Objective

- Review Types of Wounds & Healing
- Identify Methods of Wound Closure
- Discuss Principles of Wound Closure
- Discuss Complications in Wound Management
- Describe Basic Knot-Tying Techniques
- Perform Simple Suturing Technique

The Skin - Review
Wound Healing

- Primary and Secondary Intention
- Immediate response phase (seconds to hours)
- Inflammatory phase (hours)
- Epithelialization phase (hours to weeks)
  - Everted – bridging occurs in 18-24 hrs
  - Approximated -36 hrs
  - Inverted – 72 hrs
- Maturation (Tissue Remodeling) - collagen synthesis phase (days to months)

Factors That Influence Wound Healing

- Type of Wound / Injury
- Patient Characteristics
- Patient Medications
- Wound Preparation

Type of Wound / Injury

- Mechanism of injury – shearing, tension, compression, puncture, animal bite, injection injury, oils/inks
- Type of force – crush vs. shearing.
- Time between injury and presentation for repair.
- Intentional or unintentional act.
- Any home remedies or treatments of the wound.
**Patient Characteristics**

Advanced age.
Malnourished, Poor hygiene.
Alcoholism, DM, PVD.
Uremia, Liver disease, Connective tissue diseases
Hypoxia.
Anemia.
Multiple trauma.

**Patient Medications**

Corticosteroids
NSAIDS
Colchicines
Anticoagulants
Antineoplastic agents
Penicillamine

**Wound Preparation**

Use of tissue-toxic wound prep solutions.
Use of detergent scrub solutions.
Inadequate cleansing and irrigation.
Anesthetics containing epinephrine.
Inadequate hemostasis, wound hematoma.
Reactive suture material.
Excessive suture tension.
Tincture of benzoin.
Goals of Wound Closure

- Elimination of dead space (serum & blood = infection)
- Accurate approximation of deep tissue layers to each other (minimal tension)
- Avoidance of tissue ischemia and strangulation (sutures too tight)
- Decrease risk of infection – close wound within 3-8 hrs

Assessing and Preparing for Wound Closure

- Allergies (anesthetic agents, antibiotics, latex, suture material).
- Tetanus?
- Mechanism of injury – shearing, tension, compression, puncture, animal bite, injection, ink/oil.
- Type of force – crush vs. shearing.
- Time.
- Intentional or unintentional act.
- Any home remedies or treatments of the wound.

Assessing and Preparing for Wound Closure

- Is this the only injury?
- Are all the deep structures intact?
- Have I removed all dead tissue?
- Is this wound suitable for immediate closure?
- Do the wound edges have a good blood supply?
- Is suturing the best way to close the wound?
Assessing and Preparing for Wound Closure

- Do I have the right equipment (instruments and correct suture material)?
- Will the wound benefit from steri strips?
- Do I have an appropriate dressing to cover and protect the wound?

Physical Examination of Wound

- Location
- Size in cm
- Description in graphic terms
  - “questionable viable flap”
  - “multiple ground-in foreign bodies”
  - “severely contused wound edges”
  - Cosmetic concerns
- Hemostasis (don’t close a bleeding wound) epinephrine or tourniquet —finger tourniquets
  - Old approach of no epi to fingers/toes – not supported by current research
- X rays

X-Rays

- Failure to dx. A retained foreign body -2nd leading cause of malpractice
- Radiopaque material — metal, glass (2mm or larger), gravel
- Detection rate low — wood and plastic — ultrasound higher sensitivity 87%, ?CT scan (timing, & smaller sizes)
Flourescence

- Use of fluorescein solution is sometimes used to identify glass foreign body in an outpatient setting
- Use of fluorescent lamp or ophthalmoscope on the fluorescent mode will illuminate the FB
- Rinse thoroughly to remove stain and minimize infection

Wound Preparation

- Sterile technique – standard of care
- Irrigation
  - Large amounts of saline (splash guard)
  - Betadine on surrounding skin only!
- Hair Removal
- Debridement
  - Remove devitalized tissue (crushed, torn edges)
  - Excision with a surgical blade

