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Understanding Amputations in the World of Trauma: The Various Types, Indications and Issues Associated with Them

Cynthia Blank-Reid, MSN, RN, TCRN, CEN
Trauma Clinical Nurse Specialist
Temple University Hospital
Philadelphia, PA

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Disclosures

- I have nothing to disclose except I only know how to play slot machines and bingo.
- Do not ask my advice on how to play any other game of chance.

Objectives

- Differentiate between the different types of amputations.
- Describe various patient populations that are prone to primary and secondary amputations.
- Describe the pathophysiology that occurs with various types of amputations.
- Identify key nursing and physician assessments and interventions that can prevent secondary amputations from occurring.
- Discuss injury prevention programs to prevent primary amputations.

Definitions

- Congenital amputations: a portion of the body is missing before birth
- Amputation: the surgical or traumatic separation of a body part from the body
- Surgical Amputation: a body part is removed due to tissue destruction, infection or disease due to being impossible to repair or it endangers the person's life.
- Double amputation: removal of both hands, feet, arms or legs

Definitions

- Traumatic amputation: sudden non-surgical removal of any body part. Can include arms, hands, fingers, legs, feet, toes, ears, nose, eyelids and genitalia.
- Primary amputation: performed without an attempt at limb salvage
- Secondary amputation: amputation of an extremity after an initial attempt for limb salvage.

Definitions:

- Physiologic Amputation:
  - Aka cryoamputation
  - bridge for high-risk surgical pts.
  - Allows time for management of comorbidites and reversal of metabolic and hemodynamic instability before surgery
  - Halts:
    - myonecrosis
    - myogloburia
    - rhabdomyolysis.

Physiologic/Cryoamputation

- Dry ice applied to ischemic limb.
- Extremely cold temperature physiologically amputates nonviable extremity and results in rapid control of sepsis and pain control.
- Is irreversible and must lead to a formal amputation.
- Pts can be managed for up to 6 weeks with this.

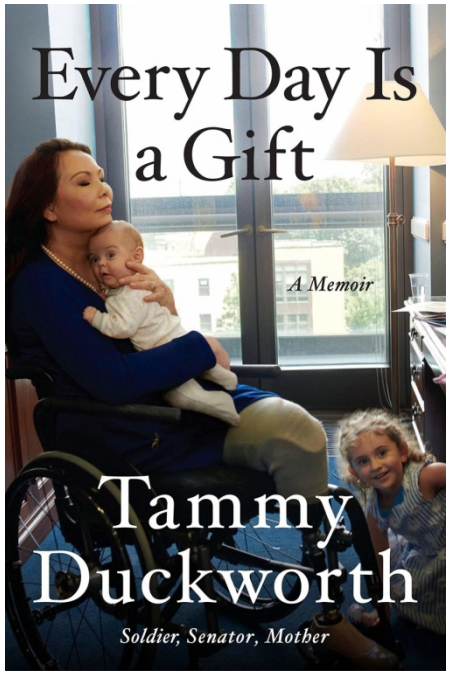
History of Amputations

- Neanderthals: 45,000 years ago lost upper limb and it appears to have been removed surgical
- Cave paintings in Spain, France and New Mexico from 36,000 years ago suggest the practice of self-mutilation to please gods during religious ceremonies.
  - Ritualistic or punishment – seal the remaining limb in boiling oil
- Ancient Greece: Hippocrates - first to use ligatures
- 1st century AD Rome: Aulus Cornelius Celsus – created skin flaps to cover the stump

History of Amputations

- 1330's - Gunpowder reached Europe: cannon balls can shatter bones and musket balls are 3 cm in diameter and did extensive damage
- 1529 - Amboise Pare (1510 – 1590) introduced "artery forceps"
  - 1579 – published his complete works on amputations and prosthetics
- 1674: Etienne J. Morel introduces the tourniquet
- 1843: Sir James Syme: reported procedure for ankle amputation
- Robert Liston (1794-1847): invented the rapid amputation
- April 12, 1861 – April 9, 1865: US Civil War (approx. 60, 000 amputations with a 26.3% mortality rate)

Amputations Across the Life Span



Age Spectrum: Pediatric Trauma Amputations

- Age Peaks for PTA:
  - 0-5 – fingers caught between objects
  - 15-17 – firearms, MV
- 3:1 male to female ratio
- Most common type:
  - finger (54%)
  - toe (20%)

Age Spectrum: Pediatric Trauma Amputations

- Common mechanisms:
  - Caught between mechanism (16.3%)
  - Machinery
  - Powered lawn mowers
  - MV collisions
  - Firearms
  - Off-road vehicles

Age Spectrum: Military Service

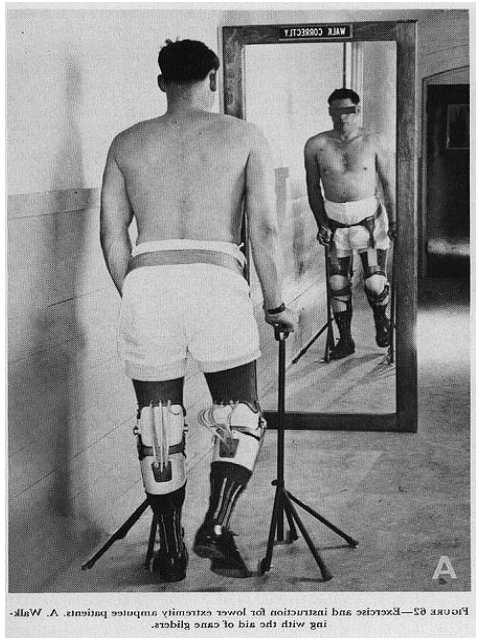


Figure 52—Exercise and instruction for lower extremity amputee patients. A. Walking with the aid of cane gliders.

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The Age Spectrum: Traumatic Amputation

- 20 – 65 years: 90% are upper extremity
- Male:Female = 4:1
- Most are at level of digit
- Major limb amputations less common
- Revascularization possible if incomplete amputation
- Replantation possible for some complete amputation

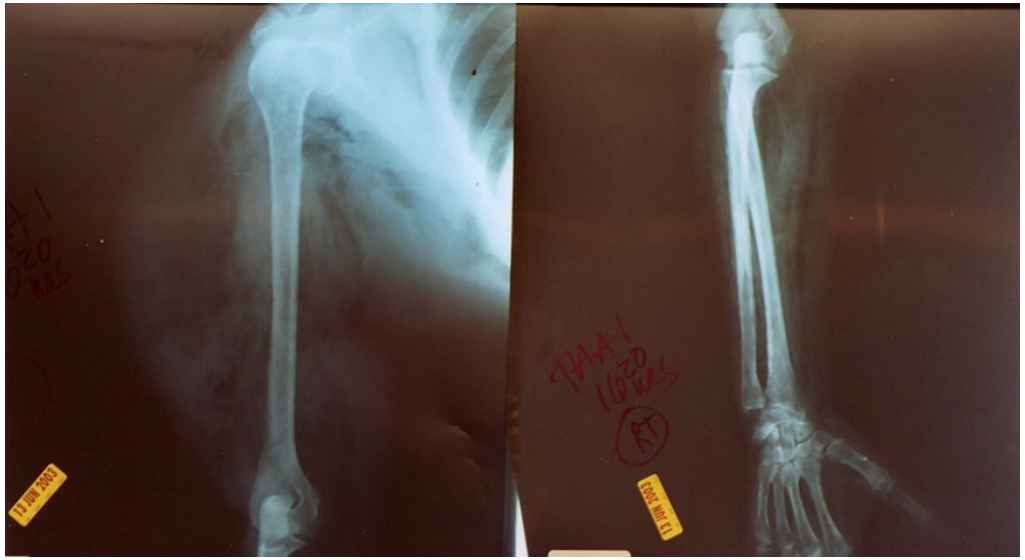
The Age Spectrum – Geriatric Amputations

