# *Respiratory Bacterial Infections*

**RESPIRATORY SYSTEM**

**2025-2026**

Pseudomonas aeruginosa

Moraxella catarrhalis

Bacillus anthracis

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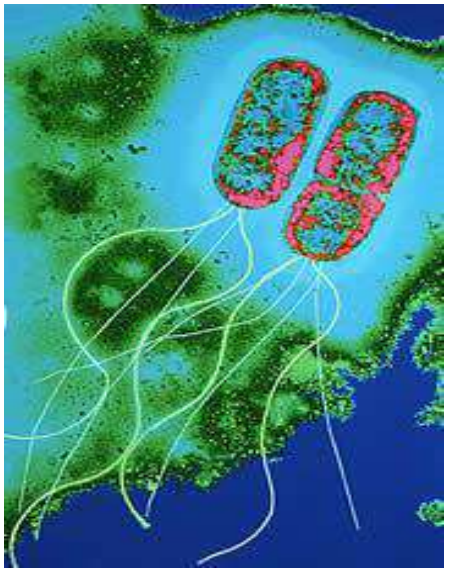
# Pseudomonas

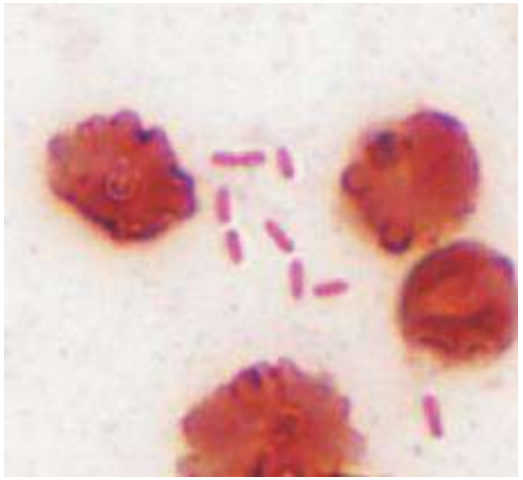
## Structure and Physiology



- Gram-negative rods.
- Motile with polar flagella.
- Obligate aerobe.
- Oxidase-positive.
- Encapsulated.

Do not ferment carbohydrates.

Resistant to multiple drugs.



**Extremely opportunistic infections of multiple sites**

# *P. aeruginosa*: Pathogenesis and Immunity

This organism is widely distributed in nature and is commonly present in moist environments in hospitals. It is pathogenic only when introduced into areas devoid of normal defenses, e.g.,

1. Disruption of mucous membrane and skin.
2. Usage of intravenous or urinary catheters.
3. Neutropenia (as in cancer therapy).

*P. aeruginosa* can infect almost any external site or organ.

*P. aeruginosa* is invasive and toxigenic. It attaches to and colonizes the mucous membrane or skin, invade locally, and produces systemic diseases and septicemia.

*P. aeruginosa* is resistant to many antibiotics. It becomes dominant when more susceptible bacteria of the normal flora are suppressed.

# *P. aeruginosa*

## Virulence Factors

### Antigenic structure, enzymes, and toxins

Pili and nonpilus adhesions.

Capsule seen in cultures from patients with cystic fibrosis.

LPS- endotoxin, multiple immunotypes.

Pyocyanin: catalyzes production of toxic forms of oxygen that cause tissue damage.

Pyoverdin: a siderophore.

Proteases

protease cause tissue damage and help bacteria spread.

Phospholipase C: a hemolysin

Exotoxin A: causes tissue necrosis and is lethal for animals (disrupts protein synthesis); immunosuppressive.

Exoenzyme S and T: cytotoxic to host cells.

# *P. aeruginosa*

## Clinical Diseases

•External otitis is the most common infection due to *Pseudomonas* spp. particularly in the tropics and in swimmers: patients present with pain, swelling, and redness of the external portions of the ear as well as a purulent discharge. Malignant (necrotising) external otitis is more serious affecting diabetic patients presenting as severe pain and discharge. Damage to cranial nerves, particularly the facial nerve, is common.

External otitis

Malignant
(necrotising) external


Chronic paronychia presents as a greenish discoloration of the nail

paronychia

# P. aeruginosa

## Clinical Diseases

•Spa pool folliculitis is a pseudomonas infection acquired in inadequately chlorinated hot tubs. Patients present with tchy follicular papules and pustules on any part of the body submerged in the tub.

