# BASIC PRINCIPLES

- Stages of Wound Healing
- Abnormal Healing
- Factors Influencing Wound Healing
- Wound Closure
- Management of Contaminated Wounds
- Dressings
- Sutures and Suturing Techniques
- Skin Grafts
- Other Grafts
- Flaps

# THE HAND

- History of Trauma
- General Assessment
- General Management
- Amputations
- Tendons
- Fractures and Dislocations
- Dupuytren's Contracture
- Carpal Tunnel Syndrome
- Hand Infections
- Rheumatoid Hand

# THERMAL INJURIES

- Burns
- Zones of Thermal Injury
- Diagnostic Notes
- Indications for Admission
- Acute Care of Burn Patients
- Chemical Burns
- Electrical Burns
- Frostbite

# SOFT TISSUE INFECTIONS

- Cellulitis
- Necrotizing Fasciitis

# MALIGNANT SKIN LESIONS

- Management

# ULCERS

- Pressure Sores
- Leg Ulcers

# CRANIOFACIAL FRACTURES

- Radiographic Examination
- Mandibular Fractures
- Maxillary Fractures
- Nasal Fractures
- Zygomatic Fractures
- Orbital Blow-out Fractures

# PEDIATRIC PLASTIC SURGERY

- Cleft Lip
- Cleft Palate
- Syndactyly
- Microtia

# AESTHETIC SURGERY

- Face
- Breast
- Other
BASIC PRINCIPLES

STAGES OF WOUND HEALING

- **inflammatory phase - 0-2 days**
  - debris and organisms cleared via inflammatory response
    - e.g. macrophages, granulocytes

- **re-epithelialization phase - 2-5 days**
  - from edges of wound and from dermal appendages
    - i.e. pilo-sebaceous adnexae
  - epithelial cells migrate better in a moist environment,
    - i.e. wet dressing

- **proliferative phase - 5-42 days**
  - fibroblasts attracted to wound by macrophages
  - collagen synthesis by fibroblasts leads to increasing tensile strength
  - granulation tissue formed with neovascularization

- **remodeling phase - 6 weeks-1 year**
  - collagen cross-links, scar flattens
  - at 6 months, tissue strength plateaus at 80% of normal tissue strength

ABNORMAL HEALING

- occurs in areas where skin is under tension
- hypertrophic scars
  - hypertrophic tissue does not cross the boundaries of the scar
  - common sites include back, shoulder, sternum
  - red, raised, frequently pruritic
  - treatment is conservative
  - amenable to surgical revision
- keloid scars
  - tissue extends beyond the scar boundaries
  - common sites include sternum, deltoit, earlobe
  - collagen: whorls rather than bundles
  - increased frequency in darker skinned people
  - treatment: pressure, silicone sheets, topical steroids, intradermal steroid injection, intralesional excision and marginal steroid injection
  - may recur with surgical revision

FACTORS INFLUENCING WOUND HEALING

**Local:**
- trauma
- tension
- infection
- hematoma/seroma
- blood supply
- retained foreign body
- previously irradiated tissues

**General:**
- nutrition
- chronic illness
- steroids
- diabetes
- chemotherapy
- immunocompromise

WOUND CLOSURE

**Primary Healing (First Intention)**
- definition: wound closure by direct approximation within hours of wound creation (i.e. with sutures, flap, skin graft, etc...)
- indication: clean wounds

**Secondary Healing (Second Intention)**
- definition: wound left open to heal by granulation, epithelialization and contraction (myo)fibroblasts
- indication: when primary closure is not possible or not indicated for any reason, including infection, delay in medical attention, loss of skin
- inferior cosmetic result, requires dressing changes, psychological impact of open wound

**Tertiary Healing (Delayed Primary Closure)**
- definition: intentionally interrupt healing process (i.e. with packing), then wound is usually closed at 4-10 days post-injury
- indication: contaminated wounds where initial primary closure is contraindicated
- prolongation of inflammatory phase lowers bacterial count and lessens chance of infection after closure
MANAGEMENT OF CONTAMINATED WOUNDS

- A wound is considered contaminated when it contains more than 100,000 bacteria/gram.
- Acute contaminated wound (should be closed within 6-8 hours post injury depending on the state of the wound):
  - Most can be closed with primary intention after adequate debridement (i.e. blade, irrigation).
  - Cleanse and copiously irrigate open wound with physiologic solutions i.e. normal saline or Ringer's (no soap, alcohol, or other irritants).
  - Contraindications to primary closure: animal and human bites, crush injuries.
  - +/- systemic antibiotics (see Emergency Medicine Notes).
  - +/- tetanus (Tetanus toxoid 0.5 mL IM):
    - Always check tetanus immunization status: reimmunize if patient has received less than three tetanus immunizations, if the last Td was more than 10 years ago, or if last Td unknown.
    - If high risk wound (e.g. soil equipment, major trauma), then reimmunize if last Td was more than 5 years ago.
  - Wound closure with monofilament.
  - Follow up in 48 hours.

- Chronic contaminated wounds (e.g. lacerations > 24 hours, ulcers):
  - Debridement: mechanical (e.g. “wet-to-dry” dressings), or surgical.
  - Frequent dressing changes.
  - Topical antibacterial creams (see Table 7).
  - Systemic antibiotics are not useful - no penetration into the bed of granulation tissue.
  - Final closure via delayed wound closure or skin graft.
  - Successful closure depends on changing a chronic wound to an acute wound by decreasing bacteria count to 100,000/gram or less.

DRESSINGS

- Goals are absorption, protection, compression, acceptable cosmesis.
- 1st layer (contact layer):
  - Clean wounds: heal by re-epithelialization. First layer is nonadherent to protect new tissues (impregnated gauze such as Jelonet, Bactigras or Sofratulle).
  - Chronic wounds: initial goal is debridement of nonviable tissue. First layer is Saline or Betadine soaked gauze --> dead tissue adheres to gauze and is removed with dressing change (known as “wet-to-dry” dressing).
- 2nd layer (absorbent layer):
  - Saline soaked gauze, to encourage exudate into dressing by “wick” effect.
- 3rd layer (protective layer):
  - Dry gauze held in place with roller gauze or tape.