- The majority of amputations for those over 65 years of age are related to medical conditions:
  - IDDM
  - PVD
  - Non-healing wounds
  - Burns

Causes of Amputation

- Congenital Deformities
- Malignant Tumors
- Peripheral Vascular Disease
- Neurologic Conditions
- Infections
- Burns
- Trauma

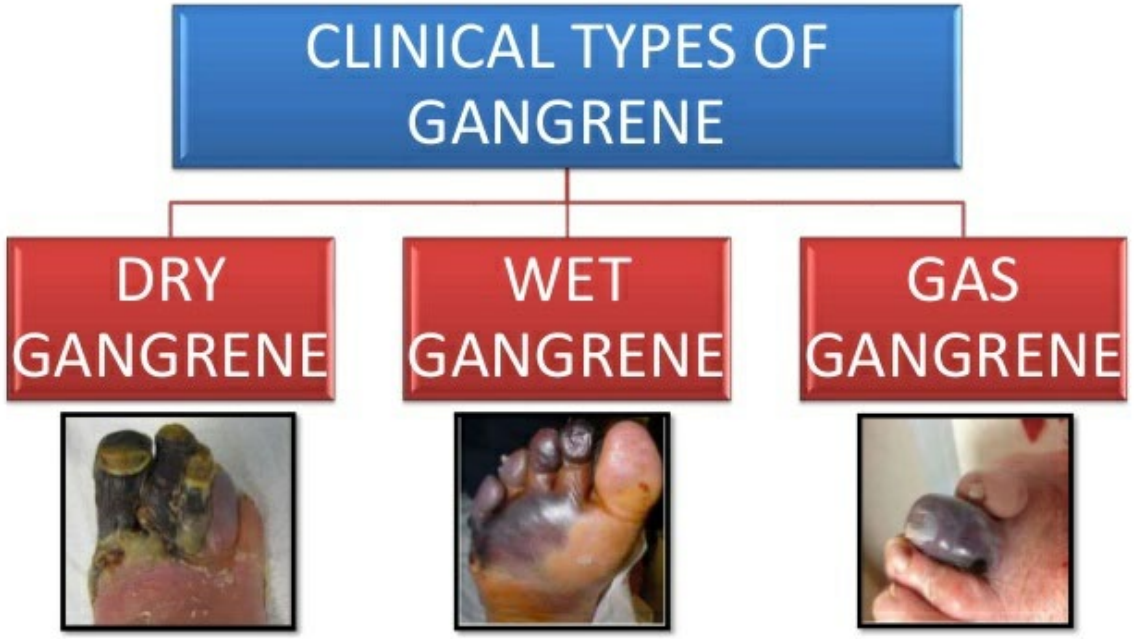
Gangrene



Gangrene

Differences between Dry and Wet Gangrene

Dry Gangrene	Wet Gangrene
• Clear line of demarcation is seen.	• Line of demarcation is vague.
• Dry, shriveled, mummified.	• Edematous, putrefied, discolored
• Slow, gradual loss of blood supply.	• Sudden loss of blood supply.
• Separation is by aseptic ulceration.	• Septic ulceration causes separation.
• Limits to the demarcation.	• Can extend proximally rapidly.
• Causes are- atherosclerosis, TAO (Thromboangitis obliterans).	• Emboli, trauma are the causes.
• Limited amputation is sufficient.	• Major higher amputation is often needed.



Causes of Traumatic Amputations

- Farm workers secondary to heavy machinery
- Factory workers when is limb is caught by heavy machinery

- Motorcyclists who have a collision with a driver of another vehicle
- Snow blowers
- Lawn blowers
- Power tools (saws, etc)

Causes of Traumatic Amputation

- Mechanical power press
- Power press brakes
- Powered and nonpowered conveyors
- Printing press
- Roll-forming/roll bending presses
- Food slicer
- Meat grinder
- Meat-cutting band saw
- Drill presses
- Shears
- Grinders
- Slitter

Types of Traumatic Amputations

- Crush
- Guillotine
- Avulsion

Crush Injury Amputations

- Most common amputation injury
- Can result in significant tissue damage and injury
- May be life-threatening
- Difficult to treat due to cellular destruction and damage to vessels and nerves
- Less likely to be successfully reattached

- Sequelae
  - Hemorrhage, hypovolemic shock
  - Destruction: muscles, bones
  - Myoglobinuria, rhabdomyolysis, metabolic acidosis, renal failure, compartment syndrome
  - Infection, pain
  - Loss of NV function distal to injury

Crush Injuries

- Administer IV crystalloid to increase urinary output and excrete myoglobin.
- Continually reassess urinary output, presence of myoglobin in urine
- Rhabdomyolysis leads to acute renal failure, systemic sepsis and death.
- Prepare for multiple surgical debridements

Myoglobinuria and Rhabdomyolysis

- Presence of excess amount of myoglobin in urine.
- Mostly caused by muscle breakdown which releases myoglobin in blood.
- Rhabdomyolysis is a disorder from having myoglobinuria
  - Can lead to AKI, hyperkalemia, compartment syndrome, systemic sepsis, DIC, cardiac arrest.

Ways to See if You Have Rhabdo

Guillotine Amputations

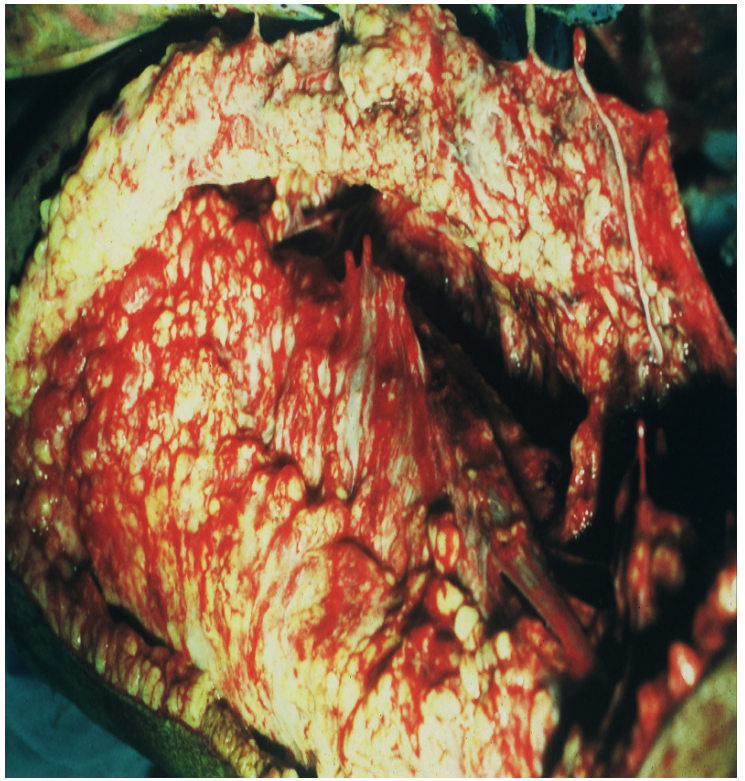
- involve sharp edges, resulting in less tissue disruption
- body parts amputated by guillotine forces are more likely to have better reattachment and recovery outcomes

