Management of Pediatric Farm and Rural injuries:

A Plastic Surgeon's Perspectives

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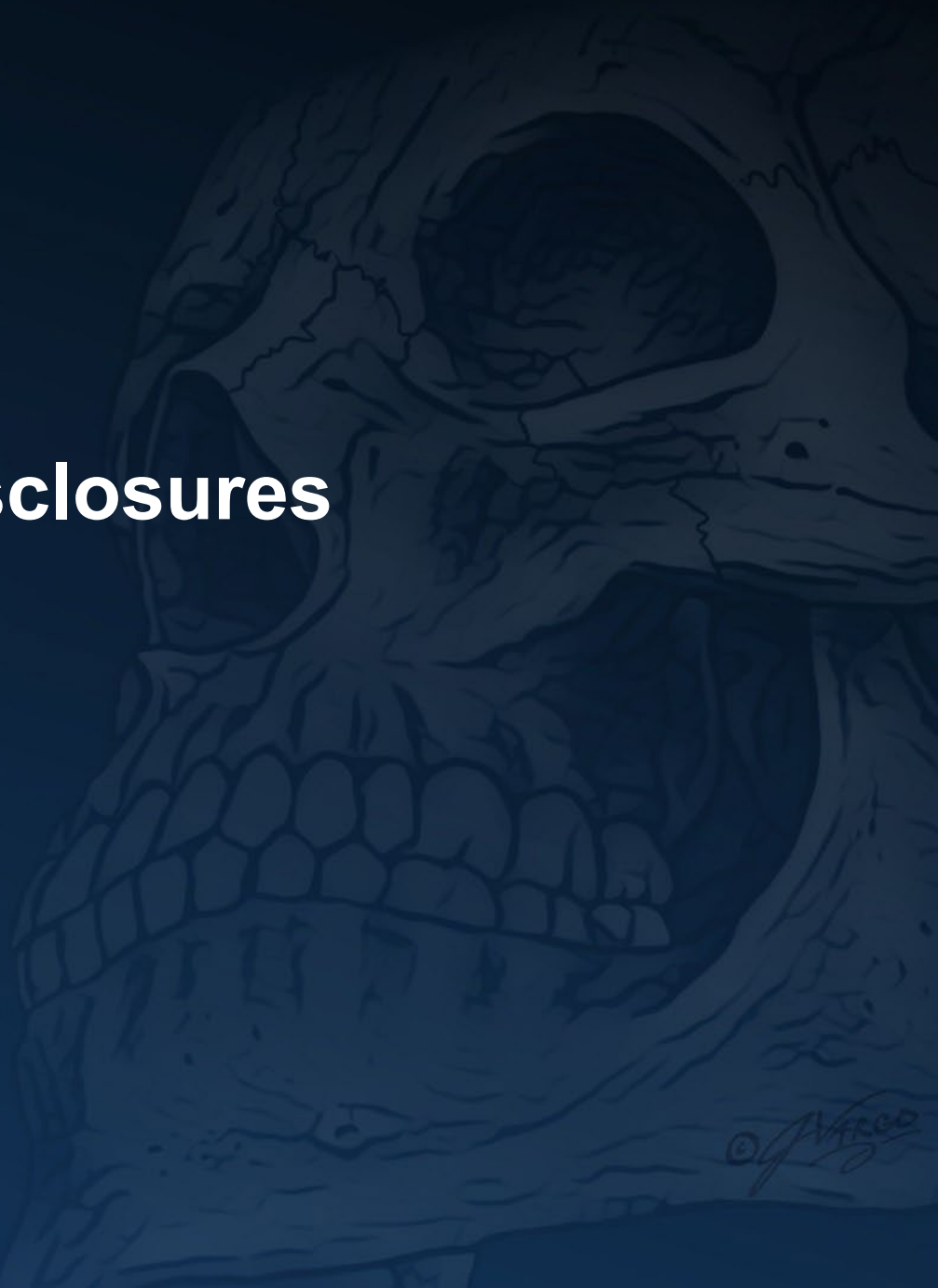
9/15/2023

