# Surgical Considerations in Upper Limb Amputation

Jay T Bridgeman, MD
Assistant Professor
University of Missouri

# Disclosures

- Institutional
  - None
- Financial
  - None

# Objectives

- Identify the indications for upper extremity amputation
- Understand the principles and goals of upper extremity amputation
- Review specific levels of amputation and important considerations for each
- Review special considerations involving upper extremity reconstruction

# Upper Extremity: Purpose

- Prehensile
  - Grip
- Nonprehensile

# Prehensile

- Power Grip
  - Ulnar hand
  - Ring and little fingers

# Prehensile

- Precision Grip
  - Radial side
  - Thumb, Index, Middle
  - “3 jaw chuck”

# Nonprehensile

- Touching
- Feeling
- Pressing down
- Lifting
- Pushing

# How is the upper extremity different from the lower?

- Don’t walk on our hands

- Minimal sensation better than prosthesis

# Indications for Amputation

Trauma

- –90%
- –20-40 y/o males

# Indications for Amputations

- Trauma
  - Acute
  - Chronic
- Burn
- Infection

# Indications for Amputations

- Peripheral Vascular Disease
- Neurological disorders
  - Brachial plexopathy
- Congenital deformities
- Malignant tumors
  - Clear margin

# Goals of Amputation Surgery

- Preservation of Length
- Preservation of useful sensibility
- Prevention of symptomatic neuromas
- Minimize phantom limb pain

# Goals for Amputation Surgery

- Prevention of adjacent joint contractures
- Early prosthetic fitting
- Early return to function
- Malignant tumors—restore function while preserving life

# General Amputation Principles

- Skin
- Muscle
- Nerves
- Blood Vessels
- Bone

# Skin

- Painless, pliable, nonadherent scar

- Scar placement  and prosthetic wear

Coverage:

  - Flap coverage
  - Skin graft

# Muscle

- Myofascial closure
  - Minimal muscle stabilization
- Myoplasty
  - Opposing muscle groups
- Myodesis
  - Attached to bone
- Tenodesis
  - Tendon attached to bone

# Nerves

Separate from vessels

- Pain generator

Traction on nerve and sharply transect

- Retracts to safety

# Blood Vessels

- Suture ligate major vessels
- Full-thickness skin flaps
  - Minimize wound necrosis
- Hemostasis prior to closure
  - Drains

# Bone

- Minimize sharp edges
  - Beveling/filing
- Narrow metaphyseal flare/condyles
- Cap intramedullary canal
  - Minimize bleeding
- Minimize periosteal stripping
  - Spurs

# Levels of Amputation

# Levels of Amputation

- Digit
- Hand
- Radiocarpal/Wrist disarticulation
- Transradial
- Elbow disarticulation
- Transhumeral
- Shoulder disarticulation
- Scapulothoracic disarticulation

# Digit

Interphalangeal

- Leave cartilage
- Trim condyles

- Transect tendons and nerves
  - Do not sew tendons together

# Digit

- DIP amputation
  - Lumbrical plus finger
- Amputation distal to FDS
  - Good function
- Proximal to FDS= PIP disarticulation

**M 80**

# Digit

Ray resection

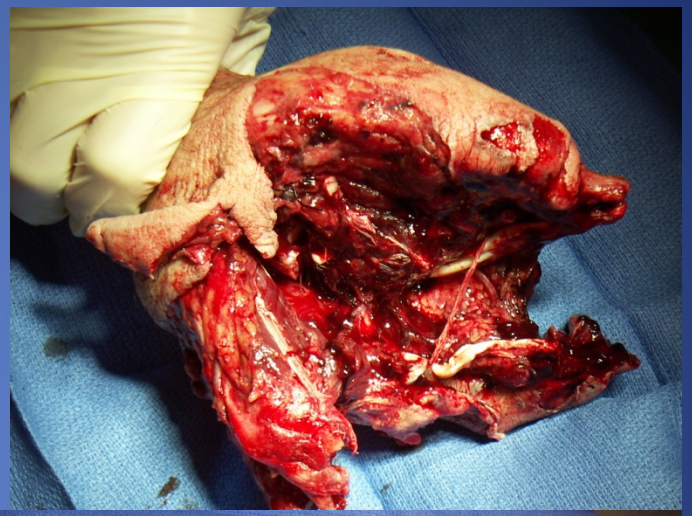
- –Middle Finger
- –Ring Finger

# Partial Hand

**M 100**

Basic Hand

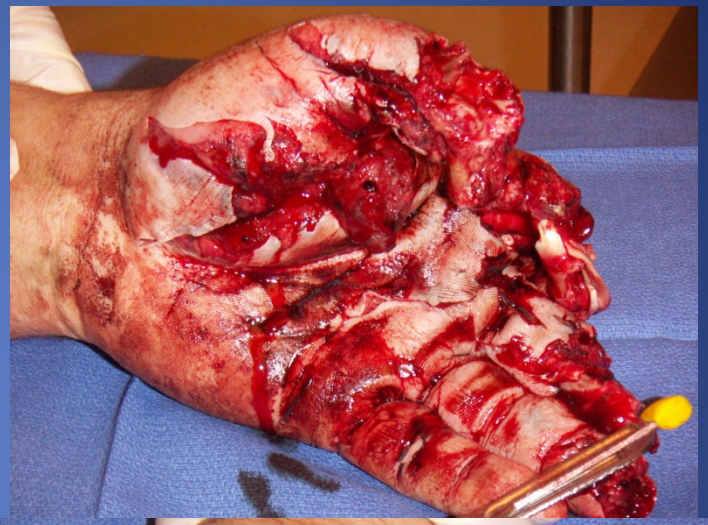
- Thumb
- At least one finger
- Weak pinch
- Minimal grasp



