CASE 2 – THE BODY SYSTEMS & *P. AERUGINOSA*

ADAPTED FROM WRITING & IMAGES AT:
HTTP://WIKI.UBC.CA/COURSE:PATH417201 7W2/CASE_2

Introduction

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The Case: A House Fire

Marian has suffered second degree burns extending deep into the dermis layers in her upper limbs. After three days in hospital, she is released. Marian and her sister treat her burn wounds with honey. Marian experiences pain associated with her burns which are producing more fluid than before. After a bad nights sleep her sister takes her back to the hospital and the laboratory grows *Pseudomonas aeruginosa* from her wound.

I. Signs & Symptoms

Signs = objective characteristics that can be observed by a healthcare practitioner

Pus is composed of dead white blood cells, including neutrophils, macrophages and dendritic cells. These cells migrate to the epithelium to fight infection and do so easily due to increased vascular permeability. *P. aeruginosa* releases alkaline protease and eleastase to inhibit/inactivate leukocytes.

Exudate is released from burn wounds, especially those that have been infected. Again due to increased vascular permeability fluid builds, and increased pressure pushes it to flow out. The fluid may also collect in vesicular lesions under the epithelium – blisters.

Redness (erythema) is caused by hyperemia in capillaries closer to the surface of the skin due to increased blood flow.

Symptoms = subjective characteristics that the patient experiences

Pain can be due to swelling and increased pressure in the area due to the inflammatory response and recruitment of many components to fight the local infection.

Marian's **Trouble Sleeping** may be due to fever or malaise as a result of the inflammatory response.

2. Effected Body System

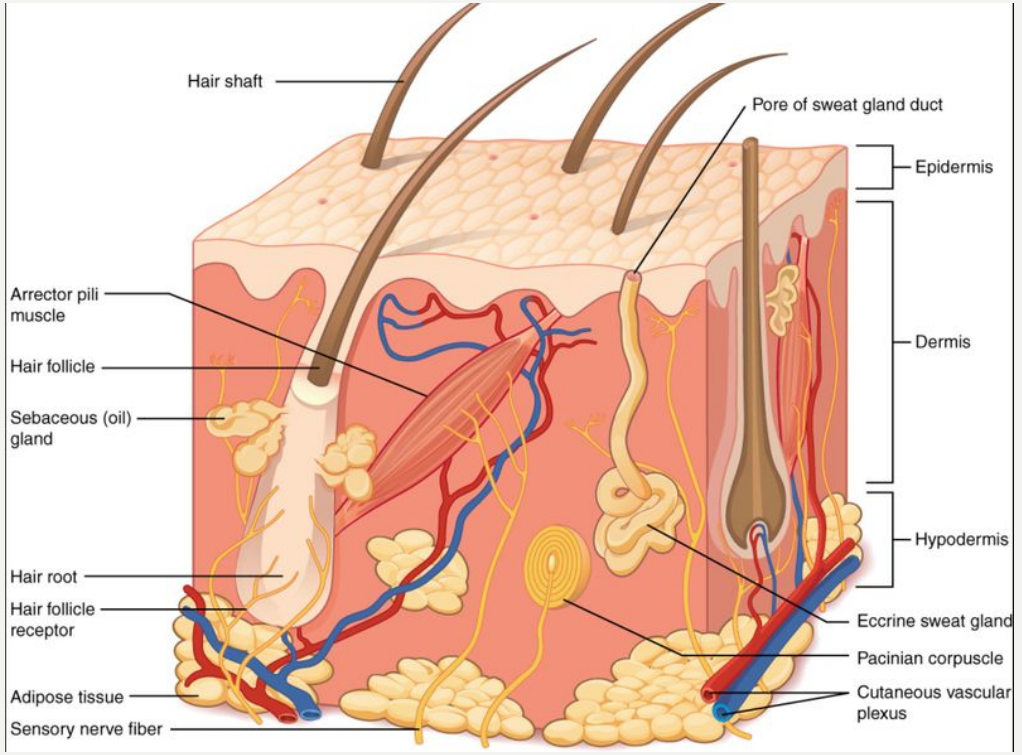
EFFECTED BODY SYSTEM: THE INTEGUMENTARY SYSTEM

Normal Structure & Function

- **The integumentary system = the skin, hair, nails, and sebaceous and sweat glands**
- **It functions to maintain thermoregulation, transmit sensation and act as a barrier to pathogens**
- **The 2 layers of the skin are:**

Epidermis:
- Non-vascular, outer-most layer that serves as a primary barrier
- Houses epithelial cells, keratinocytes & Langerhans cells, which are all important for the immune response