No Disclosures

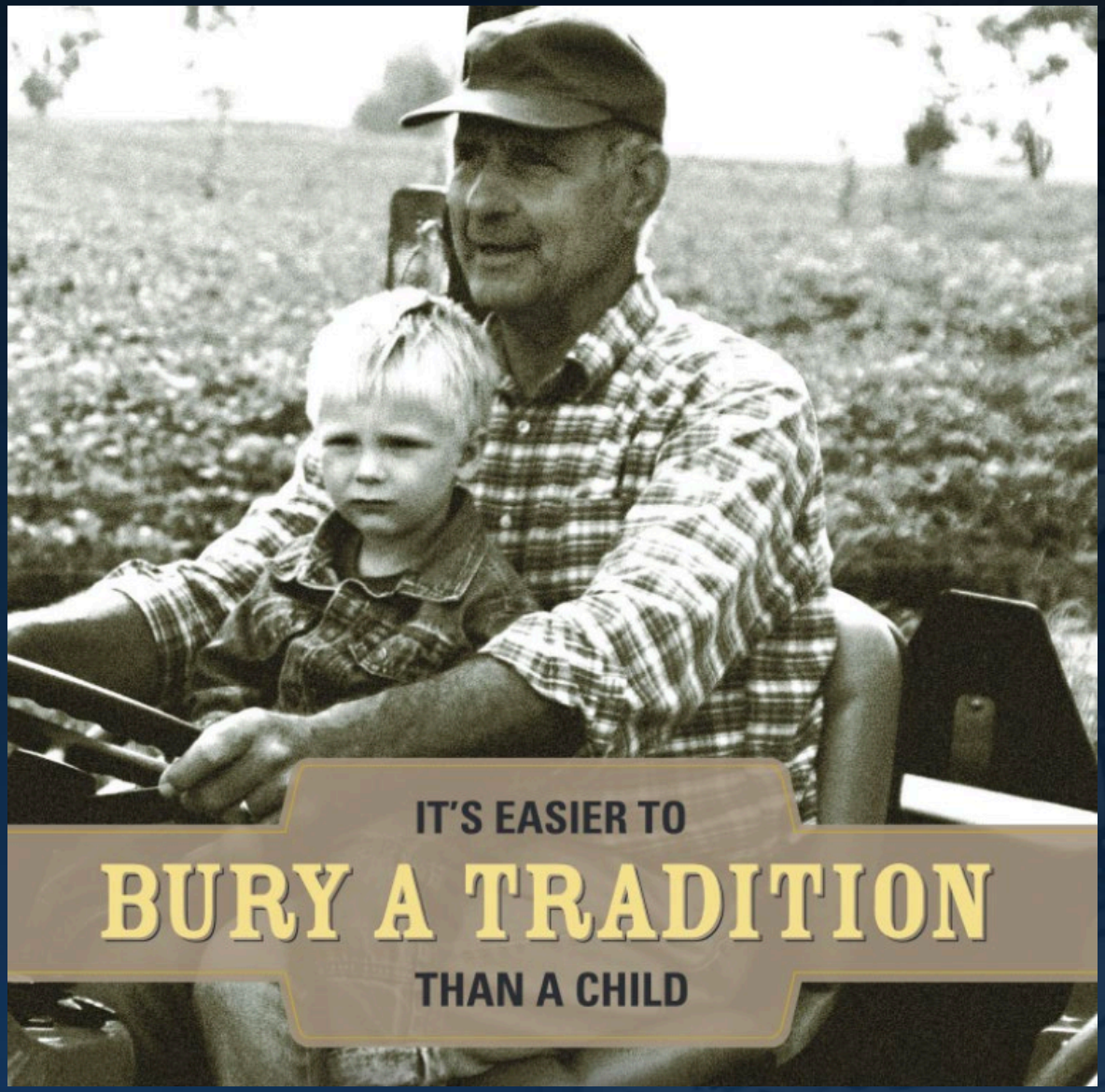


Pediatric farm injuries involving soft tissues can encompass a variety of specific injuries and conditions due to the diverse and potentially hazardous environments found on farms. Some common types of pediatric farm soft tissue injuries include:

1. **Lacerations and Cuts**: Children on farms may suffer lacerations or cuts from contact with sharp tools, equipment, or objects. These injuries can damage skin, muscles, tendons, or ligaments.
2. **Abrasions and Contusions**: Farm-related accidents can lead to abrasions (scrapes) and contusions (bruises) when children come into contact with rough surfaces, machinery, or objects.
3. **Burns**: Exposure to hot surfaces, machinery, or hazardous materials on farms can cause burns, affecting the skin and underlying tissues. This can include thermal burns, chemical burns, or electrical burns.
4. **Crush Injuries**: Children may encounter situations where their limbs or soft tissues can get caught or crushed in farm equipment, leading to severe soft tissue damage, including muscle and nerve injuries.
5. **Fractures with Soft Tissue Involvement**: Broken bones often accompany soft tissue injuries. Fractures can cause damage to surrounding soft tissues, including skin, muscles, and blood vessels.
6. **Avulsion Injuries**: Avulsions occur when a portion of skin or soft tissue is torn away from the body. These injuries can be especially severe and may require extensive reconstruction.

7. **Puncture Wounds**: Children can sustain puncture wounds from various sources on a farm, such as stepping on nails or encountering sharp objects. These wounds may result in damage to deep soft tissues and carry a risk of infection.
8. **Animal-Related Injuries**: Farms often house animals, and encounters with them can lead to soft tissue injuries, including bites, scratches, and crushing injuries. These injuries can be prone to infection.
9. **Infections**: Any open wound, cut, or abrasion sustained on a farm carries a risk of infection due to exposure to soil, manure, or other contaminants commonly found in agricultural settings.
10. **Amputations**: In severe cases, farm accidents can result in the traumatic amputation of limbs or digits, necessitating complex soft tissue reconstruction procedures.
11. **Repetitive Strain Injuries**: Over time, children who work on farms may develop repetitive strain injuries, such as tendinitis or carpal tunnel syndrome, due to the physical demands of farming activities.
12. **Foreign Body Injuries**: Children might get foreign objects embedded in their soft tissues, requiring surgical removal and repair.

It's crucial to recognize that pediatric farm soft tissue injuries can vary widely in severity, from minor cuts and bruises to life-threatening situations. Prompt and appropriate medical attention is essential for assessing and treating these injuries to minimize long-term complications and ensure the best possible outcomes for young patients. Moreover, safety education and preventive measures are vital to reducing the incidence of these


IT'S EASIER TO
BURY A TRADITION
THAN A CHILD

Farm Demographics

- ~1,000,000 kids <18 live on farms/ranches in the US
- 250,000 additional youths hired to work on farms and ranches
- 24,000,000 youths visit farms annually

Childhood Agricultural Injury Survey (CAIS) Results. Available at: https://www.cdc.gov/niosh/topics/childag/cais/demotables.html

Unique Risks

- Exposure to heavy machinery
  - Tractors
  - Augers
- Exposure to poisonous chemicals
  - Fertilizers
  - Pesticides
- High degree of wound contamination

Injury Demographics

- >26,000 non-fatal farm related injuries annually

- $1.4B cost of treatment annually
  - Medical costs
  - Short- and Long- term work
  - Quality-adjusted life years

THE JOURNAL OF RURAL HEALTH

NRHA

ORIGINAL ARTICLE

Pediatric Farm Injuries Presenting to United States Emergency Departments, 2001-2014

Alicia L. Zagel, PhD;[1] Nathaniel S. Kreykes, MD;[2,3] & Erica A. Handt, PA-C[3]

1 Children's Minnesota Research Institute, Minneapolis, Minnesota
2 Department of Pediatric Surgery, Children's Minnesota, Minneapolis, Minnesota
3 Children's Minnesota Trauma Services, Minneapolis, Minnesota

- All unintentional injuries
- 279,279 farm related injuries
  - ~20,000 injuries per year
- 45,757,881 home related injuries

