Lower Extremity Amputations Secondary to Trauma

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Original Authors: Douglas G. Smith; March 2004; Steven A. Olson; March 2007; Daniel J. Stinner; 2011; Lisa K. Cannada; 2015
What is an amputation?

“Sometimes the extremities become gangrenous...you must cut off that limb as far as the disease has spread, so that the patient may escape death or greater affliction, greater than the loss of the limb.”

Albucasis, c. A.D. 1000
Moving forward

Benjamin Bell (1796)

- bad compound fractures, extensive lacerations or contusions

Increased use

US Civil War

• 53% amputation rate for severe LE trauma

• 40% mortality rate associated with amputation

Debridement

• Described as early as 3000 BC
• Championed by Pierre-Joseph Desault during the French Revolution
• Expanded and mainstreamed by Dominique Jean Larrey
• Modernized by Reyher

Karl von Reyher and the origins of debridement. White, E. Wounds UK | Vol 15 | No 3 | P 85; 2019
Modern era

• Anesthesia
• Antisepsis
• Antibiotics
• Vascular surgery
• Debridement


OVERVIEW

• Amputation Decisions
  • Indication
  • Level

• Amputation Technique
  • Below Knee Amputation (BKA)
  • Above Knee Amputation (AKA)
  • Knee Disarticulation (KD)

• Amputation Postop Care
  • Pain Control
  • Rehab
  • Prosthetic Selection
Who to Amputate?

• Sometimes the answer is obvious
• Other times things are less clear, at least initially
Amputation versus limb salvage

• Do the outcomes matter if we decide to amputate?

• LEAP data
  • No difference in Sickness Impact Profile (SIP) in prospective cohort study
  • More related directly to educational level of patient

Who to amputate?

• Scoring system? – none are predictive
  • MESS
  • NISSS
  • Others

• Plantar Sensation? - Not helpful as an indication for amputation


Who to amputate? Occupation?

- Civilian-LEAP
  - Equivalent
- Military-METALS
  - Favors Amputation

The Military Extremity Trauma Amputation/Limb Salvage (METALS) study: outcomes of amputation versus limb salvage following major lower-extremity trauma. Doukas WC; Mazurek MT; et al. JBJS (AM) January 16, 2013 - Vol 95(2), p 138-145

Things to consider

• Vascularity
• Compartment Syndrome
• Amount of muscle damage
• Ipsilateral associated injuries

Meta-analysis of prognostic factors for amputation following surgical repair of lower extremity vascular trauma.
Perkins ZB; Yet B; Glasgow S; Cole E; Marsh W; Brohi K; Rasmussen TE; Tai NR.
Things to consider

Patient resuscitation (Stability?)
  • High ISS-esp. proximal injury
  • Transfusion requirements
  • Bilateral injury
  • Mechanism

Acute bilateral leg amputation following combat injury in UK servicemen. Penn-Barwell JG; Bennett PM; Kay A; Sargeant ID; Severe Lower Extremity Combat Trauma (SeLECT) Study Group. Injury. 45(7):1105-10, 2014 Jul.
Things to consider

• Local capability
  • Military
    • Limited blood products
    • Holding capacity
    • Vascular repair
  • Smaller civilian hospital
    • Same as above
    • Critical care team?
Healthcare Cost

• Amputation
  • Requires less surgery
  • Quicker return to function

• Limb Salvage
  • Cheaper
  • More reoperations
  • Lower functional outcome

Financial Cost of Amputation

• Lost work time
  • 14-30 months recovery

• Patient’s Occupation
  • Retraining commonly required

• 50-60% return to work


Religious Concerns

- Religious opposition to amputation
- Amputated limbs
  - burial

What does the patient want?

• When in doubt, ask the patient, or the family
• Give them the options and the possible outcomes
• Guide the discussion
• Don’t make the decision
Timing

• Resuscitated patient
  • Higher ISS and MESS associated with amputation in theater
• Informed patient and family
Delayed Amputation

- No functional differences between early and delayed amputation
- No Psych differences
- No pain differences
- Increase in complications/LOS


Early versus delayed amputation in the setting of severe lower extremity trauma. Williams ZF; Bools LM; Adams A; Clancy TV; Hope WW. American Surgeon. 81(6):564-8, 2015 Jun.
Delayed Amputation

- Infection often the reason for late amputation
- Outcomes similar to early amputation
  - SIP
  - SF-36

The Military Orthopedic Trauma Registry: The potential of a specialty specific process improvement tool. Rivera JC; Greer RM; Spott MA; Johnson AE. J Trauma/Acute Care Surgery. 81(5 Suppl 2):S100-S103, 2016 11.

