Surgical Considerations in Lower Extremity Amputation

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Disclosures

– None

– Original presentation by Brett Crist, MD
Objectives

• Understand the indications for lower extremity amputation
• Understand the principles and goals of lower extremity amputation
• Review specific levels of amputation and important considerations for each
• Review special considerations involving lower extremity reconstruction
Lower Extremity:
Purpose

• Ambulation/locomotion
Indications for Amputations

• Trauma
  – Acute
  – Chronic

• Medical Co-morbidities
Amputation Due to Trauma

- Trauma
  - 20-40 y/o males
  - 16% of amputations
  - 45% of amputees
Indications for Amputation

- LEAP
  - 569 patients followed prospectively
  - Amp vs. limb salvage
  - 2 and 7 year data
  - Hospitalization
  - White collar
  - =?

Bosse et al. NEJM 2002; JBJS 2005
Indications for Amputation

- Lack of plantar sensation
  - Not equal automatic amputation
  - >50% of salvages with initial lack of plantar sensation recovered by 2 years

Bosse et al. JBJSAm 2005
Indications for Amputation

• Military
  – Pushing the envelope
  – Extremity War Injuries
  – Symposia
Amputations Among Military

- Increased number of 3 and 4 extremity amputees
- IED’s = infection
- Soldiers with tourniquets
- Significant psychological and societal implications
Indications for Amputations

• Infection
  – 2º to diabetes

• Peripheral Vascular Disease
  – 2º to diabetes (71%)
  – 80% of lower extremity amputees
Indications for Amputations

• Neurological disorders
  – Peripheral neuropathy 2⁰ to diabetes
  – Lack of protective sensation
• Burn
• Congenital deformities
• Malignant tumors
  – Clear margin
Successful Amputation

• Removal of dysfunctional/devitalized tissue
  – easy

• Reconstruction of a durable residual limb
  – challenging
Goals of Amputation Surgery

- **Preservation of Length**
  - Prevention of adjacent joint contractures

- **Preservation of function**
  - Minimize energy expenditure

- **Early return to function**
  - Early prosthetic fitting when possible

- **Painless residual limb**
  - Prevention of symptomatic neuromas
  - Minimize phantom limb pain

- **Preservation of Life**
Energy Expenditure

• Normal energy expenditure
  – Walking
  – O2 consumption

• Level of amputation
  – Higher = more energy

<table>
<thead>
<tr>
<th>Amputation Level</th>
<th>Energy Above Baseline (%)</th>
<th>Speed (m/min)</th>
<th>O₂ Cost (mL/kg/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long transtibial</td>
<td>10</td>
<td>70</td>
<td>0.17</td>
</tr>
<tr>
<td>Average transtibial</td>
<td>25</td>
<td>60</td>
<td>0.20</td>
</tr>
<tr>
<td>Short transtibial</td>
<td>40</td>
<td>50</td>
<td>0.20</td>
</tr>
<tr>
<td>Bilateral transtibial</td>
<td>41</td>
<td>50</td>
<td>0.20</td>
</tr>
<tr>
<td>Transfemoral</td>
<td>65</td>
<td>40</td>
<td>0.28</td>
</tr>
<tr>
<td>Wheelchair</td>
<td>0-8</td>
<td>70</td>
<td>0.16</td>
</tr>
</tbody>
</table>

Gottschalk, Frank; Rehabilitation: Gait, Amputations, Prostheses, Orthoses, and Neurologic Injury, Chpt. 10.
General Amputation Principles

- Skin
- Muscle
- Nerves
- Blood Vessels
- Bone
Skin

• Painless, pliable, nonadherent scar

• Scar placement and prosthetic wear
  – Viable level

• Coverage:
  – Flap coverage
  – Skin graft
Muscle

• Myofascial closure
  – Provides minimal muscle stabilization
• Myoplasty
  – Balances opposing muscle groups
• Myodesis
  – Attach muscle to bone
• Tenodesis
  – Attach tendon to bone
Nerves