Avulsion

- Poorest outcomes in regard to reattachment.
- Ring finger injury very common
- Degloving injury, tendons, ligaments, nerves, arterial and venous vessel interruption can occur

Degloving Injury

- A serious type of avulsion injury resulting from high-energy shearing forces that tear large areas of skin and subcutaneous tissue away from the underlying vascular supply.



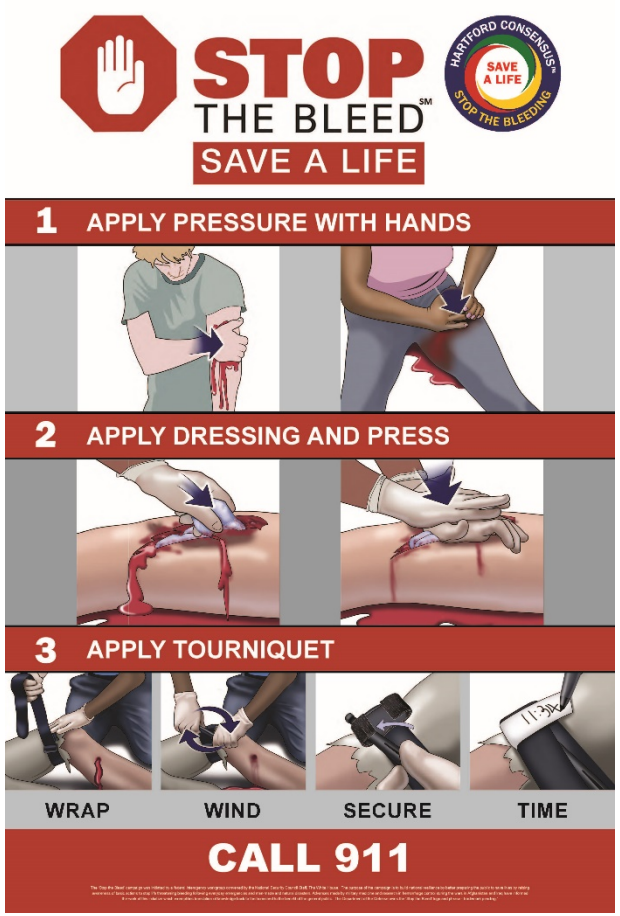
Mangled Extremity

- Variant of the crush injury
- Extensive injury
  - Bone
  - Soft tissue
  - Nerve
  - Vasculature
- Remains attached to the body
- Mangled Extremity Severity Score (MESS)
  - Salvage or amputate?

Reproduced from Bain, K., Parizh, D., Kopatis, A., & Kilaru, R. (2016). Mangled extremity: To salvage or not to salvage? *BMJ Case Reports*. Retrieved from http://casereports.bmj.com/content/2016/bcr-2016-218359.full

Pre-Hospital Management

- Apply direct pressure or tourniquet
- Call 911
- Wrap amputated stump and part in clean sheet/towel or clean container
- Send the body part with patient
- Determine destination and transport time - “time is tissue”

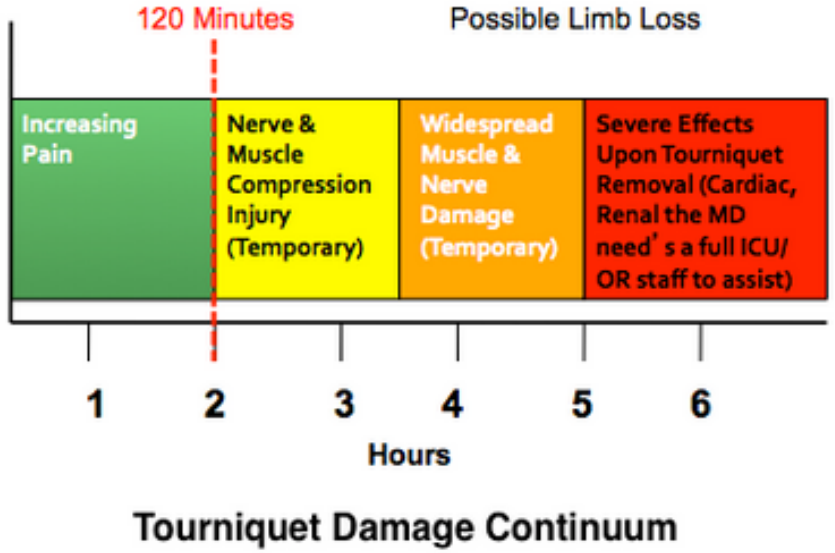


Pre-Hospital Scene

- Primary assessment and ABCs
- Establish and maintain hemodynamic stability
- Control any bleeding
  - Either severe or controlled
  - Partial amputations bleed more
  - Monitor for hypovolemic shock
- Obvious tissue loss, collect part(s)
- Pain control

At The Hospital

- Staying at facility or moving on?
- If body part not with them - send for it?
- How long has tourniquet been on?
- Pain meds
- Tetanus, antibiotics



At The Hospital

1. Wash amputated part with water to remove gross contaminants

2. Wrap amputated part in moist gauze

3. Place wrapped amputated part in dry plastic bag

4. Place bag with amputated part in another plastic bag with ice

What Are We Going To Do?

Replantation: Limiting Factors

- Availability of a replantation team
- Amount of damage to the attached and amputated parts
  - Severely crushed or mangled parts
  - Multiple levels of injury
  - Sharp, guillotine-like cuts have better outcome than crush or avulsion injuries
- Method of preservation of the amputated part and time elapsed since injury
  - > 6 hours ischemic time
  - Severe contamination
- Other serious injuries patient may have
- Co-morbid conditions patient may have
  - Peripheral vascular disease
  - Atherosclerotic vessels
  - Diabetes
  - Smoking
  - Severe mental health issues
  - Others

Replantation

- Muscles can survive 12 hours of cold ischemia; bone tendon and skin can survive 24 hours; warm survival time is much less
- Predicted outcome of replantation further determined by age, occupation, motivation and general physical condition of patient.
- Upper extremity replantation more successful than lower.
- Children usually have better outcomes than adults.