Functional and psychological outcomes of delayed lower limb amputation following failed lower limb reconstruction. van der Merwe L; Birkholtz F; Tetsworth K; Hohmann E. Injury. 47(8):1756-60, 2016 Aug.

Risk Factors for and Results of Late or Delayed Amputation Following Combat-related Extremity Injuries CPT Melvin D. Helgeson, MD; MAJ Benjamin K. Potter, MD; et al. Orthopedics. 2010;33(9)
Preoperative planning

• Perioperative pain control
• Level selection
• Timing of wound closure
Pain Control

• Think about it before surgery
• Peripheral nerve catheter
• Multimodal pain control
  • Gabapentin
  • NSAID’s

Debridement

- Removal of all nonviable tissue
- Decrease potential for infection
- Leave behind tissue with highest healing potential
- Systematic
- Repeated (esp higher energy such as blast or crush)
Level Selection

• Bone length

• Skin coverage

• Muscle cover/function

Level Selection (Trans Tibia (TTA) vs Trans Femoral (TFA))

- No significant functional or outcome differences depending upon the level
- No difference in relative energy cost (percent of maximum capacity) for walking
- Decreased cadence associated with amputation level


TFA vs Knee Disarticulation (KD)

- No increase in disability rating
- No difference in totally disabled
- Psych Issues
- No difference in functional outcomes
- Decreased pain in KD

Characterization of disability following traumatic through knee and transfemoral amputations. Tennent DJ; Polfer EM; Sgromolo NM; Krueger CA; Potter BK. Injury. 49(6):1193-1196, 2018 Jun.

TFA Length

- No difference in gait or VO2 max with 56% of uninjured limb length as cutoff between short and long TFA
- Self selected walking speed slightly faster in longer TFA

Bone Slice Culture

• Attempt to evaluate residual infection
• Used slice of bone at surgery
• Guide antibiotic treatment

Coverage

• STSG ok if muscle below
• Tissue expanders to increase coverage
• Negative pressure wound therapy
• Dermal regenerate
• Free Flap


Coverage in the Zone of Injury

• LEAP Data
  • 87 Rotational Flaps
  • 107 Free Flaps
    • Fracture

Filet flap

*Waste not want not*
  *Anterior coverage*
  *Distal coverage*
  *Heel pad skin*
  *Increased durability*


Skin Grafting

• CONS
  • Requires Blood Supply
  • Poor flexibility
  • Donor Site Issues

• PROS
  • Readily available
  • Easy to perform
Length Preservation

• Fix a fracture
  • Expect complications
• Bone transport


Rockwood and Green 9th ed., Pg 670, Fig 20-5
Length Preservation

• Fix a fracture
  • Expect complications

• Bone Transport
  • Expect complications
  • Simultaneous soft tissue and bone expansion
  • Slow distraction


Amputation Technique

• Nerve management
  • Traction (gentle)
  • Local insufflation (maybe)
  • Sharp transection (definitely)
• Location (end of flap vs back of knee for sural)

Proximal sural traction neurectomy during transtibial amputations. Tintle SM; Donohue MA; Shawen S; Forsberg JA; Potter BK. Journal of Orthopaedic Trauma. 26(2):123-6, 2012 Feb
Nerve Management

• Targeted Nerve Implantation (primary)

• Neuroma Excision (revision)

Wound Closure

• Timing

• Drain

Delayed Closure Is Associated with Decreased Infection Rate in Amputations after Trauma.

