Integumentary System

- Epidermis
  - Outer layer of the skin
  - 5 layers: corneum, lucidum, granulosum, spinosum, basale
  - Repairs and regenerates every 28 days
  - Synthesis of vitamin D and cytokines
  - Division and mobilization of cells
  - Pigmentation
- Dermis
  - 2 layers: papillary and reticular
  - Composed of collagen, reticulum, and elastin fibers
  - Contains network of nerve endings, blood vessels, lymphatics, capillaries, sweat and sebaceous glands, and hair follicles
  - Delivers nutrition, blood, and oxygen
  - Resistance against shearing forces
  - Inflammatory response
  - Moisture retention
  - Sebum from sebaceous glands
- Hypodermis
  - Composed of adipose and connective tissue
  - Contains major blood vessels, nerves, and lymphatic vessels
  - Thermal insulation
  - Storage of calories
  - Controls body shape
  - Mechanical “shock absorber”
- Extracellular Matrix (ECM)
  - Fibrous proteins
    - Collagens: up to 80% of the dermis, made by fibroblast cells
      - Type 1 collagen: “weak collagen”
      - Type 3 collagen: “strong collagen”, replaces type 2 during maturational phase of wound healing to increase the tensile strength of the scar
    - Elastin: provide tissue resilience to stretching, coiled protein molecules
  - Adhesive proteins
    - Laminin: provides structural support
    - Fibronectin: provides preliminary matrix for collagen deposition, found in plasma
  - Polysaccharides
    - Proteoglycans: core protein with GAG chains; form a gel-like carbohydrate-based substance that fills extracellular spaces
    - GAGs: disaccharide chains
  - Helps cells attached and communicate with nearby cells for growth, movement, and other functions
  - Involved in repairing damaged tissue
- Skin pH:
  - Normal: 4-6.5% (acidic)
  - Increased pH may lead to infection, decreased epidermal lipid formation, decreased protection against alkaline substances, increased risk of damage
    - Conditions that can increase pH: dry skin, eczema, dermatitis, diabetes, CKD, CVD
- Macrophage: ingest and digest bacteria and other substances
- Mast cells: contain histamine
- Cytokines
- Fibroblasts
- Melanocytes
- Phagocytes
-

Skin Lesions

- Primary morphology
  - Flat
    - Macule: <10mm
    - Patch: >10mm
  - Raised
    - Papule: <10mm
    - Plaque: >10mm
  - Raised
    - Constituency
      - Liquid-filled
        - Vesicle: <10mm
        - Bulla: >10mm
      - Pus-filled: Pustule
      - Solid: Nodule
  - Skin bleeding: may flat or raised, non-blanchable, the result of thrombocytopenia
    - Petechiae: non-palpable <3mm
    - Purpura: larger areas of hemorrhage: 3-10mm
    - Ecchymosis: non-palpable >10mm
  - Telangiectasia: small, dilated blood vessels
  - Urticaria: red, rounded, and raised rash; allergic reactions
  - Ulcers: loss of epidermis and partial loss of dermis
  - Excoriation: scratch marks; erosion of the skin that is linear in shape
  - Crusts: dried out exudate/sebum on skin
- Secondary morphology
  - Shape
    - Round: annular
      - Rounded with central clearing tinea, secondary syphilis, lupus
    - Line: linear
      - Contact dermatitis
    - Coin-shaped: nummular
      - Nummular eczema
    - Target: targetoid
      - Erythema migrans, erythema multiforme
    - Web-like: reticular
      - Lacy network, livedo reticularis
    - Snake-like: serpiginous
      - Squiggly, branching lesion, parasitic infections
    - Herpeteform: clusters of papules or vesicles, Herpes simplex virus infections, dermatitis herpetiformis
    - Zosteriform: confined to a dermatome, Herpes zoster (shingles)
  - Texture
    - Hyperkaratosis: thickening of skin callouses, tinea pedis
    - Verrucous: irregular, raised, dark, seborrheic keratosis, warts
    - Lichenification: thickening of skin, increased visibility of skin lines, scratching
    - Xanthoma: raised yellow lesion, composed of fats/cholesterol, familial hypercholesterolemia
    - Indurated: thickening of skin due to swelling and edema
    - Umbilicated: belly button, molluscum contagiosum

Principles of Wound Management

- **Partial thickness wound**
  - Level of wound is through the epidermis and/or dermis
  - Heals through regeneration

- **Full thickness wound**
  - Level of wound is into the subcutaneous or deeper
  - Heals through remodeling (filling in with granulation forming collagen and contraction); fat, tendon, muscle, etc. are not regenerated
  - **Primary**: All layers approximated at time of surgery or injury
    - Minimal amount of granulation tissue and epithelia cells required; thin scar line
  - **Secondary**: fills in from wound base over time
    - Large amount of granulation tissue with wound contraction; wide scarring
  - **Tertiary**: contaminated wound left open until antibiotics or debris removed; later closed by primary intention
- **Acute wound healing: hemostasis, inflammation, proliferative (granulation formation), maturation (epithelialization and remodeling); tissue repair predictable**
  - Wound healing occurs via overlapping phases: each phase triggers the next phase
  - Injury: disruption of blood vessels, bleeding, exposure of blood to collagen
    - Cell disruption and release of histamine leads to vasodilation
    - **Hemostasis (day 1-3)**: coagulation pathways activated and fibrin clot formed; platelets degranulate and release growth factors
    - Chemoattraction of neutrophils and macrophages
    - Stop bleeding
  - **Inflammatory phase (day 3-20)**: leakage of plasma, neutrophils, and macrophages into wound bed; may observe edema, warmth, exudate
    - Debridement of necrotic tissues; phagocytosis of bacteria
    - New framework for blood vessel growth
    - Chronic wounds often stuck in this phase
  - **Proliferative or granulating or rebuilding phase (week 1-6)**: continued production and recruitment of growth factors
    - Granulation tissue formation: ingrowth of new capillaries providing oxygen and nutrients; connective tissue synthesis provides a support matrix
    - Contraction of wound edges: contractile proteins (myofibroblasts) develop
    - Wound defect filled
    - Epithelial resurfacing: migration of skin cells from wound edges across bed of granulation tissue
    - Pulls the wound closed: wound resurfaced
  - **Maturation phase (week 6-2 years)**: collagen lysis and synthesis; scar formation
    - **Remodeling or maturation**
- **Chronic wound healing: does not progress in orderly manner; wound becomes stalled**
  - Exudate contains pro-inflammatory elements: cytokines and proteases
- Principles of wound management
  - Identify and control or eliminate the cause
    - Mechanical factors: pressure, shear, friction, MARSI, skin tear
    - Moisture and chemical factors: wound drainage, incontinence, perspiration, MASD
    - Vascular: arterial, venous, mixed
    - Neuropathic (aka diabetic)
    - Atypical: radiation, trauma, cancer, vasculitis, thermal, infections
    - Surgical
  - Support the host
    - Control and stabilize health issues
    - Optimize nutrition status
    - Pain control
  - Optimize the physiologic wound environment (TIME)
    - Tissue: remove macro and micro revitalized tissue
    - Infection/inflammation control: prevent or treat
    - Moisture balance
    - Edge of wound: fill dead space, protect peri wound, prevent/remove epibole, callous

- Comprehensive assessment: patient (history, systems, medication, OLDCART), focused exam (wound, diagnostics)
- **Moist wound healing: moisture is vital to tissue viability and should be maintained in most wounds at the wound/dressing interface; promotes faster healing, less scarring, protects from infection from external contamination, promotes autolysis, improves patient comfort**
    - Passive dressings: absorb, hydrate, do not add ingredients to wound
    - Active dressings: add active ingredients to wound (e.g. antibiotics, growth factors)
    - Advanced therapies

