Chapter 5

Inflammation and Healing

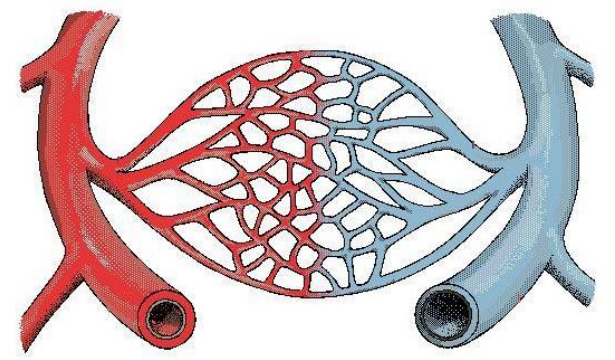
Review of Body Defenses

- First line of defense
  - Nonspecific
  - Mechanical barrier
  - Unbroken skin and mucous membranes
  - Secretions such as tears and gastric juices
- Second line of defense
  - Nonspecific
  - Phagocytosis
  - Inflammation

Review of Body Defenses (Cont.)

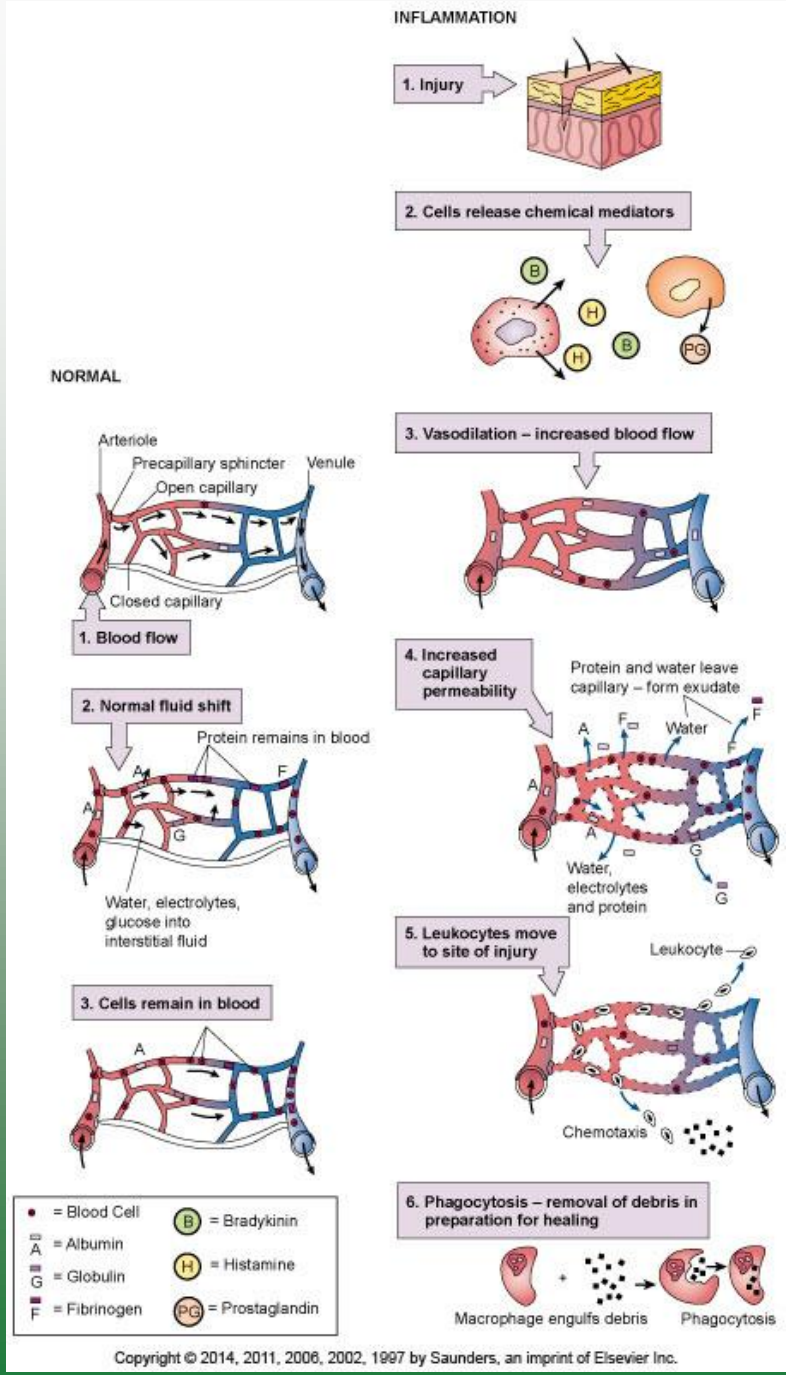
- Third line of defense
  - Specific defense
  - Production of specific antibodies or cell-mediated immunity