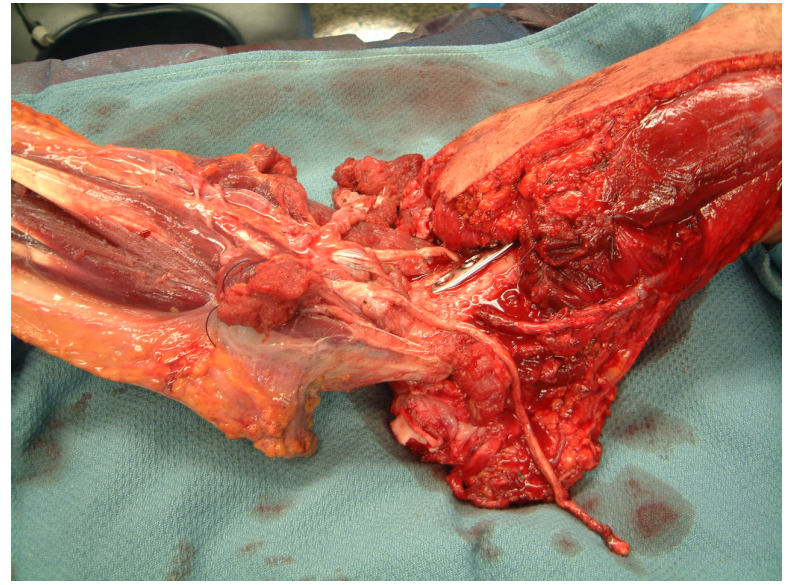
Amputation: Major Limb Replantation Outcomes

- >2/3 survival rate
- Can be a life threatening undertaking
- Multiple Surgeries often required
  - Nerve, Bone, Tendon Surgeries
- Function of major upper extremity replantations superior to prosthetic function

- Upper extremity non-weight bearing
  - Less durable skin acceptable
  - Decreased sensation better tolerated
  - Joint deformity better tolerated
  - Late amputations rare

Major Limb Replantation

Include Surgical Prep of Legs
for vascular and nerve grafts



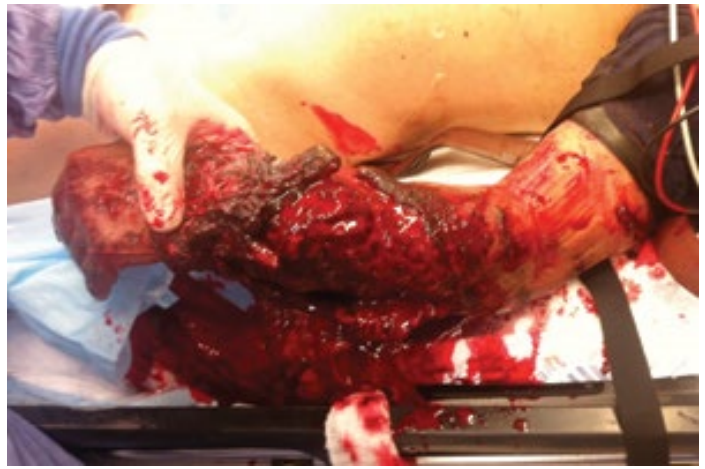
Rapid Bone Stabilization
Ready for Anastomosis

Major Limb Replantation

- Myonecrosis is greater concern than in digit replant
- Immediate shunting to obtain arterial inflow may be necessary
- High Potassium levels (>6.5 mmol/l) in venous outflow from amputated part negative prognostic factor
- Sequence of repair similar to digit
  - Identify structures, debride, rapid bone stabilization, vascular repair (artery then veins), tendons and nerves

Peri-Operative Phase

- Physician determines level of amputation and where to place additional tourniquets if needed.
- Tourniquets occlude lymphatic and vascular flow to and from the extremity.



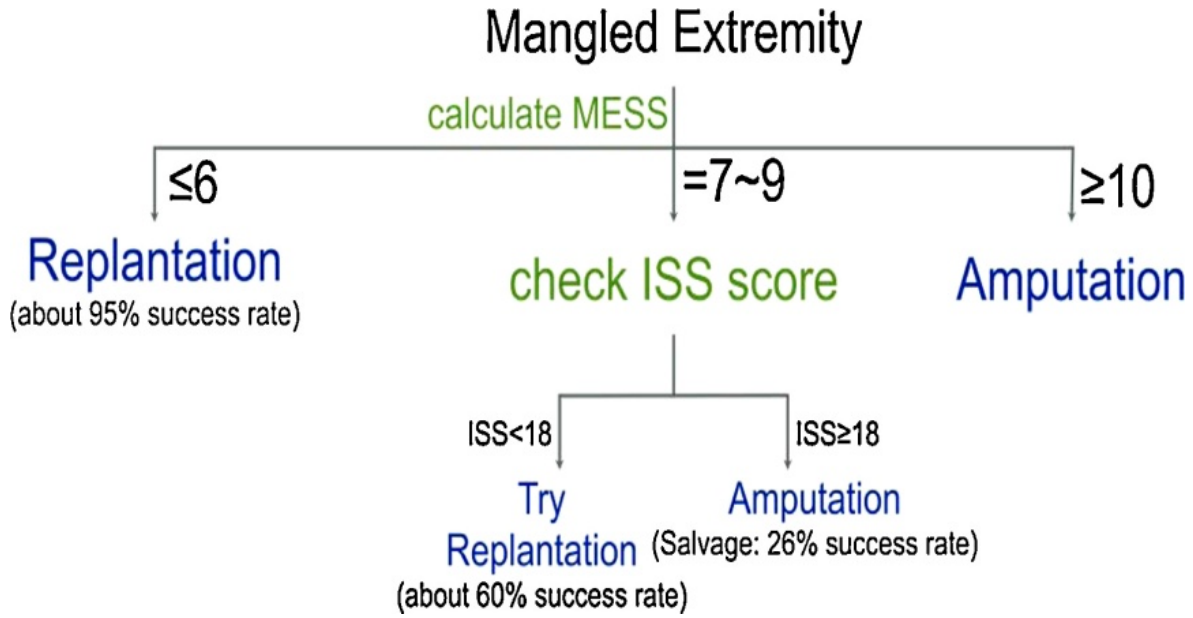
Decision to Amputate

Mangled Extremity Severity Score (MESS)

