Staphylococcus aureus, *Klebsiella pneumoniae*, and non-fermenting Gram-negative bacilli

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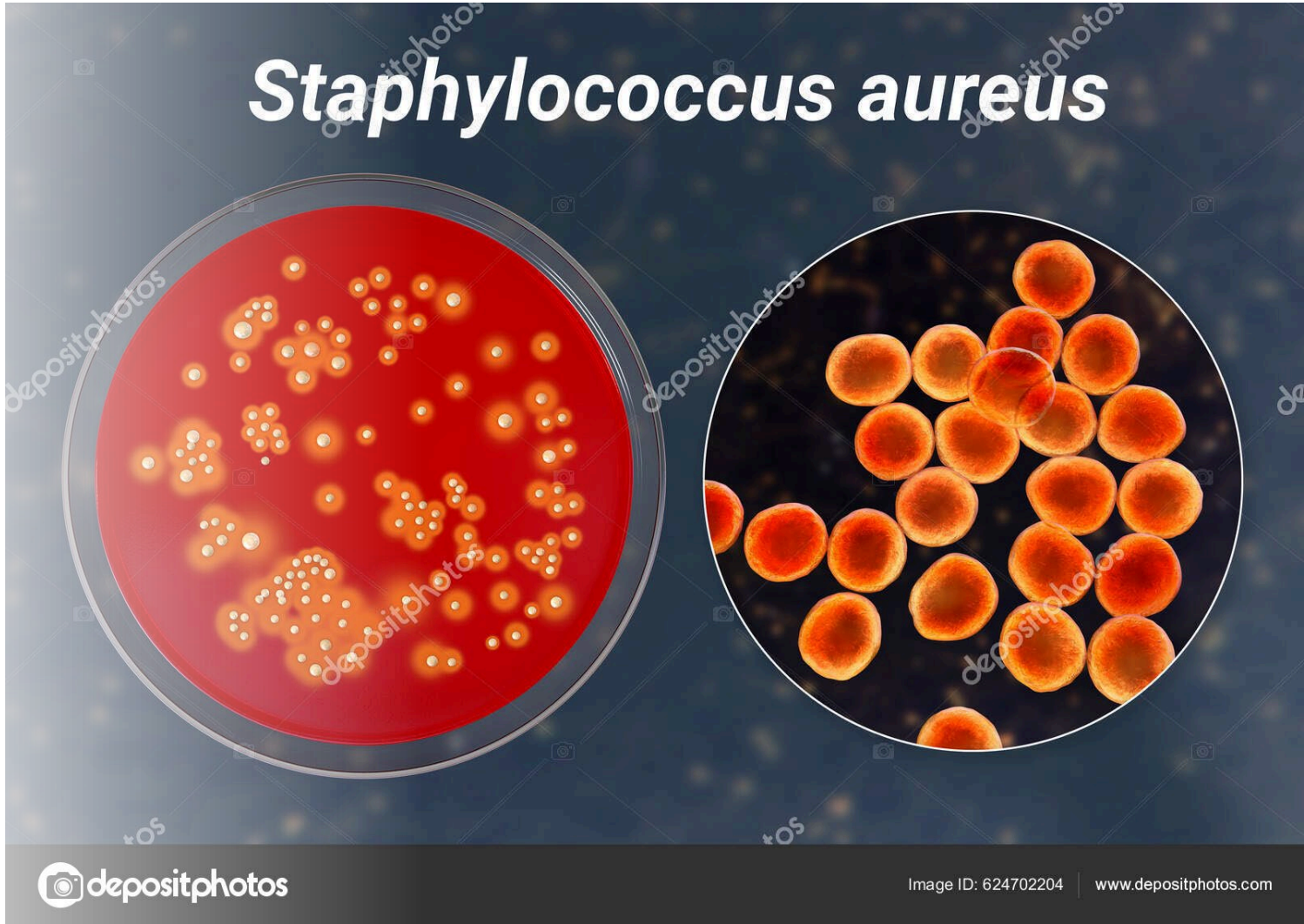
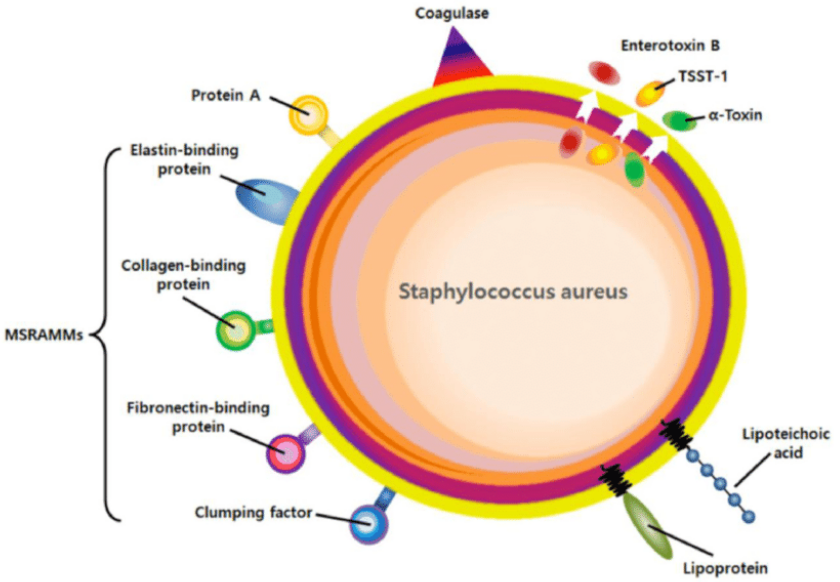
Staphylococcus aureus overview