Complications

- Failure to recognize underlying deep structure injury or foreign body due to:
  - Unfamiliarity with the anatomy
  - Inadequate or misleading history
  - Inadequate hemostasis
  - Failure to explore the wound (visually and digitally)
  - Failure to obtain ancillary diagnostic studies
Timeline of Wound Closure

- **Primary**
  - Within 3-8 hours "golden period"; face and scalp 24 hrs
  - Clean wounds without tissue loss
- **Secondary**
  - Days to weeks
  - "secondary intent" (small partial avulsions, fingertip amputations)
- **Tertiary** (delayed primary closure) saliva, feces, exudate or >8 hours after injury
  - 3-5 days after injury
  - Daily wound care
  - Same technique as primary closure

Wound Closure Materials

- Adhesive Tape (Steri Strips)
- Tissue Adhesive (Dermabond)
- Staples
- Sutures

Adhesive Tape

- Superficial, no tension
- Conjunction with deep sutures
Tissue Adhesive (Dermabond)

- Facial & torso
- Extremities – minimal tension

Staples

- Scalp & torso (or surgical)
- Multiple trauma

Sutures

- Size and tensile strength
- Needle Size (Bite)
- Monofilament vs. multifilament strands
- Absorbable vs. nonabsorbable
Principles of Suture & Needle Selection

• Suture size
  – Finest size suture commensurate with the natural strength of the tissue to be sutured.
  – Use retention sutures to reinforce approximately sized primary sutures.
• Needle Size (Bite)
  – Typically referred to as large bite or small bite
  – Should approximate the width of the wound you are suturing

Principles of Suture & Needle Selection

• Foreign bodies may convert contamination into infection
  – Avoid multifilament
  – Use monofilament or non-absorbable (resist harboring infection)
• Cosmetic results
  – Use the smallest inert monofilament (nylon, polypropylene)
  – Avoid using skin sutures alone (subcuticularly)
  – Sterile skin closure strips

Synthetic Absorbable Sutures

• Polyglycolic acid (Dexon)
• Polyglactin 910 (Vicryl)
• Polyglconate (Maxon)
• Monocryl
Synthetic Nonabsorbable Sutures

- Silk
- Nylon (Ethilon, Dermolon)
- Polypropylene (Prolene)
- Dacron (Mersilene)
- Polybutester (Novafil)

Suture Handling Tips

- Read labels.
- Check expiration dates and rotate stock.
- Open only those sutures needed.
- Straighten sutures with a gentle pull.
- Don’t pull on needles.
- Avoid crushing or crimping suture strands with instruments.

- Don’t wet rapidly absorbing sutures.
- Keep silk dry.
- Wet linen and cotton to increase their strength.
- Draw nylon between gloved fingers to remove the packaging “memory”.
- Arm a needle holder properly.
Suture Selection
Based Upon:
• His/ her area of specialization.
• Wound closure experience (training).
• Knowledge of healing characteristics of tissues and organs.
• Knowledge of physical and biological characteristics of various suture materials.
• Patient factors

Basic Suturing – Anesthesia
• Lidocaine
  – Dilute lidocaine with sodium bicarbonate 1:10 (1 ml bicarb + 9.0 ml lidocaine); shelf life is 7 days
  – Max dose 4-5 mg/kg
• Lidocaine w/Epinephrine
  – Highly vascular areas
• Bupivacaine
  – 4x duration of lidocaine
  – Max dose 2-3 mg/kg
• Topicals – typically used prior to injection in pediatrics

Direct Wound Infiltration
• Inject immediately beneath the dermis at the junction of the superficial fascia
• Inject slowly.
• Inject into subcutaneous plane instead of intradermal plane.
• In clean wounds, insert needle thru the wound edges.
• In contaminated wounds, infiltrate the skin.
• Small needle 27g or 30 g.