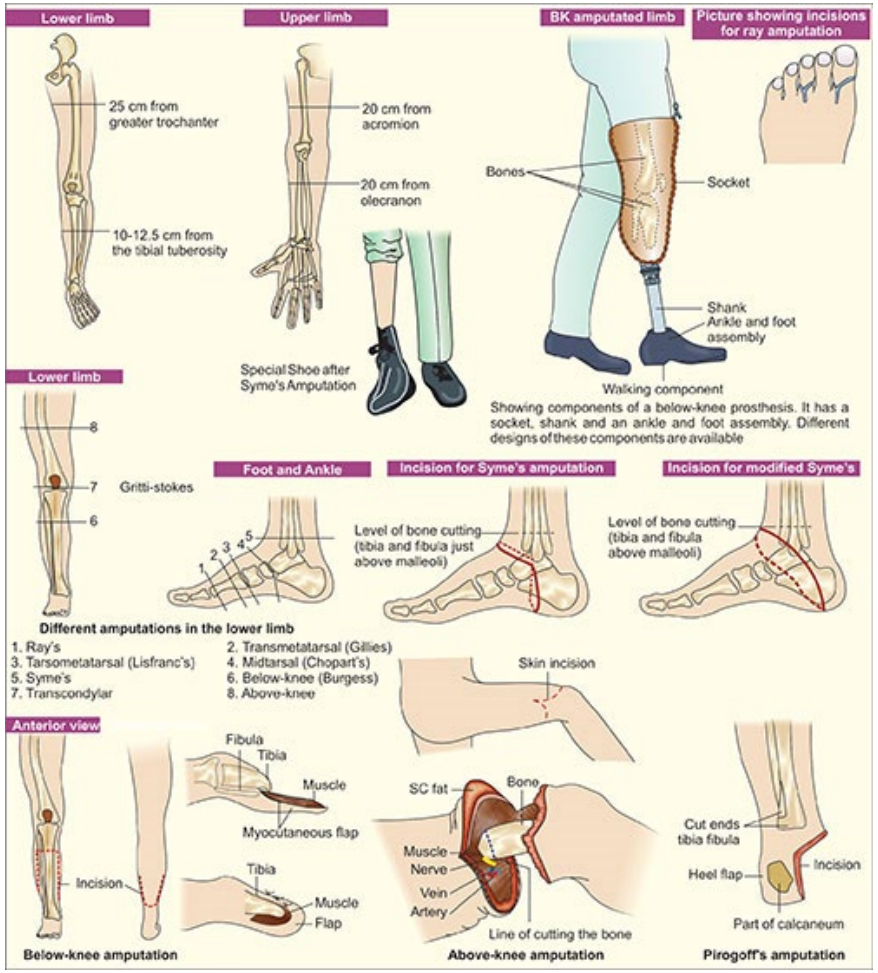
Type	Characteristics	Injury	Points
1	Low energy	stab wound, simple closed fx, small-caliber GSW	1
2	Medium energy	Open/multilevel fx, dislocation, moderate crush	2
3	High energy	shotgun, high-velocity GSW	3
4	Massive crush	Logging, railroad, oil rig accidents	4
Shock Group			
1	Normotensive	BP stable	0
2	Transiently hypotensive	BP unstable in field but responsive to fliud	1
3	Prolonged hypotension	SBP <90mmHg in field and responsive to IV fluids in OR	2
Ischemia Group			
1	None	Pulsatile, no signs of ischemia	1
2	Mild	Diminished pulses without signs of ischemia	2
3	Moderate	No dopplerable pulse, sluggish cap refill, paresthesia, diminished motor activity	3
4	Advanced	Pulseless, cool, paralyzed, numb without cap refill	4
Age Group			
1	<30y/o		0
2	>30 <50		1

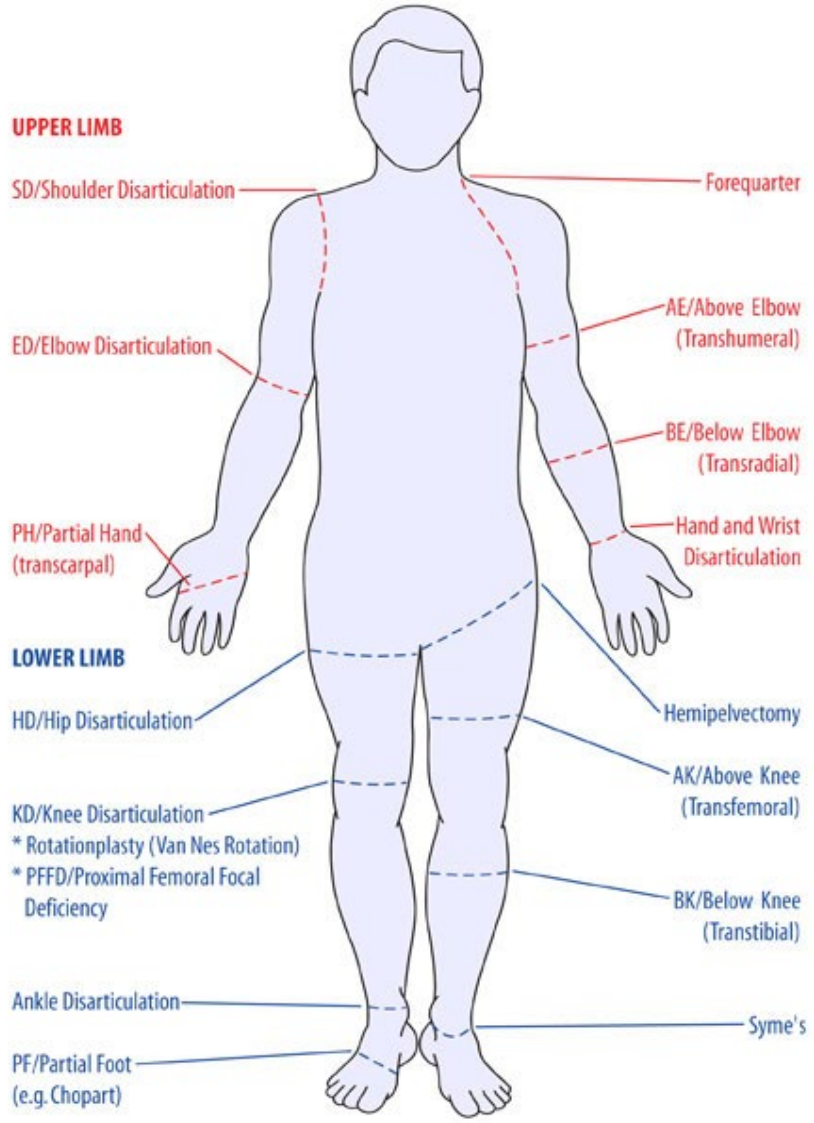
MESS score: six or less consistent with a salvageable limb. Seven or greater amputation generally the eventual result.

From Helfet DL, Clin Orthop 1990 256:80



Determining Levels of Amputations





Surgical Approaches to Amputation

- **Standard Amputation:** remove the limb, and anchor muscles to the cut end of the bone and cover it with skin.

- **Osseointegration (OI): remo**ve a body part and insert a steel implant into the stump of the leftover bone. A prosthetic can attach to that implanted piece.

- **Rotationplasty:** might be a choice for some patients with a tumor in bone or soft tissue, surgeons remove the part of the limb where the cancer is, and any healthy tissue below the tumor is turned around and re-attached.