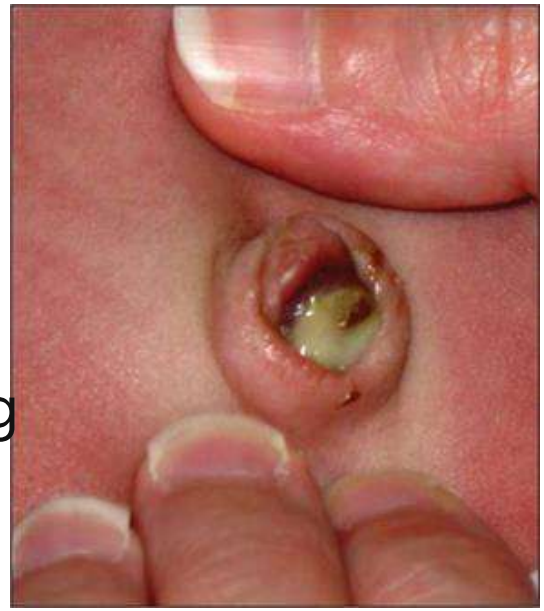

•Puncture wounds of the foot and the patient will present with a sweet, fruity-smelling discharge. Cellulitis and osteomyelitis are common complications.

# P. aeruginosa

## Clinical Diseases

•Ecthyma gangrenosum typically develops in neutropenic patients as erythematous, ulcerated, purple or black skin lesions in the axillary, inguinal, or anogenital areas.

Infection of the umbilical stump in he neonate present as a spreading erythema associated with the typical green fruity-smelling discharge.



# *P. aeruginosa*

## Laboratory Diagnosis

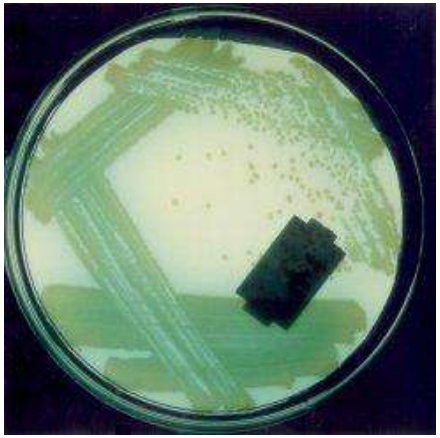
Specimen: skin lesions, pus, urine, blood, spinal fluid, sputum.

Culture: blood agar plate and differential media.

## Treatment

Combined antibiotic therapy is generally required to avoid resistance that develops rapidly when single drugs are employed.

Aminoglycoside, antipseudomonal B-lactam or a quinolone



## *P. aeruginosa*

Forms round colonies with a fluorescent greenish color, fruity odor, and β-hemolysis.

Pyocyanin- nonfluorescent bluish pigment;

pyoverdin- fluorescent greenish pigment;

Identification of *P. aeruginosa* is usually based on oxidase test and its colonial morphology: β-hemolysis, the presence of characteristic pigments, sweet odor, and growth at 42 $^{o}$C.

# *P. aeruginosa*

## Prevention and Control

Spread is mainly via contaminated sterile equipments and cross-contamination of patients by medical personnel.

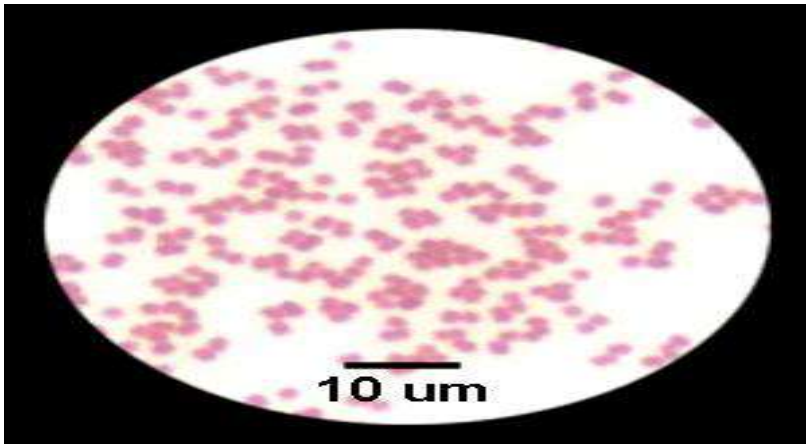
Control:

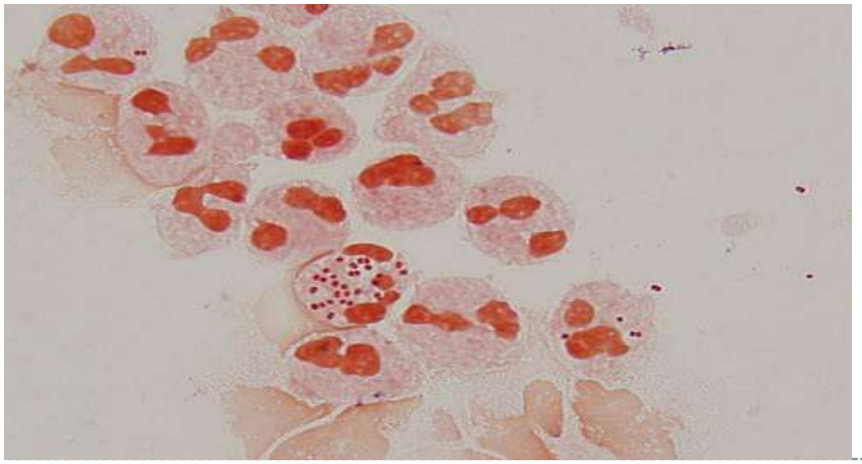
1. Patients at high risk should not be admitted to a ward where cases of pseudomonas infection are present.
2. Patients infected with *P. aeruginosa* should be isolated.
3. Sterilize all instruments, apparatus, and dressing

# PSEUDOMONAS

- **Mnemonic: "PSEUDOMONAS"**

**P** – **Pneumonia** (esp. in cystic fibrosis, ventilator-associated pneumonia)
**S** – **Sepsis** (especially in immunocompromised patients)
**E** – **Ecthyma gangrenosum** (necrotic skin lesions in neutropenic patients)
**U** – **UTIs** (catheter-associated or nosocomial)
**D** – **Diabetic infections** (e.g., malignant otitis externa)
**O** – **Oxidase positive** (important lab test)
**M** – **Motile**, polar flagella
**O** – **Opportunistic** infections (burns, cancer, ICU, CF, etc.)
**N** – **Nosocomial infections** (very common in hospitals)
**A** – **Aerobic**, obligate aerobe (but can grow anaerobically with nitrate)
**S** – **Slime layer** (biofilm → chronic infections, esp. in CF lungs)



# *MORAXELLA CATARRHALIS*

# *Moraxella catarrhalis*

- General characteristics
  - Aerobic, gram-negative cocci or cocobacilli
  - Diplococci or diplococcibacilli
  - Non motile
  - Oxidase positive
  - They don't ferment carbohydrates

- Normal commensal of the respiratory tract (humans only)
- Has become an important opportunistic pathogen

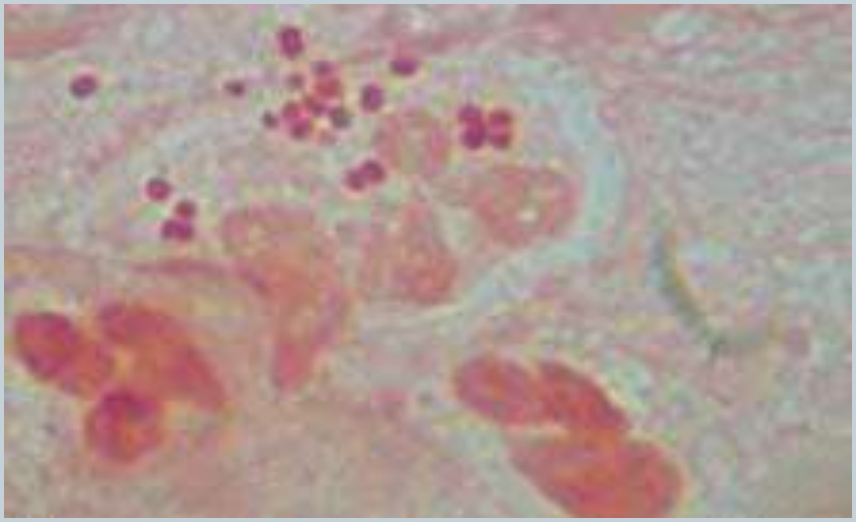
# Clinical infections

- Clinical infections
  - Pneumonia
  - Sinusitis
  - Otitis media (3rd most common cause)
  - Eye, CNS, Joints infection
- Predisposing factors
  - Advanced age
  - Immunodeficiency
  - Neutropenia
  - Other debilitating diseases

M. catarrhalis can be both extracellular and intracellular, as it is capable of surviving and multiplying on host mucosal surfaces (extracellular) and can also actively invade and persist within host epithelial cells (intracellular). This dual lifestyle allows it to colonize mucosal surfaces and evade immune responses by subverting host cell clearance mechanisms.