Digital Block

Equipment
• Sterile drape & gloves
• Betadine
• 10 cc syringe with 25 gauge needle, 1 ½ inch
• 1% lidocaine (no epinephrine)/Sodium bicarbonate
• Informed consent

Digital Block Procedure
• Introduce needle into dorsal, lateral aspect of proximal phalanx in web space, just distal to the MCP point (small wheal)
• Advance slowly until touch bone
• Aspirate and then inject 1 cc
• Back needle out slightly & then pass closely adjacent bone to the volar surface
• Aspirate and then inject 1 cc continuously as the needle is withdrawn
• Repeat procedure on opposite of finger
Complications of a Digital Block

- Infection - rare
- Hematoma –
  - avoid multiple needle insertions, use 25 g
- Gangrene of the digits
  - avoid epinephrine, limit volume to 2ml each side of digit
- Nerve injury
  - systemic toxicity is rare; do not inject when the patient complains of pain
Suturing Terminology

- Bite
- Throw (knots)
- Percutaneous closure (skin closure)
- Dermal closure (deep closure)
- Interrupted closure (single sutures)

The Needle

- The point
- The body (shaft)
- Swaged end

Needle Handling Guidelines

- The needle holder should be held in a way that is comfortable and affords maximum control. Most clinicians grasp the needle holder by partially inserting the thumb and ring finger into the loops of the handle. Note that the index finger provides additional control and stability.
• This illustrates the same grasp, but with the hand pronated. Supination and pronation are required to manipulate the curved needles.

• As a rule, the needle should be grasped at its center or perhaps 50-60% back from the pointed end. The needle should be grasped 1-2 mm from the tip of the needle holder.

Addison Forceps

• Small toothed forceps, such as the Addison forceps shown here, should be used to grasp the skin edges during suturing. Forceps with teeth provide a secure grasp with minimal pressure, thereby avoiding crushing of the skin edge. The forceps should be held in the first three fingers as one would hold a pen, using the first three fingers.
Suturing Techniques

- Simple suture or everting interrupted suture
- Simple running suture
- Mattress suture (vertical or horizontal)
- Subcuticular suture

Simple Interrupted Suture

- Avoid grasping the suture material or the distal end of the needle with the needle holder, since this will damage the suture.

Placement of the 1st suture is begun by grasping and slightly evverting the skin edge. The right hand is rotated into pronation so that the needle will pierce the skin at a 90 degree angle. Note that the trailing suture is placed away from the clinician to avoid tangling.
• The needle is driven through the full thickness of the skin by rotating the needle holder (supinating). By keeping the shaft of the needle perpendicular to the skin surface at all times, one takes advantage of the needle’s curvature in traversing the skin as atraumatically as possible.

• The needle has been released and is about to be regrasped. The forceps maintain their grasp, to prevent the needle from retracting. The right hand has been fully pronated in preparation for regrasping the needle.

• Pronation in the previous step makes it possible to complete passage of the needle with a smooth, natural supination which rotates the needle upwards and away from the clinician. This minimizes trauma to the tissues.
• Here the needle is being regrasped in preparation for passage through the opposite skin edge. This was traditionally done by grasping the needle with the non-dominant hand. However, given the risks of HIV and hepatitis, it is probably advisable to train yourself to use the forceps for this instead of fingers.

• The skin edge closest to the clinician has been grasped and everted slightly, while the right hand is pronated to "cock" the needle and position it for passage through the skin.

• Again, the right hand is supinated in order to rotate the needle through the full thickness of the skin, keeping the shaft at a right angle to the skin surface.
• After releasing the needle, the right hand is pronated before the needle is regrasped.

• and the right hand is then supinated in order to rotate the needle through the skin atraumatically.

• The suture material is drawn through the skin, leaving 2-3 cm. protruding from the far skin surface. The forceps are then dropped or "palmed" so the left hand can grasp the long end in preparation for an instrument tie. Note that the needle holder is positioned between the strands over the wound.
• The long strand is being wrapped around the needle holder to form the loop for the first throw of a square knot. You will loop twice for the first throw.

• The needle holder is then rotated away from the clinician to grasp the short end of the suture.