# Partial Hand

Tripod pinch

- Two ulnar fingers
- Thumb
- Improved grip
- Grasp large objects



# Partial Hand

Reconstruct

# Partial Hand

- Toe transplants
- Dominant hand
  - Index/middle finger position
  - Fine pinching
- Non-dominant
  - Ring/little finger
  - Pulp to pulp pinch

# Partial Hand Problems

- Nail deformity
  - Ablate germinal matrix and skin graft
- Quadriga
  - FDP scar together
  - Limited excursion of unaffected fingers
  - Release adherence

# Radiocarpal/Wrist Disarticulation

- Maintains forearm pronation/supination
- Longer lever arm

- Palmar : dorsal flaps
  - 2:1

- DRUJ maintained

# Radiocarpal/Wrist Disarticulation

- DRUJ not reconstructable, consider trans-radial amputation
- Shape radial and ulnar styloids
- Tendons transected and stabilized under physiologic tension

# Transradial

Preserve length

- Supination/pronation
- Stronger lever arm

- Myodesis deep compartments
- Myoplasty superficial compartments
- Maintain long head of biceps for elbow flexion

# Transradial

- Biceps removed
  - Resect radius
  - Attach to ulna to maintain elbow flexion
    - 4-5cm ulna needed for prosthesis
- Unequal bone length
  - Maintain lever arm
  - Create “one bone” forearm

# Transradial

- ~1/3 require revision surgery
- Bulbous/flabby residual limbs
  - Revise
- Elbow contracture
  - Release
  - Fusion

# Case Example

41y/o  smoker s/p MCC

- Intubated for ~1 week
- ORIF  of BBFA
- Woke up w/o sensation or use of hand and wrist
- Likely compartment syndrome
- Nonunion repair x2
- c/o burning extremity

# Case Example

PMH:

- Depression
- alcoholism

- Lack of sensation
- Wrist and finger contractures
- Active bicep function
- Liability

Plan:

  - Hardware removal
  - Transradial amputation

# Elbow Disarticulation

Controversy

- Vs. long trans-humeral

Prosthesis

- Enhanced suspension and rotational control
- External hinge poor cosmesis

# Elbow Disarticulation Technique

Longer posterior flap

Biceps and triceps attached at physiological length

# Transhumeral

- Preserve length
- Preserve deltoid insertion

Short transhumeral functionally similar to shoulder disarticulation

  - Better cosmesis
  - Better prosthetic suspension

# Transhumeral

Short transhumeral

- Abduction contracture
- Consider arthrodesis

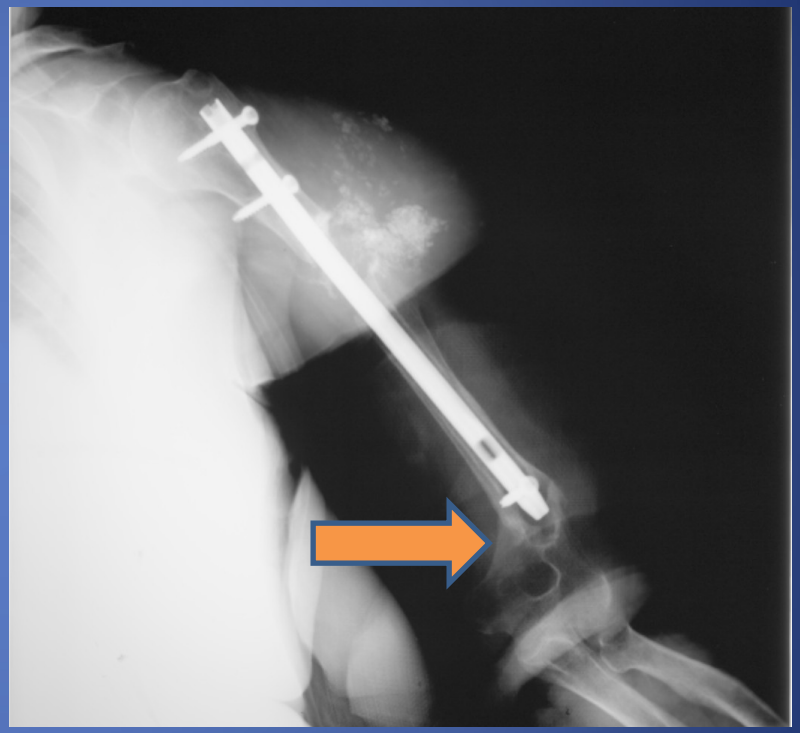
# Transhumeral

Technique

- Long posterior flap
- Angular osteotomy considered for prosthetic wear
- Triceps over bone
- Myodese triceps and biceps
- Surgical neck level = shoulder arthrodesis

# Case Example

- 59y/o s/p fall 1995
- Nonop humeral shaft
- 1997 nonunion repaired with IM nail proximal locking bolts only
- 1998 nonunion repair with distal locking bolts and bone graft
- s/p fall May 2009 with new fracture