Wound Bed Preparation and Infections

- **Debridement**
    - Indications: necrotic tissue or debris; remove or reduce biofilm, infection, odor control
        - Do not debride ischemic wounds with dry gangrene or stable heel eschar
    - Goals: reduce bioburden, infection control, facilitate wound visualization, interrupt chronic wound cycle
- **Forms of non-viable tissue**
    - **Eschar**: necrotic (devitalized) tissue; leathery black or brown appearance; can be soft, firm, adherent, or loose
    - **Slough**: consists of avascular (necrotic/devitalized) tissue, serous exudate, bacteria, fibrin, cell debris, intact leukocytes; soft, moist, white, yellow, tan, firm or loosely adherent
- **Debridement**
    - **Autolytic debridement: uses body's own WBCs, enzymes, and moisture to rehydrate, soften, remove, and liquify hard eschar and slough**
        - Benefits: painless, easy with moisture retentive dressing, aides in combination debridement methods
        - Disadvantages: takes time
        - Precautions: do not use on neutropenic patients with infected wounds; hydrocolloids caution in diabetic patients
    - **Enzymatic: selective debridement using collagenase (Santyl) to dissolve collagen anchors of necrotic tissue to wound bed**
        - Benefits: faster than autolysis, often used with CSWD, option for patients with increased bleeding risk, safe in infected wounds, changed daily, nickel thick application, cover dressing needed, cross hatch eschar
        - Disadvantages: expensive, daily application, transient sting
        - Contraindications: do not use with heavy metals (e.g. silver), avoid use with antiseptics
    - **Chemical debridement:**
        - **Sodium hypochlorite solutions (e.g. Anascept, Dakin's, Vashe): selective debridement using sodium hypochlorite to dissolve collagen anchors of necrotic tissue to wound bed**
            - Benefits: necrotic, infected wounds, reduces odor, cheap, use short term, change every 12 hrs, keep moist, stop when infection gone, 0.125% antimicrobial
            - Disadvantages: controversial, 0.25% cytotoxic
            - Contraindications: clean wounds, keep away from light
        - **Silver nitrate: non-selective, caustic, chemical debridement agent that burns contacted tissues; reduces fibroblast proliferation**
            - Benefits: remove excess granulation and necrotic tissue, open up epibole, reduce bioburden, chemical cautery for bleeding
            - Disadvantages: controversial, painful, stains, silver absorption
            - Contraindications: pediatrics
    - **Biosurgical: Maggot therapy: use of medical grade maggots to liquefy necrotic tissue through proteolytic enzymes; possible ingestion of microbes**
            - Benefits: selective chemical debridement

        - Disadvantages: bleeding, pain, crawling sensation
        - Contraindications: poorly profused wounds, exposed vessels, necrotic bone, limb threatening infections
    - **Mechanical debridement**
        - **Wet-to-dry: use open weave damp gauze that is allowed to dry in wound to trap non-viable tissue which is pulled off with each dressing change**
            - Benefits: use in heavily necrotic and infected wounds without granulation, cheap
            - Disadvantages: painful, non-selective, time consuming
            - Contraindications: clean granulating wounds
        - **Wound irrigation or pulsatile lavage: use of fluid 4-15 PSI pf pressure via 19-gauge angio-catheter and 35 ml syringe to remove surface debris and bacteria from wound base without damaging healthy tissue or driving bacteria into deep tissues**
            - Benefits: wound cleansing
            - Disadvantages: potential for splash contamination
        - **Ultrasonic mist: use of low frequency, non-contact ultrasound device: acoustic energy to produce mechanical and thermal effects to degrade fibrin and remove biofilm**
            - Benefits: painless, wound cleansing, biofilm reduction, cavitation-mechanical tissue fragmentation, stimulates cells
            - Disadvantages: cost, time, inconclusive research
- Wound related pain
    - Nociceptive (acute): visceral or somatic
    - Neuropathic: nerve damage
        - Episodic
            - Noncyclic: during debridement, drain removal
            - Cyclic: dressing changes, turning, or repositioning
        - Persistent: chronic persistent pain without a trigger
        - Claudication pain: pain with ambulation that resolves with rest
            - Intermittent claudication: usually precipitated with moderate to heavy activity and rapidly disappears within 10 minutes of rest
            - Nocturnal pain: in bed, caused by elevation and reduced cardiac output
            - Rest pain: typically indicates advanced occlusive disease, dependent position
- Biofilm: 60% of chronic wounds have biofilms. Polysaccharide type of matrix with bacteria film attached to wound bed, cannot be affected by topical or systemic antimicrobials. Removed via debridement.
- Planktonic bacteria: free floating bacteria, occurs in contamination and colonization
- Osteomyelitis: infection of the bone, MRI most definitive for diagnosis, but X-rays serve as alternative
- Colonization: occurs within 3-4 weeks, microorganisms adhere to wound surface and replicates, does not impair healing
    - No treatment
- Critical colonization: increased bioburden, polymicrobial; renders the would indolent/stagnant; bioburden creates competition for oxygen and nutrients to wound
    - Exudate; friable granulation tissue; pain
    - Treat with topical antimicrobials
    - NERDS:
        - Non-healing wounds
        - Exudative wound
        - Red and bleeding wounds
        - Debris
        - Smell

- Infection: bacterial invasion into viable tissue, local or system; elevated WBC, sed rate, or CRP; >100,000 bacteria
    - STONEES:
        - Size is bigger
        - Temperature increase
        - Os (exposed bone or probes to bone)
        - New area of breakdown
        - Erythema/edema
        - Exudate
        - Smell
- Antimicrobial wound agents/cleansers
    - Acetic acid 0.25-0.5%: bactericidal: pseudomonas
    - Cadexomer iodine: broad spectrum: MRSA
    - Chlorhexidine gluconate (CHG 0.02%): broad spectrum: staph, E. coli
    - Medical grade honey: produces H2O2, contains antioxidants: creates acidic environment
    - Hydrofera blue: MRSA, VRE, Staph. aureus, Staph. epidermidis, serratia, E. coli
    - Mupirocin 2% ointment: blocks enzyme in bacteria that makes proteins: MRSA, beta-hemolytic strep, strep pyogenes
    - Povidone-iodine 1-10%: broad spectrum: no reported resistance
    - Silver: broad spectrum: in wound dressings; MRSA, VRE
    - Sodium hypochlorite: chlorine action kills organisms: Dakin's, Vashe, Anascept: antimicrobial, non-cytotoxic
    - Polyhexamethylene biguanide (PHMB): broad spectrum, bactericidal: 0.5% foam, cellulose, gauze, non-adherent dressings
    - Hydrogen peroxide: oxidative debridement; removes debris, not in closed areas, does not reduce organisms, not typically used

Nutritional evaluation

- **Albumin 3.2 - 5.0 mg/dl:** major plasma protein synthesized by the liver; carrier for metabolites, enzymes, drugs, hormones, and metals; patient may be malnourished before test indicates; half-life 14-20 days
    - 3.5-5 normal
    - 3-3.5 mild depletion
    - 2.4-2.9 moderate depletion
    - <2.4 severe depletion
    - <3 indicates tissue edema
- **Pre-albumin 16 - 42 mg/dl: more sensitive marker for protein and calorie deficiency and response to nutrition therapy; half-life 2-3 days**
    - 16-35 normal
    - 10-15 mild depletion
    - 5-10 moderate depletion
    - <5 severe depletion
- Referral to dietician for unintended weight loss
    - 5% loss in body weight in 1 month
    - 10% loss in body weight in 6 months
- Hemoglobin 12 - 16 mg/dl Female 14 - 18 mg/dl Male
- Hematocrit 37 - 47% Female 40 - 54% Male
- Glucose 80-130 in diabetics
- Hemoglobin A1C < 6

<u>Mechanical Factors Leading to Skin Integrity Issues</u>

- **Moisture Associated Skin Damage (MASD)**: inflammation and erosion of the skin caused by prolonged exposure to vapors sources of moisture, including urine or stool perspiration, wound exudate, mucus, or saliva
- **Intertriginous (ITD)**

    - Perspiration or moisture trapped in skin folds
- **Peristomal**
    - Urine, stool, chemical irritants and this with pH extremes, mechanical injury
- **Periwound**
    - Wound exudate, varies types of chemical irritants, pH extremes, mechanical injury (point of entry - organisms)
- **Incontinence Associated Dermatitis**
    - Urine and stool
- Mechanical Factors
    - Friction: the resistance encountered when one body or surface is moved in contact with another: causes superficial skin loss: abrasion or rug burn
    - Shear
        - Stress: the amount of force on the body or surface that is exerted parallel to the surface of the skin
        - Shear: the amount of distortion of underlying tissue from shear stress
        - Superficial damage from shear may result in skin tears
        - Deep shear of the dermal layer from the underlying hypodermis (subcutaneous) tissue
    - Pressure: amount of force perpendicular to the skin resulting in tissue/vessel compression
        - Capillary occlusion: vessel compression resulting in tissue ischemia then necrosis
        - Reperfusion injury: damage to cell by-products and WBC obstructs capillaries and leads to accumulation of O2 free radicals that contributes to cell death
        - Impaired lymphatic system: occlusion of lymph vessels results in impaired removal of waste products and increased edema
        - Unrelieved pressure: direct damage to cytoskeleton of muscle cell due to muscle deformation
    - Top down skin injury: MASD, skin tears, MARSI, abrasions
        - Damage to surface of skin due to moisture or friction causing partial thickness wounds
    - Bottom up skin injuries: pressure injuries
        - Damage to deep tissues due to ischemia causing full thickness wounds
        - Shear and pressure forces
- MARSI: erythema and/or other manifestation of cutaneous abnormality persists 30 minutes or more after removal of adhesive dressings and tapes

