Surgical Considerations in Upper Limb Amputation

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• Institutional
  – None

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  – 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
Digit

Ray resection
  – Middle Finger
  – Ring Finger
Partial Hand

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
Case Example

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