Demographics

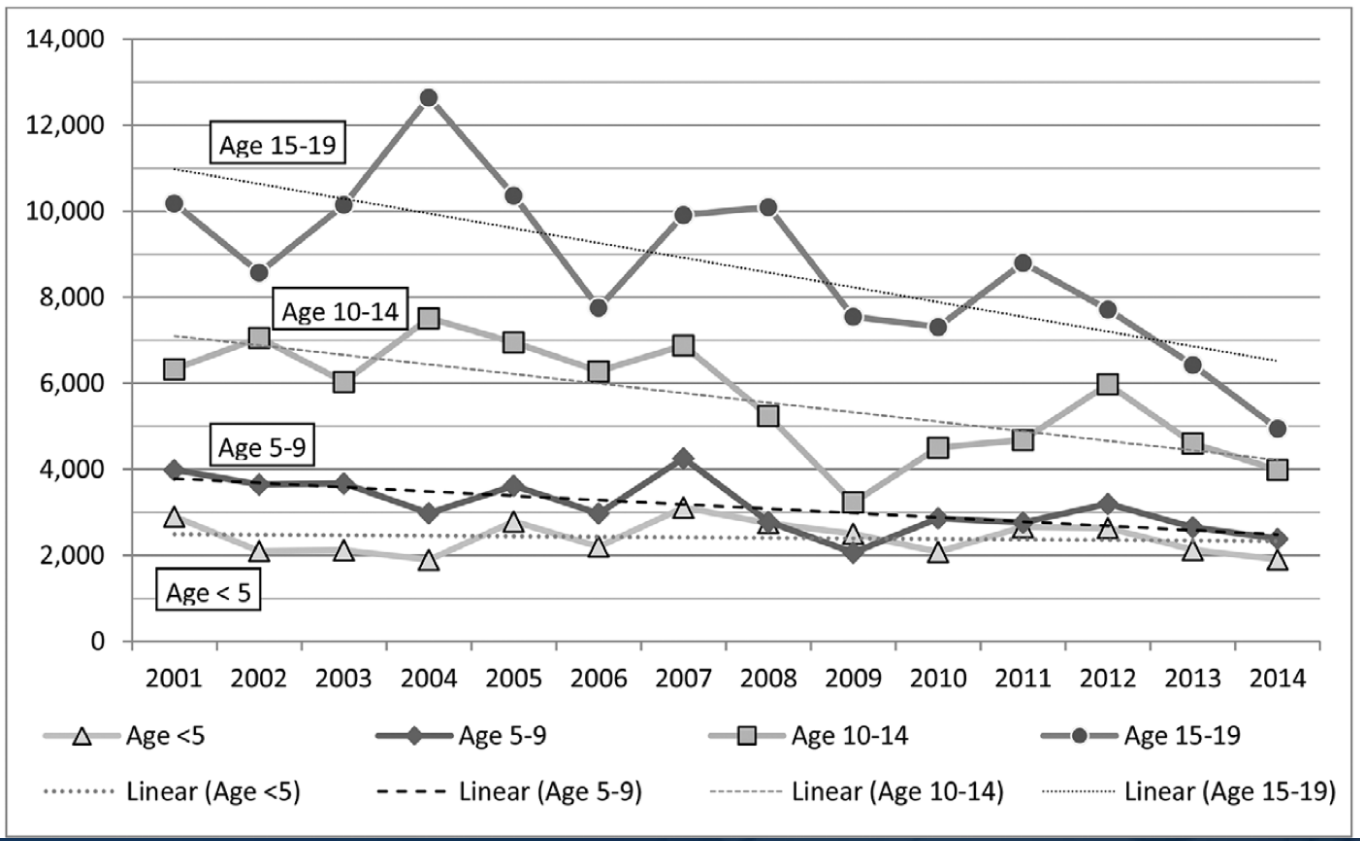
- 43% of home injuries were in children <5 years old
- 43.8% of farm injures were in 15–19 year-olds
- In both groups, males were injured more than females
- Males had higher rates of injury on farms (65% vs 57%)

Findings

- Farm injuries
  - Head/Neck 27%
  - Trunk 14%
  - Arm/hand 32%
  - Leg/Foot 24%
  - Internal 3%
- Home injuries
  - Head/Neck 41%
  - Trunk 6%
  - Arm/hand 27%
  - Leg/Foot 19%
  - Internal 6%
- Farm injuries more likely to be orthopedic 29% vs 22%
  - Fractures, sprain, dislocation, avulsion or amputation
- Farm injuries much more likely to be machinery (27% vs 4%) or transportation (7% vs 0.1%) related
- 59% were soft tissue injuries