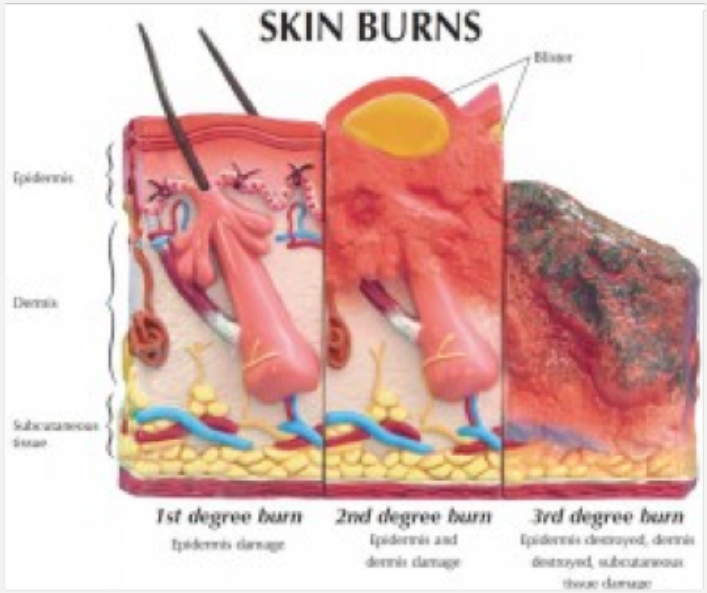
Dermis:
- Contains nerve endings, lymphatics & vasculature
- Hosts lymphocytes, mast cells & macrophages that mediate innate immunity
- Involved in fluid balance, thermoregulations, protection from trauma & skin repair



2. Effected Body System

MARIAN'S BURNS: DISTURBANCE TO THE SKIN AND A PRECURSOR TO INFECTION

Effects of Marian's 2nd degree burns on **integumentary** & **immune** function



Obtained from: https://www.cardiacsafe.com.au/treating-thermal-burns/burns-levels/

Epidermal Damage: Loss of protective barrier and Langerhans cells increases risk for bacterial colonization

Dermal Damage: Marian will experience delayed healing and vulnerability to infection as damage to blood vessels makes it difficult for immune cells to migrate to the area. The damage will include destroyed hair follicles, exocrine gland and nerve endings.

Decreased activation of macrophages and naturel killer cells. Release of prostaglandin E2 by macrophages supresses T-Cell activity; specifically, there are decreased levels of CD4+ T helper cells.

Components of the Complement Cascade are both activated and consumed by burn injuries. Excessive amounts of C3a and C5a may be present and cause alerted blood pressure and leukocyte function. The Membrane Attack Complex may also be altered and target host cells at the injury.

Burn tissue may produce immunosuppressive factors specifically against cell-mediated immunity. Serum immunoglobins (IgG in particular) are significantly reduced in burn victims

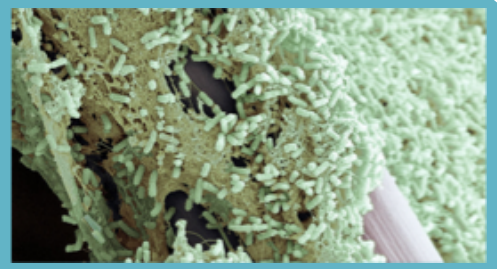
2. Effected Body System

DISTURBANCE DUE TO INFECTION

Biofilm: Allows for protection of *P. aeruginosa* as it lives within. It prevents healing, leading to prolonged infection. Infections cause an exaggerated immune response with increased release of cytotoxic granules that damage the host tissue

Pyocyanin: this exotoxin causes phagocytic neutrophils to undergo apoptosis and die

Primary damage from the burn, paves the way for secondary infection by *P. aeruginosa*



A *P. aeruginosa* Biofilm:

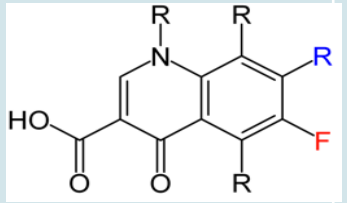
Type III Secretions: *P. aeruginosa* injects effector proteins into host cells. ExoS, ExoU and ExoA cause apoptosis of host epithelial cells, hinder protein synthesis and prolong the infection.

3. Antibiotic Treatment

Antibiotic drugs are antimicrobial agents that function by a variety of mechanisms to interfere with growth or promote death of bacterial pathogens in the body. Drugs can have various molecular targets: components of the cell wall or cell membrane, ribosomes, DNA, RNA and metabolic enzymatic biochemical pathways.

Empirical Therapy: Initially, while the bacterial cause if unknown, Marian would be started on treatment with broad spectrum antibiotics that will collectively fight against a wide range of bacteria. The recommended combination is →

Combination Therapy: This is a type of treatment that involves using a beta-lactam antibiotic with and aminoglycoside or fluoroquinolone. Together, they are effective in treating infection with gram-negative bacteria like *P. aeruginosa*.