SUTURES AND SUTURING TECHNIQUES

Anesthesia

- Lidocaine +/- epinephrine.
- Never use epinephrine for fingers, toes, penis, nose and ears.
- Inject anesthetic into, not around, wound before debridement and irrigation.
- Toxic limit of lidocaine:
  - Without epinephrine 5 mg/kg/hour.
  - With epinephrine 7 mg/kg/hour.
  - (1 cc of 1% solution contains 10 mg lidocaine)
- Early signs of toxicity are excitation followed by convulsive activity, then depression, arrest, or death.
Table 1. Suture Materials

<table>
<thead>
<tr>
<th>Site</th>
<th>Subcutaneous</th>
<th>Cutaneous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>usually absorbable</td>
<td>nonabsorbable: nylon (Dermalon)</td>
</tr>
<tr>
<td></td>
<td>organic: catgut - plain or chromic</td>
<td>absorbable: fast-absorbing catgut</td>
</tr>
<tr>
<td></td>
<td>synthetic: polyglycolic acid (Dexon, Vicryl)</td>
<td></td>
</tr>
<tr>
<td>Advantages</td>
<td>decreased dead space (potential for abscess),</td>
<td>good approximation of tissues, good</td>
</tr>
<tr>
<td></td>
<td>decreased tension on more superficial sutures,</td>
<td>eversion of wound edges, minimal</td>
</tr>
<tr>
<td></td>
<td>hemostasis (less risk of hematoma/seroma)</td>
<td>tissue reaction to nylon, no need for</td>
</tr>
<tr>
<td>Disadvantages</td>
<td>introduces foreign body (inflammation, source of</td>
<td>removal if using catgut suture</td>
</tr>
<tr>
<td></td>
<td>infection), increased scar if used near skin</td>
<td>nylon sutures require removal, can</td>
</tr>
<tr>
<td></td>
<td>surface</td>
<td>leave marks if left in place too long,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>more time consuming than other</td>
</tr>
<tr>
<td></td>
<td></td>
<td>methods (staples, glue)</td>
</tr>
<tr>
<td>Comments</td>
<td>organic sutures undergo enzymatic breakdown -</td>
<td>fast-absorbing catgut can be used for</td>
</tr>
<tr>
<td></td>
<td>causes more tissue reaction than synthetic sutures</td>
<td>mucosal sutures, as well as in children</td>
</tr>
<tr>
<td></td>
<td>(hydrolytic breakdown); braided sutures offer</td>
<td>provided there is minimal tension;</td>
</tr>
<tr>
<td></td>
<td>more tensile strength but provide medium for</td>
<td>surgical glue to be used only in</td>
</tr>
<tr>
<td></td>
<td>infection</td>
<td>wounds where there is very little</td>
</tr>
<tr>
<td></td>
<td></td>
<td>tension; staples are very quick, but</td>
</tr>
<tr>
<td></td>
<td></td>
<td>can move in place and irritate wound</td>
</tr>
<tr>
<td></td>
<td></td>
<td>if not covered by proper dressing</td>
</tr>
</tbody>
</table>

Basic Suturing Techniques

- **basic principles**
  - minimize tissue trauma: follow curve of needle, handle wound edges gently
  - enough tension to approximate edges - do not strangulate
  - use the finest needle and suture possible
  - to avoid suture marks in skin
    - evert skin edges when closing
    - avoid tension on skin (close in layers)
    - follow lines of relaxed skin tension or skin crease lines if possible
    - keep sutures close to wound edges
    - remove sutures within 7-10 days; on face remove
      sutures in 5 days; over joints, remove sutures in 14 days
  - to evert skin edges
    - enter the tissue with needle at right angles
    - take a bigger bite in the depth of the wound
    - take equal tissue on both sides of the wound
    - place knot to one side of the wound
- **basic suture methods**
  - simple interrupted - face and when scarring is less important
  - subcuticular - good cosmetic result, not as strong as interrupted
  - vertical mattress - for areas difficult to evert (e.g. dorsum of the hand)
  - horizontal mattress - evertong, time saving
  - continuous over and over - time saving
**SKIN GRAFTS**

- **Definition:** A segment of skin detached from its blood supply and transplanted to a recipient site (new blood supply).
- **Donor site selection:**
  - Must consider size, colour, hair pattern, texture and thickness of skin required.
  - Usually taken from inconspicuous areas (e.g., buttocks, lateral thighs, etc...).
  - For facial grafts, preferable to take graft from above clavicle (e.g., post-auricular area).
- **Skin graft take occurs in 3 phases:**
  1. Plasmatic imbibition - nourishment via diffusion (first 48 hours).
  2. Inosculation - vessels in graft connect with those in recipient bed.
  3. Neovascular ingrowth - graft revascularized by ingrowth of new vessels into bed.
- **Requirements for survival:**
  - Bed: well vascularized (bone and tendon are unsuitable beds).
  - Contact between graft and recipient bed: fully immobile.
    - Staples, sutures, splinting, and appropriate dressings (pressure) are used to prevent hematoma, seroma, and movement of graft.
  - Recipient site: clean (to prevent infection).
- **Types:**
  - Autograft - from same individual.
  - Allograft - from same species, different individual.
  - Xenograft - from different species (e.g., porcine).