<u>Medical Adhesive Related Skin Injury</u>

- **MARSI:** Erythema or other manifestation of cutaneous abnormality persists 30 minutes or more after removal of adhesive dressings or tapes
    - A common skin injury that can be avoided
- Mechanism of injury
    - Irritant contact dermatitis (ICD): Triggered by exposure to irritant such as rubbing alcohol, bleach, solvents, deodorants, soaps, cosmetics, fragrances, plants; erythema, edema, vesicles; transepidermal water loss (TEWL) normalizes in 6-12 days
        - Treatment: identify and void the cause; cool wet compresses; anti-itch creams
        - S/sx: red rash, itching, dry cracked, scaly skin, bumps and blisters (sometimes with oozing and crusting), swelling, burning, tenderness
        - Prevent: make sure skin is clean and dry before application; skin prep, avoid tackifiers
    - Allergic contact dermatitis (ACD): Immune related inflammatory response
        - Antigen specific susceptibility: diffuse rash, erythema, macule, papule, vesicles, wheals; appearance generally mirrors placement of allergen; patch testing
        - Costume jewelry, perfume, cosmetics, hair dyes, poison ivy
        - Treatment: anti-histamine, topical steroids
        - Prevent: identify type of tape causing reaction; try alternative tape; barrier film not likely to prevent
    - Mechanical trauma: skin stripping-detachment of epidermal skin cells with removal of adhesive; deeper stripping occurs in skin tear; moist or glistening surface

        - Stripping: as tape is removed, the epidermis remains attached to the adhesive
            - Prevent: gentle tape, possible use of tape over a platform if frequent changes
    - Tension blisters: stretching or strapping with application; shear force lifts epidermis from dermis
        - Mechanical injury due to tension: inappropriate strapping of tape upon application and distention of skin under tape; tape tries to regain its original shape lifting the epidermis
        - Prevent: apply without tension; if swelling, edema, movement expected use a tape that stretches and direction of stretch follows swelling; reposition/replace as needed
    - Folliculitis: inflammation/pustules at hair follicles
        - Caused by having or bacteria entrapment
        - Use clippers or depilatory as necessary
    - Maceration: moisture is trapped against skin for extended period of time; skin turns white or gray and may soften or wrinkle; increased permeability of skin places patient at higher risk for damage from friction and irritants
        - Maceration: over hydration of skin under adhesive dressing with little/minimal breathability or increase in microclimate of skin (TEWL increase)
        - Keep taped skin clean and dry, replace soiled tape, try breathable tape, avoid occlusive tape
- Selecting correct adhesive product: combo of coating and backing determines strength, conformability, stretch ability
    - Multiple layers but has two key layers; medical adhesives are time and pressure sensitive
    - When the adhesive comes into contact with the skin, firm pressure activates the adhesive to conform to the microscopic and uneven epidermis surfaces
    - The warmth created under the dressing once in contact with the body further allows the adhesive to fill in gaps on the epidermis thus creating a stronger bond with the skin
    - Acrylate adhesives take longer to fill the gaps and is slower to adhere
    - Silicone adhesives fill in the gaps at a faster more constant rate
    - Adhesive coating: acrylates, silicone, rubber, hydrocolloids, hydrogels, zinc oxide, latex
    - Adhesive backing: paper, plastic, blends, fabric, silk, foam, polyurethane film
- Skin preparation: remove excess hair with clippers (do not shave), clean/dry skin, alcohol free liquid barrier film (spray or wipes) let dry
- Correct application: without tension or stretch, apply firm and gentle tension to activate viscoelastic polymers to fit into contours or epidermis; remove if edema occurs
- Correct removal: push/pull method of removing; low and slow horizontal removal; stretch and release for transparent films, adhesive removers for stronger adhesives or residue; use surfactant base cleanser
    - Product related factors, user technique of both application and removal, and intrinsic and extrinsic patient risk factors
- Alternative dressings for securement: tubular elastic net dressing (tubifast), elastic tubular bandage (tubigrip), self-adherent elastic bandage (coban), conforming gauze bandage (soft kling), abdominal dressing holders (montgomery straps)

<u>Mechanical Injuries: Skin Tears</u>

- **Top down skin injury:** damage to skin surface due to moisture causing partial thickness wounds
- Prevent skin tears with providing a safe environment, maintaining adequate nutrition and hydration, protecting patient from self-inflicted or caregiver injury
- **International Skin Tear Advisory Panel (ISTAP Classification System)**
    - Skin tears have high risk of becoming complex chronic wounds
    - Equal to or greater rates when compared to pressure injury prevalence
    - Can occur in all age ranges
    - **Type 1: No Skin Loss**
        - Linear skin tear: full thickness; can be fully approximated

                - Flap: partial thickness; can be fully approximated
                - Can be soaked first before trying to approximate
            - **Type 2: Partial Flap Loss**
                - Scant, moderate, or large tissue loss
            - **Type 3: Total Flap Loss**
                - Partial thickness wound without epidermal flap present
    - Treatment
        - Approximate tissue flap
        - Use skin barrier to reduce further trauma and pain with later removal of dressing
        - Minimize frequency of dressing changes
        - Non-adherent or low adhesive moisture vapor transmission rate (MVTR) dressings such as silicone foam (e.g. allevyn or mepilex)
        - Possibly use arrow to indicate removal of dressing
        - Avoid use of transparent adhesives, hydrocolloid dressing, closure strips
- Assess, cleanse, approximate wound edges
    - Goals: treat cause, implement prevention protocol, moist wound healing, avoid trauma, protect periwound skin, manage exudate, avoid infection, pain control
    - Non-adherent mesh dressings: dry or exudative wounds; atraumatic removal, may need secondary dressing
    - Foam dressing: moderate exudate; longer wear time (2-7 days), use non-adhesive versions when possible
    - Hydrogels: donates moisture for dry wounds; may results in peri wound maceration if highly exudative wound; secondary dressing needed
    - 2-octyle cyanoacrylate topical bandage (aka skin glue): for approximating wound edges; use within first 24 hrs
    - Calcium alginates: moderate to heavy exudate; can dry out wound bed; needs secondary dressing
    - Hydrofiber: moderate to heavy exudate; can dry out wound bed; needs secondary dressing
    - Acrylic dressing: mild to moderate exudate without bleeding; can stay on for extended period; careful removal
    - Methylene blue and gentian violet: broad spectrum antimicrobial including antibiotic resistant organisms; non-traumatic to wound bed; use with infection; needs secondary dressing
    - Silver dressings: broad spectrum antimicrobial including antibiotic resistant organisms; do not use indefinitely; use with infection; needs secondary dressing
- Other things to mention
    - Electrodes
    - Infection: adhesives may promote microorganism growth
    - Location on body, skin movement, edema
    - Substances that incase stickiness: tincture of benzoin
- Tape Application
    - Apply tape without tension to clean dry skin; do not pull or stretch tape; remove hair if necessary
    - Barrier film: spray or wipes
    - Minimize touching of adhesive
    - Smooth tape in place with gentle pressure; avoid gaps and wrinkles
    - Rub in place to seal
    - Tape should extend at least one half inch beyond the dressing
    - If swelling/tension occurs, loosen and refasten if able
    - If you expect an area to swell
        - Non-woven soft cloth tape that stretches in cross direction and on the bias (medipore)
- Tape removal
    - Loosen edges of tape; if needed press a small piece of tape onto corner to start an edge
    - Stabilize skin with a finger and remove tape with low and slow method in direction of hair growth

Bottom-Up Injuries of the Skin (Pressure Injuries)

