Nosocomial Infection

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Nosocomial infection is defined as a localised or systemic condition that results from adverse reaction to the presence of an infectious agent(s) or its toxin(s), and that was not present or incubating at the time of admission to the hospital. Critically ill patients are especially prone to nosocomial infections due to the severity of their illness, immunosuppressed state, prolonged antimicrobial use and presence of invasive devices. Nosocomial infections carry significant attributable mortality, cost and extra length of stay.

Common types of nosocomial infections in the paediatric ICU

1. Blood stream infections (BSI)
2. Urinary tract infections (UTI)
3. Pneumonia
4. Surgical site infection (SSI)
5. Device associated infection:
    - Central line associated BSI (CLABSI)
    - Catheter associated UTI (CAUTI)
    - Ventilator associated pneumonia (VAP)

General risk factors include:

- Presence and duration of invasive medical devices
- Length of stay
- Immunocompromised state
- Parenteral nutrition
- Severity of illness (e.g. PRISM-III)
- Prolonged/ multiple antimicrobial use
- Environment:
    - Physical: isolation facilities, staffing ratio
    - Non-physical: education, expertise, attitude of staff

The most important step in prevention of nosocomial infections is establishing hand hygiene during the five moments of patient care.

Blood stream infection (BSI)

Laboratory-confirmed bloodstream infection (LCBI):
Must meet one of the following criteria:

1. Patient has a recognized pathogen cultured from one or more blood cultures and organism cultured from blood is not related to an infection at another site.

2. Patient who has at least one of the following signs or symptoms:

- fever (>38^{o}C), chills, or hypotension **and**
- signs and symptoms and positive laboratory results are not related to an infection at another site **and**
- common skin contaminant [i.e., diphtheroids (*Corynebacterium* spp.), *Bacillus* (not *B. anthracis*) spp., *Propionibacterium* spp., coagulase-negative staphylococci (including *S. epidermidis*), viridans group *streptococci*, *Aerococcus* spp., *Micrococcus* spp.] is cultured from two or more blood cultures drawn on separate occasions.

3. Patient < 1 year of age who has at least one of the following signs or symptoms:

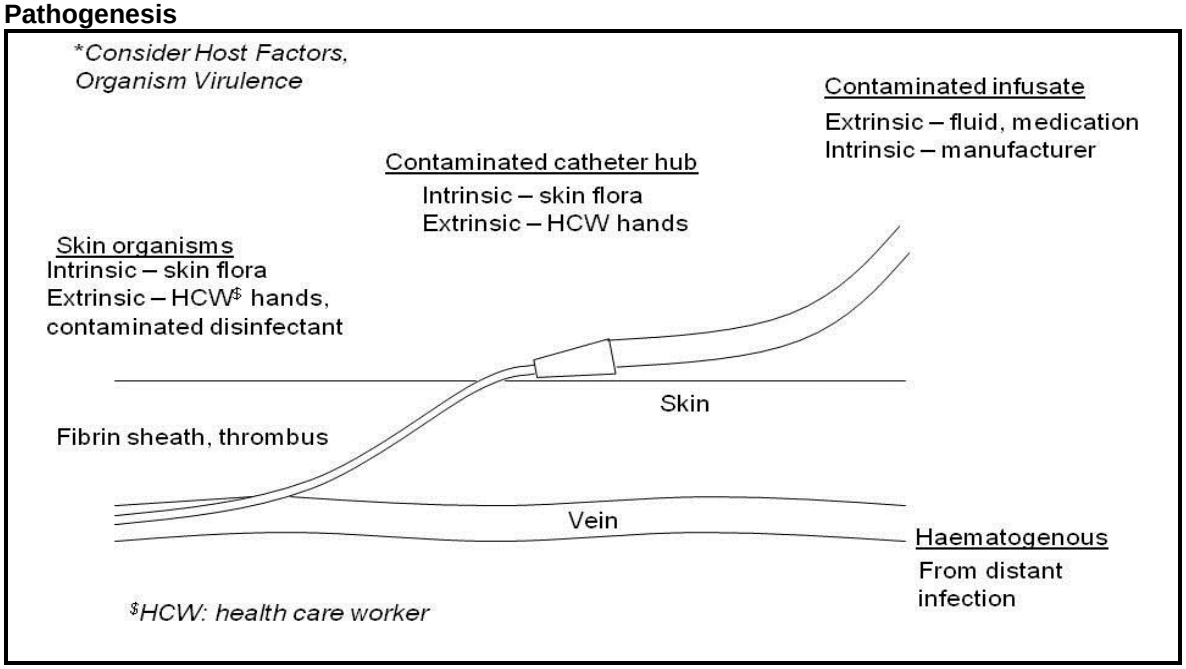
- fever (>38^{o}C core), hypothermia (<36^{o}C core), apnea, or bradycardia **and**