- **Gram-positive** cocci in clusters ("grape-like")
- Catalase-positive, coagulase-positive
- Golden pigment (staphyloxanthin).
- Colonizes: **nares**, skin, perineum
- Exists as: MSSA (methicillin-sensitive); MRSA (methicillin-resistant). Hospital- and community-acquired



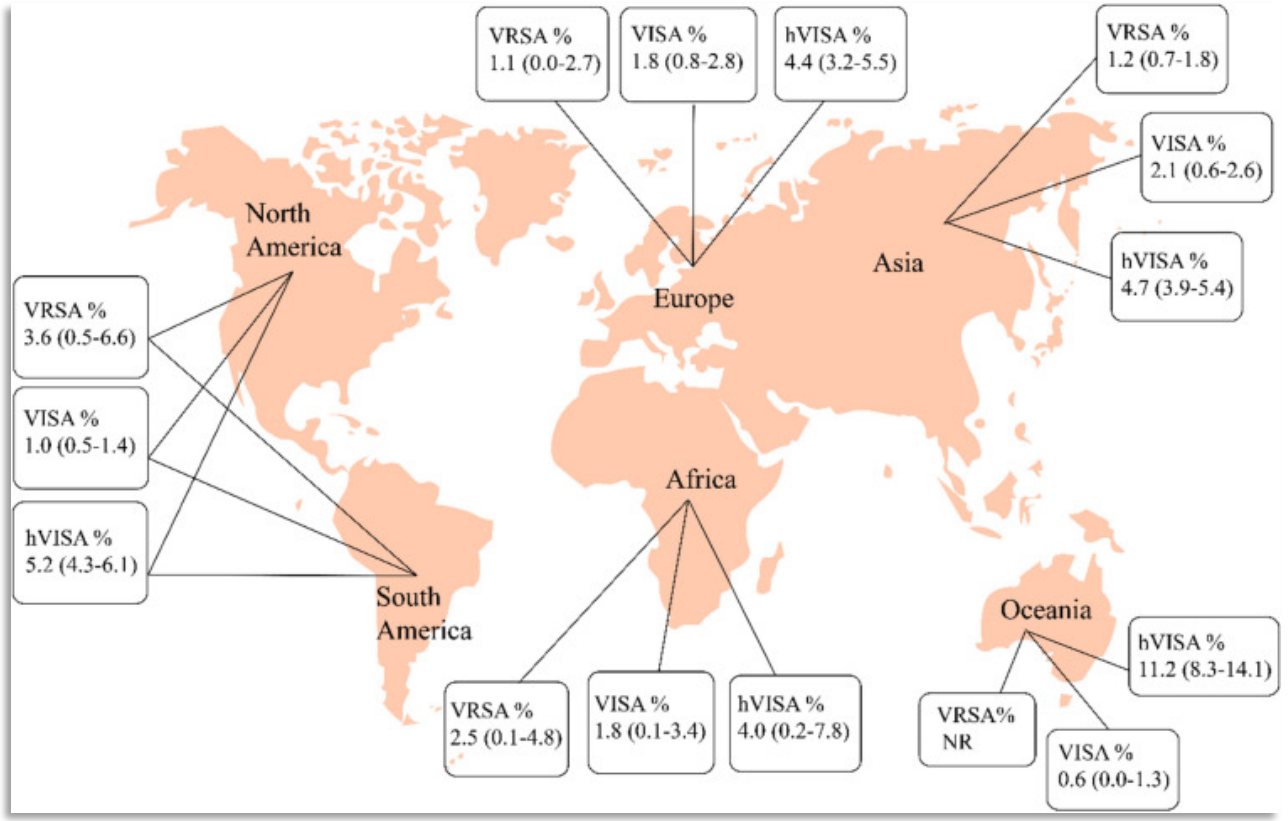
S. aureus virulence factors

- Surface adhesins: Protein A, clumping factors, fibronectin-binding proteins → adhesion, immune evasion
- Toxins. α-hemolysin: pore-forming, causes necrosis in lung → necrotizing pneumonia. Panton-Valentine leukocidin (PVL): leukocyte destruction → abscesses, **severe necrotizing pneumonia**.
- Enzymes. Coagulase: fibrin clot formation → shields bacteria; Hyaluronidase, lipases, proteases → tissue invasion.
- Protein A binds Fc portion of IgG → prevents opsonization
- Staphyloxanthin (carotenoid pigment) neutralizes ROS → survival inside neutrophils



Antibiotic Resistance in *S. aureus*

- MRSA: altered penicillin-binding protein PBP2a encoded by *mecA*. Mechanism: low affinity for β-lactams → all penicillins/cephalosporins ineffective (except Ceftaroline)