# Laboratory diagnosis

- Colonies appear smooth with a grayish- white color
- When colonies pushed with loop, they “scoot” across media (hocky puck sign).



**Direct smear from an otitis media sample showing intracellular gram-negative diplococci**

***M. catarrhalis*** **growing on chocolate agar after 48 hours of incubation**

# Laboratory Diagnosis and treatment:

- Oxidase positive
- Catalase positive
- All sugar fermentation negative
- Produce beta- lactamase
- DNase positive

Treatment: fluoroquinolones, most second and third generation cephalosporins, erythromycin, and amoxicillin-clavulanate.

# MORAXELLA

**Mnemonic: "MORAXELLA"**

**M** – **M**eningitis (rarely, can cause CNS infections in children)

**O** – **O**titis media (common in children)

**R** – **R**espiratory tract infections (bronchitis, pneumonia – especially in COPD patients)

**A** – **A**erobic (obligate aerobe)

**X** – "X" as a placeholder: **Gram-ne**gative diplococcus (resembles Neisseria)

**E** – **E**lderly (risk group, especially with COPD)

**L** – **L**ung infections (in people with chronic lung disease)

**L** – **β-L**actamase producer (resistant to penicillin, treat with macrolides, cephalosporins, etc.)

**A** – **A**symptomatic colonization common in upper respiratory tract

# MORAXELLA

- **Mnemonic for Laboratory & Treatment: "CATARRHALIS"**
- **C – Catalase positive**
  **A – Associated with respiratory disease**
  **T – Treat with macrolides, 2nd/3rd gen cephalosporins**
  **A – Amoxicillin/clavulanate** (alternative treatment)
  **R – Resembles Neisseria** on Gram stain
  **R – Rarely causes invasive disease**
  **H – Human nasopharynx** is reservoir
  **A – Aerobic**, Gram-negative
  **L – Lipid-rich outer membrane** (virulence factor)
  **I – Intracellular survival** not typical (unlike some pathogens)
  **S – Sinusitis** and otitis media (esp. in children)

# *Bacillus*

***B. anthracis*: anthrax of the animals and humans.**

## Morphology and Physiology

- Aerobic or facultative anaerobic.
- Large gram-positive rods, have square ends, arranged in long chains.
- Spore is located in the center of the cell.
- Most are saprophytic (soil, water, air, and on vegetation.)

# *B. anthracis*

## Pathogenesis and Immunity

- Primarily a disease of herbivores (sheep, cattle, horses); humans are rarely affected.
- In animals, portal of entry is mouth and GI tract. In humans, scratches in the skin (95% of infection), ingestion or inhalation lead to infection.
- The spores germinate in the tissue at the site of entry, and growth of the vegetative forms results in gelatinous edema and congestion. *Bacillus* spread via lymphatics to the blood and other tissues.

# *B. anthracis*

## Pathogenesis and Immunity

### Virulence factors

- Capsule (encoded from a plasmid)
- Exotoxins:
  - Edema toxin is composed of protective antigen (B-subunit) and edema factor (EF; an adenylate cyclase). This toxin complex increases vascular permeability which leads to shock.
  - Lethal toxin is composed of protective antigen and lethal factor (LF; a metalloprotease). This toxin causes cell death and stimulates macrophages to release proinflammatory cytokines.

# *B. anthracis*

## Clinical Diseases

Inhalation anthrax (wool-sorters' disease): long incubation time (2 months or more).

Progressive hemorrhagic lymphadenitis /Mediastinitis (enlargement of mediastinal lymph nodes), sepsis, and meningitis (50% patients).

Pulmonary disease rarely develops. Fatal if untreated 100%

Cutaneous anthrax

Gastrointestinal anthrax (very rare)