### Table 2. Skin Grafts

<table>
<thead>
<tr>
<th></th>
<th>Split Thickness</th>
<th>Full Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition</strong></td>
<td>Epidermis and part of dermis</td>
<td>Epidermis and all of dermis</td>
</tr>
<tr>
<td><strong>Donor site</strong></td>
<td>More sites</td>
<td>Limited donor sites</td>
</tr>
<tr>
<td><strong>Healing</strong></td>
<td>Re-epithelialization via dermal appendages</td>
<td>Primary closure or split thickness skin graft</td>
</tr>
<tr>
<td><strong>Re-harvesting</strong></td>
<td>~10 days (faster on scalp)</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Graft take</strong></td>
<td>Good; shorter nutrient diffusion distance</td>
<td>Lower rate of survival</td>
</tr>
<tr>
<td><strong>Contraction</strong></td>
<td>More</td>
<td>Less</td>
</tr>
<tr>
<td><strong>Sensation</strong></td>
<td>Poor</td>
<td>Good</td>
</tr>
<tr>
<td><strong>Aesthetic</strong></td>
<td>Poor</td>
<td>Good</td>
</tr>
<tr>
<td><strong>Comments</strong></td>
<td>Can be meshed for greater area</td>
<td>Use on face, fingers tips and over joints</td>
</tr>
</tbody>
</table>

![Figure 2. Split and Full (Whole) Thickness Skin Grafts](image)
OTHER GRAFTS

Table 3. Various Grafts

<table>
<thead>
<tr>
<th>Graft Type</th>
<th>Use</th>
<th>Preferred Donor Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone</td>
<td>repair rigid defects</td>
<td>cranial, rib, iliac, fibula</td>
</tr>
<tr>
<td>Cartilage</td>
<td>restore contour of ear and nose</td>
<td>ear, nasal septum, costal cartilage</td>
</tr>
<tr>
<td>Tendon</td>
<td>repair damaged tendon</td>
<td>palmaris longus, plantaris</td>
</tr>
<tr>
<td>Nerve</td>
<td>conduit for regeneration across nerve gap</td>
<td>sural, forearm, cutaneous arm</td>
</tr>
<tr>
<td>Vessel</td>
<td>bridge vascular gaps (i.e. free flaps)</td>
<td>forearm or foot vessels for small vessels, saphenous vein for larger vessels</td>
</tr>
<tr>
<td>Dermis</td>
<td>contour restoration (+/- fat for bulk)</td>
<td>thick skin of buttock or abdomen</td>
</tr>
</tbody>
</table>

FLAPS
- definition: tissue transferred from one site to another with vascular supply intact unlike a graft
- classified according to blood supply to skin: random and axial
- indications for flaps
  - soft tissue coverage i.e. padding bony prominences
  - reconstruction i.e. after facial, breast, or lower leg tissue loss
  - provide vascular recipient bed for skin graft
  - to improve blood supply to bed i.e. bone
  - improve sensation (nerves to skin flap intact)
- may require use of tissue expanders pre-operatively to increase available tissue (especially in scalp area)
  - consists of subcutaneous silicon reservoir into which saline is injected intermittently over several weeks

Random Pattern Flaps (see Figure 3)
- skin and subdermal tissue with random vascular supply
- limited length:width ratio to ensure adequate blood supply (on face 1.5:1, rest of body 1:1)
- rotation/transposition flaps
  - Z-plasty - used to gain or to change the line of direction of the central limb of Z (i.e. release of scar contractures)
  - Limberg
- advancement flaps (V-Y, Y-V, single/bipedicle)

Axial Pattern Flaps
- flap contains a well defined artery and vein
- allows greater length:width ratio (5-6:1)
  - a) peninsular flap - skin and vessel intact in pedicle
  - b) island flap - vessel intact
  - c) free flap - vascular supply anastomosed at recipient site by microsurgical techniques
- can be sub-classified according to tissue content of flap:
  - musculocutaneous/myocutaneous - vascular supply to skin from musculocutaneous perforating vessels
  - fasciocutaneous - vascular supply from plexus superficial to fascia
**THE HAND**

**HISTORY OF TRAUMA**
- hand dominance, occupation, hobbies
- time, place (especially if at work), and mechanism of injury
  (position of hand, direction, duration and magnitude of force)
- visible arterial spurting at time of injury
- previous hand trauma/surgery
- tetanus status, meds, allergies, complicating conditions
- label digits thumb, index, middle, ring, little or D1-D5 respectively
GENERAL ASSESSMENT
- compare with unaffected region/hand
- neuromotor
  - hand (see Table 4)
  - fingers - assess digital nerves at distal tips with two-point
discrimination on radial and ulnar aspects
- vascular
  - capillary refill (< 1 second), Allen’s test, temperature,
skin turgor, Doppler probe, colour
- tendons
  - each joint in the hand has a prime mover
  - palpate tendons
  - never test tendons against resistance if tendon laceration
    is suspected - let patient actively move joints themselves
- phalangeal fractures
  - look for a) rotation b) shortening
c) overlap of fingers with flexion (“scissoring”)

Table 4. Neuromotor Examination of the Hand

<table>
<thead>
<tr>
<th></th>
<th>Median</th>
<th>Ulnar</th>
<th>Radial</th>
</tr>
</thead>
<tbody>
<tr>
<td>sensory</td>
<td>radial aspect of index finger pad</td>
<td>ulnar aspect of little finger pad</td>
<td>dorsal web space of thumb</td>
</tr>
<tr>
<td>motor extrinsic</td>
<td>flex distal IP joint of index finger (flexor digitorum profundus)</td>
<td>flex distal IP joint of little finger (flexor digitorum profundus, extensor carpi radialis)</td>
<td>extend wrist and thumb (extensor pollicis longus)</td>
</tr>
<tr>
<td>motor intrinsic</td>
<td>thumb to ceiling with palm up (abductor pollicis brevis)</td>
<td>abduct index finger (first dorsal interosseous)</td>
<td>--------------------------</td>
</tr>
</tbody>
</table>

Table 5. Tendon Examination of the Hand

<table>
<thead>
<tr>
<th></th>
<th>MCP</th>
<th>PIP</th>
<th>DIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>extensor</td>
<td>Ext. dig.</td>
<td>Intrinsics (lateral bands)</td>
<td>Intrinsics (lateral bands)</td>
</tr>
<tr>
<td>tendons</td>
<td>communis</td>
<td>(lateral bands)</td>
<td>(lateral bands)</td>
</tr>
<tr>
<td>flexor</td>
<td>Intrinsics</td>
<td>Flex. dig.</td>
<td>Flex. dig.</td>
</tr>
<tr>
<td>tendons</td>
<td>(lumbricals)</td>
<td>superficialis</td>
<td>profundus</td>
</tr>
</tbody>
</table>