ORTHO TRAUMA

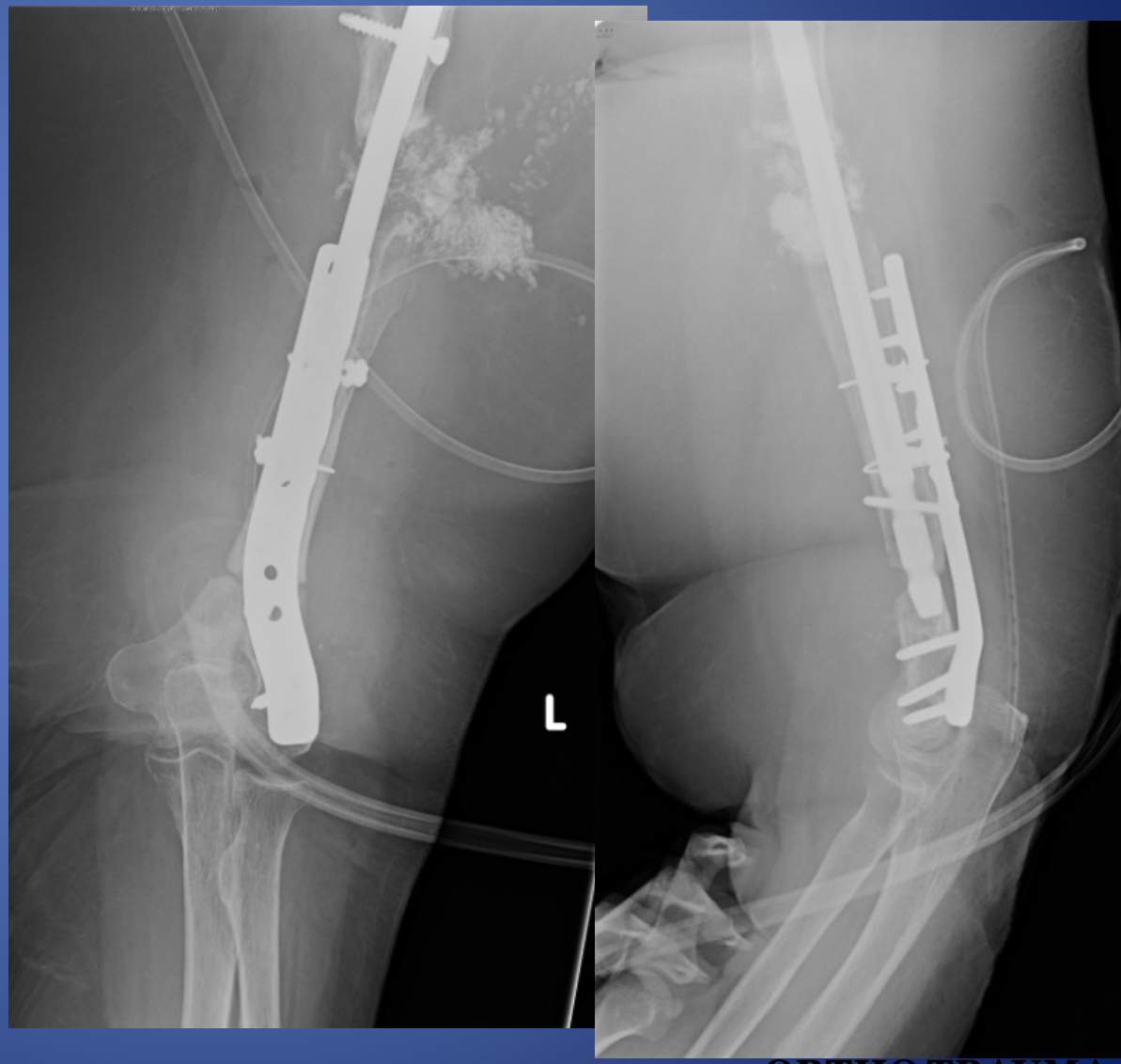
# Case Example

- Morbid Obesity BMI 47.2 s/p gastric bypass
- NIDDM
- COPD, on home O2
- CAD s/p CABG
- Depression