Peri-Operative Phase

- Gigli saw – flexible wire saw for bone cutting. Used when bones have to smoothly cut

Determination of Level of Amputation

- Preservation of functional residual limb length

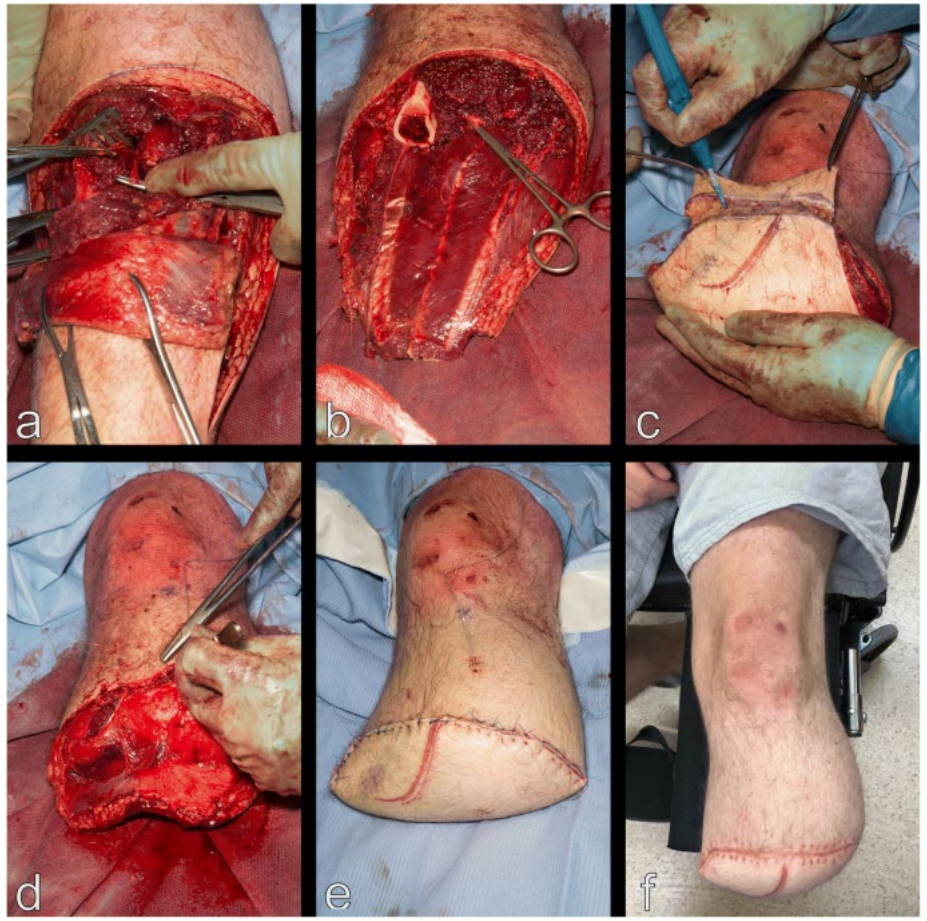
balanced with

- Soft tissue reconstruction to provide a well-healed, non-tender, physiologic residual limb

- Zone of Injury (trauma)
- Adequate margins (tumor)
- Adequate circulation (vascular disease)
- Bone and joint condition
- Control of infection
- Nutritional status

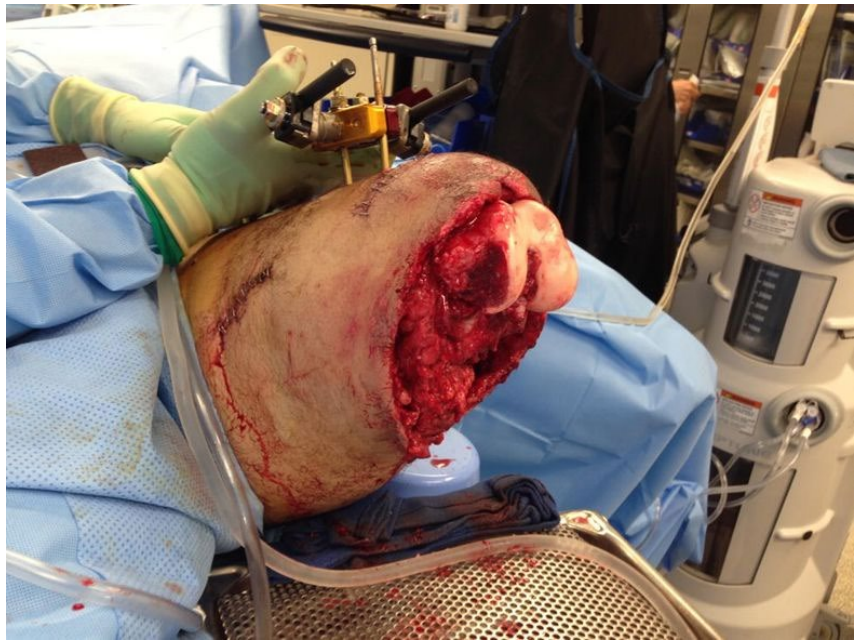
Levels of Amputation

- Preserving a joint while doing debridement of all nonviable tissue and foreign material
- Several debridements may be required
- Primary wound closure often contraindicated



Types of Amputation Closures

- Open amputation:
  - Wound is left open over stump
  - Flaps are not closed primarily, the amputation is revised at a later date with reamputation, or plastics repair
  - Guillotine technique:
    - Most primitive type
    - all tissues cut at same level, used for severe crush injuries and severe infections
    - Always followed by reamputation and then a skin flap

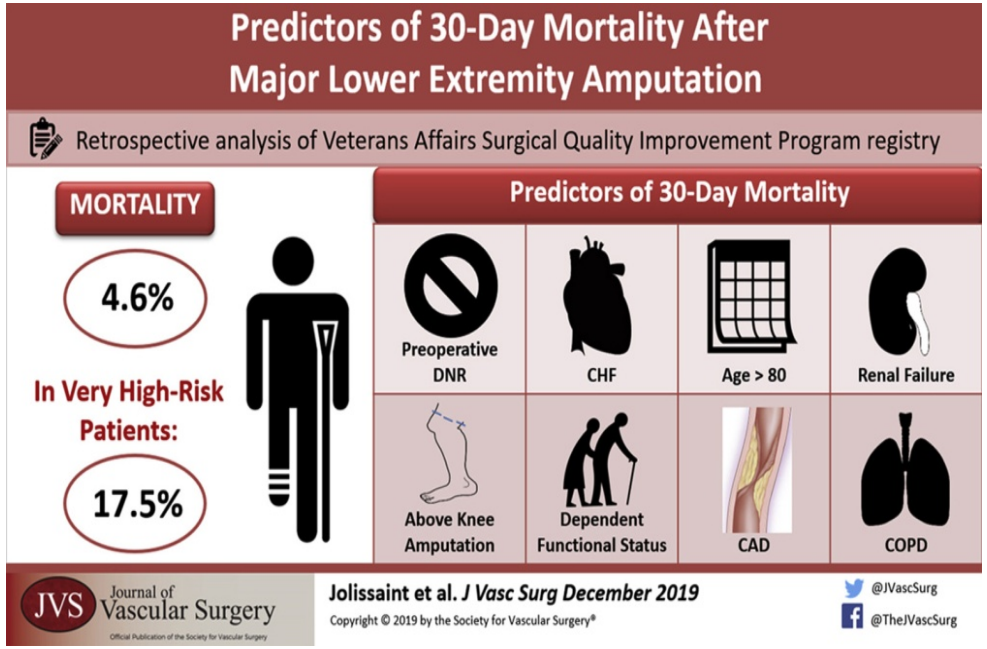


Types of Amputation Closures

- Closed amputation:
  - Usually an elective procedure
  - Flaps are fashioned and are closed primarily during surgery