Figure 5. Sensory Distribution in the Hand

Figure 6. Testing Profundus

Figure 7. Testing Superficialis (Sublimus)
GENERAL MANAGEMENT

Nerves
- primary repair for a clean injury within 24 hours and without concurrent major injuries --> otherwise secondary repair
- epineural repair of digital nerves with minimal tension
- post-operative: dress wound, elevate hand and immobilize
- follow-up starting at 3 weeks post-operative and at 6 week intervals thereafter
- Tinel’s sign (cutaneous percussion over the repaired nerve) produces paresthesias and defines level of nerve regeneration (a peripheral nerve regenerates at 1 mm/day or 1 inch/month, after the first 4 weeks as a result of Wallerian degeneration)
- physiotherapy to prevent joint contracture

Vessels
- often associated with nerve injury (anatomical proximity)
- control bleeding with direct pressure and hand elevation
- avoid probing, clamping, and tying off artery as incidence of nerve injury can be significant
- repair optimal if within 6 hours
- dress, immobilize, and splint hand with finger tips visible
- post-operatively monitor colour, capillary refill, skin turgor, fingertip temperature

Tendons
- most tendon lacerations require primary repair
- never test against resistance
- never immobilize joints > 3 weeks, will lead to stiffness and significantly increases rehabilitation time

AMPUTATIONS

Hand or Finger
- initial treatment: wrap amputated part in a saline soaked sterile gauze and place inside waterproof plastic bag on ice
- considerations for patient selection
  • patient: age, hand dominance, occupation, hobbies, motivation for rehabilitation
  • level of injury: functional results vary accordingly
  • nature of injury: guillotine better results than avulsion amputations
- indications for replantation:
  • child, thumb, clean hand, wrist, or multiple digits involved
- if replant contraindicated manage stump with thin split thickness skin graft, pedicle grafts, or allow to heal by secondary intention, especially in children

TENDONS

Common Extensor Tendon Deformities
- location described by zones (see Figure 11)
- mallet finger (zone 1): DIP in flexion with loss of active extension caused by extensor tendon rupture at DIP joint
- Boutonniere deformity (zone 3): PIP in flexion, DIP in hyperextension; associated with rheumatoid arthritis, trauma (laceration, volar dislocation, acute forceful flexion of PIP)
- Swan Neck deformity (zone 3): PIP hyperextension, DIP flexion
- de Quervain’s tenosynovitis (zone 7): inflammation in 1st dorsal wrist compartment
  • +ve Finkelstein’s test (pain induced by making fist, with thumb in palm, and ulnar deviation of wrist)
**Flexor Tendon**
- Flexor tendon zones (importance for prognosis of tendon lacerations)
  - "No Man's Land"
    - between distal palmar crease and mid-middle phalanx
    - zone where superficialis and profundus lie ensheathed together
    - recovery of glide very difficult after injury

**Common Flexor Tendon Deformities**
- Stenosing tenosynovitis (trigger finger/thumb)
  - Majority idiopathic
  - Tendon/pulley size discrepancy causes locking flexion/extension
  - May palpate nodule at palmar aspect MCP
  - Treatment: Steroid injection into the sheath, surgical release is necessary if injection unsuccessful
  - Surgical treatment includes release of A1 pulley, synovectomy, removal of tendon nodule
**FRACTURES AND DISLOCATIONS**

- about 90% of hand fractures are stable in flexion
- stiffness secondary to immobilization is the most important complication
- key: early motion
- preferred position of hand splinting is position of function and comfort
  (like a hand holding a pop can)
  - wrist extension 15°
  - MCP flexion 45°
  - IP flexion (slight)
  - thumb abduction/rotation
  - contraindications: post repair of flexor tendons, median/ulnar nerve (some wrist flexion to decrease the tension on the repair required)
- safe position - maximal flexion at the MCP joint to maximize ROM in case of extensor injury
  - wrist extension 45°
  - MCP flexion 60°
  - PIP and DIP in full extension
  - thumb abduction and opposition

**Figure 12. Safe Position**

Drawing by Jackie Robers

- Distal Phalanx Fractures
  - require symptomatic protection
  - soft tissue injuries more important than bone

- Proximal and Middle Phalanx Fractures
  - undisplaced or minimally displaced - buddy tape to neighbouring stable digit, elevate hand
  - displaced - percutaneous pins (K-wires), splinting
  - check for malrotation of finger ("scissoring") on making a fist

- Metacarpal Fractures
  - Boxer’s fracture: head or neck of metacarpal of little finger
    - loss of prominence of metacarpal head, scissoring of fingers on making a fist
    - volar displacement of head
    - up to 30-40° angulation acceptable unless reduced range of motion or esthetic problem
    - if stable, splint with PIP and DIP joints free, otherwise surgery
  - Bennett’s fracture: intra-articular fracture/dislocation of base of thumb metacarpal
    - larger distal radial fragment displaced by abductor pollicis longus
    - treat with percutaneous pinning, thumb spica x 6 weeks
  - Rolando’s fracture: T-shaped intra-articular fracture of thumb metacarpal
    - difficult to treat, treat with open reduction

**Figure 13. Bennett’s Fracture**

Drawing by Meaghan Brierley

**Figure 14. Rolando’s Fracture**
Digital Dislocations
- PIP and DIP dislocations (PIP more common than DIP)
  - usually dorsal dislocation
  - closed reduction and splinting (30° flexion for PIP and full extension for DIP)
- MCP dislocations relatively rare
  - most commonly thumb, index, little finger
  - dorsal dislocation of proximal phalanx on metacarpal head
  - neurovascular structures can be compromised
  - usually requires prompt open reduction
- gamekeeper's thumb: MCP ulnar collateral ligament rupture
  - mechanism: forced abduction of thumb (ski pole injury)
  - apply lateral stress with MCP at 0° and 45° flexion; if greater than 15° more than other thumb, may require surgery