• Avoiding painful neuromas
  1. Separate nerve from vessels
  2. Traction nerve and sharply transect
     -Retracts to safety
  3. Nerve preparation
     -Injection of alcohol
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
  – Exostosis
Levels of Amputation
Levels of Amputation

- Toe
- Ray resection
- Partial forefoot
- Transmetatarsal
- Symes
- Modified Symes
- BKA
- Through knee
- AKA
- Hip Disarticulation
- Hemipelvectomy
• Interphalangeal
  – Leave cartilage
  – Trim condyles

• Transect tendons and nerves
  – Do not sew tendons together

• Great toe
  – Leave 1cm
  – Foot balance and function
Ray Resection and Partial Foot

- Includes toe and part of metatarsal
- Preserve 1st MT length
  - Orthosis
  - Foot balance
- Avoid sharp bony prominences
- Multiple lateral rays
Transmetatarsal

• Considered
  – 2 or more medial rays
  – More than one central ray
• Preserve length
• Maintain arch and metatarsal cascade
• Avoid Achilles contracture
  – Achilles lengthening
Transmetatarsal

Ng et al. JAAOS 2010
Negatives for Transmetatarsal

– Foot balance
– Prosthetic fit
– Wound healing
  • 33% primary wound closure
  • 56% may require revision to higher level
Symes

• Ankle disarticulation

• Required
  – Viable heel pad

• Modifications
  – Malleoli excision
  – Incision
**Symes**

**Benefits**
- Longer limb/less energy
- High level walkers
- End bearing for obese patients
- Ambulate without prosthesis

**Negatives**
- Wound healing
- Compliance
- Heel pad instability
Symes

- Must preserve posterior tibial arterial supply

Ng et al. JAAOS 2010
Below Knee Amputation

- Most common

- Longer is better
  - Always?
  - Soft tissue

- Minimum to utilize BKA prosthesis
  - 2.5 cm per 30cm pt height
  - 5cm distal to the tubercle
Below Knee Amputation: Techniques

• Long posterior myocutaneous flap

• Modify skin flaps based upon available skin

• ID neurovascular structures

• Isolate fibula and transect 1.5cm above tibia
• Tibial cut

• Bevel bone cuts

• Ligate vessels and transect nerves

• Myodesis vs. myoplasty
Below Knee Amputation

Staged

– Traumatic or infection
– Guillotine
  • Allows soft tissues and bone to declare
Ertl Procedure

• Tibiofibular synostosis

• Indication
  – Young
  – Proximal tib/fib instability
  – High activity level

• Outcomes
  – Functional scores = no benefit (Ng et al. JAAOS 2010)
Technique

- Fibula cut at same level
- Leave medial periosteal hinge
- Connect to tibia
  - Metal
  - Suture

Ng et al. JAAOS 2010
Case Example

- 45y/o s/p MCC
- Police officer
- Right open femur fx
- Right open tib/fib with vascular insufficiency
- Ex-fix
- Multiple debridements
- Progressive necrosis
Case Example
Case Example
Case Example

• Femur infected
  – ABX beads
  – IV abx
  – debridements

• 2 STSG
• Suture removal

• 11mo
After prosthesis

- c/o knee pain and crepitance
BKA at all costs

• Improved energy expenditure

• Soft tissue reconstruction to maintain length and knee function
  – Skin graft or substitute
  – Muscle flap

• More functional prosthesis
Case Example

- 40y/o male s/p BKA due to mangled lower extremity after go-cart accident

- Within 2 weeks of BKA and DPC
  - Infected
  - Necrotic skin
Options

• Revision to AKA

• Reconstruct soft tissue weight-bearing surface
Case Example

- Multiple debridements
- Negative pressure wound therapy (NPWT)
Case Example

- STSG low probability

- Muscle flap required
  - Gracilis rotation flap
Case Example

- Gracillis covering tibia

- STSG over muscle
Through Knee Amputation/Knee Disarticulation

• Prosthetists
  – Thumbs up or down

• End bearing residual limb

• Soft tissue coverage
  – Improved with posterior flap technique
Indications

- Trauma
- Infection
- Dysvascular
- Nonambulatory
  - *Risk of knee contractures with BKA
Through Knee Amputation/Knee Disarticulation

