

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.

SKIN RESIDENT FLORA

- Survives on the skin more than 24 hours
- Not easily removed, hours of scrubbing
- Complete sterilization impossible
- Low virulence
- Staphylococci, diptheroides,
- 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...

Handwashing to get rid of transient, not resident flora

General shift towards Gram negative flora in hospitals

Invasive procedures provides portal of entry to different flora:

Antibiotic therapy:

In a study of patients on ampicillin long term Rx, --90% colonized by ampicillin resistant enterobacteria, --controls only 10%

In animal studies:
Number of bacteria to colonize gut of animal=
Normal-----10,000,000
Germ free-----100

FLORA AT COLONIZATION SITES

OROPHARYNX

- Streptococcus viridans* group
- Streptococcus pyogenes*
- Streptococcus pneumoniae*
- Staphylococci
- Moraxella catarrhalis*
- Neisseria* spp
- Corynebacterium* spp
- Haemophilus* spp
- Anaerobes: Bacteroides
- Candida albicans*

NASOPHARYNX

- Staphylococci
- Streptococci
- Moraxella catarrhalis*
- Neisseria* spp
- Haemophilus* spp

CONJUNCTIVA

- Staphylococci
- Corynebacteria
- Haemophilus

SKIN

- Staphylococci
- Corynebacteria
- Propionibacteria
- Candida
- Malassezia furfur*

GENITOURINARY TRACT

- Staphylococci, Streptococci
- Enterococci
- Lactobacillus* spp,
- Corynebacterium*
- Neisseria* spp, Anaerobes
- Candida albicans*

UPPER INTESTINE

- Streptococci
- Lactobacillus* spp
- Candida* spp

LOWER INTESTINE

- Aerobic G- bacilli: *E.coli*, Klebs
- Enterobacter, Proteus, Serratia
- Providencia, Bacteroides,
- Anaerobic
- Enterococci, Streptococci,
- Candida

WATER

Splash from sink drain, toilet flushing, Faucet aerator, faucet, water lines
Plants harbor Aeromonas, Pseudomonas, Acinetobacter.
Water from vase in surgical ward: with 8 E6 CFU/ml of water



Bacteria: Aeromonas, Acinetobacter, Pseudomonas, Flavobacterium, Flavimonas, Legionella, Mycobacteria

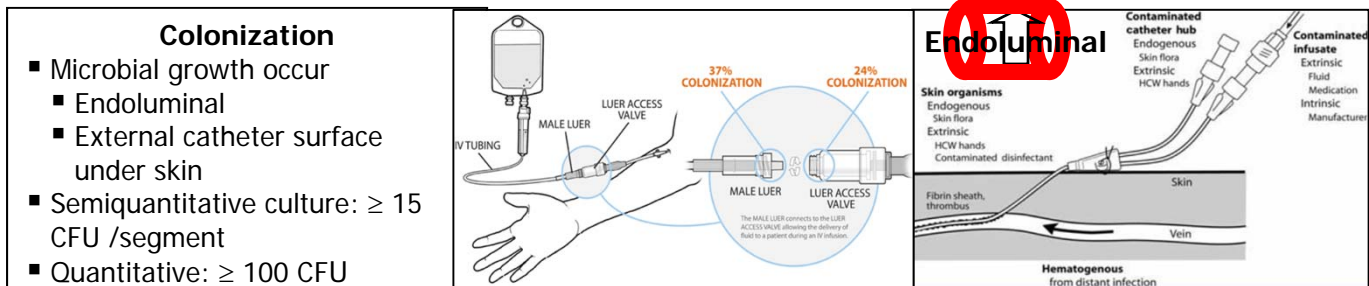
FOOD

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**

Central Line-Associated Blood Stream Infections (CLABSI)



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:
- Roberts FJ 1991. Rev ID 13: 34-46: 7% transient bacteremias in 2000 blood cultures
- 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

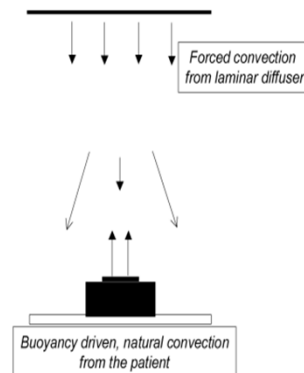


Exogenous SSI: HCW

- 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

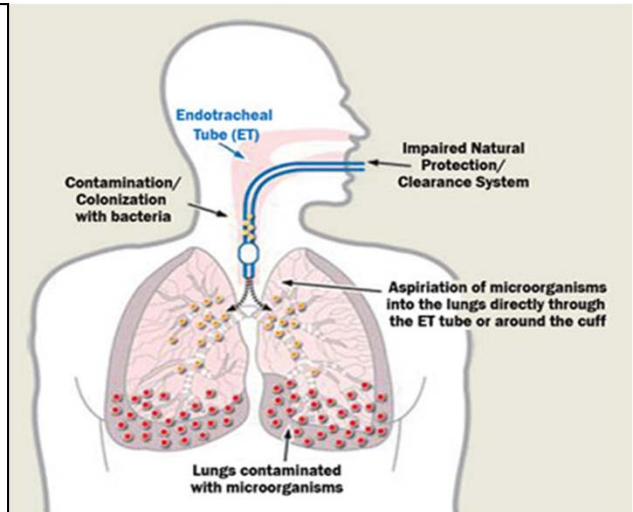
- HCW are main source of airborne particles
- HAM showed migration from URT o SS
- Few outbreaks of β hem. Strep SSI:
 - Ancillary personnel
 - Exercise from anal / genital carrier
- \Rightarrow air contamination
- Studies of laminar airflow and UV protection
 - \Rightarrow effective protection in super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