Healing adjuncts

• Topical antibiotics

• Incisional wound Negative Pressure Wound Therapy

Intrawound Antibiotic Powder Decreases Frequency of Deep Infection and Severity of Heterotopic Ossification in Combat Lower Extremity Amputations Pavey, GJ; Formby, PM; et al. CORR: April 2019, 477(4) p 802-810

Postop-General

- Splint
- Elevation
- Rehab
- Early mobility


Clinical Practice Guidelines for the Rehabilitation of Lower Limb Amputation: An Update from the Department of Veterans Affairs and Department of Defense. Webster, Joseph B. MD; Crunkhorn, Andrea DPT; et al; American Journal of Physical Medicine & Rehabilitation. 98(9):820-829, September 2019.
TTA/Below Knee Amputation Technique

• Ideal Situation
  • Long posterior flap (Burgess)
  • At least 2cm longer than the diameter of the leg at planned amputation level
  • Mark medial and lateral before incision

TTA/BKA Technique

• Cut and bevel tibia

• Cut fibula 1-2cm proximal to tibial cut

• Ensure no sharp edges

TTA/BKA Technique

- Myodesis of gastroc or gastroc soleus to tibia
  - Drill holes in tibia
  - Large braided polyester suture
  - Secure muscle to tibia
    - Padding
    - Function
The reality

To Ertl or not to Ertl?

• Bone bridging transtibial amputation

• Bone or bone and periosteal hinge swung onto tibia from fibula

• An Osteoplasty Originated in 1920’s by Janos Ertl

Rockwood and Green 9th ed., Pg 675, Fig 20-8

Traumatic and Trauma-Related Amputations: Part I: General Principles and Lower-Extremity Amputations. Tintle, LT Scott M. MD; Keeling, CDR John J. MD; et al. JBJS (AM). 92(17):2852-2868, December 1, 2010

Ertl Osteoplasty

• No clinical benefit
• Increased operative time
• Biomechanical and anecdotal support

Comparison of functional outcomes following bridge synostosis with non-bone-bridging transtibial combat-related amputations. Keeling JJ; Shawen SB; et al. JBJS (AM) 95(10):888-93, 2013 May 15.

Knee Disarticulation/Through Knee Amputation

- Anterior and posterior flaps
  - Gastroc coverage
- Preserve Adductor insertion
- Suture patella over bone end
- Myodesis of quad to hamstring
- Need adequate soft tissue coverage


Rockwood and Green 9th ed., Pg 668, Fig 20-4
Posterior Flap Technique
TFA/Above Knee Amputation Technique

• Flaps anterior and posterior
  • 1cm longer than ½ diameter

• Sharp dissection to bone laterally, anterior, and posterior

• Medially careful isolation and elevation of adductor magnus insertion

Rockwood and Green 9th ed., Pg 670, Fig 20-6
TFA/AKA Technique

• Bone cut 12-15 cm proximal to knee center of rotation
  • 15 cm above knee center of rotation Allows for a rotator

Rockwood and Green 9th ed., Pg 670, Fig 20-6

Myodesis

- Posterolateral drill holes
- Secure adductor lateral
- Suture Quadriceps posterior
- Add hamstring

Postop Care

• Splint for protection
  • Hip spica wrap
• Drain
• Elevation
• Tummy time
Outcomes

• Low Back Pain
• Bone Mineral Density
• Hypertension
• Pain
• Prosthetic Wear
General Outcomes- Transtibial

- 75% able to ambulate with prosthesis
- 24% Reoperation rate
- 2% Conversion to TFA


General Outcomes - Transfemoral

- SF-36 scores worse than BKA
- Equivalent 500m walking
- Increased prosthetic use and decreased pain vs KD/TKA

Outcomes in lower limb amputation following trauma: A systematic review and meta-analysis
Author links open overlay panelJowan G. Penn-Barwell. Injury Volume 42, Issue 12, Dec 2011, Pg 1474-1479
Low Back Pain

• Exceedingly Common
• May improve with PT
• Gait/Prosthetic fitting???

Chronic low back pain in individuals with lower-limb amputation. Kusljugic A; Kapidzic-Durakovic S; Kudumovic Z; Cickusic A. Bosnian Journal of Basic Medical Sciences. 6(2):67-70, 2006 May.