- **Pressure Injury: localized damage to skin and underlying soft tissue usually over a bony prominence or related to a medical or other device; can present as intact skin or open ulcer and may be painful; occurs as results of intense and/or prolonged pressure or pressure in combination with shear; the tolerance of soft tissue for pressure and shear may also be affected by microclimate, nutrition, perfusion, co-morbidities, and conditions of soft tissue.**
    - **Stage 1: Non-blanchable erythema**
        - Intact skin, non-blanchable redness; may be painful, soft, warmer or cooler
    - **Stage 2: Partial thickness skin loss**
        - Partial thickness loss of dermis presenting as shallow open ulcer with red pink wound bed, without slough; may also present as intact or open serum filled blister
        - Presents as shiny or dry shallow ulcer without slough or bruising
    - **Stage 3: Full thickness skin loss**
        - Full thickness tissue loss; subcutaneous fat may be visible but bone, tendon, or muscle are not exposed; slough may be present but does not obscure depth; may include undermining and tunneling
        - Depth varies by anatomical location; nose bridge, ear, occiput, and malleolus do not have subq tissue; can also be very deep without bone, tendon, muscle exposure
    - **Stage 4: Full thickness tissue loss**
        - Full thickness loss with exposed bone, tendon, or muscle; slough or eschar may be present on some parts; often has undermining and tunneling
        - Depth varies on location; can extend into supporting structures making osteomyelitis possible
    - **Unstageable: Depth unknown**
        - Full thickness tissue loss in which base of ulcer is covered by slough and/or eschar
        - Until enough slough/eschar is removed wound cannot be staged
    - **Deep Tissue Pressure Injury (DTPI)**
        - Purple or maroon localized area of discolored intact skin or blood-filled blister due to damage or underlying soft tissue from pressure and/or shear
- Pressure and shearing forces mainly affect deeper tissue layers
    - Shearing: parallel force that damages deeper tissue
- Friction mainly affects superficial layers
- Incontinence: fecal and urinary as risk factors; fecal incontinence 22x mores likely to develop PI; moisture increases skin permeability and decreases resistance to friction
- **Braden scale**: sensory perception, moisture, activity, mobility, nutrition, friction, and shear
    - **Risk: none-low >18, mild 15-18, moderate 13-14, high 10-12, very high <10**
- Immobility: most significant risk factor for pressure injury formation
- **Nutrition care: 30-35 kcal/kg body weight per day with 1.25-1.5 g/kg/day protein and 1 ml fluid per kcal per day or 30-35 ml/kg body weight (kg x kcal)**
- Partial thickness wounds show evidence of healing in 1-2 weeks
- Full thickness wounds show evidence of healing in 2-4 weeks
- One strategy for protecting the sacrococcygeal area against friction is the use of gentle adhesive foam dressings and low friction textiles such as bed linens and patient gowns
- Support surfaces: redistribute pressure
    - Preventive vs. therapeutic device: active vs. reactive
    - Type: wheelchair, overlay, mattress replacement, specialty bed, operating table
        - Beds: large full thickness wounds, stage 3 or 4, ulcers that involve multiple turning surfaces, a low air loss or air fluidized surface may be indicated
    - Medium or components (gel, air, foam, water)
- Unavoidable PI: hemodynamic instability, poor nutrition and hydration, advance directives prohibiting nutritional support, multi-system failure, or end of life

Lower Extremity Venous Disease

- Risk factors: valvular dysfunction, calf muscle pump dysfunction
    - Triggers: cellulitis, trauma, contact dermatitis, rapid onset of edema, burns, itching
- **Wound characteristics**
    - Location: lower extremity; anywhere between ankles and knees or typical **gaiter area; medial malleolus**
    - Shape: irregular
    - Wound base: shallow with ruddy red color, a yellow film that can be adherent or loose
    - Wound edge: poorly defined, without undermining
    - Peri-wound: crusting, scaling reflecting dermatitis with hyper pigmentation; maceration is often present
    - Exudate: moderate to large exudate, serous to serosanguineous, bloody, odorous if infected
    - Other: pitting edema of varying severity from ankle to knee; pain is dull/aching, worse at end of day; pain improved after prolonged elevation; venous duplex ultrasound to check for reflux and obstruction
- **Dermatitis: itching, erythema/hyperpigmentation, inflammation, vesicles/crusting/scaling, no port of entry, unilateral/bilateral, no fever, weeping**
- **Cellulitis: painful, especially with palpation, progressing erythema, inflammation/warmth, no crusting, port of entry present, unilateral, fever, leukocytosis**
- **LEVD treatment: compression is gold standard**
    - Reduces edema, inflammation, exudate, dermatitis, and pain
    - Treatment: contain exudate, elevate limbs, exercise, meds, surgery, prevention
        - Raise legs above the level of the heart 30 min 3-4x day
        - Interventional treatment: endovenous laser ablation, radiofrequency ablation, sclerotherapy, procedures to repair veins and valves
    - Compression therapy: venous hypertension (varicose veins, edema)
        - Restore venous system to as normal as possible; lifetime therapy
        - **Static compression**: applied and does not move (wraps, bandages, garments)
            - **Therapeutic compression: 30-40 mmHg; ABI 0.8 or greater**
            - **Modified compression: 25-30 mmHg; ABI <0.8 and >0.5**
            - Inelastic disposable: unna's boot: high compression with ambulation, able to wear shoes, must be ambulatory; does not adapt to fluctuation in edema
            - Inelastic reusable: circaid, comprilan: reusable, can be readjusted for edema, long term, washable, must be ambulatory
            - Elastic disposable: profore, coban 2 layer: therapeutic if walking or at rest, highly absorptive, compression level can be modified, bulky, difficult to wear shoes
            - Elastic reusable: surpress, setopress: convenient if frequent changes needed, less skill, frequent re-wrapping to adjust to compression
        - **Dynamic compression**: movement through automatic pumps; **intermittent pneumatic compression (IPC)**
            - Intolerant of static compression, ulcer >6 months, useful for immobile patients
        - **Graduated compression:** exert greatest degree of compression at the ankle and decreases of the garment
        - **No compression: ABI <0.5**, arterial disease, uncompensated (symptomatic) CHF
        - Medications: Pentoxifylline (Trental), horse chestnut seed
- **Lymphedema: swelling of an affected body part (limb) due to impairment of lymph fluid flow**
    - Primarily occurs in subcutaneous fat of arms and legs
    - Causes: surgery, radiation, trauma, infection, congenital, hereditary
    - Protein rich fluid that accumulates in the soft tissues
    - **Characteristics: limb distortion, positive stemmer sign, lipodermatosclerosis (firm and woody)**

    - **Management: complete decongestive therapy (CDT); manual lymph drainage (MLD), compression**
- **Lipedema**
    - Ankle to groin, bilateral and symmetric
    - Causes: hereditary
    - **Characteristics: soft rubbery tissue, pain on palpation, painful bruising, negative stemmer sign, abnormal fat distribution from ankles to hips**
    - Management: weight loss, liposuction
- **LEVD diagnostics: Venous Duplex Ultrasound** is gold standard; ABI/TBI to determine amount of compression if any suspicion for LEAD

Lower Extremity Arterial Disease (LEAD)

- **LEAD**
    - **Etiology: atherosclerosis**; endothelial dysfunction, inflammation, progressive disease
    - **ABI <0.9**
- LEAD characteristics
    - **Location: tips of toes** (spontaneous or trauma); pressure points of foot/ankle, areas of trauma to LE
    - Shape: usually small, shape and depth vary, tunneling may be present
    - Wound base: pale or minimal, no granulation tissue, often dry, varying degrees of necrotic tissue, eschar, wet or dry gangrene
    - Wound edge: well defined, smooth, possible undermining
    - Periwound: edema not typical unless other co-morbidities, dry, local edema may indicate infection
    - Exudate: usually minimal, odor reflects infection or heavy bioburden
    - Other: infection or cellulitis is common, but often subtle; often painful and worse with activity or elevation, risk for limb loss high ABI/TBI diagnostics
- **Ankle Brachial Index (ABI): highest pressure of the 2 arteries of the ankle divided by the brachial arterial systolic pressure**
    - ABI >1.3 calcified vessels (obtain TBI)
    - ABI $\geq$ 1.0 normal
    - ABI $\leq$ 0.9 LEAD
    - ABI = 0.6-0.8 borderline perfusion
    - ABI $\leq$ 0.5 severe ischemia
    - ABI $\leq$ 0.4 critical ischemia, limb threatened
- Toe Brachial Index (TBI)
    - > 0.7 normal
    - 0.5-0.7 mild
    - 0.35-0.5 moderate
    - < 0.35 and toe pressure 40 mmHg moderate-severe
    - < 0.35 and toe pressure < 30 mmHg severe
- LEAD wound care
    - Paint dry, stable eschar with betadine
    - Avoid hydrocolloids due to increased risk for infection (reduced MVTR)
    - Hydrogels donate moisture if needed, foam to absorb, antimicrobials
    - Non-adherent dressings, liquid skin barrier, barrier creams
- Conservative care: patients refuse surgery or poor candidates
    - IPC: critical ischemia (ABI $\leq$ 0.4) or claudication symptoms; 3-4x day for 45-60 min
    - Edema control for mix diseases if ABI 0.5-0.8: modified compression
    - HBOT: only covered by medicare for acute ischemia
- Medications: statins, anti-platelets, prostanoids, ACE-inhibitors, pain meds
- **Surgery: critical limb ischemia; ABI 0.4 or less**
    - **Bypass surgery with vein graft; gold standard for revascularization**
    - Endovascular: first line for iliac, superficial floral, infra-popliteal lesions, angioplasty