- Vancomycin-intermediate *S. aureus* (VISA): thickened cell wall prevents drug penetration.
- VRSA (rare): *vanA* gene from enterococci → full resistance.
- Clinical consequence: therapy depends on local MRSA prevalence and site of infection.



S. aureus RT clinical syndromes

Hospital-acquired pneumonia (HAP/VAP): often severe, multi-lobar.

Post-influenza pneumonia: *S. aureus* thrives after viral ciliary destruction.

PVL-associated necrotizing pneumonia: hemorrhagic, rapidly fatal.

Empyema & lung abscesses from toxin-mediated destruction.

Table 1. Classical characteristics of community-acquired methicillin-resistant *Staphylococcus aureus* versus hospital-acquired methicillin-resistant *Staphylococcus aureus*.

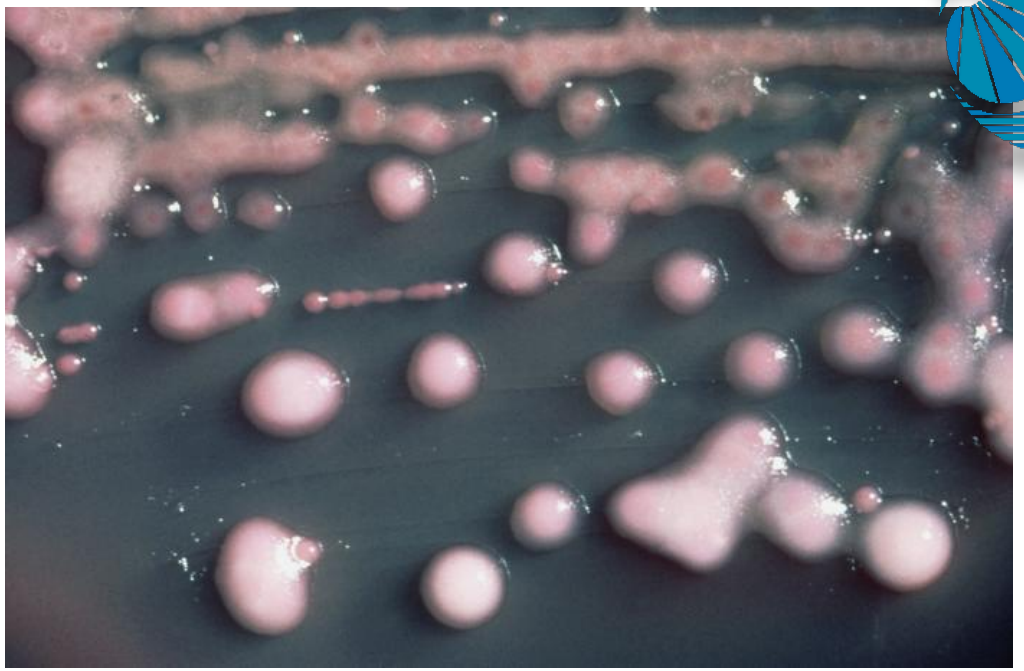
	CA-MRSA	HA-MRSA
Usual SCCmec type (clone)	IV and V (USA-300)	I, II and III (USA-100, USA-200)
PVL toxin	Common	Rare
Population commonly affected	Younger healthier; post-influenza	Older; more comorbidities; exposure to long-term care facilities
Antimicrobial resistance	β-lactam alone common Most susceptible to clindamycin and TMP/SMX	Resistance to multiple drug classes common

