### HAI Sources

**WHERE DO NOSOCOMIAL INFECTIONS COME FROM?**

**Colonization**

Food & Water  
Hands: HCW, visitors  
Others:  
- Fomites  
- Environment

**COLONIZATION**: Definition

Colonization = presence of a microorganism on/in a host, with growth and multiplication of the organism, but without interaction between host and organism (no clinical expression, no immune response).

Carrier = individual which is colonized + more

Subclinical or inapparent infection = presence of microorganism and interaction between host and microorganism (sub clinical response, immune response). Often the term colonization is applied for relationship host-agent in which the immune response is difficult to elicit.

Contamination = Presence of a microorganism on a body surface or an inanimate object.

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### FLORA AT COLONIZATION SITES

<table>
<thead>
<tr>
<th>Site</th>
<th>Flora</th>
</tr>
</thead>
<tbody>
<tr>
<td>OROPHARYNX</td>
<td>Strep. viridans group, Strep. pyogenes, Strep. pneumoniae, Staphylococci, Moraxella catarrhalis, Neisseria spp, Corynebacterium spp, Haemophilus spp, Anaerobes: Bacteroides, Candida albicans</td>
</tr>
<tr>
<td>NASOPHARYNX</td>
<td>Staphylococci, Streptococci, Moraxella catarrhalis, Neisseria spp, Haemophilus spp</td>
</tr>
<tr>
<td>CONJUNCTIVA</td>
<td>Staphylococci, Corynebacteria, Haemophilus</td>
</tr>
<tr>
<td>SKIN</td>
<td>Staphylococci, Corynebacteria, Propionibacteria, Candida, Malassezia furfur</td>
</tr>
<tr>
<td>GENITOURINARY TRACT</td>
<td>Staphylococci, Streptococci, Enterococci, Lactobacillus spp, Corynebacterium, Neisseria spp, Anaerobes, Candida albicans</td>
</tr>
<tr>
<td>UPPER INTESTINE</td>
<td>Streptococci, Lactobacillus spp, Candida spp</td>
</tr>
<tr>
<td>LOWER INTESTINE</td>
<td>Aerobic G- bacilli: E.coli, Klebs Enterobacter, Proteus, Serratia Providencia, Bacteroides, Anaerobic Enterococci, Streptococci, Candida</td>
</tr>
</tbody>
</table>

### SKIN RESIDENT FLORA

- Survives on the skin more than 24 hours
- Not easily removed, hours of scrubbing
- Complete sterilization impossible
- Low virulence
- Staphylococci, diphteroides,
- mostly Gram +, very few Gram -

### SKIN TRANSIENT FLORA

- Survive on skin less than 24 hours
- Easily removed with soap and water
- Acquired during contacts with contaminated areas mouth, nose, perineal area, genitals, anal area catheter, bedpan, urinal, patient care casual contact
- May have high virulence - Enterobacteria, Gram - bacilli, Pseudomonas...

### WATER

Splash from sink drain, toilet flushing, Faucet aerator, faucet, water lines  
Plants harbor Aeromonas, Pseudomonas, Acinetobacter.  
Water from vane in surgical ward: with 8 E6 CFU/ml of water  
**Bacteria**: Aeromonas, Acinetobacter, Pseudomonas, Flavobacterium, Flavimonas, Legionella, Mycobacteria

### FOOD

Bacteria from food can infect immunocompetent patients  
Pseudomonas, Enterobacter, Klebsella, Citrobacter, Serratia frequently found on vegetables:  
Typical kitchen salad from a hospital had **200,000 CFU/g**

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(800) 256-2748
Central Line-Associated Blood Stream Infections (CLABSI)

Colonization
- Microbial growth occurs
- Endoluminal
- External catheter surface
- Under skin
- Semiquantitative culture: ≥ 15 CFU/segment
- Quantitative: ≥ 100 CFU

Local catheter infection
- Exit site infection:
  - Purulent drainage from catheter exit site
  - Or erythema, tenderness & swelling within 2cm of catheter exit site
- Port pocket infection
  - Erythems & necrosis over reservoir of totally implantable device
  - Or purulent exudate in subcutaneous pocket containing reservoir
- Tunnel infection: erythema, tenderness & swelling of tissue overlying catheter more than 2cm from exit site
- Differentiate infection from simple phlebitis due to local inflammation. Physico-chemical phlebitis occur in 30% peripheral venous cath in 2-3 days

Transient Bacteremias are very common
- Very common:
  - StaphCoagNeg 40%, StrepViridans 30%
  - Best practices: 2%-3%
- Transient bacteremia associated with indwelling IV often undetected and requires no therapy except in patients with valvular heart disease, intravascular prostheses, or immunosuppression. In such patients, a prophylactic antibiotic Tx advised, especially for prevention of endocarditis.
- The outcome of more serious bacteremia depends on:
  - How quickly and thoroughly the source of infection can be eliminated.
  - Underlying disease prognosis and accompanying systemic dysfunctions. Antibiotic treatment should be started empirically after Gram stains and bacterial cultures have been obtained.