    - Amputation
- Avoid leg elevation, cold exposure, constrictive clothing; exercise; proper foot care, inspect feet
- Diagnostics LEAD
    - Transcutaneous oximetry (TcPO2) determines surrounding tissue oxygen if no progress or ABI/TBI falsely elevated
    - Segmental Limb Pressures or arterial duplex ultrasound determines location or stenosis of blockage

Lower Extremity Neuropathic Disease (LEND)

- Foot ulcer development: damage to nerves interfering with communication between brain/spinal cord and lower legs/feet
    - Causes: systemic disease, diabetes mellitus, hypothyroidism, trauma, infectious disease, autoimmune disorders, Charcot-marie-tooth disease, idiopathic
    - Risk factors: metabolic syndrome, diabetes, loss of protective sensation (LOPS), LEAD, smoking, alcohol abuse, obesity, age
- **Peripheral neuropathy**
    - **Sensory: tactile sensation is altered:** loss of protective sensation, numbness, paresthesias, pain, loss of vibration and position sensation, sensory ataxia
    - **Motor: biomechanics and muscles are altered:** motor loss, muscle weakness, atrophy, anatomical manifestations (foot drop, claw toes)
    - **Autonomic: sympathetic alteration:** decreased vasomotor activity with anhidrosis of feet, vasodilation, arteriovenous shunting, edema, increased atherosclerosis plaque formation, possible disturbed microvascular circulation to cutaneous tissue, results in dry skin, cracks, fissures
- **Lower Extremity Amputation Prevention (LEAP) Program**
    - Annual foot screening, patient education, daily self-inspection, footwear selection, management of simple foot problems
- Footwear: never barefoot, need special assistance in choosing footwear, 1/2 inch between longest toe and end of shoe
- **Charcot:** progressive bony destruction: acute, hot, swollen red foot, bounding pulses, large veins, no pain, fever; needs immediate offloading of foot
- **Progression of neuropathic foot to ulceration**
    - Walking with heavy gait
    - Callus forms due to repetition of stress
    - Bony deformities form or exist: adds more pressure
    - Pressure continues: inflammation, local swelling and necrosis, develops deeper tissue damage
    - Ulceration develops
    - Mal perforan ulcer: ulcer located on the plantar surface of foot over the joint that connects the door to the toe
- **Clinical characteristics of neuropathic ulcers**
    - **Location: plantar aspect of feet** over pressure points and deformities; most common is interphalangeal joint of great toes and 1st and 5th metatarsal heads
    - Shape: **punched out appearance**, round or oblong, may be covered with hemorrhagic callus, may resemble laceration, puncture, or blister
    - Wound base: variable, necrotic, pink, pale, varying depth; probe to bone possibly osteomyelitis
    - Wound edge: well defined, smooth edges, may have undermining
    - Periwound: callus formation around wound; even continues after debridement if inadequate off-loading, erythema and induration may indicate infection (subtle signs), maceration may be present
    - Exudate: small to moderate; large amount may indicate complications (infection, CHF, renal failure, venous disease); color serous or clear
    - Other: high risk for infection and limb loss; ABI/TBI if s/sx arterial insufficiency
- **LEND: offloading is first priority**

- Knee scooter, half shoes, shoes with rocker bottoms, custom felt pads, custom walkers, clam shell walkers
- **Gold standard is total contact casting (TCC)**

- Diagnostics: ABI/**TBI,** x-ray, **MRI (if probes to bone)**

Surgical Wounds and Special Patient Populations

- Classifications and assessments for surgical wounds and methods of closure
  - **Primary closure: Clean wounds: approximated**
    - Standard of care: maintain original dressing 48-72hrs; sterile dressing and technique for 48 hrs; antimicrobials high infection risk; NPWT high dehiscence risk
    - Day 1-4: **Inflammation and epithelial resurfacing**
    - Day 5-9: **Proliferative phase:** healing ridge may be palpated
    - Day 10-14: Continued **proliferative phase and early remodeling**: sutures/staples usually removed
    - Day 15+: Continued **remodeling**: ridge softens, incision pink to gray; healed tensile strength at 80%
  - **Secondary closure: goal to fill wound defect with granulation and epithelial resurfacing**
  - Flap: closure of larger defects with other body tissue
  - Graft: donor tissue
    - Autograft
    - Allograft
    - Xenograft/biologics
- Guidelines for surgical incision care
  - Prevention of SSI: hand washing, CHG, no shaving, control hyperglycemia
- **Surgical wound complications and management**
  - Surgical Site Infection (SSI): 2nd most common HAI; within 30 days or within 1 year if implant
    - Risk factors: obesity, diabetes poorly controlled, smoking, age, poor nutrition, immunosuppressants, COPD, PVD, CKD, excessive blood loss, incisions near folds/genitals, persistent drainage, serum, or hematoma
    - **Superficial SSI: Involves only skin and subq; within 30 days and purulent drainage, positive culture, dehiscence, fever, pain, and/or tenderness**
    - **Deep Incisional SSI: involves deep tissues including muscle and fascia; purulent drainage, dehisces or is opened by physician, abscess or infection seen on exam, scan, labs**
- Indications and goals for palliative wound care
  - Approach to care to improve quality of life for patients and families facing a life threatening illness: shift from healing to symptom management
  - Pain and odor control, exudate management, bleeding control, skin tear prevention, avoid aggressive adhesives
- Special skin care needs of:
  - Pediatric/neonates: increased TEWL, increased toxicity risk, decreased trauma resistance
    - Risk assessment every shift or twice daily; no skin disinfectants, antibiotic ointment, or adhesive removers; ok to use silicone, wraps, hydrocolloids, zinc, petrolatum, antifungal; MASD, PI
    - Minimize dressing frequency
    - Peds: wounds heal quickly with minimal scarring
    - Atopic dermatitis and contact dermatitis
    - Epidermolysis Bullosa (EB): 1/50,000: blistering of arms and legs, later of the feet and hands: use liberal moisturizer, avoid friction
  - Geriatric: increased time for cell turnover, decreased fibroblast, reduced proliferation, lower levels of cytokines and chemokine, decreased inflammatory response, decreased melanocyte, loss of pigmentation, Langerhans cells less able to eradicate cancer cells, decreased vitamin D and estrogen, decreased sensory, flattening of dermal-epidermal junction, thinning of dermis, adipose tissues, increased skin pH, decreased sweat/oil, photo aging

        - Partial and full thickness wound healing prolonged
        - Prone to top-down skin issues: MARSI, skin tears, MASD, skin and soft tissue infections common: herpes simplex 1&2, shingles (clustered, fluid filled vesicles, red base follows dermatome), ADE, lesions, fungal, scabies
    - Bariatric: >30 BMI:
        - Increased: perspiration, TEWL, dry, sebaceous gland activity, pH, inflammation due to increased gland activity
        - Intertrigo, IAD, SSI
        - PI: increased risk, pressure from skin folds
        - Foot dysfunction: increased weight causes problems
        - Bariatric equipment and increased staff assistance
        - Maintain CBGs 80-180
            - Hyperglycemia affects every phase of wound healing: prolonged inflammation, reduced collagen synthesis, epithelial migration, compromised WBC function and vasculature
    - Spinal Cord Injury (SCI): immobility, inactivity, impaired blood flow and oxygenation, atrophy, abnormal weight bearing
        - Need to learn cleans transfers, safe landing, incontinence management, spasticity management
        - Vascular changes (decreased TcPO2 levels; 5x less innervated tissue), decreased collagen and extracellular matrix (ECM) production, more type 3 than type 1 collagen, less phagocytosis, endovascular growth, less fibroblasts, less ECM formation, constant inflammatory state
            - Advance technologies: E-stim, platelet rich plasma (PRP) or gel, NPWT, skin or tissue flap surgery
    - Fungus
        - Common sites are skin folds, perineal, periwound, peristomal
        - Candidiasis, tinea, and bacteria can occur in same area
        - Candidiasis: most common, erythematous, macular/papular, non-follicular pustules and satellite lesions outside advancing edge, maceration, burning and itching
            - Skin scrape for diagnostics; treat with topical anti-fungal, nystatin, miconazole
    - Dermatophyte or Tinea
        - Fungus of skin, nails, hair; infects only dead keratin
        - Itchy, red, scaly, slightly elevated, often circular (ring worm), vesicles if severe
            - Tinea pedis (athletesfoot), tinea cruris (jock itch), tinea corporis (ring worm), tinea barbea (beard), tinea capitis (scalp)
                - Antifungals: terbinafine, butenafine, azoles, tolfanate
    - Herpes simplex
        - HSV-1: cold sores
            - Broken vesicles on lips, mouth, gingiva; topical anti-virals
        - HSV-2: genital herpes
            - Cluster of painful vesicles on erythematous base in genitals, partial thickness once blisters unroofed; oral anti-virals, antibiotics if infection develops, moist wound therapy
        - Usually prodromal period before lesion eruption: itching, burning, shooting pain, fever, malaise, lymphadenopathy
    - Varicella-Zoster virus: shingles
        - Chicken pox lies dormant in nerve ganglion; reactivated by trigger; unilateral; oral anti-virals, pain meds, moist wound therapy