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

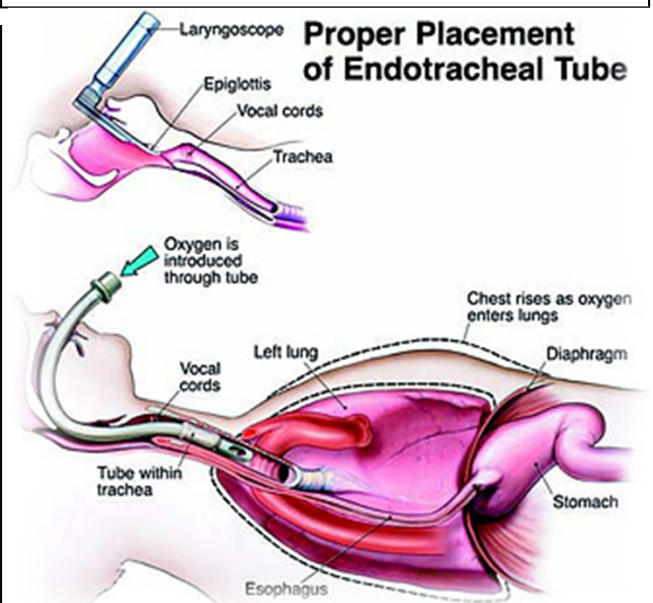


From Colonization To Infection

- 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.



Ventilator Associated Pneumonias

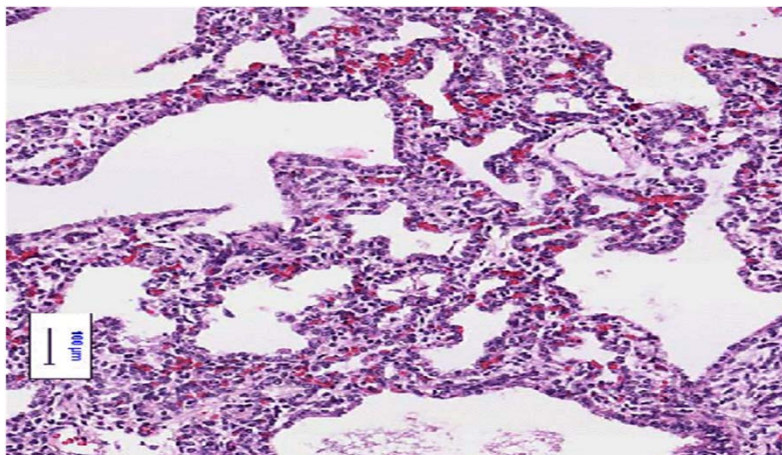
Sources of Infection

- 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



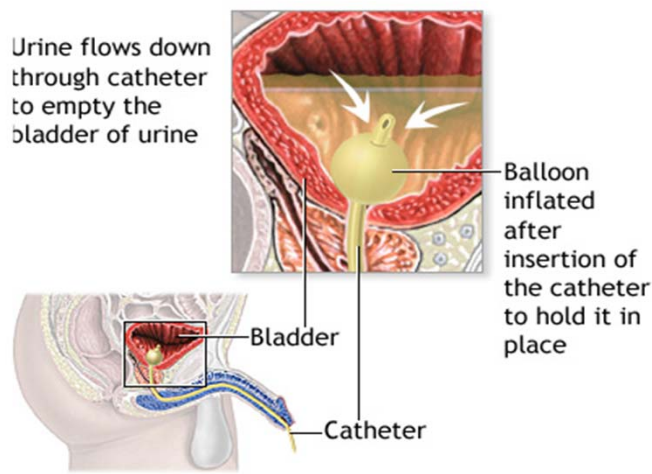
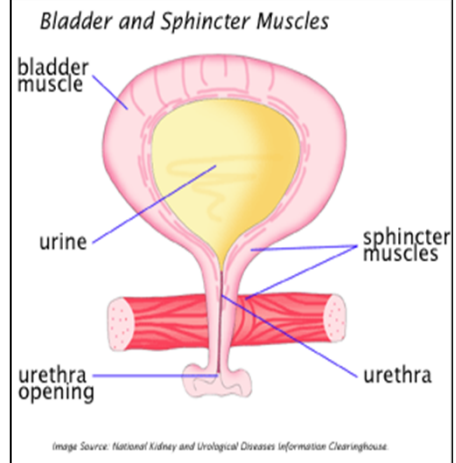
Pneumonias

- 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



Catheter-Associated Urinary Tract Infections (CAUTI)

- **Microbes migrate**
 - Up lumen: even non-motile bacteria
 - Up external surface of catheter
- **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

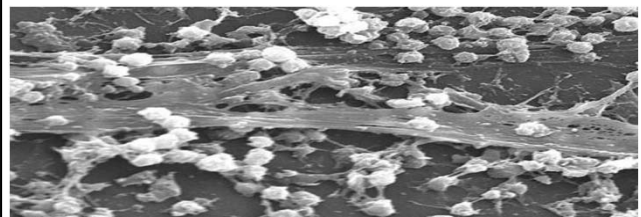


Urinary Catheter Risks

- **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

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



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