- signs and symptoms and positive laboratory results are not related to an infection at another site **and**
- common skin contaminant [i.e., diphtheroids (*Corynebacterium* spp.), *Bacillus* (not *B. anthracis*) spp., *Propionibacterium* spp., coagulase-negative staphylococci (including *S. epidermidis*), viridans group *streptococci*, *Aerococcus* spp., *Micrococcus* spp.] is cultured from two or more blood cultures drawn on separate occasions.

Catheter-related BSI (CRBSI)
Isolation of the same organism (i.e. identical species, identical antibiogram) from:

- Quantitative blood cultures (two sets with at least one drawn percutaneously) **or**
- Differential quantitative cultures of two sets with at least one drawn percutaneously **or**
- Positive differential time-to-positivity of greater than two hours from two sets of blood cultures drawn simultaneously from the suspected vascular access and percutaneously **or**
- distal catheter segment and blood culture positive with clinical symptoms of sepsis and no other apparent source of infection

Pathogenesis



Treatment
Central venous access in the paediatric population can be challenging. Ideally, central venous catheters (CVC) should be removed when there is evidence of catheter-related blood stream infection. However, if the CVC is essential and access is difficult, the existing catheter may be retained while antimicrobials are started.

Remove central venous catheter however, if there is evidence of:

- Tunnelled CVC or other centrally placed peripheral devices (eg. Portacath) infection/ abscess
- Exit site infection or pus
- Florid sepsis
- Persistent BSI
- Metastatic complications (e.g., septic emboli/ thrombus)
- Specific Organisms e.g., *Staph. Aureus, Candida, Malassezia, Mycobacteria*

Duration of antimicrobial therapy ranges from 7-14 days up till 4-6 weeks for complicated infections.

Risk factors for CRBSI
Host factors:

- Neutropenia
- Need for mechanical ventilation
- Pre-existing infections from other sources
- Existing implanted devices

Catheter related factors:

- Multiple CVCs
- Guide-wire exchange of CVCs
- TPN through CVC
- CVC dwell time
- Multiple manipulations of CVC

Ventilator associated pneumonia (VAP)

Ventilator associated pneumonia (VAP) is a nosocomial pneumonia in a patient on mechanical ventilatory support (by endotracheal tube or tracheostomy) for ≥ 48 hours; and is defined by the presence of radiologic and clinical **with/without** laboratory criteria.

If a child or infant fulfils the radiological and clinical criteria but not the laboratory criteria, it is considered a clinically defined VAP.