DUPUYTREN'S CONTRACTURE
- contraction of longitudinal palmar fascia, forming nodules, cords and eventually joint contractures
- genetic disorder, repetitive trauma plays no role and connection with alcohol is controversial
- order of digit involvement: ring > little > long > index > thumb
- often bilateral
- stages
  1. palmar pit or nodule - no surgery
  2. palpable band/cord with no limitation of extension of either MCP or PIP - no surgery
  3. lack of extension at MCP or PIP - surgical fasciectomy indicated
  4. irreversible periarticular joint changes/scarring - surgical treatment possible but poorer prognosis compared to stage 3
- surgery is the only satisfactory treatment
- may recur, especially in Dupuytren's diathesis

CARPAL TUNNEL SYNDROME (see Neurosurgery Notes)

HAND INFECTIONS
Principles
- trauma is most common cause
- 5 cardinal signs: rubor (red), calor (hot), tumour (swollen), dolor (painful) and function laesa (loss of function)
- 90% of hand infections are caused by Gram positive organisms
- most common organisms (in order) - S. aureus, Strep. viridans, Group A Strep., S. epidermis, and Bacteroides melanin
- infection vs. inflammation sometimes diagnostically challenging; look at history, physical (severe pain on axial compression of finger suggests infection), WBC count, XR, etc...

Types of Infections
- paronychia
  - infection of soft tissue around fingernail, often begins as "hangnail"
  - treated with antibiotics, and drainage if abscess present
- felon: deep infection of pulp space
  - treated with incision and drainage and antibiotics (oral cloxacillin)
- flexor tendon sheath infection (acute suppurative tenosynovitis)
  - Kanavel's 4 cardinal signs
    1. symmetrical swelling of digit
    2. tenderness along flexor tendon sheath
    3. flexed or semi-flexed attitude (posture) of finger
    4. severe pain on passive extension of DIP (most important)
  - treated promptly in the operating room with incision and drainage, irrigation, and antibiotics
- human bites
  - most common over dorsum of MCP (punch in mouth)
  - serious as mouth has 10⁹ microorganisms/mL, (get trapped in joint space when MCP's extended and can cause septic arthritis)
  - treatment: Clavulin (see Emergency Medicine Notes)
- dog and cat bites (pathogens: Pasteurella multocida, S. aureus, S. viridans)
  - treatment: Clavulin (see Emergency Medicine Notes)
THE HAND . . . CONT.

- deep palmar space infections
  - uncommon, involve thenar or mid-palm, treated in operating room
- herpetic whitlow
  - painful vesicle around finger tip of medical personnel
  - treatment is protection (cover), but some recommend oral acyclovir
- gonococcal arthritis (uncommon)
  - high index of suspicion based on history (STD, IV drugs)
  - can destroy entire joint in short time
  - treatment: penicillin

RHEUMATOID HAND

- general principles
  - non-surgical treatments form the foundation in the management of the rheumatoid hand
  - surgery reserved for selected cases in which patient’s goals of improved cosmesis or function may be achieved
- common problems
  - Synovitis
    - proliferation of synovium can lead to invasion into and subsequent rupture of tendons (usually extensor), requires tendon repair
    - proliferation of synovium leads to increased pressure in carpal tunnel and subsequent carpal tunnel syndrome
    - trigger finger (see “Common Flexor Tendon Deformities”)
  - Ulnar drift
    - multifactorial etiology; results in radial deviation of wrist, ulnar deviation of MCP’s, and subluxation of carpal bones
    - often results in severe functional loss of both precision pinch and power grip strength
    - treatment may include MCP arthroplasty, resection of distal ulna, soft tissue reconstruction around wrist
  - Thumb deformities
    - can be successfully treated by arthrodesis
  - Swan Neck
    - PIP hyperextension, DIP flexion
    - treatment can include soft tissue reconstruction, arthrodesis, or arthroplasty
  - Boutonniere
    - patients generally have functional loss due to DIP hyperextension rather than PIP flexion (e.g. holding a cup)
    - release of the extensor tendon allowing flexion of DIP provides excellent results

THERMAL INJURIES

Physiology of the Skin
- skin: epidermis and dermis
- blood vessels and nerves are found in the dermis
- acts as a barrier to infection, prevents loss of fluids, maintains body temperature

BURNS
- etiology: Children - scald burns
  - Adults - flame burns

ZONES OF THERMAL INJURY
- zone of coagulation - cells irreversibly damaged
  - zone of stasis - cells injured and will die in 24-48 hours without proper treatment; sludging of capillaries (need to prevent swelling and infection)
  - factors favoring cell survival: moist, aseptic environment, rich blood supply
- zone of hyperemia - cells will recover in 7 days
THERMAL INJURIES ... CONT.

Notes

DIAGNOSTIC NOTES
- estimate burn size (total body surface area = TBSA) - rule of 9's
  - includes second and third degree burns only (different in children)

- age - more complications if < 3 or > 60 years old
- depth classification
  - see Table 6
- location
  - face, hands, feet, perineum cause special problems and warrant hospitalization
  - circumferential burns are managed with escharotomy (an incision down to and including fat) to prevent tourniquet effect of eschar
- watch for inhalation injury, associated injuries (fractures), co-morbid factors (concurrent disability - alcoholism, renal disease)

Table 6. Staging of Burns

<table>
<thead>
<tr>
<th>Nomenclature</th>
<th>Traditional Nomenclature</th>
<th>Depth</th>
<th>Clinical Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>superficial thickness</td>
<td>first degree</td>
<td>epidermis</td>
<td>erythema, white plaque</td>
</tr>
<tr>
<td>superficial partial</td>
<td>second degree</td>
<td>into superficial dermis</td>
<td>clear fluid, superficial blisters, painful</td>
</tr>
<tr>
<td>thickness</td>
<td></td>
<td>into deep dermis</td>
<td>difficult to distinguish from full thickness</td>
</tr>
<tr>
<td>deep partial thickness</td>
<td>second degree</td>
<td>through dermis</td>
<td>hard, leather-like texture of skin</td>
</tr>
<tr>
<td>full thickness</td>
<td>third degree</td>
<td>involves underlying tissue</td>
<td>eschar formation</td>
</tr>
<tr>
<td></td>
<td>fourth degree</td>
<td></td>
<td>purple fluid, insensate</td>
</tr>
</tbody>
</table>
THERMAL INJURIES ... CONT.