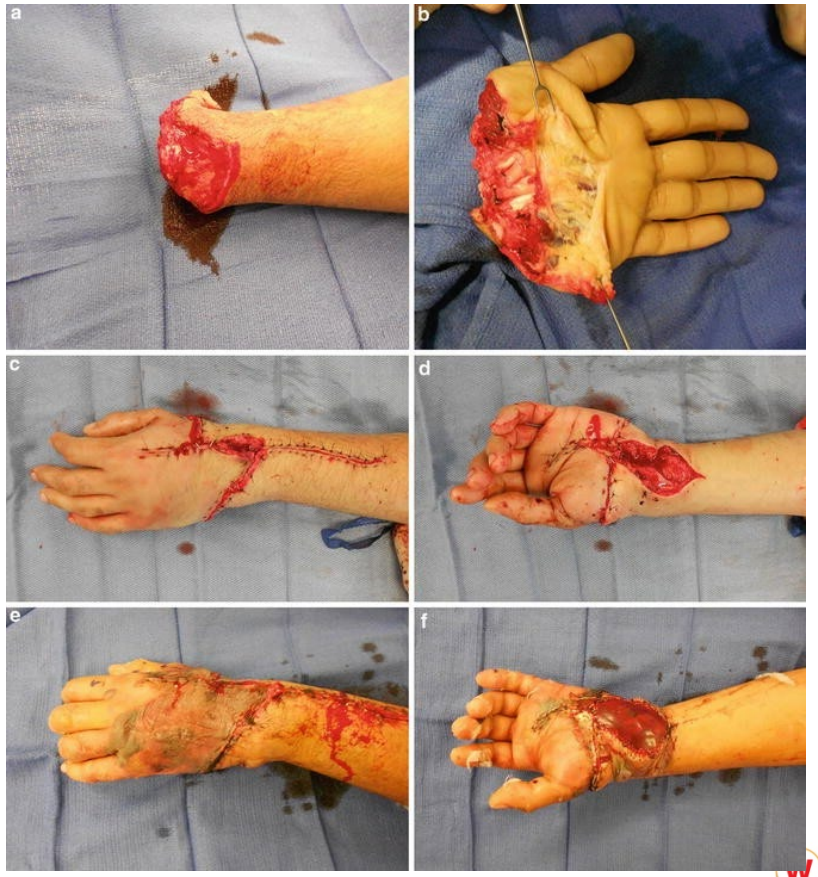
Post-Op Issues

- Goals of Post-Op Management
  - Prompt, uncomplicated wound healing
  - Control of edema
  - Control of post-op pain
  - Prevention of joint contractures
  - Rapid rehabilitation
- Early Issues:
  - Bleeding & hematoma
  - Failure to heal - flap necrosis
  - Surgical wound infection



Post-Operative Replantation Monitoring

- Examination
  - color
  - capillary refill
  - temperature
  - turgor
  - bleeding
- Pulse Oximeter
- Dopplers
- Examination – visual, palpation



Failing Replantation

Sign	Venous Insufficiency	Arterial Insufficiency
Color	Purple	Pale
Turgor	Engorged	Flaccid
Cap Refill	Brisk	Slow
Temp	Low	Low
Pulse	Intact	Absent

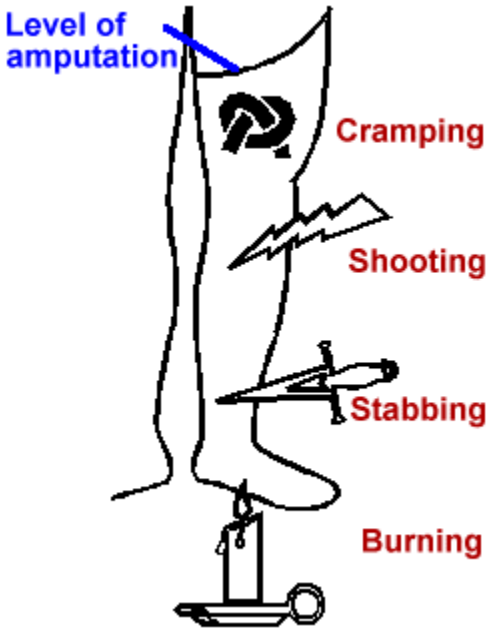
Failing Replantation

- Remove dressing
- Check BP
- Warm patient
- Regional block
- Re-explore
- Leech therapy

- Indications for Leech Therapy
- Venous insufficiency
  - 60-70% salvage rate on digit replants and pedicle flaps
- Not arterial insufficiency
  - leech will not attach
  - risk infection of ischemic tissue

Phantom Pain

- Almost universal in pts who undergo amputation
- Remaining nerve connections in the spinal cord and brain “remember” the body part
- Feels like shooting, stabbing, boring, squeezing, throbbing, burning
- Decreases in 75% of the time approx. 2 years after amputation



Post-Amputation Issue

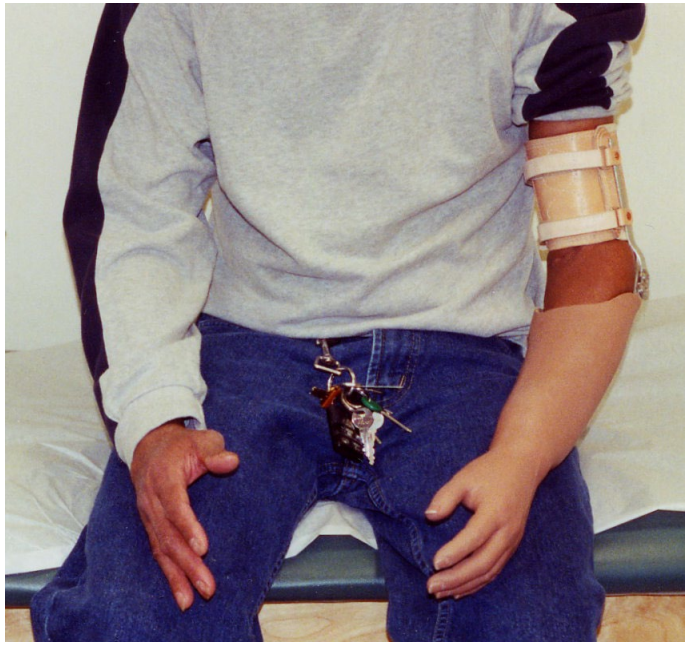
- Infection and sepsis can develop quickly
- Culture stump, x-ray for foreign bodies
- Appropriate antibiotic coverage
- Negative pressure wound therapy for closure

Post-Amputation Issues

- Pts with a transfemoral amputation after 10 years have approx four-fold increased risk of cardiac event .
- The risk of a cardiac event is the same no matter what the cause of the amputation was.
- These individuals also have increased risk of non-cardiac mortality .