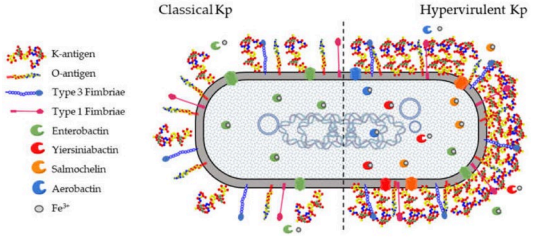
CA-MRSA: Community-acquired MRSA; HA-MRSA: Hospital-acquired MRSA; SCCmec: Staphylococcal cassette chromosome mec; TMP/SMX: Trimethoprim/sulfamethoxazole.

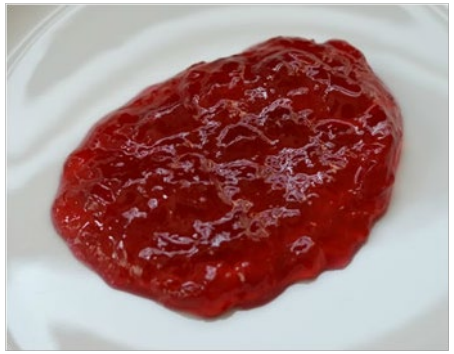
Source: Woods, C., & Colice, G. (2014). Methicillin-resistant Staphylococcus aureus pneumonia in adults. Expert Review of Respiratory Medicine, 8(5), 641–651.

Morphology & Basic Biology: *K. pneumoniae*

- **Gram-negative rod**, lactose fermenter, mucoid colonies
- Prominent polysaccharide capsule.
- Normal flora of GI tract; opportunistic pathogen in lungs
- Major cause of hospital-acquired pneumonia, often in debilitated or aspirating patients
- Classic risk groups: Alcoholics ("currant jelly sputum"), diabetics, elderly, ventilated patients