Normal Capillary Exchange



- Movement of fluid, electrolytes, oxygen, and nutrients on arterial end based on net hydrostatic pressure
- Venous end—osmotic pressure will facilitate movement of fluid, carbon dioxide, and other wastes.

Normal Capillary Exchange Versus Inflammatory Response



Physiology of Inflammation

- A protective mechanism and important basic concept in pathophysiology
- Disorders are named using the ending *–itis.*
- Inflammation is a normal defense mechanism
- Signs and symptoms serve as warning for a problem:
  - Problem may be hidden within the body.
- It is not the same as infection.
  - Infection, however, is one cause of inflammation.

Causes of Inflammation

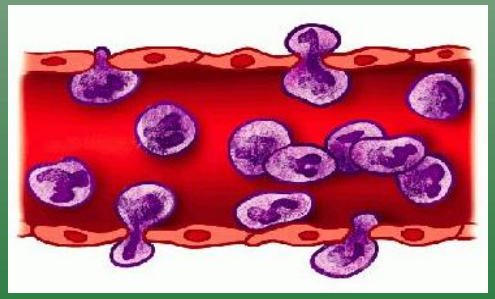
- Direct physical damage
  - Examples: cut, sprain
- Caustic chemicals
  - Examples: acid, drain cleaner
- Ischemia or infarction
- Allergic reactions
- Extremes of heat or cold
- Foreign bodies
  - Examples: splinter, glass
- Infection

Steps of Inflammation

- Injury to capillaries and tissue cells
- Release of bradykinin from injured cells
- Bradykinin stimulates pain receptors.
- Pain causes release of histamine.
- Bradykinin and histamine cause capillary dilation.
- Break in skin allows bacteria to enter tissue
- Neutrophils phagocytize bacteria.
- Macrophages (mature monocytes) leave the bloodstream and phagocytose microbes.

Acute Inflammation

- Process of inflammation is the same, regardless of cause.
- Timing varies with specific cause
- Chemical mediators affect blood vessels and nerves in the damaged area:
  - Vasodilation
  - Hyperemia
  - Increase in capillary permeability
  - Chemotaxis to attract cells of the immune system



Diapedesis – leukocytes exiting the circulation by squeezing between endothelial cells.

Cardinal Signs of Inflammation

By Celsus, 1st Century A.D.

Calor, dolor, rubor, and tumor
Heat, pain, redness, and swelling.

Later "functio laesa", loss of function, was added (by a debatable source).

Local Effects of Inflammation

- Redness and warmth
  - Caused by increased blood flow to damaged area
- Swelling (edema)
  - Shift of protein and fluid into the interstitial space
- Pain
  - Increased pressure of fluid on nerves; release of chemical mediators (e.g., bradykinins)
- Loss of function
  - May develop if cells lack nutrients; edema may interfere with movement.

Exudate

- Serous
  - Watery, consists primarily of fluid, some proteins, and white blood cells
- Fibrinous
  - Thick, sticky, high cell and fibrin content
- Purulent
  - Thick, yellow-green, contains more leukocytes, cell debris, and microorganisms

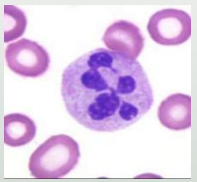
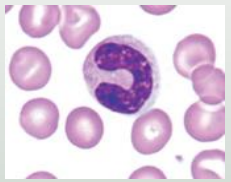
Systemic Effects of Inflammation

- Mild fever (pyrexia)
  - Common if inflammation is extensive
  - Release of pyrogens
- Malaise
  - Feeling unwell
- Fatigue
- Headache
- Anorexia

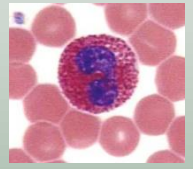
Changes in the Blood with Inflammation

1. Leukocytosis - elevated white blood cell count.

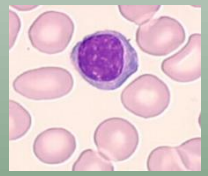
2. An altered differential count:
   - bacterial infections produce a "left shift" or increased number of immature neutrophils called "bands".

