis*
- *Streptococci*
- *Enterococci*
- *Clostridia*
- *Gram-negative bacteria*
- *Anaerobes*
Infections of the male and female reproductive systems are the cause of septic shock in 10% of patients, and the following are the common pathogens:

- *Neisseria gonorrhoeae*
- Gram-negative bacteria
- Gram-positive bacteria
- Streptococci
- Anaerobes
– **Foreign bodies** leading to infections are the cause of septic shock in 5% of patients, and *S aureus*, *S epidermidis*, and fungi/yeasts (*Candida* species) are the common pathogens.

– **Miscellaneous infections** are the cause of septic shock in 5% of patients, and *Neisseria meningitidis* is a common pathogen.
Pathophysiology of Catheter-Related Infection

All sources of infection are potential targets for prevention.

Critically ill patient: 2-4 vascular access devices