Radiological criteria:
≥ two chest radiographs with at least one of the following:

- New or progressive and persistent infiltrates, consolidation, cavitation, pneumatocoeles (≤ 1year of age);

Clinical criteria:
FOR ANY PATIENT, at least **one** of the following:

- Fever (>38°C) with no other recognized cause
- Leukopenia (<4000 WBC/mm3) or leukocytosis (>12,000 WBC/mm3) **and** at least **two** of the following:
    - New onset of purulent sputum, or change in character of sputum, or increased respiratory secretions, or increased suctioning requirements
    - New onset or worsening cough, or dyspnea, or tachypnea
    - Rales or bronchial breath sounds
    - Worsening gas exchange (e.g., O_2 desaturations, P_aO_2/F_iO_2 < 240), increased oxygen requirements, or increased ventilator demand

Alternate criteria for infants <1 year old:
Worsening gas exchange (e.g., O_2 desaturations), increased oxygen requirements, or increased ventilator demand **and** at least **three** of the following:

- Temperature instability with no other recognized cause
- Leukopenia (<4000 WBC/mm3) or leukocytosis (>15,000 WBC/mm3) and left shift (>10% band forms)
- New onset of purulent sputum or change in character of sputum, or increased respiratory secretions or increased suctioning requirements
- Apneoa, tachypnea, nasal flaring with retraction of chest wall or grunting
- Wheezing, rales, or rhonchi
- Cough
- Bradycardia (<100 beats/min) or tachycardia (>170 beats/min)

Alternate criteria for child >1 year old or ≤ 12 years old, at least **three** of the following:

- Fever (>38.4°C) or hypothermia (<36.5°C) with no other recognized cause
- Leukopenia (<4000 WBC/mm3) or leukocytosis (≥15,000 WBC/mm3)

- New onset of purulent sputum, or change in character of sputum, or increased respiratory secretions, or increased suctioning requirements
- New onset or worsening cough, or dyspnea, apnea, or tachypnea
- Rales or bronchial breath sounds
- Worsening gas exchange (e.g. O_2 desaturations), increased oxygen requirements, or increased ventilator demand
- Worsening gas exchange

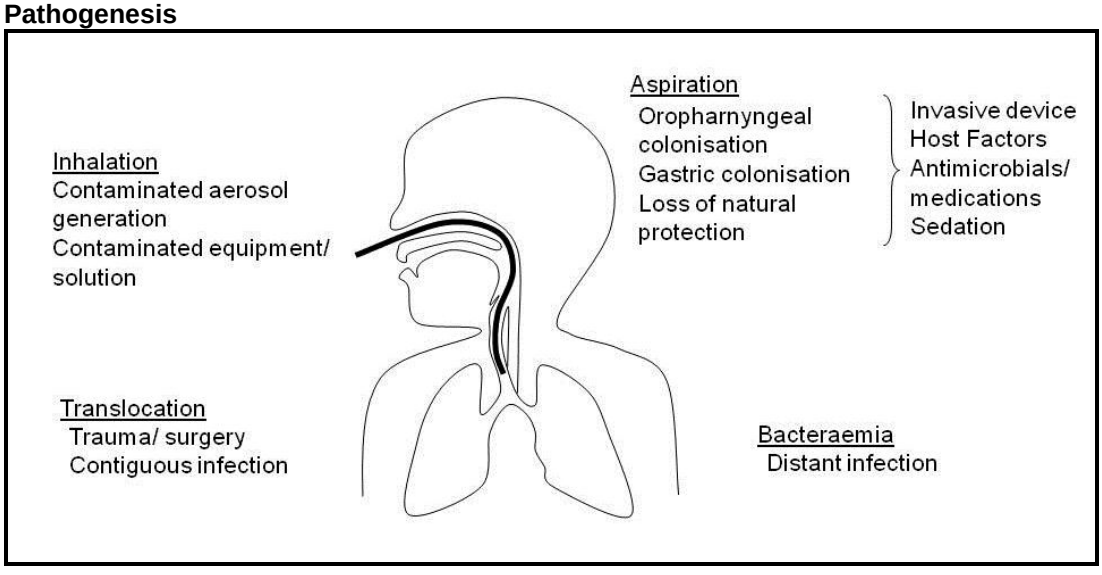
Laboratory criteria:

Requires ≥ 1 of the following:

- Positive blood culture not related to other source
- Positive pleural fluid culture
- Positive quantitative culture from minimally contaminated lower respiratory tract (LRT) specimen
- ≥ 5% cells obtained via bronchoalveolar lavage (BAL) with intracellular organisms on direct microscopic exam
- Histopathologic confirmation: abscess/ consolidation in lungs with intense PMN accumulation; positive quantitative culture of lung parenchyma; invasion of lung parenchyma with fungal hyphae or pseudohyphae

Specimen collection/technique	**Values**
Lung parenchyma	≥ 10^4 cfu/g tissue
Bronchoscopic specimens:	
• BAL	≥ 10^4 cfu/ml
• Protected BAL	≥ 10^4 cfu/ml
• Blind protected Specimen Brush (PSB)	≥ 10^3 cfu/ml
Non Bronchoscopic specimens:	
• BAL	≥ 10^4 cfu/ml
• Protected BAL	≥ 10^4 cfu/ml
• Endotracheal aspirate	≥ 10^5 cfu/ml

Pathogenesis



Treatment

- Appropriate antibiotic therapy. Expected duration 7-10 days (unless complicated)
- Respiratory toilet/ suctioning
- Chest Physiotherapy

- Adequate ventilation to prevent further atelactasis

Catheter-associated urinary tract infection (CAUTI)

Catheter associated urinary tract infections (CAUTIs) is defined as urinary tract infections that are catheter-associated (i.e. patient had an indwelling urinary catheter at the time of or within 48 hours before onset of the event).

The diagnosis can be further differentiated into:

1. Patient had an indwelling urinary catheter in place at the time of specimen collection or onset of signs or symptoms **and** at least 1 of the following signs or symptoms with no other recognized cause:
   - fever (>38°C), suprapubic tenderness, or costovertebral angle pain or tenderness *and*
   - a positive urine culture of ≥10^5 colony-forming units (CFU)/ml with no more than two species of microorganisms

2. Patient had indwelling urinary catheter removed within the 48 hours prior to specimen collection or onset of signs or symptoms **and** at least 1 of the following signs or symptoms with no other recognized cause:
   - fever (>38°C), urgency, frequency, dysuria, suprapubic tenderness, or costovertebral angle pain or tenderness *and*
   - a positive urine culture of ≥10^5 CFU/ml with no more than two species of microorganisms(see Comments section below)

3. Patient had an indwelling urinary catheter in place at the time of specimen collection or onset of signs or symptoms **and** at least one of the following signs or symptoms with no other recognized cause:
   - fever (>38°C), suprapubic tenderness, or costovertebral angle pain or tenderness **and**
   - at least one of the following findings:
     - positive dipstick for leukocyte esterase and/or nitrite
     - pyuria (urine specimen with ≥10 white blood cells [WBC]/mm3 of unspun urine or ≥3 WBC/high power field of spun urine)
     - microorganisms seen on Gram stain of unspun urine **and**
   - a positive urine culture of ≥10^3 and <10^5 CFU/ml with no more than two species of microorganisms