INDICATIONS FOR ADMISSION

American Society of Plastic and Reconstructive Surgeons
- total 2° and 3° burns > 10% TBSA in patients < 10 or > 50 years of age
- total 2° and 3° burns > 20% TBSA in patients any age
- 3° burns > 5% TBSA in patients any age
- threat of serious functional or cosmetic impairment (i.e. face, hands, feet, genitalia, perineum, major joints)
- inhalation injury
- electrical burns
- chemical burns posing threat of functional or cosmetic impairment
- burns associated with major trauma

ACUTE CARE OF BURN PATIENTS

Respiratory Distress
- if inhalation injury suspected (burn sustained in closed space, singed nose hairs/eyebrows, soot around nares and oral cavity, history of explosions or flash burns), intubate immediately before edema occurs
- acute causes
  - CO poisoning (treat with 100% O2 decreases half-life of carboxyhemoglobin from 210 minutes to 59 minutes)
  - eschar encircling chest (perform escharotomy)
- late onset
  - due to smoke inhalation and pulmonary injury
  - risk of pulmonary insufficiency (up to 48 hours) and pulmonary edema (48-72 hours)
  - if humidified O2 not successful, may need to intubate and ventilate
  - watch for secondary lung infections (after 1 week)

Burn Shock
- definition: hypovolemia due to movement of H2O and Na+ in zone of stasis and generalized increased capillary permeability in all organs (occurs if > 30% TBSA)
- resuscitation with Parkland formula: 4 cc Ringer's/kg/% TBSA over first 24 hours
  - TBSA does not include 1st degree areas
  - 1/2 of this in 1st 8 hours post burn, rest in next 16 hours
  - in following 6 hours give 0.35-0.5 cc plasma/kg/% TBSA, then DSW at rate to maintain normal serum sodium
- Parkland underestimates fluid requirements in electrical and inhalation injuries
- monitor resuscitation
  - maintain urine output > 0.5 cc/kg/hr (adults) and 1.0 cc/kg/hour (children < 12 years)
  - also maintain a clear sensorium, HR < 120/minute, mean blood pressure > 70 mmHg

Burn Wound
- goals of 3rd degree burn wound care
  - prevent infection (one of the most significant causes of death in burn patients) --> most common organisms include S.aureus, P. aeruginosa and C. albicans
  - remove dead tissue
  - cover wound with skin as soon as possible
- surgically debride necrotic tissue, excise to viable (bleeding) tissue
- topical antimicrobials to prevent bacterial infection (from patient's gut flora or caregivers) and secondary sepsis
- important to obtain early wound closure
- deep second or third degree burn > size of a quarter: indication for skin graft
- prevention of wound contractures: pressure dressings, joint splints, early physiotherapy

Table 7. Topical Antibiotic Therapy

<table>
<thead>
<tr>
<th>Antibiotic</th>
<th>Pain with Application</th>
<th>Penetration</th>
<th>Adverse Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silver nitrate</td>
<td>None</td>
<td>Minimal</td>
<td>Methemoglobinemia, stains</td>
</tr>
<tr>
<td>Silver sulfadiazine</td>
<td>Minimal</td>
<td>Medium</td>
<td>Slowed healing, leukopenia</td>
</tr>
<tr>
<td>Mafenide Acetate</td>
<td>Moderate</td>
<td>Well</td>
<td>Slowed healing, acid-base abnormalities</td>
</tr>
</tbody>
</table>
Other Considerations
- nutrition: calories, vitamin C, vitamin A, Cu, Zn, Fe
- immunosuppression and sepsis
- GI bleed (tube feeding or NPO and H₂ blockers)
- renal failure secondary to hypovolemia - rare
- tetanus toxoid

CHEMICAL BURNS
- severity depends on: type of chemical (acid and alkalai), concentration, quantity, and contact time
- inspect eyes
- common agents: cement, hydrofluoric acid, phenol
- treatment:
  - dilution with water
  - wash eyes out with saline and refer to ophthalmology
  - local care after 12 hours: debridement, topical antibiotics
  - beware: fluid resuscitation, renal, liver, and pulmonary damage

ELECTRICAL BURNS
- depth of burn depends on voltage and resistance of the tissue
- in decreasing order of resistance: bone, fat, tendon, skin, muscle, blood, and nerve
- often small punctate burns on skin with massive deep tissue damage which requires debridement
- watch for:
  - cardiopulmonary injuries e.g. ventricular fibrillation
  - renal: myoglobinuria/hemoglobinuria
  - fractures and dislocations, especially shoulder and spine
  - tissue necrosis secondary to vessel thrombosis
  - decrease in RBC (beware of hemorrhages)
- electrical burns require ongoing monitoring as latent injuries become manifest

FROSTBITE
- ice crystals form between cells
- mechanisms of tissue injury:
  - cellular dehydration
  - ischemia (secondary to peripheral vasoconstriction)
- superficial frostbite: only skin and subcutaneous tissues frozen
- deep frostbite: underlying tissues frozen as well
- management:
  - rewarm in water bath (40-42ºC)
  - after rewarming, tissue becomes purple, edematous, painful blisters may appear, resolving after several weeks
  - leave injured region open to air
  - leave blisters intact
  - debride skin gently with daily whirlpool immersion (scrubbing, massage and topical ointments not required)
  - surgery may be needed to release constrictive, circumferential eschars

SOFT TISSUE INFECTIONS

CELLULITIS
- non-suppurative infection of skin and subcutaneous tissues
- signs and symptoms:
  - pain, tenderness, edema, erythema with poorly defined margins
  - fever, chills, malaise
  - can lead to lymphangitis (visible red streaking in areas proximal to infection)
- skin flora most common organisms: S. aureus, β-hemolytic Streptococcus
- treatment is antibiotics: first line Pen G 1.2 million units q6-8h IV + cloxacillin 1 g q6-8h IV
NECROTIZING FASCIITIS
- infection leading to gangrene of subcutaneous tissue, and subsequent necrosis of more superficial layers
- Type I: β-hemolytic streptococcus, Type II: polymicrobial
- natural history
  - severe pain, fever, edema, tenderness
  - infection spreads very rapidly
  - patients are often very sick and toxic in appearance
  - skin turns dusky blue and black
    (secondary to thrombosis and necrosis)
  - induration, formation of bullae
  - cutaneous gangrene, subcutaneous emphysema (Type II)
- diagnosis
  - severely elevated CK
  - hemostat easily passed along fascial plane
  - fascial biopsy
- treatment
  - surgical debridement: removal of necrotic tissue, copious irrigation, often requires repeated trips to the OR
  - IV antibiotics: clindamycin 900 mg q8h IV + Pen G 6 million units q4h IV