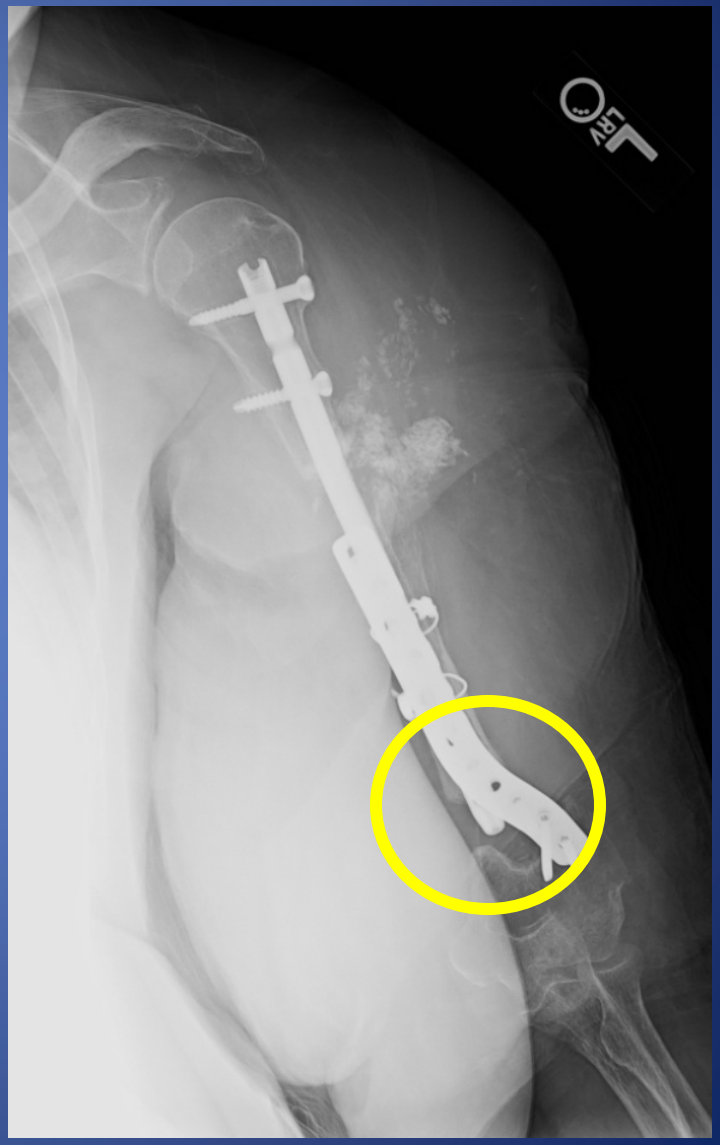
ORTHO TRAUMA

# Case Example

- Nonunion repair
- Shortening
- Plating & BMP



# 6 Weeks Postop



# Options

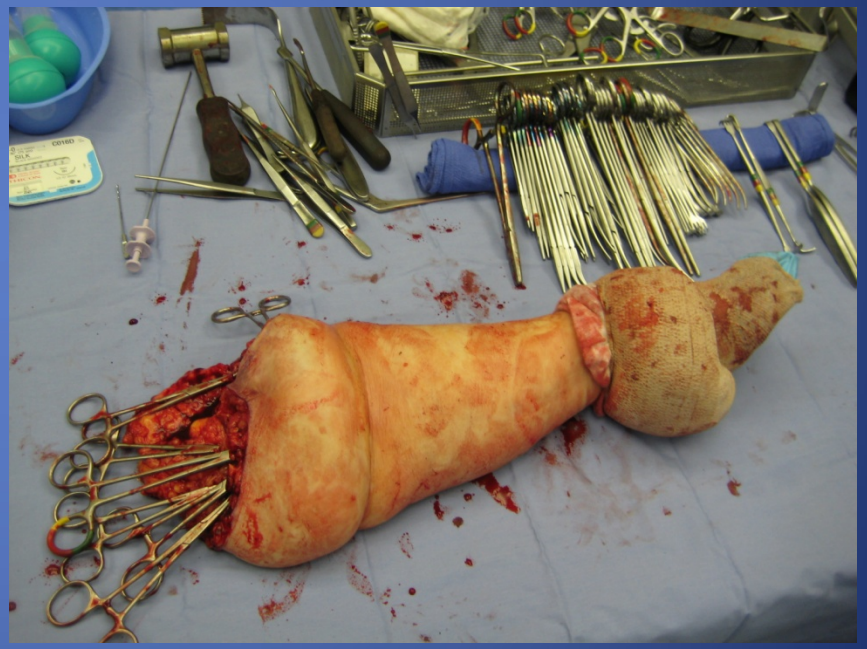
- Revision nonunion repair

  vs.

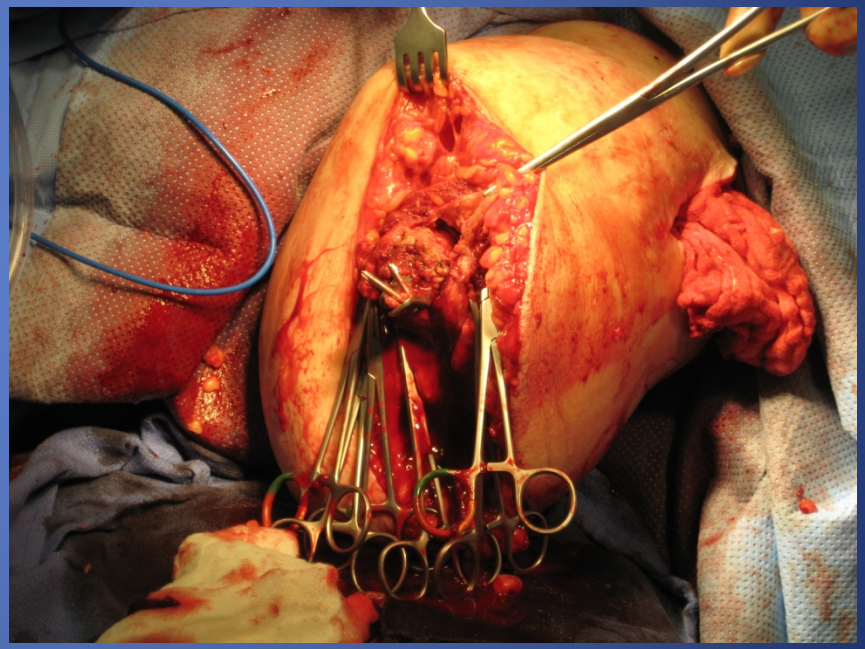
- Transhumeral amputation through nonunion

- Considerations
  - Co-morbidities
  - Failed previous nonunion repair
  - Limited function