Bone Mineral Density

- Decreased
- Level Association
- Bilaterality
- Time to weight bearing

Bone mineral density loss after combat-related lower extremity amputation. Flint JH; Wade AM; Stocker DJ; Pasquina PF; Howard RS; Potter BK. Journal of Orthopaedic Trauma. 28(4):238-44, 2014 Apr.
Hypertension

• Present in amputees
• Questionable association
  • Cardiovascular Disease (CVD)
  • Mortality

Heterotopic Ossification

• Common in blast injury
• Amputation within zone of injury
• Partial excision
• Early removal (6 months)


Pain

• **Exceedingly Common**
  • Phantom pain
  • Residual Limb
    • Neuropathic

Phantom Limb Pain: A Review. Luo, Yong PhD, MD; Anderson, Thomas A. PhD, MD International Anesthesiology Clinics. 54(2):121-139, Spring 2016.

Pain Control

• Peripheral nerve catheter
• Multimodal pain control
• Multidisciplinary approach
• Cognitive/Behavioral

Neuropathic Pain

• Neuroma Excision

• Targeted Muscle Renervation


Osseointegration

• Skeletal Fixation
• Percutaneous prosthetic interface
• Avoids socket fitting issues


Osseointegration

• How do they do?
  • Significant improvement over Socket TFA
  • 55% reoperation rate
  • 100% superficial infection rate

Keeping Clean

• Derma clean is recommended for cleaning gel liners and the skin
• Mild neutral soaps can be used also
• Recommend only washing the residual limb once daily
Other Lower Extremity Amputations

• **Midfoot Amputation**
  - Trans metatarsal or Lisfranc disarticulation level, plantar based flap is best
  - Needs an Achilles lengthening to prevent equinus
  - Inadequate lever arm for walking so poor for active person

• **Hindfoot Amputation**
  - Chopart, or Boyd
  - Develops equinus
  - Poor walking lever arm – apropulsive gait
  - Associated with ankle fusion does give stable platform but not propulsive
Other Lower Extremity Amputations

- Ankle Disarticulation (Syme’s)
  - End bearing with few complications
  - Requires healthy skin over heel
  - Must protect posterior tibial artery as provides blood to posterior flap
  - Malleoli removed and heel pad sutured to anterior tibia
  - Need a dynamic responsive foot prosthesis
Syme’s Amputation

• Pitfall: heel pad migration
  – Anchor heel pad to anterior tibia
  – Excise subchondral bone – scar
  – Consider temporary pin stabilization
  – Tenodesis of Achilles to posterior tibia


• Very functional level
  – Easier suspension of socket but fewer prosthetic options than TTA
Other Lower Extremity Amputations

• Ray amputations – metatarsal and corresponding toe
  • 5th no disability
  • Central ray – wound healing problems
  • 1st ray decreases medial column stability
  • Narrow foot, forefoot equinus, shoe fitting problems
  • “tennis racket” incision around base of toe

• Toes
  • Better tolerated, little functional loss
  • Usually isolated
  • Commonly for diabetic infections
  • Plantar based incision if possible
  • Retain proximal phalanx if 2nd toe amputated as spacer to prevent Hallux drift
Team

• Meet the patient prior
• Previous amputees
• Come to hospital, rehab, clinic
Communication

• Realistic Expectations of Life Changes
• Simple questions
• Reassurance
• How long until prosthesis?
• Can I have the best?
Summary

• Whole patient approach
• Team
• Limb Salvage vs. Amputation is a Marathon, not a Sprint
SLIDE PICTURE REFERENCES


7. Slide 58: Bone mineral density loss after combat-related lower extremity amputation. Flint JH; Wade AM; Stocker DJ; Pasquina PF; Howard RS; Potter BK. Journal of Orthopaedic Trauma. 28(4):238-44, 2014 Apr.


REFERENCES


• Karl von Reyher and the origins of debridement. White, E. Wounds UK | Vol 15 | No 3 | P 85; 2019


• The Military Extremity Trauma Amputation/Limb Salvage (METALS) study: outcomes of amputation versus limb salvage following major lower-extremity trauma. Doukas WC; Mazurek MT; et al. JBJS (AM) January 16, 2013 - Vol 95(2), p 138-145


• Meta-analysis of prognostic factors for amputation following surgical repair of lower extremity vascular trauma. Perkins ZB; Yet B; Glasgow S; Cole E; Marsh W; Brohi K; Rasmussen TE; Tai NR. British Journal of Surgery. 102(5):436-50, 2015 Apr.