Refractory Wounds and Adjunctive Treatments

- Definition, risk factors, and characteristics of a refractory or difficult to heal wound
    - **Refractory wound: chronic wound does not respond normally to treatment**
        - No improvement 1-2 weeks in partial thickness

        - No improvement 2-4 weeks in full thickness
        - No reduction in wound size in predicted period of time
    - **Acute/healing wounds**
        - High proliferative cellular activity and growth factors
        - Low inflammatory cytokines and protease levels
        - Mitotically competent cellular response to growth factors
    - **Chronic wounds**
        - Low proliferative cellular activity and growth factors
        - High inflammatory cytokines and protease levels
        - Senescent cellular response
    - Intrinsic vs Extrinsic risk factors
- Basic features, method of action (MOA), benefits, and contraindications or adjunctive treatment modalities
    - **Mechanical debridement: Ultrasonic mist**
        - **Use of low frequency, non-contact ultrasound device: acoustic energy to produce mechanical and thermal effects to degrade fibrin and biofilm**
            - Benefits: painless, enhanced debridement, reduced bacterial counts, increased fibroblast migration, improved blood flow
            - Theory: stimulate cells to accelerate healing process and remove barriers
            - Disadvantages: costly, time consuming, non-reimbursement, inconclusive research
    - **Biosurgical debridement: maggot therapy**
        - **Use of medical grade maggots to liquify necrotic tissue through proteolytic enzymes**
        - Benefits: selective chemical debridement
        - Disadvantages: bleeding, pain, crawling sensation
        - Contraindications: poorly perfused wounds, exposed vessels or necrotic bone, limb threatening infections
    - **Tissue management: remove non-viable tissue**
        - Non-instrumental: autolytic, enzymatic/chemical, biosurgical, mechanical
        - Instrumental: conservative sharps wound debridement (CSWD), surgical sharp
    - **Collagen and metalloproteinase (MMP) inhibitors**
        - **Protein based dressing made from an animal source to promote intrinsic collagen production and ECM**
        - Benefits: binds excessive MMPs, allows healthy collagen formation, promotes ECM, bio-absorbable, absorb exudate
        - Indications: clean refractory wound; various medium/form
        - Disadvantages: expensive, availability
        - Contraindications: sensitivity to animal derived products, infected/necrotic wounds
    - **Growth Factors**
        - **Use of exogenous growth factors to reduce deficiency in refractory wounds**
        - **Autologous:** derived from patient's own blood, treating platelet to release growth factors then applying to wound bed or development of PRP gel
        - **Commercially made platelet derived growth factor (PDGF)**
        - Indication: refractory full thickness diabetic foot ulcer, clean, non-infected, perfused, offloaded
        - Benefits: promote cell migration for repair, stimulate granulation and epithelial
        - Disadvantages: only 1 brand for diabetic foot ulcers (Becaplermin, Regranex), expensive, only 1 type of growth factor, remove after 12 hrs
        - Contraindications: infected/necrotic, black box warning (increased cancer risk)
    - **Negative Pressure Wound Therapy (NPWT)**
        - **Application of device where the wound bed/tunnels are filled with foam or gauze and sub-atmospheric or negative pressure applied through suction at controlled level**

- MOA and benefits: **removes exudate, moist wound healing, reduced edema, improved perfusion, macro-deformation promotes wound contraction, micro-deformation and mechanical stretch result in increased angiogenesis, granulation tissue, and reduced bioburden**
- Indications: wound with minimal or no necrotic tissue, bacterial loads controlled, and goal is wound healing
  - Acute wounds: surgical incision (high infection risk), traumatic, partial thickness burns first 12-24 hrs, dehisced wounds, flaps and grafts
  - Chronic wounds: refractory diabetic, PI 3 or 4, venous ulcers, enteric fistulas

- Disadvantages: sponges left in, bleeding, device related PI, periwound dermatitis, expensive, painful application and removal, staff knowledge and skill
- Precautions: high risk for bleeding, treated infected wounds, exposed tendon/ ligament/bone/organ, near vagus nerve, palliative, hx poor compliance
- Contraindications: bleeding, exposed vessels/organs/nerves, eschar or thick slough (wounds with >25% necrosis), malignancy
- Foam open cell: deep, but visible wound cavity; skin graft bolsters use with contact layer
- Foam high density, moist, open cells: deep tunnels or undermining, presence exposed structures, bleeding, fixable tissue, reduce tissue adherence and pain with removal
- Gauze bases filler: deep visible wound cavity, deep tunnels or undermining
- Contact layer under filler: exposed structures, friable tissue
- Wound infection: antibacterial layer under filler, silver foam, irrigation with open cell foam
- Disposable: minimal exudate, SSI with small drainage
- Application: skin barrier, cover exposed structures, fill wound, activate
  - 125 mm Hg, 75-80 for pain/bleeding, at least 20/24 hrs, no more than 2 hr disruption

- **E-stim**
  - **Electric current delivery to wound and periwound tissues; most often used in stalled PIs**
  - **Galvanotaxic effect of migration of inflammatory cells (neutrophils and macrophages)**
  - **Stimulatory effect to increase fibroblasts and collagen formation**
  - **Increased blood flow**
  - **Antibacterial effect or certain bacteria**
  - Benefits: reduced edema/inflammation, increased perfusion, promotes cell migration
  - Disadvantages: cost, time, inconclusive research
  - Contraindications: cancer, osteomyelitis, pacemakers, near phrenic nerve, heart, or carotid
- **Hyperbaric oxygen treatment (HBOT)**
  - **Patient breaths 100% oxygen under pressure in chamber causing oxygen to diffuse into the blood plasma: provides 10x normal supply; encourages formation of new blood vessels and thus O2**
  - Benefits: correction of tissue hypoxia, reduced edema, lessening toxic effects aerobic bacteria, kills anaerobic bacteria, improved leukocyte ability, stimulates fibroblasts, support collagen synthesis and angiogenesis, enhanced epithelial migration, stem cell mobilization and activation
  - Indications: diabetic LE wound, soft tissue radionecrosis, osteoradionecrosis, compromised flaps and grafts, chronic osteomyelitis, acute peripheral arterial insufficiency, necrotizing fasciitis, compartment syndrome, crush injuries
  - Frequency: daily (M-F) 2 hrs; 20-60 sessions
  - Contraindications: problems with air filled cavities, poor lung and heart, malignancy, some chemo hx

- **Cellular and tissue-based products (CTPs)**
  - **Use of tissue engineered products to stimulate cellular repair and tissue regeneration by providing signaling, structural or cellular elements in a dressing system with or without living cells or tissues**
  - Indications/benefits: prevents bacterial colonization and fluid loss and mimic native tissues
    - **Autograft (autologous): organ/tissue transplanted from one part of the patient to another**
    - **Allograft (allogeneic): tissue from one species transplanted to another of same species; cadavers amniotic, fetal foreskin**
    - **Xenograft (xenogeneic): tissue from one species transplanted to another of different species (e.g. pig to human)**
    - **Extracellular matrix (ECMs): collagen scaffolds to provide structure for native blood vessels, cytokines and growth factors; often seeded with growth factors and fibroblasts,**
    - Cellular composition: cellular, acellular (scaffold)
    - Anatomic structure: epidermal (keratinocytes), dermal (fibroblasts), bilayer
    - Acellular: provides scaffold for attachment and migration of cells
      - Biologic tissue
        - Animal: oasis, endoform
        - Human: graft jacket
        - Plant: oxidized regenerated cellulose/collagen
      - Synthetic: hyalomatrix (silicone and hyaluronic acid)
      - Composite: biobrane (silicone and porcine)
    - Epidermal (autologous): epidermal harvest system; gathers basal keratinocytes onto transparent dressing
      - Indications: clean granulating wounds ready for final closure; DM, venous, surgical
    - Dermal: dermagraft: cryopreserved human fibroblast derived
    - Bilayer: apligraf: living cell-based product
- **Myocutaneous flaps**
  - **Surgical reconstructive procedure to close large gaping chronic wound by transferring skin and underlying structures to fill a defect, pad bony prominence or protect vital organs; transferring and maintaining native blood supply is crucial**
  - Indication: closure stage 3 or 4 PI, reduce risk for osteomyelitis or sepsis, expedite wound closure
  - Pre/post op management: reduce cofactors, control spasms, NPWT, specialty bed
  - Disadvantage: may need skilled care up to 6 weeks, expensive, reoccurrence
  - Contraindications: active infections, uncontrolled spasms, tobacco