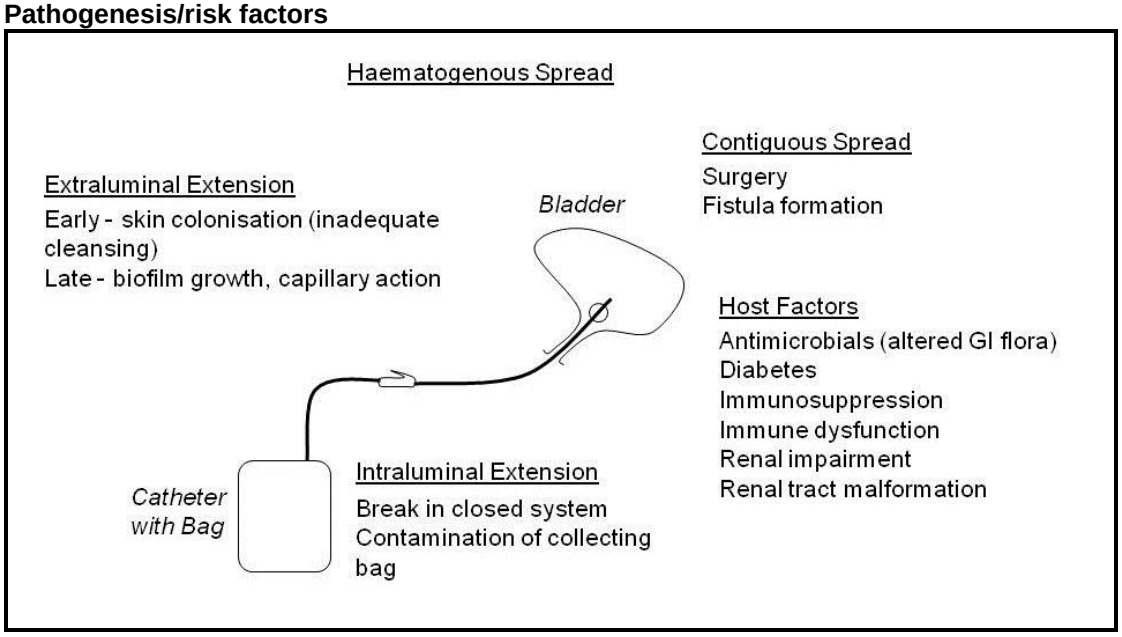
4. Patient had indwelling urinary catheter removed within the 48 hours prior to specimen collection or onset of signs or symptoms **and** at least one of the following signs or symptoms with no other recognized cause:
   - fever (>38°C), urgency, frequency, dysuria, suprapubic tenderness, or costovertebral angle pain or tenderness **and** at least one of the following findings:
     - positive dipstick for leukocyte esterase and/or nitrite
     - pyuria (urine specimen with ≥10 white blood cells [WBC]/mm^3 of unspun urine or ≥3 WBC/high power field of spun urine)
     - microorganisms seen on Gram stain of unspun urine **and**
   - a positive urine culture of ≥10^3 and <10^5 CFU/ml with no more than two species of microorganisms

5. Patient ≤1 year of age: an indwelling urinary catheter at the time of or within 48 hours before onset of the event has at least 1 of the following signs or symptoms with no other recognized cause:
   - fever (>38°C core), hypothermia (<36°C core), apnea, bradycardia, dysuria, lethargy, or vomiting **and** at least one of the following findings:
     - positive dipstick for leukocyte esterase and/or nitrite

- pyuria (urine specimen with ≥10 WBC/mm^3 of unspun urine or ≥3 WBC/high power field of spun urine)
- microorganisms seen on Gram's stain of unspun urine **and**

- a positive urine culture of between ≥10^3 CFU/ml with no more than two species of microorganisms.

Pathogenesis/risk factors



Prevention

Preventive measures include:

- Minimising the need for catheterisation
- Aseptic technique at insertion of catheter
- Maintaining a closed drainage system
- Allowing unobstructed urinary flow
- Decreasing duration of catheterisation- review the need for a urinary catheter on a daily basis
- Antiseptic/ antibiotic-impregnated catheters

Diagnosis

- Urine cultures – suprapubic vs. catheter vs. mid-stream (clean catch)
- Urinalysis (supportive)
- Renal ultrasound
- +/- IVU, DMSA/ MAG-3

There is a need to clearly rule out other sites of infection before treating as for UTI as many catheters can be colonised with pyuria ("bacteriuria") but are NOT infected (unless recent urologic manipulation, obstruction, renal malformation).