• Acute bilateral leg amputation following combat injury in UK servicemen. Penn-Barwell JG; Bennett PM; Kay A; Sargeant ID; Severe Lower Extremity Combat Trauma (SeLECT) Study Group. Injury. 45(7):1105-10, 2014 Jul.
REFERENCES

- Predictors and timing of amputations in military lower extremity trauma with arterial injury. Kauvar DS; Thomas SB; Schechtman DW; Walters TJ. JTACS. 87(1S Suppl 1):S172-S177, 2019 07.
- Early versus delayed amputation in the setting of severe lower extremity trauma. Williams ZF; Bools LM; Adams A; Clancy TV; Hope WW. American Surgeon. 81(6):564-8, 2015 Jun.
- The Military Orthopedic Trauma Registry: The potential of a specialty specific process improvement tool.
- Rivera JC; Greer RM; Spott MA; Johnson AE. J Trauma/Acute Care Surgery. 81(S Suppl 2):S100-S103, 2016 11.
- Risk Factors for and Results of Late or Delayed Amputation Following Combat-related Extremity Injuries
- CPT Melvin D. Helgeson, MD; MAJ Benjamin K. Potter, MD; et al. Orthopedics. 2010;33(9)
REFERENCES


• Characterization of disability following traumatic through knee and transfemoral amputations. Tennent DJ; Polfer EM; Sgromolo NM; Krueger CA; Potter BK. Injury. 49(6):1193-1196, 2018 Jun.


• Major amputation of lower extremity: prognostic value of positive bone biopsy cultures. Vaznaisiene D; Beltrand E; Laiskonis AP; Yazdanpanah Y; Miguad H; Senneville E. Orthopaedics & traumatology, surgery & research. 99(1):88-93, 2013 Feb.
REFERENCES

- Proximal sural traction neurectomy during transtibial amputations. Tintle SM; Donohue MA; Shawen S; Forsberg JA; Potter BK. Journal of Orthopaedic Trauma. 26(2):123-6, 2012 Feb
- Delayed Closure Is Associated with Decreased Infection Rate in Amputations after Trauma. Ali Y; Halvorson J; Nunn A; Miller P. American Surgeon. 85(5):501-504, 2019 May 01.
REFERENCES

• Intrawound Antibiotic Powder Decreases Frequency of Deep Infection and Severity of Heterotopic Ossification in Combat Lower Extremity Amputations Pavey, GJ; Formby, PM; et al. CORR: April 2019, 477(4) p 802-810


• Clinical Practice Guidelines for the Rehabilitation of Lower Limb Amputation: An Update from the Department of Veterans Affairs and Department of Defense. Webster, Joseph B. MD; Crunkhorn, Andrea DPT; et al; American Journal of Physical Medicine & Rehabilitation. 98(9):820-829, September 2019.


• Traumatic and Trauma-Related Amputations: Part I: General Principles and Lower-Extremity Amputations. Tintle, LT Scott M. MD; Keeling, CDR John J. MD; et al. JBJS (AM). 92(17):2852-2868, December 1, 2010

• Do Patients With Bone Bridge Amputations Have Improved Gait Compared With Patients With Traditional Amputations? Kingsbury T, Thesing N, Collins JD, Carney J, Wyatt M, CORR. 2014 Oct; 472(10): 3036–3043

• Comparison of functional outcomes following bridge synostosis with non-bone-bridging transtibial combat-related amputations. Keeling JJ; Shawen SB; et al. JBJS (AM) 95(10):888-93, 2013 May 15.

REFERENCES


• Amputation and rehabilitation. Colette Marshall, Tarig Barakat, Gerry Stansby Surgery (Oxford) Volume 34, Issue 4, April 2016, Pages 188-191


• Outcomes in lower limb amputation following trauma: A systematic review and meta-analysis. Jowan G.Penn-Barwell1. InjuryVolume 42, Issue 12, Dec 2011, Pg 1474-1479

• Chronic low back pain in individuals with lower-limb amputation. Kusljugic A; Kapidzic-Durakovic S; Kudumovic Z; Cickusic A. Bosnian Journal of Basic Medical Sciences. 6(2):67-70, 2006 May.


REFERENCES

• Phantom Limb Pain: A Review. Luo, Yong PhD, MD; Anderson, Thomas A. PhD, MD International Anesthesiology Clinics. 54(2):121-139, Spring 2016.