<u>Atypical Wounds</u>

- Differentiate other types of wound etiologies; appropriate studies and consultations
  - **Vasculitic ulcers**
    - **Autoimmune connective tissue disease targets blood vessels**
    - Acute pain, palpable purpura (raised non-blanchable erythema), typically on lower legs
    - Referral: dermatology, rheumatology for biopsy/treatment
    - Anti-inflammatory medications
  - **Sickle cell ulcers**
    - **Inherited hematologic disorder**
    - Most common in medial and lateral malleoli, painful, indolent and intractable and slow to heal
    - Referral: hematology

        - Treat Sickle cell anemia, routine topicals, **compression,** pain control, prevent trauma with wraps, shin guards, edema control
    - **Pyoderma gangrenosum (PG)**
        - **Chronic inflammatory skin disease; many patients also have irritable bowel disease; biopsy to rule out other conditions**
        - Acutely painful nodule or pustule breaks down to form ulcer with bright red halo, typically purple border and may have undermining, inflamed necrotic base, boggy tissue, purulent drainage
            - Pathergy: minor trauma leads to development of skin lesion
        - Reduce inflammation and pain, control underlying disease, do not sharp debride; medihoney gel for autolytic debridement, xtrasorb to protect from maceration, bioguard after debridement
    - **Calciphylaxis (calcific uremic arteriolopathy)**
        - Most common in patients with kidney disease or hemodialysis
        - **Painful ulcers, star shaped, deep purple, often gangrenous**
        - Manage calcium and phosphate-PTH axis; topical therapy to minimize potential trauma, HBOT
    - **Malignant wounds: squamous and basal cell carcinomas**
        - **Basal cell: papule that enlarges and develops central crater, spreads locally, squamous firm red nodule or scaly crusted flat lesion, may spread**
            - **Marjolin's ulcer: chronic wound undergoes malignant transformation**
        - Dermatology or plastics, remove tumor, sun safety
    - **Factitious ulcers: dermatitis artefacta**
        - **Artificially created by patients with mental disorder**
            - Easily reached places, mechanical injury from fingernails, etc., poor prognosis, waxes and wains
            - Diagnosis of exclusion, being caught
            - Mental health referral
    - **Radiation dermatitis**
        - **Inflammatory response to damage of rapidly dividing cells**
        - Grades 1-4
        - Personal hygiene, non-alkaline soap, electric razors, unscented hydrophilic lotions, hydrocortisone, aloe vera, avoid trauma, sun, pools, hot/ice packs, tapes/adhesives
        - Dry desquamation: normal saline, soak, hydrophilics, calendula, emulsion, hydrogels, hyaluronic acid
        - Wet desquamation: non-adherent absorptive, foam, some hydrogel sheets
    - **Extravasation**
        - **Leakage of solution/drug into surrounding tissue from infiltrated IV**
            - Non-vesicant: swelling without damage
            - Irritant solution: swelling and inflammation but no persistent damage
                - Elevate, cold or warm cloths
            - Vesicant: blistering and progressive tissue destruction
            - Remove residual drug by aspiration, elevate 24 hrs, possible debridement
    - **Thermal skin injury**
        - 3 stages of burn management
            - Emergent: fluid resuscitation and initial wound care
            - Acute: debridement and skin grafting
            - Rehab: physical and psychological support
        - **Burns**
            - Total body surface area (TBSA): Lund Browder chart, rule of nines, hand method
            - Refer to burn center: partial thickness >10%, face, hands, feet, genitalia, major joints, full thickness, chemical, electrical, inhalation
            - Primary objective of a burn excision is to reduce the risk of infection

- **Superficial**
  - **Tissue: epidermis only; sunburn, scalding**
  - **Manifestations: pain, warmth, redness, swelling, peeling**
  - **Management: cooling gels, hydrogel sheets**
  - Outcome: no scar
- **Superficial partial thickness**
  - **Tissue: epidermis and dermis**
  - **Manifestations: blistering, weeping, moist, dermal structures intact, painful**
  - **Management: biologic, biosynthetic dressings, blisters over 2 cm debride**
  - Outcome: 2 weeks, little scar formation
- **Deep partial thickness**
  - **Tissue: deeper portions of dermis**
  - **Manifestations: red with waxy white tissue, blisters, dry red wound bed, disruption of hair follicles, nails, glands**
  - **Management: biologic, biosynthetic dressings, large wounds with antimicrobials, if >21days then excision and grafting for closure**
  - Outcome: scar tissue, heals <21 days
- **Full thickness**
  - **Tissue: entire dermis extending into subq and nerves destroyed**
  - **Manifestations: waxy white to gray, charred/black leathery, no pain**
  - **Management: healing occurs at edges and by tissue replacement, closure usually needs surgical excision and skin grafts, escharotomy**
  - Outcome: closure requires skin grafts and/or flap
- Topical management
  - Silver dressings: silver sulfadiazine (SSD); **Nanocrystalline silver (new gold standard);** hydrogels, foams, and hydrofibers with silver
  - Honey: autolytic debridement and infection control
  - Biologic and biosynthetic dressings, autografts STSG, epithelial autograft, stage closures
- Itching: moisturizer, antihistamines, vibrator, cool compress, compression
- Scarring: compression, massage, hydrogel or silicone sheeting, corticosteroid injection, surgery
- Contracture: PT/OT, splinting, surgery

- **Toxic epidermal necrolysis (TEN) or Stevens-Johnson syndrome (SJS)**
  - **Maculopapular rash, erythema, painful skin and sloughing of large sheets of epidermis**
  - **Drug reaction,** involves 30% body, **+Nikolsky sign (**slight rubbing of the skin results in exfoliation of the outermost layer)
- **Graft versus host disease (GVHD)**
  - **Maculopapular rash, develops bullae, generalized erythema and desquamation, pain, pruritus**
  - Starts on palms, soles, then face, chest, arm shoulders; transplant complication
- **Necrotizing fasciitis**
  - **Bullae form then progress to necrosis**
  - **Rapid, painful, sloughing tissue and gangrene, blue gray**
- **Staphylococcal scaled skin syndrome (SSSS)**
  - **Superficial bullae then desquamation**
  - **Sandpaper texture, exfoliates after exposure to bacterial toxins, +Nikolsky sign, common in children**
- **Epidermis bullosa (EB)**
  - **Blisters, erosions after mild mechanical contact**
  - **3 main types, most involve GI lining, inherited**

Formulary of Wound Dressings

- **Alginate or calcium alginate: absorbent filler,** sheets, ropes, algisite, kaltostat, seasorb
  - Description: loose or compressed seaweed fibers; conformable, pad, rope, high or low gelling
  - Function: highly absorbent fiber derived from brown seaweed, converts to gel, atraumatic removal if moist, hemostatic properties, silver options
  - Indication: partial to full thickness, moderate to heavy exudate, use rope in tunnels, contamination or infection, slough or granular wound base; not for dry wounds or wounds with hydrogels
  - Advantages: highly absorbent, packing, easy to use, autolytic debridement
  - Use: change typically daily to every 3 days, secondary dressing needed
- **Collagen**: many are matrix metalloproteinase (MMP) inhibitors; gels, freeze dried sheets, powders, alginates, puracol, biostep, endoform, promogran
  - Function: native/animal collagen sources; binds with MMPs to reduce inflammation in chronic wound, silver options
  - Indication: partial and full thickness that are non-healing/infected, free of necrotic tissue; needs secondary dressing
  - Use: frequency depends upon product, daily to once a week
- **Composite: cover: protection, retains moisture or absorption,** different shapes and sizes; aquacel foam, tegaderm absorbent clear or foam
  - Description: bacterial barrier, absorbent layer, semi-adherent or non-adherent cover, adhesive border
  - Function: combines properties into one with adhesive border; transparent dressing with foam (3M), foam with hydrofiber (convatec), foam with hydrofiber and adhesive border (convatec), silver options
  - Indication: same as foam indications; minimal to moderate exudate, infected
  - Advantages: easy to use and understand
  - Use: change up to 3 times a week
- **Contact layer: protection of the wound base**; sheets, triact, mepitel, adaptic touch, adaptic
  - Description: non-adherent, woven polyamide net, covers wound base, exudate passes through to a secondary dressing, may deliver antimicrobial
  - Function: single porous, non-adherent layer placed on wound surface that permits exudate to pass through; protects wound or underlying structures from trauma, silicone or non-adherent porous gauze impregnated with petrolatum, bismuth, salts, silver
  - Indication: clean wound free of necrotic tissue, surface wounds especially on extremities or lining deep cavity wounds with secondary filler; full thickness donor sites), granular wounds with exudate, not for dry wounds
  - Advantages: protect wound base from trauma during dressing changes, used with NPWT
  - Use: change at least weekly, secondary dressing needed
- **Co-polymer: cover or filler, absorbent;** amorphous, powder, bead, pads, ropes, strands, pad dressings, exudry, mextra, mesorb, flexigel strands, mutidex, maltodextrin
  - Description: absorbent, varied composition; locks exudate within the polymer
  - Function: absorbent product to fill depth, varied composition of co-polymers (starch, poloxamer) lock in exudate, iodine with polyethylene glycol
  - Indication: high exudate amount, must be able to retrieve or irrigate out; shallow to deep wounds with moderate to large exudate
  - Advantages: absorbent, some antimicrobial, easy to use
  - Use: depends on exudate, usually every 1-2 days
- **Foam: cover or filler, absorbent protection;** multiple shapes, sizes, absorption ability, mepilex, biatain, allevyn, polymem
  - Description: hydrophilic, conformable
  - Function: sponge like, non-adherent, absorptive hydrophilic polyurethane or film coated layer, with or without adhesive, charcoal and silver options