Treatment

- Consider removal or change of catheter
- Start appropriate antibiotic therapy, expected duration between 7-14 days
  - If bacteraemic: 14-21 days (usually)
  - If complicated (e.g. abscess): about 4 weeks (or 14 days after last positive urine culture)

Nosocomial Surgical Site Infection

Diagnosis of a nosocomial surgical site infection (SSI) is made when time, site and clinical criteria are all met as detailed below:

Time Criteria:

- Infection occurs within 30 days after operative procedure if no implant, **or** within 1yr if implant in place and infection appears related to operative procedure; **AND**

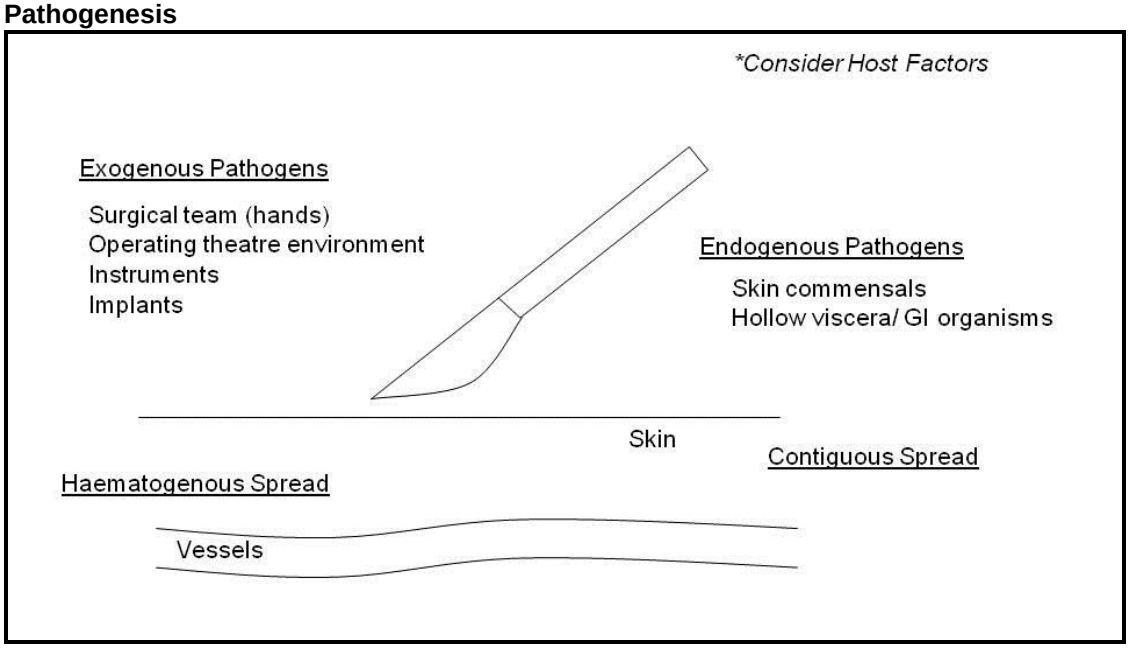
Site Criteria:

- Involves the specific site of the body that is opened or manipulated during operative procedure [e.g., superficial incisional site (skin and subcutaneous tissue over incision), deep incisional site (fascia, muscle), organ/space (intra-abdominal, ventricle, and heart)]

Clinical Criteria includes ≥ 1 of the following:

- Purulent drainage
- Organism cultured from site in aseptic manner
- For superficial site: localised pain, tenderness, redness, swelling, heat, and incision is deliberately opened by surgeon
- For deep site: spontaneous dehiscence of incision site and incision deliberately opened by surgeon
- Abscess or other evidence of infection found on direct examination or histopathology during re-operation
- Diagnosis of SSI by surgeon or physician

Pathogenesis



Risk factors

Host related:

- skin colonisation/ dermatitis
- immunosuppresion/ immune dysfunction
- congenital malformations
- illness severity
- prematurity
- trauma/ perforation of hollow viscus (“dirty wounds”)

Operating Theatre related:

- surgical expertise/ experience
- skin/ hand asepsis
- hair removal
- antimicrobial prophylaxis
- ± repeat procedures

ICU related:

- poor drain/ wound care (break in system)
- length of stay

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