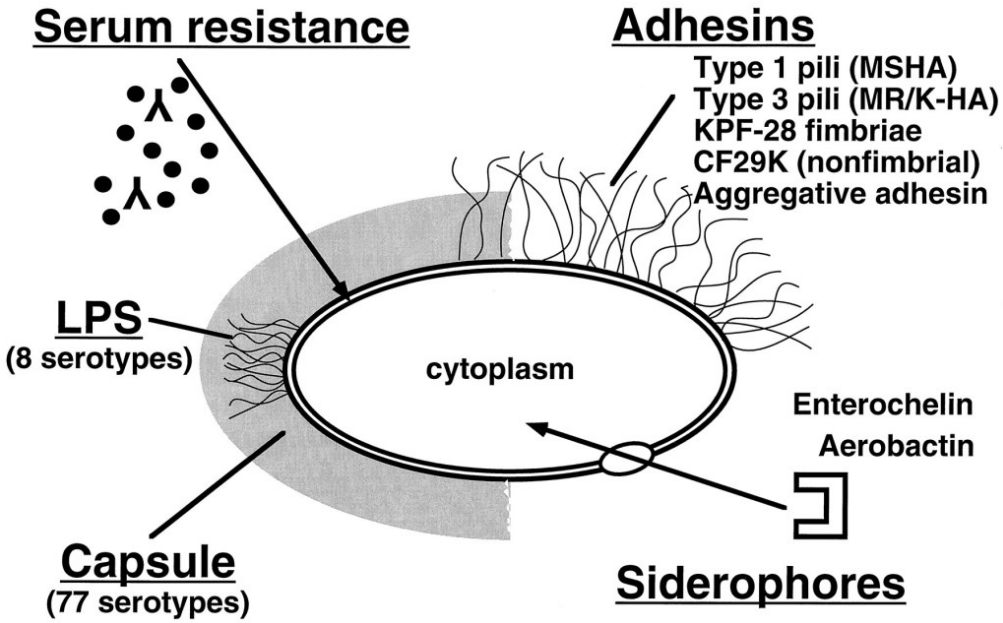






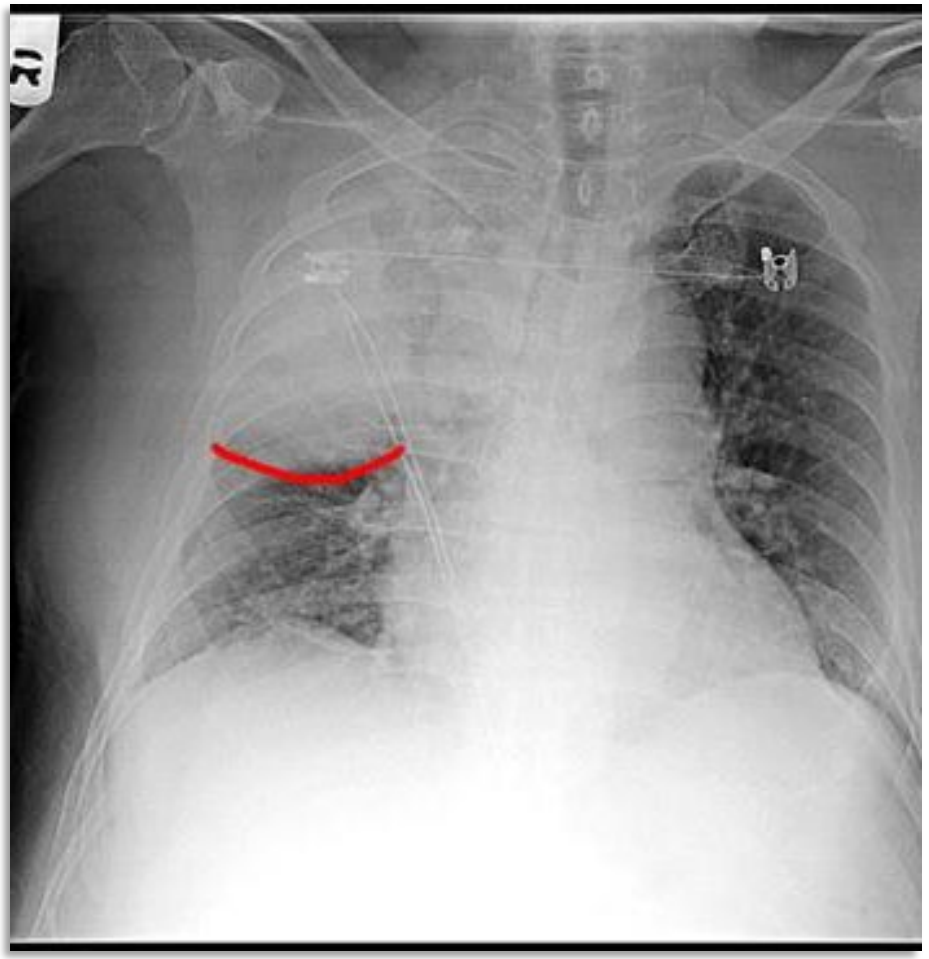
K. pneumoniae virulence factors

- Capsule (K antigen): Antiphagocytic, prevents complement deposition.
- LPS (lipopolysaccharide) Endotoxin → inflammation, septic shock.
- Siderophores: Aerobactin, enterobactin → capture iron in host tissues
- Fimbriae & adhesins: Promote adhesion to respiratory epithelium
- Enzymatic destruction (protease, gelatinase, lipase) → cavities, abscesses, tendency to form thick mucoid sputum.