MALIGNANT SKIN LESIONS
(see Dermatology Notes)

MANAGEMENT
- basal cell carcinoma (see Colour Atlas A21)
  - curettage and electrodesiccation: for smaller lesions; include a 2-3 mm margin of normal skin
  - surgical excision: deep infiltrative lesions; 3-5 mm margins beyond visible and palpable tumour border; may require skin graft or flap
  - x-ray therapy: less traumatic and useful in difficult areas to reconstruct, requires a skilled physician because of many complications
  - cure rate is the same (approximately 95%) for the above procedures in competent hands
- squamous cell carcinoma (see Colour Atlas A17)
  - same options for treatment as for basal cell carcinoma
  - more aggressive treatment because more malignant than BCC
- melanoma (see Colour Atlas A23)
  - excision is primary management
  - for lesions < 0.75 mm thickness: a 1 cm margin is recommended
  - for lesions > 0.75 mm thickness: a 2.5 cm margin is recommended
  - node dissection for lesions > 0.75 mm
  - beware of lesions that regress - tumour is usually deeper than one anticipates
ULCERS

PRESSURE SORES
- common sites: greater trochanter, ischial tuberosity, sacrum, heel, elbows, occiput
- stages
  - hyperemia - disappears 1 hour after pressure removed
  - ischemia - follows 2-6 hours pressure
  - necrosis - follows > 6 hours pressure
  - ulcer - necrotic area breaks down
- prevent with good nursing care: clean skin, frequent log rolling, special beds (Kinair), egg crate mattress
- treatment
  - debridement of necrotic tissue
  - continue with preventative methods
  - topical antibiotics of questionable value
  - osteotomy and closure with myocutaneous flap in selected cases

LEG ULCERS

Venous Stasis Ulcers
- due to venous hypertension, valvular incompetence
- painless, dependent edema, discoloration, commonly over medial malleolus
- treatment
  - elevate, pressure stockings, may need skin graft

Ischemic Ulcers
- secondary to small and/or large vessel disease
- usually located on the lateral aspects of the great and fifth toes and dorsum of foot
- painful, distal, punched out ulcers with hypersensitive/ischemic surrounding skin
- treatment
  - rest, no elevation, modify risk factors
    - (stop smoking, exercise, diet, etc...)
  - treat underlying condition
    - (diabetes, proximal arterial occlusion, etc...)
  - ultimately, may use skin graft, flap, or amputation

Diabetic Ulcers
- due to decreased sensation (neuropathy) and decreased regional blood flow
- painless
- usually located on the plantar surface of foot over the metatarsal heads or heel
- treatment
  - debride necrotic tissue, topical and/or systemic antibiotics, fastidious foot care

Traumatic Ulcers
- failure of lesion to heal, usually due to compromised blood supply and unstable scar
- usually over a bony prominence
- treatment
  - resection of ulcer, unstable scar and thin skin
  - reconstruction with local or distant flap
CRANIOFACIAL FRACTURES

- ABC’s of trauma - always remember to ensure airway, ensure breathing, prevent aspiration, control bleeding and check cervical spine
- consider intracranial trauma
- forces involved
  - low velocity vs. high velocity injuries determine degree of damage
  - frequency
    - nasal > zygomatic > mandibular > maxillary

RADIOGRAPHIC EXAMINATION

Table 8. Imaging of the Craniofacial Skeleton

<table>
<thead>
<tr>
<th>Structure</th>
<th>Appropriate Imaging</th>
</tr>
</thead>
<tbody>
<tr>
<td>mandible</td>
<td>panoramic (panorex)*</td>
</tr>
<tr>
<td></td>
<td>P-A of mandible</td>
</tr>
<tr>
<td></td>
<td>Towne's view (A-P “from above”)</td>
</tr>
<tr>
<td></td>
<td>lateral obliques</td>
</tr>
<tr>
<td>nasal bones</td>
<td>no x-ray required - clinical *</td>
</tr>
<tr>
<td></td>
<td>diagnosis: may do Water's view and/or lateral</td>
</tr>
<tr>
<td>zygomatic and orbital bones</td>
<td>CT scan*</td>
</tr>
<tr>
<td></td>
<td>Water's view (A-P “from below”)</td>
</tr>
<tr>
<td></td>
<td>Caldwell's view (P-A at 150)</td>
</tr>
<tr>
<td></td>
<td>submento-vertex</td>
</tr>
<tr>
<td>maxilla</td>
<td>CT scan - axial and coronal*</td>
</tr>
<tr>
<td></td>
<td>(conventional x-rays of little value)</td>
</tr>
</tbody>
</table>

*best imaging method

- CT: axial and coronal usually the most accurate especially in fracture of upper and middle face but not good for mandible

MANDIBULAR FRACTURES

- mechanism
  - anterior force: bilateral fractures
  - lateral force: ipsilateral subcondylar and contralateral angle or body fracture
  - note: classified as open if fracture into tooth bearing area (alveolus)
- signs
  - malocclusion, asymmetry of dental arch
  - intraoral lacerations, submucosal hematoma
  - damaged, loose, or lost teeth
CRANIOFACIAL FRACTURES . . . CONT.