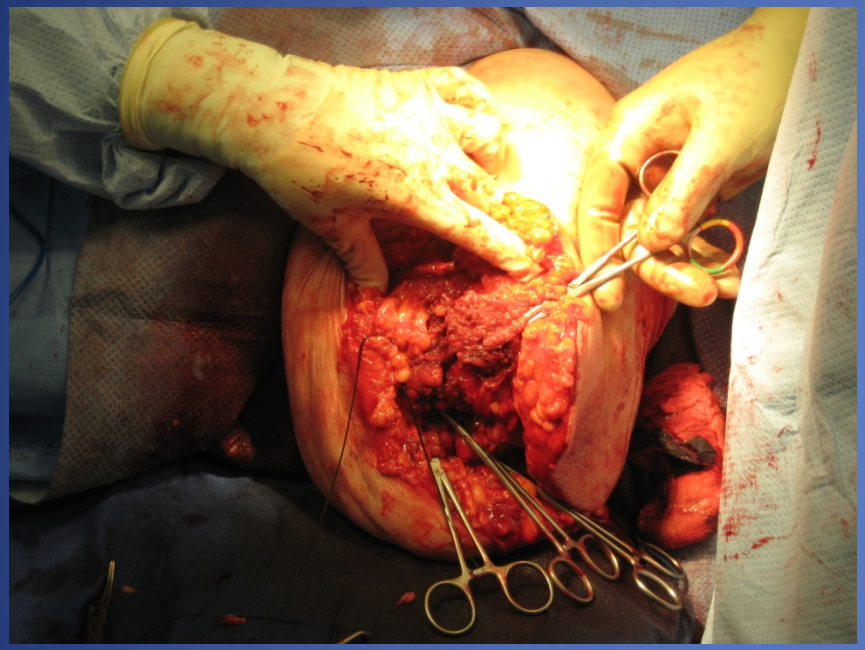
# Transhumeral Amputation

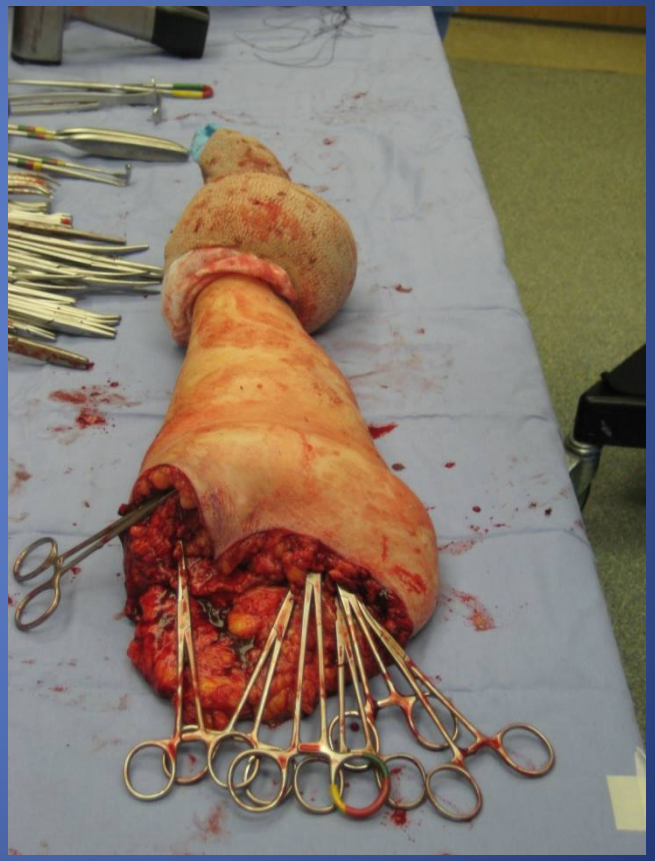


# Transhumeral Amputation

# Transhumeral Amputation

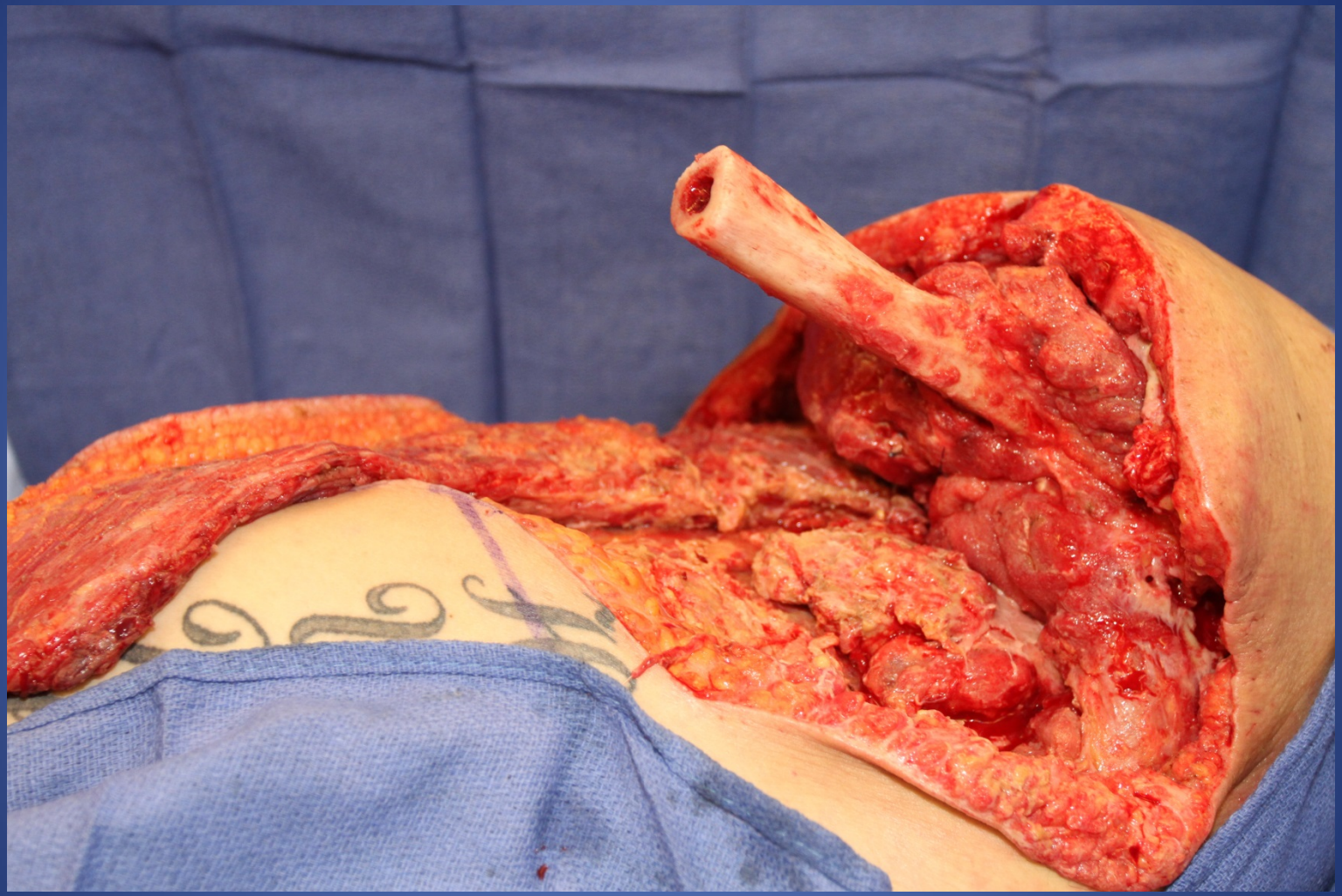


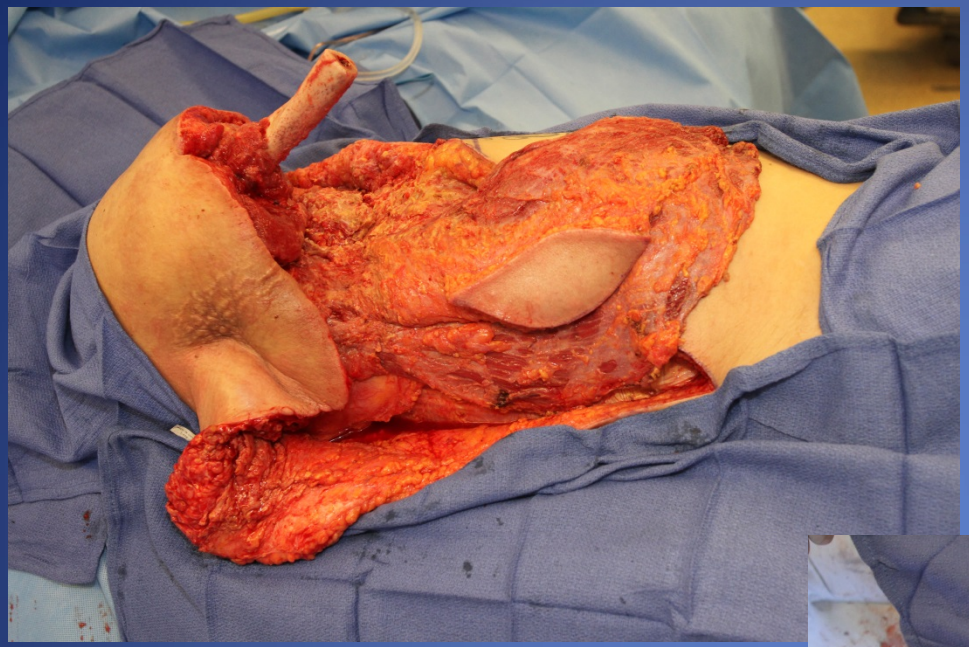


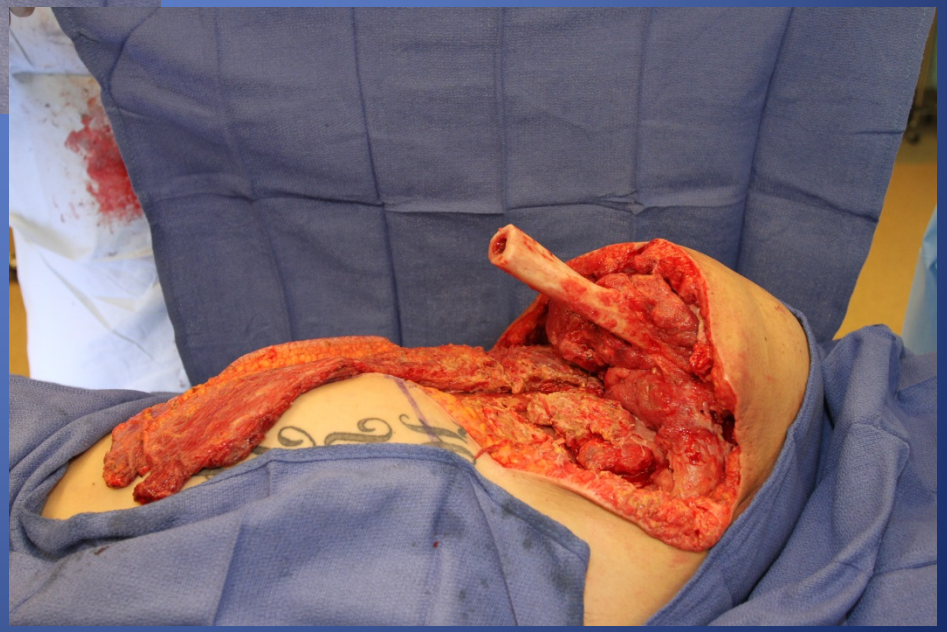
# Transhumeral Amputation

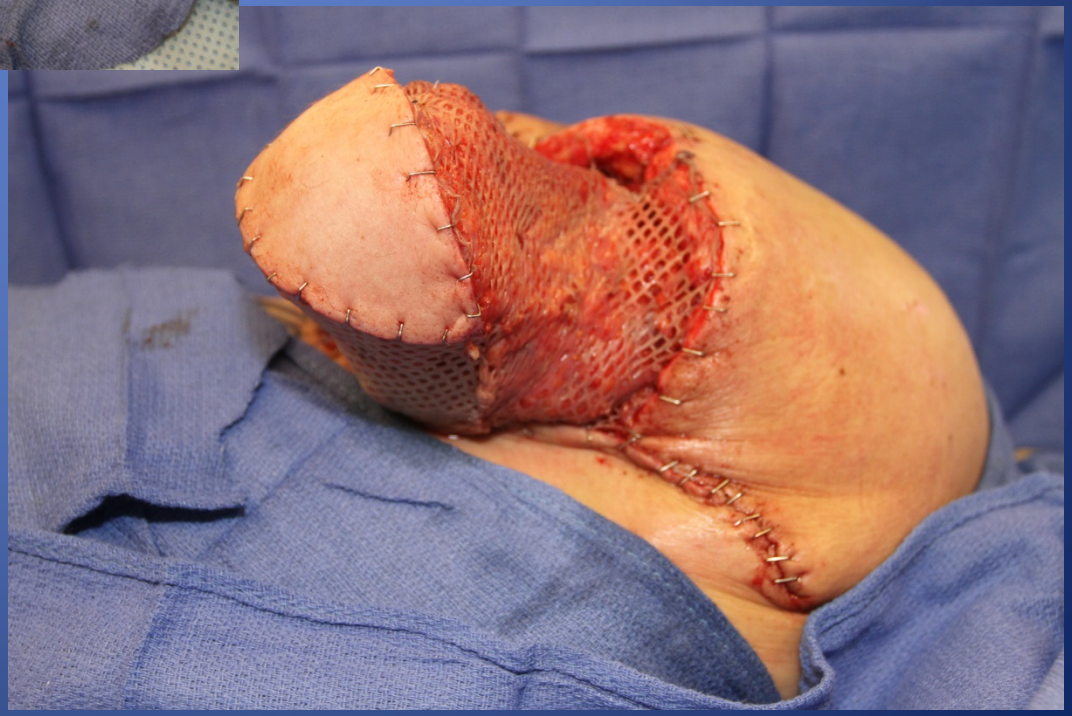
Follow-up

- Joplin, MO
- Working with prosthetist and local physician









# Shoulder Disarticulation

- Ultrashort transhumeral = modified disarticulation
  - Deltoid myofasciocutaneous flap
  - Surgical neck osteotomy
  - Latissimus dorsi and pectoralis major reattached
- Avoid brachial plexus entrapment
- Consider arthrodesis

# Shoulder Disarticulation

- Deltoid myofasciocutaneous flap
- Remove proximal humerus
- Avoid brachial plexus entrapment with vessels
- Glenoid fossa filling
  - Rotator cuff muscles
  - Pec major
  - Latissimus dorsi

# Scapulothoracic Disarticulation

Indications

- Necrotizing fasciitis
- Malignant tumors
- Severe trauma

- Remove upper extremity, scapula, majority of clavicle
- Significant cosmetic deformity

# Scapulothoracic Disarticulation

- Anterior or posterior approach
- Determines approach to subclavian vessels
- Posterior approach potentially less blood loss
- Primary closure unlikely
  - Staged management
  - Soft tissue coverage

# Complications

# Amputation Site Breakdown

Early

- Delayed wound healing
  - Immunocompromised
  - Malnourished
  - Infection
- Marginal necrosis
  - Appropriate surgical technique

# Amputation Site Breakdown

Late

- Deep infection
  - Usually associated with PVD, DM
- Adherent skin
- Poor prosthetic fit