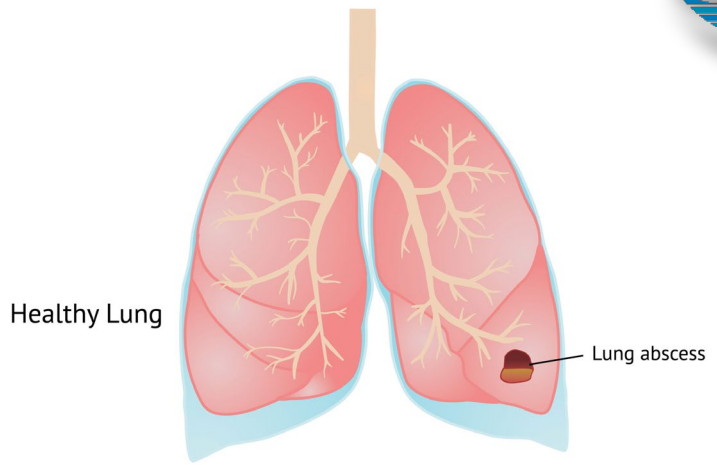


Klebsiella clinical syndromes and antibiotic resistance

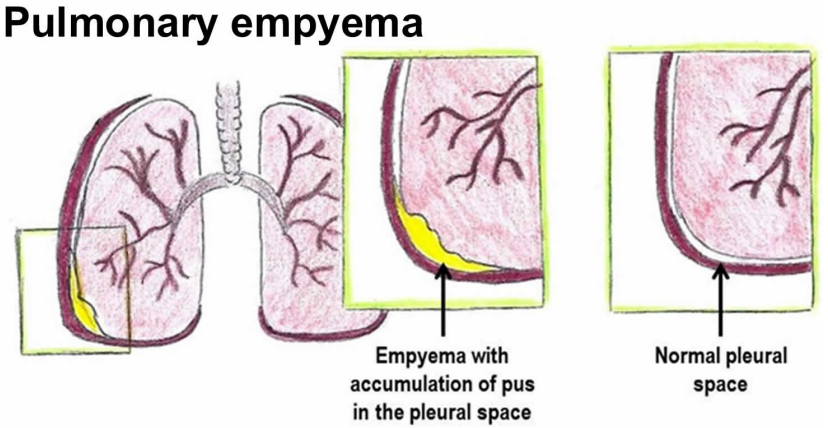
- VAP/HAP lobar, necrotizing pneumonia: Bulging interlobar fissures on imaging. Associated with alcoholism, diabetes, and aspiration.
- ESBL (extended-spectrum β-lactamases): Hydrolyze 3rd-generation cephalosporins. Treatment: carbapenems
- Carbapenem-resistant *K. pneumoniae* (CRKP). Carbapenemases: KPC, NDM, OXA-48. The CRKP are often pan-resistant and requires combination therapy (colistin, tigecycline depending on susceptibility).