   - an allergy may increase the percentage of "eosinophils"



   - a viral infection may increase the percentage of "lymphocytes".



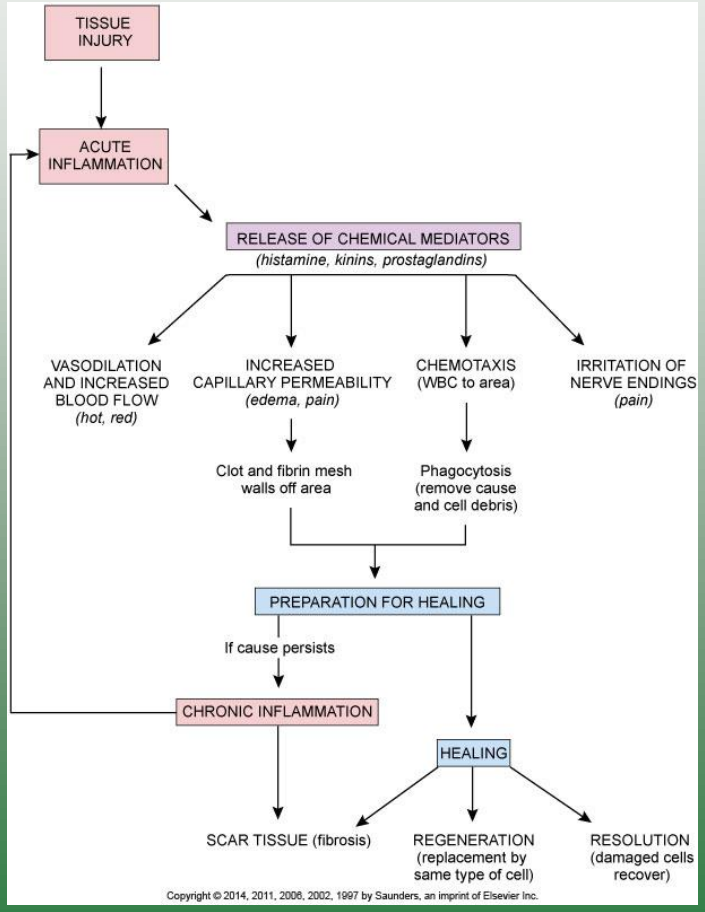
3. Changes in plasma proteins: Increased fibrinogen and prothrombin.

4. Acute Phase Reactants like "C-reactive protein" that appears 24-48 hours into inflammation.

- 5. Increased ESR - erythrocyte sedimentation rate. (Red blood cells in a tube naturally settle with the cell going to the bottom of the tube leaving the liquid part of the blood, plasma, above. The rate of settling can be measured in mm/hour)

- 6. Cell specific enzymes, "isozymes", can identify the source of the inflammation or necrosis. Example: Elevated CK(creatine kinase) is not specific and could be from inflammation or necrosis in the brain, skeletal muscle or heart; but if you fractionate it, CK-MB indicates the heart as the source of the inflammation or necrosis.

Course of Inflammation and Healing



Types of Healing

- Resolution
  - Minimal tissue damage
- Regeneration
  - Damaged tissue replaced with cells that are functional
- Replacement
  - Functional tissue replaced by scar tissue
  - Loss of function

Chronic Inflammation

- Follows acute episode of inflammation
- Less swelling and exudate
- Presence of more lymphocytes, macrophages, and fibroblasts
- Continued tissue destruction
- More fibrous scar tissue
- Granuloma may develop around foreign object

Potential Complications of Inflammation

- Infection
  - Microorganisms can more easily penetrate edematous tissues.
  - Some microbes resist phagocytosis.
  - The inflammatory exudate also provides an excellent medium for microorganisms.
- Skeletal muscle spasm
  - May be initiated by inflammation
  - Protective response to pain

Potential Complications

- Deep ulcers may result from severe or prolonged inflammation
  - Caused by cell necrosis and lack of cell regeneration that causes erosion of the tissue
    - Can lead to complications such as perforation of viscera
    - Extensive scar tissue formation