Risk factors
- Dental procedures: from tooth brushing, to extraction
- Intubation
- Lacrimal duct probing
- Burn wound manipulation
- GI endoscopy, Barium enema
- Dermato surgery
- Urologic endoscopy
- IUD replacement
Surgical Site Infection (SSI)

**Endogenous SSI**

- Majority of SSI are endogenous ie coming from native flora of the patient’s skin, mucous membranes, or hollow viscera
- *Staphylococcus aureus* (coagulase positive) and Staph epidemidis (CoagNeg)
- Present on skin, directly introduced in SS by incision or manipulations
- Cleansing & skin de-germing are useful BUT difficult for
  - Heavily colonized sites
  - Unclean sites
- Distant colonization may play role (Wiley AM 1979, Clin Orthop 139: 150)
  - Human albumin microspheres (HAM) ~ human skin squames
  - Found in SS from distant sites

**Exogenous SSI: HCW**

- From hands of surgeon by direct inoculation
- Glove perforations no role (Dodds RDA 1988, Br J Surg 75: 966)
- HAM showed some migration
  - From hair & scalp
  - From inside surgical mask unless hood present
  - From face and nostrils, increased by talking
- Very few outbreaks /SSI related to hair /scalp flora or URT flora

**Exogenous SSI: Air**

- HCW are main source of airborne particles
- HAM showed migration from URT o SS
- Few outbreaks of βhem. Strep SSI:
  - Ancillary personnel
  - Exercize from anal / genital carrier
- Air contamination
- Studies of laminar airflow and UV protection
  - Effective protection in super clean SS
- In other SS air contamination plays minor role

http://www.infectiousdisease.dbh.louisiana.gov (800) 256-2748
Ventilator-Associated Pneumonia

**Colonization**
- Colonization of upper respiratory tract
- Pathogenic organisms must reach lung tissue
- Overcome filtration, epiglottic and cough reflexes, ciliary transport, phagocytes, opsonin, cell mediated and humoral immunity
- Predominant mode: ASPIRATION
- Also: inhalation, bloodstream seeding

**From Colonization To Infection**
- Reduced capacity to clear pathogens
- Increased adherence of pathogens
- Destruction of epithelial surface
- Impaired mucociliary clearance
- Pro-inflammatory enzymes
- Fibronectin reducing proteases
- Antibiotic suppression of normal flora
- Antibiotic selection of resistant organisms

**Endotracheal Intubation**
- Artificial ventilation requires insertion of endotracheal tube into trachea.
- Long term endotracheal tube may lead to pneumonia with following:
  - Introduces microbes introduced into the lung.
  - Interferes with coughing and ability of airways to naturally sweep out particles
  - Injure the trachea lining
  - All that can give pathogens a direct conduit to the lungs.

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**Ventilator Associated Pneumonias**

**Sources of Infection**
- **Endogenous sources:**
  - Stomach and intestines
  - URT colonizers: oropharynx, sinus, nares, dental plaque
- **Exogenous sources:**
  - Sinks, faucets
  - Ventilation equipment
  - Contaminated feeding
  - Other patients, HCW, visitors
- **Route:**
  - Aspiration
  - Direct inoculation in tracheo-bronchial tree during manipulation of circuit and tubes

**Pneumonias**
- Pneumonias: accumulation of neutrophils & inflammation of bronchioles + alveoli + interstitium
- Patients with pneumonia have
  - Fever
  - Purulent sputum
  - Dyspnea, cough, pleuritic chest pain sometimes difficult to elicit
  - Signs of pulmonary consolidation
  - Xray: new and progressive infiltrates

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Microbe migration
- Bladder content sterile
- Micturition empties bladder completely
- Exfoliation of urethral cells pushes microbes out
- Any interference will increase risk of infection
- Most microorganisms causing CAUTI derive
  - From patient's own colonic and perineal flora
  - From hands of HCP during catheter insertion or manipulation of the collection system

Biofilm
- Matrix of polysaccharides
- With encased bacteria, up to 4 species (usually 1 in urine)
- Microcolonies
- Water channels

Bacteria in biofilms express different genes
- Increase production of extracellular polymeric substance (EPS)
- 50-90% of biofilm mass
- Poor antibiotic diffusion
- Slow bacterial multiplication
- Less effectiveness of antibiotics

Electron micrograph depicting round Staphylococcus aureus bacteria, with biofilm, the sticky-looking substance woven between the bacteria. (Content source: Donlan R, Carr J., Public Health Image Library, Centers for Disease Control and Prevention; 2005.)

Asymptomatic Bacteriuria
- Very common among hospitalized patients
- Endogenous organisms: Fecal flora colonizes perineum
- Exogenous organisms: From HCW hands /collection containers colonize perineum
- Colonization progresses to meatal/urethral surface
  - Kass EH 1957, NEJM 256:55: Serratia marcescens applied to perineum, in 3 days Sm appeared in urine
  - Meatal colonization more important than length of urethra. Female at higher risk of meatal colonization
- Pyuria often absent due to suppression of immune response by catheter

Catheter-Associated Urinary Tract Infections (CAUTI)

Urinary Catheter Risks
- Catheter
  - Breaches barrier
  - Balloon prevents complete emptying
  - Distends bladder
  - Pool of urine
- Condom catheter
  - Warm moist conditions inside ⇒ high inoculum
  - Travel upwards
- Closed systems
  - Never completely closed
  - Bag may have high counts
  - Travel upwards