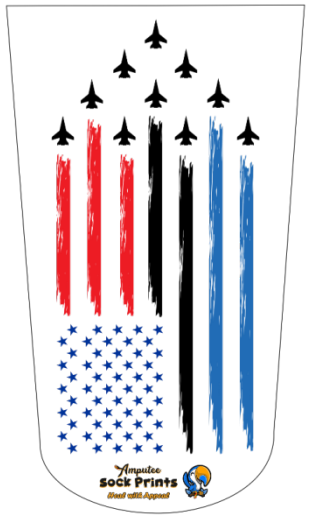
Rehabilitation and Prosthetics

- Residual Limb Shrinkage and Shaping
- Limb Desensitization
- Maintain joint range of motion
- Strengthen residual limb
- Maximize Self reliance
- Patient education: Future goals and prosthetic options



Healing and Wound Care After Amputation

- Post-amputation stump: wound needs to heal all the way; may be kept bandaged for awhile
- After initial bandaging comes off, compression device (aka shrinker sock) applied
  - Helps prepare stump for prosthesis – will gradually wear it for 23 hours/day



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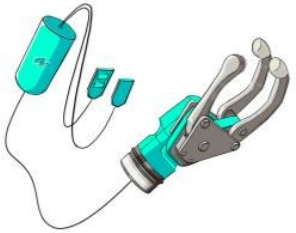
Types of Prosthetics

Aesthetic prosthetics

Mechanical prosthetics

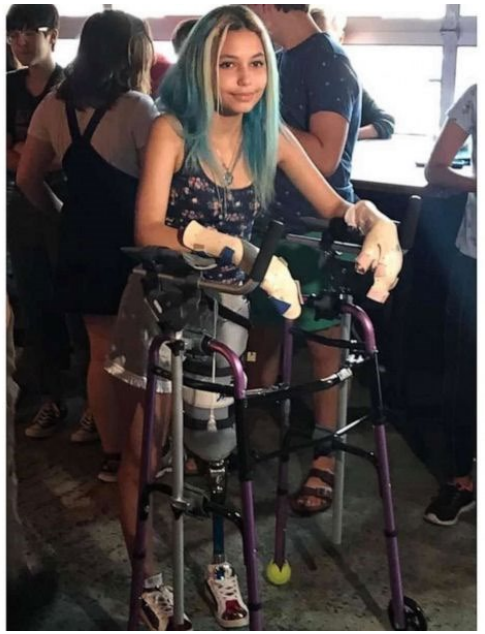


Myoelectric prosthetics

- Passive
  - Cosmetic
- Body Powered
  - Harnesses and cables
- Myoelectric
  - Surface EMG
  - Activation delay
- Neuroprosthetics
  - Investigational

Psychological Adaptation

- Amputation represents loss of function, sensation and body image
- Psychological response is determined by many variables
  - Psychosocial/Age
  - Personality
  - Coping Strategies
  - Economic/Vocational
  - Health
  - Reason for amputation



Psychological Adaptation

- Up to 2/3 of amputees will manifest postoperative psychiatric symptoms
  - Depression
  - Anxiety
  - Crying spells
  - Insomnia
  - Loss of appetite
  - Suicidal ideation
- Initial: concerns about safety, pain, disfigurement
- Later: emphasis shifts to social reintegration and vocational adjustments
- Grief Response:
  - 1. “numbness” or denial
  - 2. yearning for what is lost
  - 3. Disorganization: all hope is lost for recovery of lost part
  - 4. Reorganization

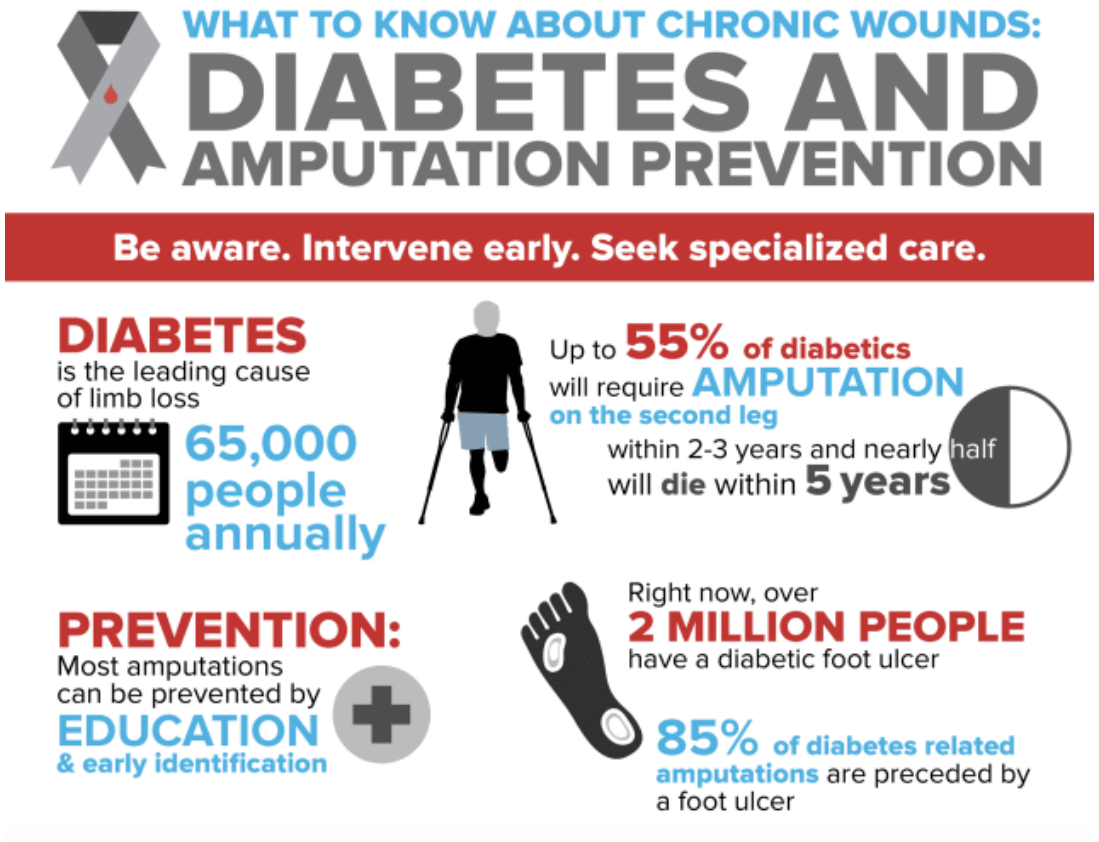
The Future

- Prosthetics will continue to improve
- Find the type right for you
- They are costly

Injury Prevention

- Injury prevention still remains highly effective
- Needs to start at pre-school level
- Personal awareness, OSHA rules and regulations at work
- The increasing knowledge of tourniquets has helped save lives.

Amputation Prevention



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Conclusions

- Degloving, partial and total amputations are common types of traumatic injuries.
- Can be life threatening; emergency treatment must be initiated quickly to avoid profuse blood loss and shock.
- Traumatic amputees undergo extreme physiological changes and psychological trauma. Stages of grief may take months and years to resolve.
- Extensive rehab with an interdisciplinary team is most successful way to return the amputee to the work place.

Conclusions

- Preparation
- Good Surgical Technique
- Rehabilitation
- Early Prosthetic Fitting
- Team Approach
- Vocational and Activity Rehabilitation

Questions

- Thank you for coming.
- Enjoy the rest of the conference!
- Be careful when you gamble – the house always wins.
- See you in Denver next year!!

References

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