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Negatives</th>
</tr>
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<tbody>
<tr>
<td>– End bearing surface</td>
<td>– Knee height</td>
</tr>
<tr>
<td>– Sitting comfort</td>
<td>– Soft tissue coverage</td>
</tr>
<tr>
<td>– Longer lever arm</td>
<td></td>
</tr>
<tr>
<td>– Balanced thigh muscles</td>
<td></td>
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<tr>
<td>– Prosthetic suspension (femoral condyles)</td>
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</tr>
</tbody>
</table>
Technique

- Suture patellar tendon to cruciates
- Patella not distal to femur
Through Knee Amputation/Knee Disarticulation

• LEAP study
  – Slowest walking speed
  – Least satisfaction

– 12/18 no gastroc coverage->poor prosthetic tolerance

Mackenzie et al. JBJS 2004
Above Knee Amputation

• Maintain length

• Energy expenditure

• Recurrent infected total knee arthroplasty
  — Alternative to knee fusion
Technique

• Fish mouth incision
  - Modify to prevent weight bearing on incision

• Myodese adductors

• Myodese quad and hamstrings

• No myodesis = poor function and pain
  – Femur moves within muscular sleeve
Above Knee Amputation
Case Example: Maintain length at all cost

- 32 y/o s/p MCC
- Left open tibial shaft fx
- Left open bicondylar tibial plateau fx
- Left open femoral shaft fx
- Left femoral neck fx
- Left clavicle fx
- Left ulna fx
Case Example
Case Example
Case Example

- Rides horses
- No residual pain
Hip Disarticulation

Indications

– Preservation of life
– Co-morbid pt with infection and sepsis
– Necrotizing fasciitis
– Non-ambulators (paraplegics)
– Advanced ischemic disease
– Tumor
Hip Disarticulation

• Problems
  – Wound management
  – Sitting balance
  – No prosthesis?
    • May choose not to wear
    • Use crutches anyway
Technique

- Lateral position
- Medial and lateral skin flaps
- Use muscles to fill dead space
- Wound complications
Hemipelvectomy

• Indications
  – Same as hip disarticulation
  – Tumor more common
  – More common in military recently

• Procedure of last resort

• Poor functional outcome
Technique

• Semi-lateral position

• Large posterior flap

• Keep as much of the hemi pelvis as possible for sitting balance
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/amputation for infected hardware

- Adherent skin

- Poor prosthetic fit
Infection

• Debridement
• Antibiotics
• Local wound care
• Secondary healing
  – Prolonged wound healing
• Revision amputation
Amputation Site Prominence

• Overgrowth
• Bone spur
• Muscle atrophy
• Failed myoplasty/myodesesis
• Skin hypertrophy
• Bursitis
• Bulbous/floppy residual limb
  – Poor surgical technique
Indications for Revision Amputation

• Tissue prominence
  – Poor prosthetic fit
  – Limited function
  – Pain
  – Skin at risk
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
Indications for Revision Amputation

• Neurologic Complications
  – Neuroma
  – Phantom limb sensation
Neuroma

• All nerve transections form neuromas

• Painful
  – Positive Tinel’s

• Causes
  – Poor surgical technique
  – High pressure area
  – Crush injury
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

• Contracture release and tenolysis may be required if fixed deformity
Summary

• Lower extremity amputations are much more common than upper extremity
• Restoring function is important
  – Reconstruction
  – Prosthesis
• Preserve length and joint motion
• Avoid complications
• Patient counseling/support
Questions?
Thank You

Email:
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References


2. Scott et al. Traumatic and Trauma-related Amputations I and II. JBJSAm Dec 2010

3. Ng and Berlet. Evolving Techniques in Foot and ankle Amputations. JAAOS April 2010