Drugs Used to Treat Inflammation

TABLE 5-4 Comparison of Drugs Used to Treat Inflammation

Actions	ASA	Acetaminophen	NSAID	Glucocorticoid	COX-2
Antiinflammatory	Yes	*No*	Yes	Yes	Yes
Analgesia	Yes	Yes	Yes	*No*	Yes
Antipyretic	Yes	Yes	Yes	*No*	*No*
Adverse Effects					
Allergy*	Yes	*No*	Yes	*No*	*Yes*
Delays blood clotting	Yes	*No*	Yes	*No*	*No*
Risk of infection	*No*	*No*	*No*	Yes	*No*
GI distress	Yes	*No*	Yes	Yes	May occur
Stomach ulceration	Yes	*No*	Yes	Yes	May occur
Edema or Increased BP	*No*	*No*	*No*	Yes	May occur
MI or CVA	*No*	*No*	*No*	*No*	May occur
Liver damage	*No*	*No*	*No*	*No*	May occur

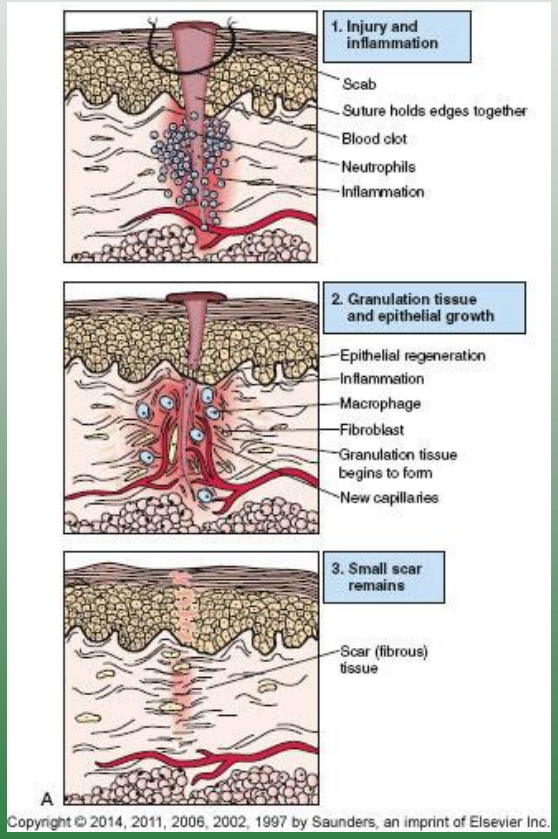
*Note allergic reactions may occur with administration of any drug.

“RICE” Therapy for Injuries

- Rest
- Ice
- Compression
- Elevation

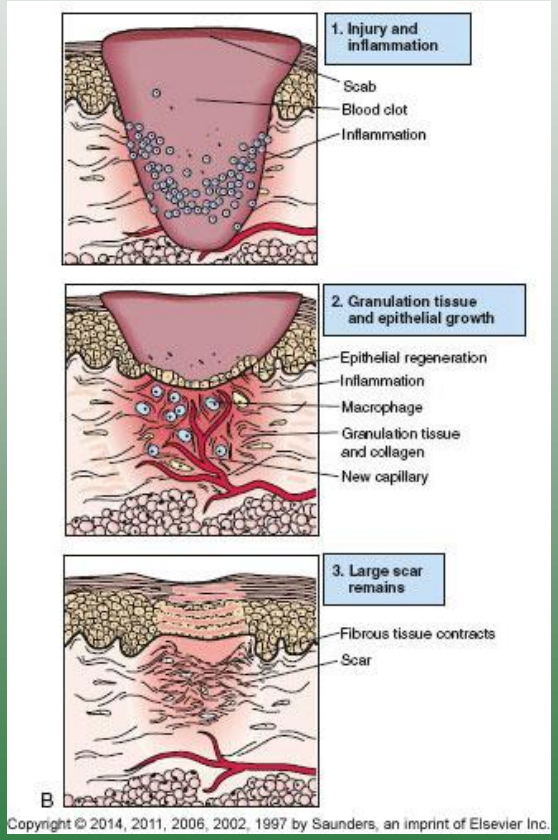
The Healing Process

- Healing of incised wound by first intention



The Healing Process (Cont.)