# Infection

- Debridement
- Antibiotics
- Local wound care
- Secondary healing
  - Prolonged wound healing

# Amputation Site Prominence

- Overgrowth
- Bone spur
- Muscle atrophy
- Failed myoplasty/myodesis
- Skin hypertrophy
- Bursitis
- Bulbous/floppy residual limb
  - Poor surgical technique

# Amputation Site Prominence

Indications for Revision Amputation

- Poor prosthetic fit
- Limited function
- Pain
- Skin at risk

# Neurological Complications

- Neuroma
- Phantom limb pain

# Neuroma

- All nerve transections form neuromas

- Painful
  - Positive Tinel's

Causes

  - Poor surgical technique
  - Scar formation
  - High pressure area

# Neuroma

- Avoid
  - Nerve stump retracts into soft tissue away from scar and prominent areas
- Management
  - Prosthetic adjustment
  - Injection
  - Scar massage
  - Surgical resection

# Phantom Limb Pain

- May be nonpainful

- Painful
  - Up to 85% in LE
  - ~40-69% in UE

# Phantom Limb Pain

- Surgical
  - Dehydrogenated alcohol and marcaine into epineureum
- Non-surgical
  - Neurontin
    - Shown effective
  - Vitamin C?
  - Regional anesthetics perioperatively?

# Joint Contracture

- Usually related to short lever arm
  - Transhumeral
  - Transradial
- Quadriga

- Avoid with early therapy
- Contracture release and tenolysis may be required if fixed deformity

# Heterotopic Ossification/Bone Spur

Associated with:

- Severe trauma
- Excessive manipulation of periosteum
- Residual bone after osteotomy

- May require surgical resection if problematic
  - Recurrence of HO

# Special Considerations

# Krukenberg Procedure

- 1916 Hermann Krukenberg
  - World War 1