Empyema and Lung Abscess Formation

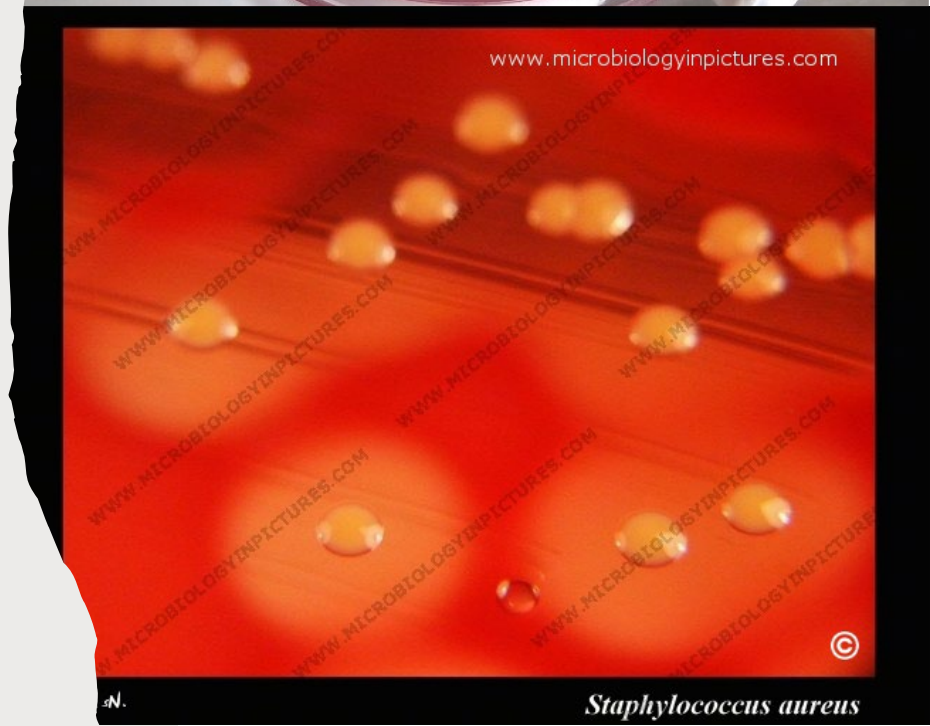


- Empyema is a purulent infection of the pleural space that requires pleural drainage in addition to antibiotics, whereas a lung abscess is a necrotizing, cavitary infection within the lung parenchyma treated with prolonged antimicrobial therapy.
- *S. aureus* toxins destroy neutrophils leading to cavities, abscesses. Empyema is also common due to pleural invasion.
- *K. pneumoniae* causes necrotizing inflammation leading to cavities. Pleural complications are possible.



Diagnosis

- **Culture:**
  - *S. aureus*: coagulase-positive, golden-yellow beta-hemolytic colonies
  - *K. pneumoniae*: lactose fermenter, mucoid colonies on MacConkey agar
- **Antimicribial susceptibility testing (AST):**
  - MRSA detection (oxacillin/cefoxitin testing)
  - ESBL and carbapenemase panels for *Klebsiella*



Management and Prevention

- *S. aureus:* MSSA: nafcillin, oxacillin, cefazolin. MRSA: vancomycin, linezolid, Ceftaroline.
- *K. pneumoniae:* ESBL-producer: carbapenems (meropenem). Carbapenem-resistant strains: ceftazidime-avibactam, meropenem-vaborbactam, tigecycline, colistin (depending on susceptibility).
- Therapy MUST be guided by minimal inhibitory concentration (MIC) + local epidemiology + patient factors (allergy, severity, comorbidities).
- Infection control: Hand hygiene, contact precautions for MRSA
- Environmental disinfection for *Klebsiella*

Non-fermenting Gram-negative Superbugs: Why We Fear These Bacteria?

- Non-fermenting, Gram-negative bacilli
- Thrive in hospital environments
- Cause severe, hard-to-treat RTIs
- Mainly opportunistic pathogens; attack when host defenses are broken (e.g., ICU, mechanical ventilation, severe underlying disease)
- If pneumonia occurs after 48 hours in hospital, think *Pseudomonas* or *Acinetobacter*.

Non-fermenting Gram-negative bacilli associated with RTIs

- *Pseudomonas aeruginosa*: Severe HAP, chronic colonization in cystic fibrosis, high mortality and require broad-spectrum antibiotics
- *Burkholderia cepacia*: Common in cystic fibrosis or immunocompromised patients
- *Acinetobacter* spp.: Survives weeks on dry surfaces, extreme multidrug resistance (MDR), forms biofilms on endotracheal tubes, causes VAP/HAP.
- *Stenotrophomonas maltophilia*: characteristic intrinsic carbapenem resistance.

Treatment & Prevention

- Cover these organisms early in critically ill patients. Use local antibiogram-guided therapy
- Common empiric options: Antipseudomonal β-lactams: Piperacillin-tazobactam; Cefepime; Ceftazidime; Meropenem/imipenem ± Aminoglycoside or fluoroquinolone for synergy (severe cases).
- Colistin (last resort); Tigecycline (selected cases)
- Infection control measures
- Antibiotic Stewardship (ASP)

Thank You!
Wishing you all the best!