• The short end is grasped and drawn back through the loop toward the clinician.
• The throw is tightened...

• ... creating a flat throw which will be tightened just enough to approximate the skin edges. Remember: approximate; do not strangulate.

• The second throw of the square knot is initiated with the needle holder pointed to the left as the long strand is wrapped around it by bringing the long strand toward the clinician.
• The needle holder is then rotated toward the clinician to retrieve the short end, ...

• ... and the short end is drawn through the loop that has been created, pulling it away from the clinician.

• The second throw is then brought down and tightened securely against the first throw.
Pearls

- Use instruments not fingers
- Take equal “bites” for both sides **Evert the wound edges**
- Each suture strand is passed thru the skin only once
- Scalp / trunk 4-0
- Face 6-0
- Extremities
  - Over joints 3-0 to 4-0
  - Hand 5-0

Horizontal Mattress

- Wounds that are under high tension
- Used as a stay stitch
- May be left in for a few days
- Used in calloused skin (palms and soles) and older, thinner skin
Disadvantages

- High risk of tissue strangulation
- Wound edge necrosis
- Suture marks

Vertical Mattress

- Maximizes wound eversion
- Reduces dead space
- Combine deep and percutaneous sutures
- Minimizes tension across the wound
- Placing each stitch precisely & taking symmetric bite
Disadvantage

• Cross hatching (due to increased tension across the wound and 4 entry and exit points)

Buried Intradermal sutures

• Subcuticular
• Best cosmetic results
• Dermis plane (do not strangle)
• Do not cause crosshatching
• Best internal splinting
• Monofilament sutures
Corner Sutures

- Half-buried horizontal mattress suture
- Positions corners and tips of flaps
Dressing and Splinting

- Area should be cleansed with NS
- Antibiotic ointment (?efficacy) for 3-5 days
- Dressing - cover for 24-48 hours and be non occlusive
- Tension wounds should be splinted for 1-2 weeks

Oral Antibiotics

- Wounds > 8-12 hrs old, especially on the hands and lower extremities
- Crushing injuries (compression) mechanism, devitalization, or extensive revisions
- Contaminated wounds
- Violation of the ear or nose cartilage
- Involvement of a joint space, tendon, bone
- Mammalian bites
- Valvular diseases or immunosuppression

Tetanus Prophylaxis

<table>
<thead>
<tr>
<th>Tetanus Wound Management</th>
<th>Clean, razor wounds</th>
<th>All other wounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vaccination History</td>
<td>Td</td>
<td>Td/Ig</td>
</tr>
<tr>
<td>Unknown or &lt;3 doses</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>3+ doses</td>
<td>No*</td>
<td>No</td>
</tr>
</tbody>
</table>

* Yes, if > 10 years since last dose
** Yes, if > 5 years since last dose
Documentation

- H & P with careful attention to neuromuscular and motor function
- Must document that all wounds were explored
- Type of anesthesia
- Type of wound repair
- Size and number of sutures
- Nature of the wound irrigation
- After care instructions
- Foreign bodies and wound contamination

After Care

- All wounds will heal with a scar
- Daily cleansing
- Signs & symptoms of infection
- Suture removal
  - Face: 4-5 days
  - Scalp 6-8 days
  - Extremities and digits: 8-10 days
  - Chest and abdomen 8-10 days
- Sunscreen to scar for at least 6 – 12 months

Referral Guidelines

- When in doubt refer it out!
- Deep wound on face
- Inside the mouth
- Around the eyes
- Into the joint
- Ligament or tendon guidelines
- Finger tip with tissue loss
- You’re not comfortable!
Resources

• Short Streaming Videos
  https://www.youtube.com/watch?v=qGU4Pn4UkME
  http://www.youtube.com/watch?v=012Tybal_s
  http://www.youtube.com/watch?v=ltM6axxETWU

• Principles of Office Anesthesia Part 1-
  American Family Physician

• Principles of Office Anesthesia Part 2-
  American Family Physician

QUESTIONS

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