    - Indication: partial and full thickness wounds with minimal to heavy exudate, contaminated/infected wounds, primary or secondary, do not use on dry wounds
    - Advantages: non adhesive for pliable periwound, may be used under compression
    - Use: sheet forms change 3 times per week, foam filler change every day
- **Gauze: wick, filler, cover**: strips, rolls, flat in various sizes and weaves, kerlix, nugauze, conform, J&J, covideen, medline
    - Function: utilized for wound cleansing, primary or secondary, woven gauze leaves behind fibers, non-woven preferred as primary dressing, little absorption capacity, dries quickly, impregnate with saline, amorphous, gels, antiseptics
    - Indication: clean or infected wounds, not ideal, easily penetrated by bacteria
    - Use: change BID to daily
- **Gauze impregnated with hypertonic saline**: rope, flat, mesalt, curasalt
    - Function: dry sodium chloride impregnated into gauze sheets or strips that draws exudate into secondary dressing
    - Indication: full thickness with/without infection or nonviable tissue, heavy exudate, may wick into tunnel
    - Use: change daily, secondary dressing may be needed
- **Hydrocolloid: cover, absorption, and protection;** many shapes and sizes, duoderm, replicare, restore, exuderm
    - Description: adhesive, moderately absorbent, conformable, can adhere to most skin, regular or thin
    - Function: gel forming agent made of gelatin, pectin, or CMG, promotes autolysis and moist wound, low MVTR, silver, or manuka honey
    - Indication: partial to full thickness wounds without depth, minimal to moderate exudate, conformable, select size 1-2 inch larger than wound, semi-occlusive, promotes autolysis; hyper granulation may result
    - Advantages: adhesive, conformable, absorptive, antimicrobial option,
    - Use: change every 3-5 days, do not use on infected wounds, primary or secondary
- **Hydrofiber or hydropolymer: filler, wick, cover, absorbent (gelling fiber):** sheets, ropes, aquacel, biosorb
    - Description: non-woven fibers of carboxymethylcellulose that gel; looks likes foam or pad with adhesive borders, multilayered, surface expands during absorption, re-adheres if removed
    - Function: fiber made of CMG, absorbs heavy exudate, 33%> than alginate, keeps wounds moist when gelled, sheets, ropes, silver options
    - Indication: partial to full thickness wounds with moderate to heavy exudate; use rope type for easy removal in tunnels, similar to alginates and foam
    - Use: change every 1-2 days, secondary dressing may be needed
- **Hydrogel: wick, filler, cover; donate moisture or hydrate;** amorphous, impregnated gauze and strips, sheets, solosite, elasto-gel, restore, woundres, vigilon
    - Description: donate fluid to wound
    - Function: glycerin or water based hydrophilic polymers, promotes wound hydration and autolysis by donating moisture, cool, non-adherent, reduces pain, minimal absorption, silver options
    - Indication: dry to minimal exudative wounds with/without depth, promotes autolysis, decreased pain
    - Use: amorphous gels change daily; sheets change every 1-3 days
- **Transparent film: cover: protection and retains moisture**: adhesive film, opsite, tegaderm
    - Description: adhesive, transparent, MVTR ranges
    - Function: semi-permeable membrane allows O2 and water exchange, yet is waterproof, facilitates autolysis, nonabsorbent, reduces friction
    - Indication: autolytic debridement of crosshatched eschar; promotes epithelialization on minimal draining partial thickness wounds or blisters, reduces contamination from incontinence; use intact skin to reduce friction

    - Advantages: promotes autolysis, conformable
    - Use: change every 3-7 days or if drainage goes beyond wound edge; remove by pulling horizontal to skin; secondary dressing
- **Antimicrobials**
    - Function: management of critically colonized or infected wounds; broad spectrum with multiple modes of action to reduce bacteria
    - Indication: short term use
    - Use: use only when indicated
- **Cadexomer iodine**: amorphous, pad, iodosorb gel, iodoflex
    - Function: slow sustained release of iodine which avoids toxic levels, bactericidal, may penetrate biofilms
    - Indication: partial and full thickness wounds with critical colonization, biofilms, or infection
    - Use: dressing will turn white when depleted, change every 1-3 days or when dressing turns white; requires secondary dressing
- **Manuka honey**: amorphous, hydrocolloid, alginate, medihoney, therahoney, manuka
    - Function: medical grade honey, strong osmotic action promotes autolysis, antibacterial due to release of hydrogen peroxide and acidic pH, may active MMPs for further autolysis, may reduce odor
    - Indication: partial and full thickness wounds, minimal to moderate exudate, critical colonized wounds with large amounts of slough
    - Use: change daily but depends upon formulation; gel daily, alginate 1-2 days, hydrocolloid 3 times a week
- **Polyhexamethylene biguanide (PHMB)** 2% or 5%: foam, biosynthesized cellulose, flat gauze, roll gauze, non-adherent, wound irrigants, kendall antimicrobial, foam or gauze
    - Function: kills bacteria absorbed into the dressing by attaching to the bacteria cell membrane, broad spectrum, no known resistance
    - Indication: partial to full thickness; more appropriate for colonization, prevent infection in high-risk patients, gauze based NPWT
    - Use: every 1-3 days
- **Gentian violet and methylene blue**: foams, hydrofera blue, RTD wound dressing
    - Function: bacteriostatic or MRSA, MRSE, VRE, yeast; some brands must be moistened with normal saline or sterile water to activate; compatible with enzymatic debridement, silver options
    - Indication: partial to full thickness wounds
    - Use: change depends upon exudate; change when turns white, every 1-3 days
- **Silver dressings**: all forms, silvasorb hydrogel, mepilex, aquacel, silvadene
    - Function: broad spectrum; silver ions bind to bacteria wall causing death, potential tissue straining
    - Indication: partial to full thickness wounds with critical colonization or infection; avoid saline with nano crystalline silver; do not use with enzymatics
    - Use: change every 1-7 days; primary or secondary dressing
- **Dialkylcarbamoyl chloride (DACC) wound dressings**: contact layer, foam, hydropolymer gel dressing, cutimed sorbact WCL, sorbact hydropolymer dressing
    - Function: renders bacteria inactive by binding it to dressing through hydrophobic attachment
    - Indication: Partial and full thickness wounds; wound bed must be kept moist; use in high risk for infection or critical colonization
    - Use: change every 1-4 days, primary or secondary dressing
- Protection: periwound skin
    - Many moisture retentive dressings protect periwound skin
    - Avoid creams, oils, when using additional adhesives
    - Assess for sensitivities
    - Proper application and removal
    - Protection products: liquid skin barriers, non-adhesive securement products
- Shallow dry wounds

    - Hydrogels: donate fluid
    - Hydrocolloids, thin foam: maintain moisture
    - Transparent film: maintain moisture
- Shallow wet wounds
    - Usually does not require filler dressing because it is shallow
    - Foam, hydrocolloid, hydrofiber, gauze to secure
- Deep dry wounds
    - Filler: gel-soaked gauze fluffed or wicked into wound, hydrogel into wound base and NS moisten gauze fluffs
    - Cover: gauze and transparent film, waterproof adhesive foam
- Deep wet wounds
    - Absorptive filler, wick, or packing may be needed and cover dressing
    - Alginate or hydrofiber with secondary (foam, polymer or copolymer), contact dressing possibly for wound base