Name	Intended against:
Cefazolin or clindamycin	Gram-positives
Vancomycin	MRSA
(optionally) a fluoroquinolone Obtained from: http://medlibes.com/entry/fluoroquinolones 	Gram-negatives and *Pseudomonas*

Types of antibiotics and their mechanism

β –lactams (e.g. penicillins & cephalosporins):

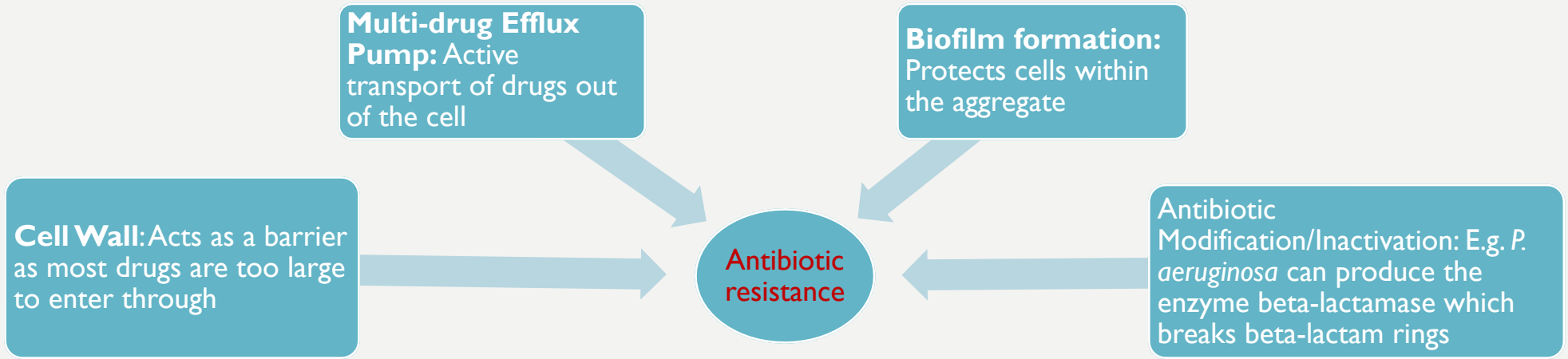
- Target bacterial Penicillin-Binding Proteins (PBPs) with their characteristic beta lactam ring (4-membered, Nitrogen containing)
- PBPs are involved in cross-linking of the bacterial cell wall and binding of the beta lactam ring inhibits this role
- Compromised cell wall synthesis leads to osmotic instability and autolysis

Aminoglycosides (e.g. gentamicin & amikacin):

- Inhibit protein synthesis by binding to bacterial ribosomes and preventing translation
- Without the ability to produce building blocks, receptors, enzymes etc. the bacteria is unable to grow

Fluoroquinolones (e.g. ofloxacin & ciprofloxacin):

- Inhibits bacterial reproduction by binding to the DNA-enzyme complex (composed of enzymes gyrase, helicase & topoisomerase IV) and breaking DNA strands
- Damage in the genome leads to cell death



4. Alternative Therapies

NATURAL ALTERNATIVE THERAPIES

Curcumin is an anti-inflammatory agent (diferuloyl-methanc). It reduces inflammation, wound size and promotes re-epithelialization.

Honey has been noted for its antimicrobial properties and is effective against *P. aeruginosa*. This is due to its high sugar content, low pH and high osmolarity.

Moist Exposed Burn Ointment contains plant steroids and berberine oil. It maintains moisture, which allows faster redistribution of keratinocytes and soothes pains.

Clove Oil has been shown to disrupt quorum sensing in P. aeruginosa thus hindering biofilm formation, which is a major factor in its colonization of a host.

Scrophularia striata extract has been shown to have anti-septic and anti-inflammatory properties due to flavonoid compounds and phenylpropanoid glycosides. Release of inflammatory factors PGE-2, IL-4 & IL-8 is blocked.

Others include: Licorice, Aloe vera gel, tannins, garlic ointment and green tea extract among more.

4. Alternative Therapies

NON-NATURAL ALTERNATIVE THERAPIES

Petroleum Jelly provides an effective physical and moisture barrier.

Acetic Acid is highly effective against gram-negative bacteria (by reducing pH and causing electrolyte imbalance), and especially important to consider for P. aeruginosa due to its growing resistance. Disadvantages include slowing of epithelial healing, but in right concentration this can be reduced.

Others include: Hydrogen peroxide, Graphene oxide, Surgical grafts and many more

Vacuum Dressings improve healing due increased blood flow. Blood flow is increased, edema is reduced, bacterial colonization is minimized and grafts are secured by this negative pressure

Blue light (415nm) is inherently anti-microbial and selective to *P. aeruginosa* over keratinocytes. Exposure to the light causes intracellular damage in the bacteria and inactivation.

Silver ions and compounds inhibit bacterial growth by interacting with thiol groups of enzymes that are important for bacterial respiration. Nano crystalline silver is able to rapidly inhibit growth and has been shown effective against multi-drug resistant *P. aeruginosa*.