- Healing by second intention



Scar Formation

- Loss of function
  - Result of loss of normal cells and specialized structures
    - Hair follicles
    - Nerves
    - Receptors
- Contractures and obstructions
  - Scar tissue is nonelastic.
  - Can restrict range of movement
- Adhesions
  - Bands of scar tissue joining two surfaces that are normally separated

Scar Formation (Cont.)

- Hypertrophic scar tissue
  - Overgrowth of fibrous tissue
    - Leads to hard ridges of scar tissue or keloid formation
- Ulceration
  - Blood supply may be impaired around scar
    - Results in further tissue breakdown and ulceration at future time

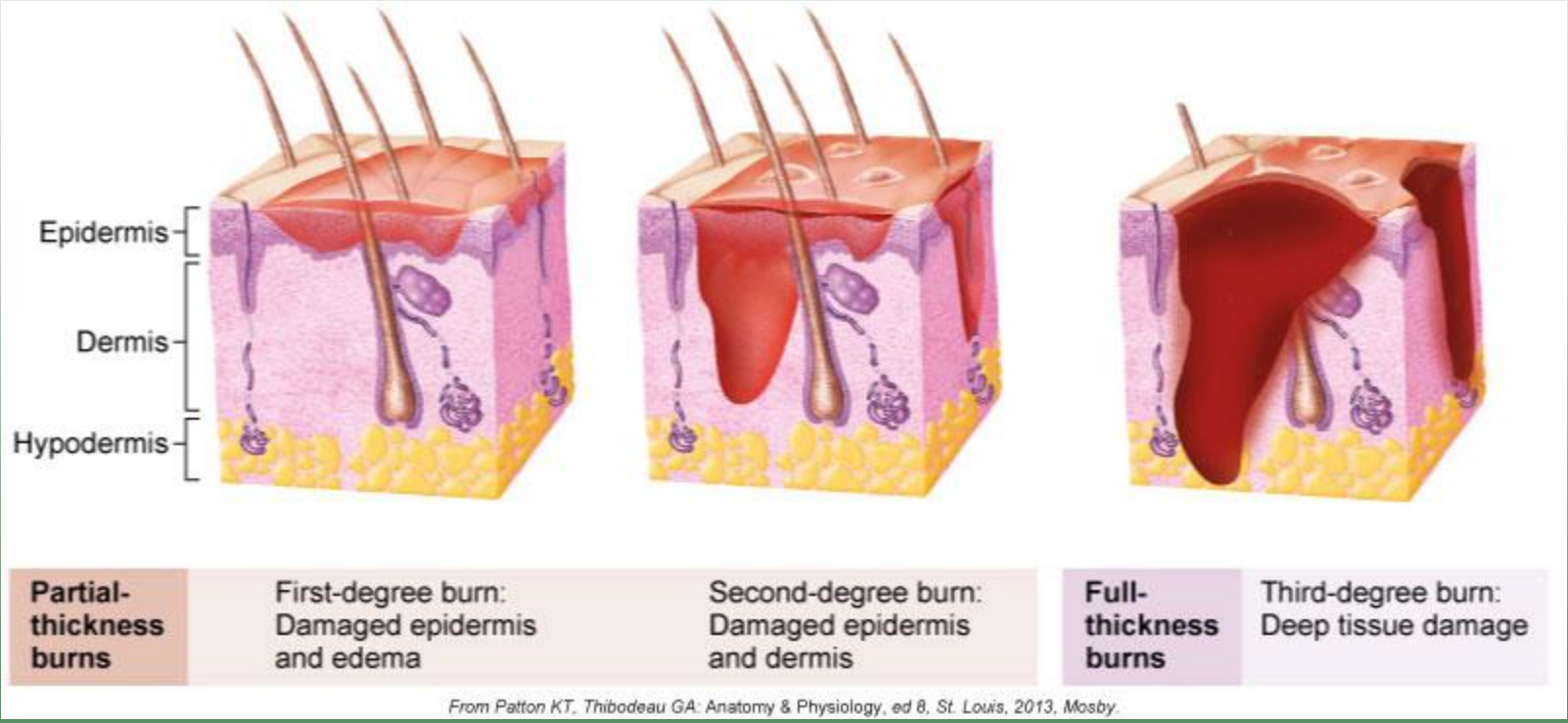
Burns

- Thermal—caused by flames or hot fluids
- Chemical
- Radiation
- Electricity
- Light
- Friction