  - Soldiers and civilians
- Sierra Leone civil war
- Transradial amputees
  - Radial and ulnar rays

# Indications

- Bilateral transradial amputee and blind
- Unilateral or bilateral
  - Highly motivated
- No access to prosthesis

# Contraindications

- < 2y/o
- Elderly dependent
- Unable to accept appearance
- Elbow contracture
- Residual limb <10cm in adult
  - Poor pincer function

# Technique

- Ulnar and radial muscles divided
- Interosseus membrane released 12cm from the proposed bone ends
- 18-20 cm distal to elbow crease
  - Radius and ulna equal lengths
- Myodesis radius and ulna
- STSG preferred over muscle debulking

- Postop web management crucial

# Krukenberg Procedure

- Create a pincer
- Allows independent function
- Doesn’t preclude prosthetic use

# Replantation

# Indications

- Children
  - Any level
- Adults
  - Above wrist level
    - Significant metabolic risk

# Indications for Digits

- Multiple
- Through palm
- Near wrist
- Thumb
- Children
- Single digit distal to FDS insertion
- Single digit in professional

# Contraindications

- Associated life-threatening disease
- Medical co-morbidities—PVD
- Severe crush or avulsion injury
- Gross contamination
- Multiple level injury
- Excessive delay in treatment

# Outcomes for Digits

- 80-90% survival all levels
- Major factors
  - Age of patient
  - Experience of surgeon
- Early reoperation
  - Vascular occlusion up to 40%
  - Up to almost 50% survive

# Outcomes

- Postoperative hemorrhage
  - Up to 50%
- Sensation
  - Nearly all have protective sensation
  - Cold intolerance
- Nonunion and malunion
  - <5%
- Secondary surgery
  - Joint contracture release/tenolysis