• numbness in V3 distribution
• palpable "step" along mandible on intra-oral or extra-oral palpation

complications
• malocclusion, malunion
• tooth loss
• TMJ ankylosis

treatment
• maxillary and mandibular arch bars wired together (intramaxillary fixation) or ORIF (open reduction and internal fixation)
  i.e. plates and screws

MAXILLARY FRACTURES

Le Fort classification
• Le Fort I: palatal segment (maxillary alveolus) separated from upper midface
• Le Fort II: pyramidal fragment containing maxillary teeth separated from face via fracture through inferior orbital rims and nose
• Le Fort III: separation of facial from cranial bones; fracture line runs through zygomaticofrontal suture, across floor of orbit and nasofrontal junction

Figure 18. Le Fort Fracture Classification

Drawing by Aimée Worrell

signs
• dish pan/equine facies (flat or protruding facies)
• periorbital hematoma, epistaxis
• malocclusion
• mobility of maxilla: tested by trying to move maxilla while watching and palpating for mobility of nasal and zygomatic bones (may not move if fragment is impacted)
• Le Fort III: battle sign, bilateral orbital ecchymosis, CSF otorrhea, hemotympanum

complications
• malocclusion
• airway compromise
• post-traumatic facial deformities

treatment
• primary goal is restoration of occlusion and functional rehabilitation (eating, speech)
• intermaxillary fixation (IMF: wiring jaws together)
• usually also require ORIF with screws and plates

NASAL FRACTURES

mechanism
• lateral force --> more common, good prognosis
• anterior force --> can produce more serious injuries
• depression and splaying of nasal bones causing a saddle deformity
CRANIOFACIAL FRACTURES . . . CONT.

- **signs**
  - epistaxis, swelling, periorbital ecchymosis, tenderness over nasal dorsum, crepitus, change in nasal contour and movement of nasal bones, septal hematoma, respiratory obstruction

- **treatment**
  - nothing
  - always drain septal hematomas as this is a cause of septal necrosis with perforation (saddle nose deformity)
  - closed reduction with Asch or Walsham forceps under anesthesia, pack nostrils with Adaptic, nasal splint for 7 days
  - best reduction immediately or at 4-5 days depending on swelling
  - rhinoplasty may be necessary later for residual deformity (30%)

ZYGOMATIC FRACTURES

- **2 types**
  1. orbitozygomatic complex fractures (tripod fracture)
     - separation of zygoma from maxilla, frontal and temporal bone
  2. depressed isolated zygomatic arch fracture

- **signs**
  - periorbital ecchymosis and subconjunctival hemorrhage
  - loss of prominence of malar eminence (view from above)
  - enophthalmos
  - vertical dystopia
  - pain over fractures on palpation
  - palpable step deformity at orbital rim
  - numbness in V2 distribution (infraorbital and superior dental nerves)
  - trismus (lockjaw)
  - diplopia
  - often associated with fractures of the orbital floor

- **treatment**
  - nothing, if undisplaced and no symptoms
  - ophthalmologic evaluation
  - elevate using Gillies approach: leverage on the anterior part of the zygomatic arch via a temporal incision
  - if Gillies approach fails or a comminuted fracture, then ORIF

ORBITAL BLOW-OUT FRACTURES

- **fracture of floor of orbit with intact infraorbital rim**

- **mechanism**
  - blunt force to eyeball --> sudden increase in intra-orbital pressure (e.g. baseball or fist)

- **signs**
  - periorbital and subconjunctival hemorrhage, enophthalmos
  - diplopia looking up or down, due to entrapment of inferior rectus and limited extraocular movements
  - check visual fields and acuity for injury to globe

- **diagnosis**
  - skull AP
  - CT (axial axis)
  - forced duction test for entrapment

- **treatment**
  - may require open reduction with reconstruction of orbital floor with bone graft or alloplastic material

**Figure 19.**
"Blow-Out" Fracture

Drawing by Aimeé Worrell
PEDIATRIC PLASTIC SURGERY

CLEFT LIP
- **epidemiology**
  - incidence of 1 in 800 in Caucasians, more in Asians less in Blacks
  - may be incomplete, complete, or bilateral
  - 2/3 are unilateral, 2/3 left sided and 2/3 male
- **etiology**
  - multifactorial
  - failure of fusion of the maxillary and nasal prominences as well as lack of mesodermal reinforcement
- **treatment**
  - contact cleft lip team at time of birth
  - surgical correction at 3 months: Millard or Tennison-Randall
  - multiple corrections to nasal and lip usually necessary later

CLEFT PALATE
- **epidemiology**
  - may be submucous, incomplete, unilateral or bilateral
  - may be isolated or in conjunction with cleft lip
  - isolated cleft palate most common in females
- **treatment**
  - special bottles for feeding
  - speech pathologist
  - surgical correction at 1 year: Von Langenbeck or Furlow Z-Plasty
- **significance**
  - hypo or hyper-nasal speech

SYNDACTYLY
- congenital fusion of 2 or more digits (failure of digits to separate)
- simple skin webbing between fingers or more commonly with associated fusion of bone and fingernail bed
  - long and ring finger most common
  - thumb and index least common
- **treatment**: surgical separation with good results

MICROTIA
- severe hypoplasia of external ear with a constricted, blind or absent auditory canal
  - may be associated with other first and second branchial arch abnormalities (Goldenhar's, hemifacial microsomia)
- **treatment**: multiple staged operations to reconstruct ear with either costal cartilage or a silastic framework

AESTHETIC SURGERY

FACE
- hair transplants: with grafts or flaps
- blepharoplasty: removal of excess eyelid skin +/- fat pads
- rhinoplasty: "nose job"
- rhytidectomy: "face lift"; lower face and neck or forehead lift
- otoplasty: for "outstanding" ears

BREAST
- augmentation: with saline filled implants (subglandular or submuscular)
- mastopexy: raises nipple in ptotic breasts
- reduction mammoplasty
- reconstruction following mastectomy
  - Alloplastic: tissue expander followed by prosthesis +/- lattisimus dorsi myocutaneous flap
  - Autologous: several flaps possible including Trans Rectus Abdominus Musculocutaneous (TRAM) flap
  - Nipple reconstruction using local flaps and grafts
  - Areolar reconstruction: full thickness grafts, tattooing

OTHER
- abdominoplasty: "tummy tuck": removal of abdominal pannus (drape of excess fat)
- liposuction: used for contouring, not weight loss
- dermabrasion: for scars, irregular skin surface
- chemical peel: usually perioral
- laser resurfacing: for scars, wrinkles