Classification of Burns

- Superficial partial-thickness (first-degree) burns
  - Involve epidermis and part of dermis
  - Little, if any, blister formation
- Deep partial-thickness (second-degree) burns
  - Epidermis and part of dermis
  - Blister formation
- Full-thickness (third- and fourth-degree) burns
  - Destruction of all skin layers and often underlying tissues

Classification of Burn Injury by Depth

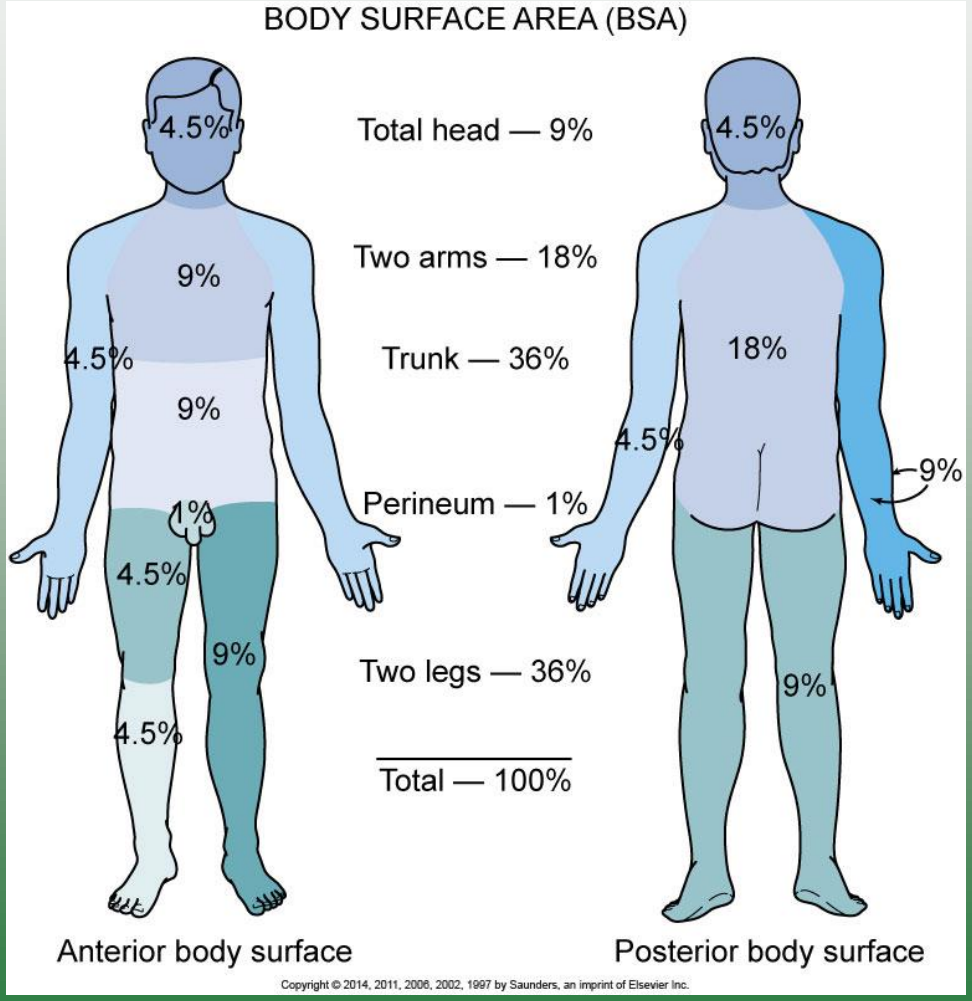


From Patton KT, Thibodeau GA: Anatomy & Physiology, ed 8, St. Louis, 2013, Mosby.

Effects of Burn Injury

- Both local and systemic
- Dehydration and edema
- Shock
- Respiratory problems
- Pain
- Infection
- Increased metabolic needs for healing period

Assessment of Burn Area Using the Rule of Nines



Healing of Burns

- Hypermetabolism occurs during healing period.
- Immediate covering of a clean wound is needed to prevent infection.
- Healing is a prolonged process.
- Scar tissue develops, even with skin grafting.
- Physiotherapy and occupational therapy may be necessary.
- Surgery may be necessary to release restrictive scar tissue.