# Replantation

Above digit level

- Adults
- <25% regain functional use
- Sensation present and some residual function = better than prosthesis

# Composite Tissue Allograft Transplantation

Hand Transplant

- 59 successful (41 patients)
- Composite tissue (vrs. Solid organ)
- Kidney tansplant protocol
- Direct Visualization/Biopsy
- Morbidity/Ethics
  - Infection/Malignancy/DM/CAD/HTN/Renal
- Bone Marrow Cell Chimerism
  - Tolerance
  - Low dose Immunosuppression

# Summary

- Upper extremity amputations above the digit are rare
- Trauma accounts for 90% of all UE amputations

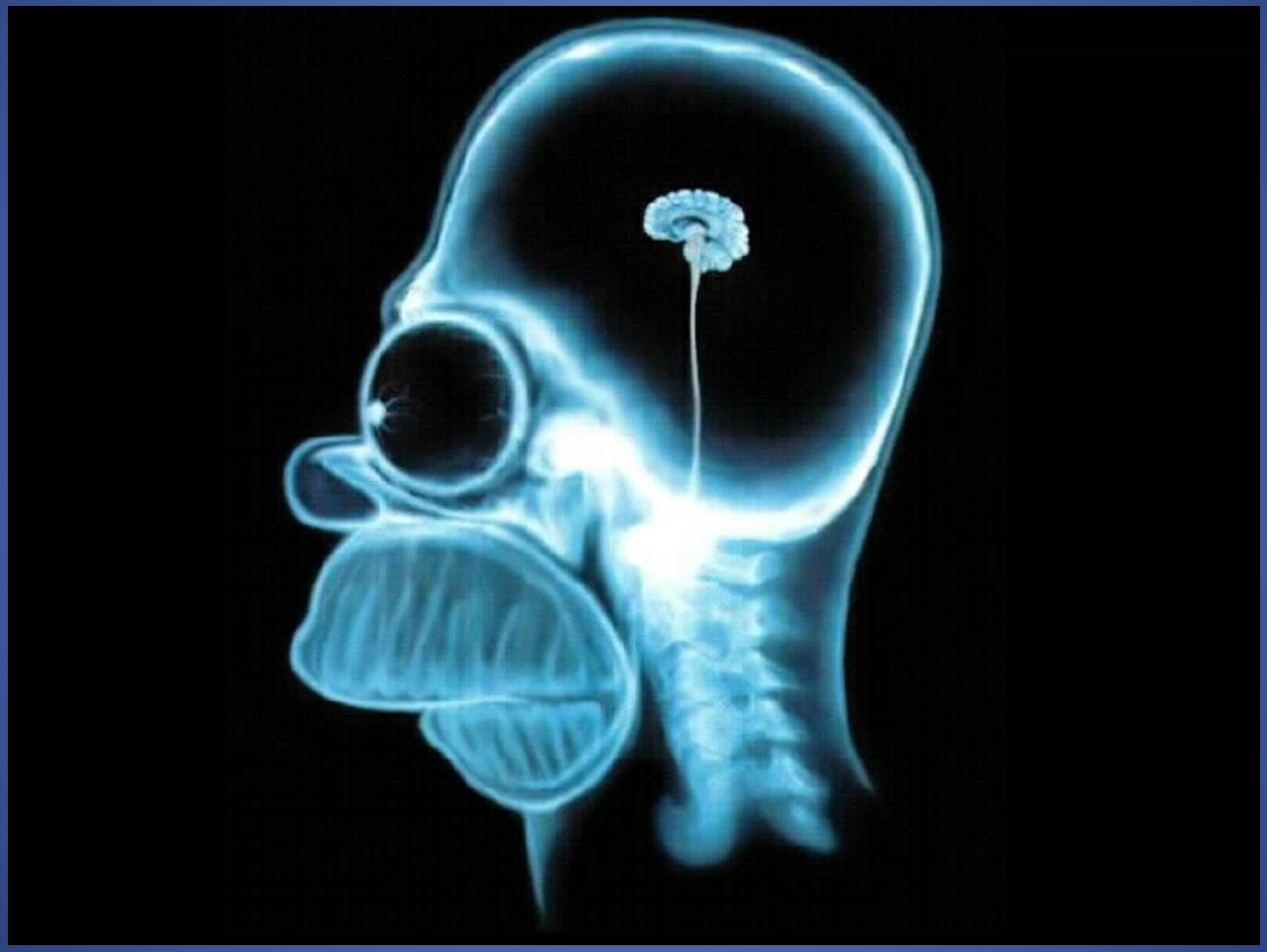
# Summary

- Restoring function is important
  - Reconstruction
  - Prosthesis
- Preserve length and joint motion
- Avoid complications

# Final Thoughts

- Sensation is key
- Be careful when using a table saw
- No matter how fun it seems, don’t hold a lit firework

# Questions?



# References


1. Smith DG, Michael JW, Bowker JH, American Academy of Orthopaedic Surgeons. *Atlas of amputations and limb deficiencies : surgical, prosthetic, and rehabilitation principles*. 3rd ed. Rosemont, IL: American Academy of Orthopaedic Surgeons; 2004.
2. Atroshi I, Rosberg HE. Epidemiology of amputations and severe injuries of the hand. *Hand Clin.* Aug 2001;17(3):343-350, vii.
3. del Pinal F. Severe mutilating injuries to the hand: guidelines for organizing the chaos. *J Plast Reconstr Aesthet Surg.* 2007;60(7):816-827.
4. Leit ME, Tomaino MM. Principles of limb salvage surgery of the upper extremity. *Hand Clin.* May 2004;20(2):v, 167-179.
5. Tamurian RM, Gutow AP. Amputations of the hand and upper extremity in the management of malignant tumors. *Hand Clin.* May 2004;20(2):vi, 213-220.