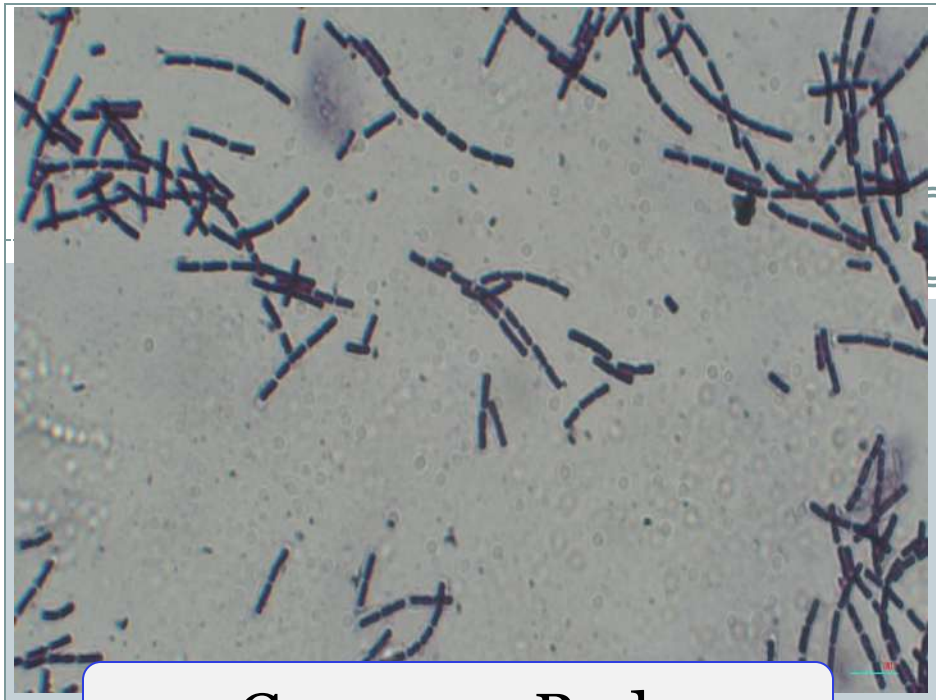

# Human Cutaneous Anthrax Sampling (Suspected)




# *B. anthracis*

## Laboratory Diagnosis

- Specimens: fluid or pus from local lesion, blood, or sputum.
- Smears: long chains (a characteristic of *B. anthracis*) of large gram-positive rods without spores can be seen. Immuno-fluorescence stain can be used for dried smears.
- Culture: nonhemolytic gray colonies with dry surface on blood agar plates.
- Identification: made in a reference lab by direct fluorescent Ab test against capsular polypeptide or PCR test.
- Serological tests: detection of antibodies to lethal toxin and edema toxin.



Gram +ve Rods

Vegetative cells + Endospores

# *B. anthracis*

## Treatment

Multi drug therapy, Ciprofloxacin, rifampin and vancomycin

## Control

•Proper disposal of animal carcasses (burning or deep burial in lime pit).

•Autoclaving of animal products.

•Protective clothing and gloves for handling infected animals.

•Vaccination of domestic animals.

•Immunization of persons at high risk with a cell-free vaccine based on the protective antigen is under investigation.

MICROBIAL GENOMICS

SHORT COMMUNICATION

Podowski *et al.*, *Microbial Genomics* 2025;11:001422

DOI 10.1099/mgen.0.001422

MICROBIOLOGY SOCIETY

OPEN DATA OPEN ACCESS

# Genomic reconstruction of *Bacillus anthracis* from complex environmental samples enables high-throughput identification and lineage assignment in Pakistan

Justin C. Podowski[1,*], Sara Forrester[2], Tahir Yaqub[3], Amin Aqel[4], Mohammad Abu Lubad[4], Nadia Mukhtar[3], Muhammad Waqar Aziz[5], Nageen Sardar[6], Hassaan Bin Aslam[3], Hamda Pervaiz[3], Alan J. Wolfe[7] and Daniel S. Schabacker[2]

# Anthrax Suspected Carcass Sampling

# ANTHRAX

- **Mnemonic: "ANTHRAX"**

**-A – Aerobic** (facultative aerobe).
**-N – Non-motile** (unusual for Bacillus species).
**-T – Two toxins** (Lethal toxin & Edema toxin).
**-H – Halo on agar** (medusa head appearance / capsule made of polypeptide).
**-R – Rod-shaped** (Gram-positive rods in chains).
**-A – Anthrax = wool-sorter's disease** (pulmonary form from inhaled spores).
**-X – Xtra** large capsule made of **poly-D-glutamate** (not polysaccharide!).

Colonies (medusa head appearance)

medusa head

# ANTHRAX

- **Lab Diagnosis Mnemonic: "BAM BAM"**

For **Bacillus Anthracis Morphology**:

**B** – Boxcar-shaped rods (Gram-positive)

**A** – Aerobic

**M** – Medusa head colonies

**B** – Beta hemolysis **absent** (differentiates from B. cereus)

**A** – Anthrax toxin genes on **plasmids (pXO1, pXO2)**

**M** – Malachite green stain shows spores (in culture, not tissue)