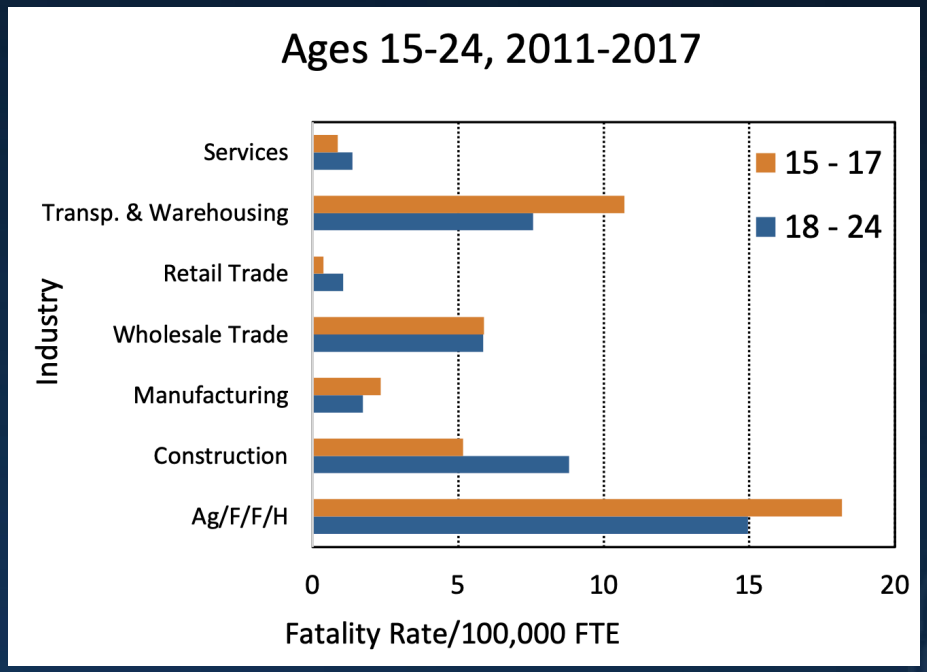
Findings

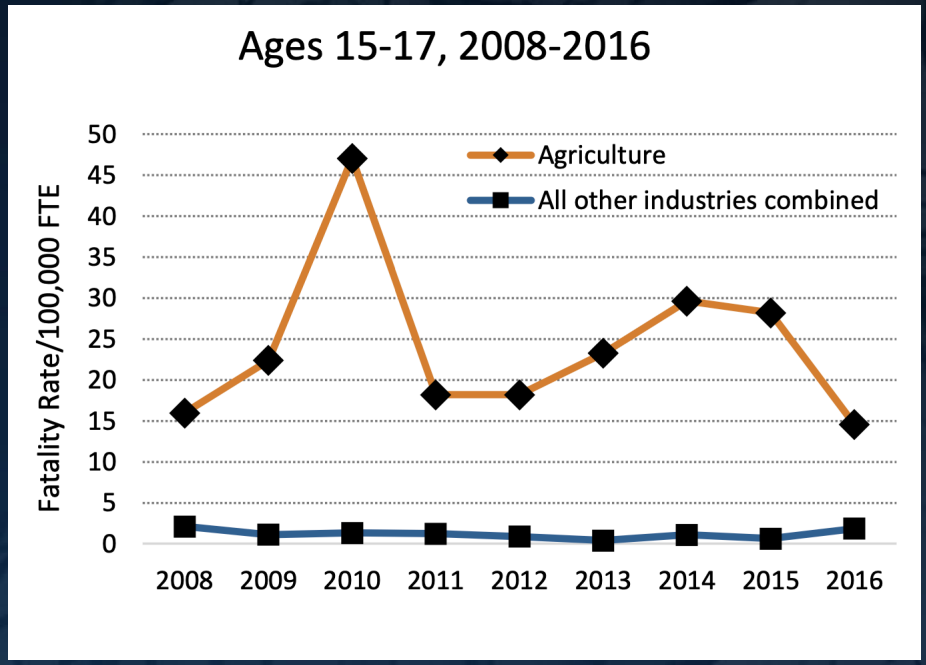
- Farm injuries more likely to require hospitalization
- 40% of farm deaths related to machinery



Fatalities

1 child dies every 3 days from a farming related accident





Ag/F/F/H = agriculture, forestry, fishing, and hunting; FTE = full-time equivalent; Transp. = transportation; Ages 15-17 unless otherwise stated
Source: Fatal injury totals were generated by NIOSH researchers with restricted access to the Bureau of Labor Statistics (BLS) Census of Fatal Occupational Injuries (CFOI) microdata; additional information at bls.gov/iif/oshcfoi1.htm[6]

General Risks

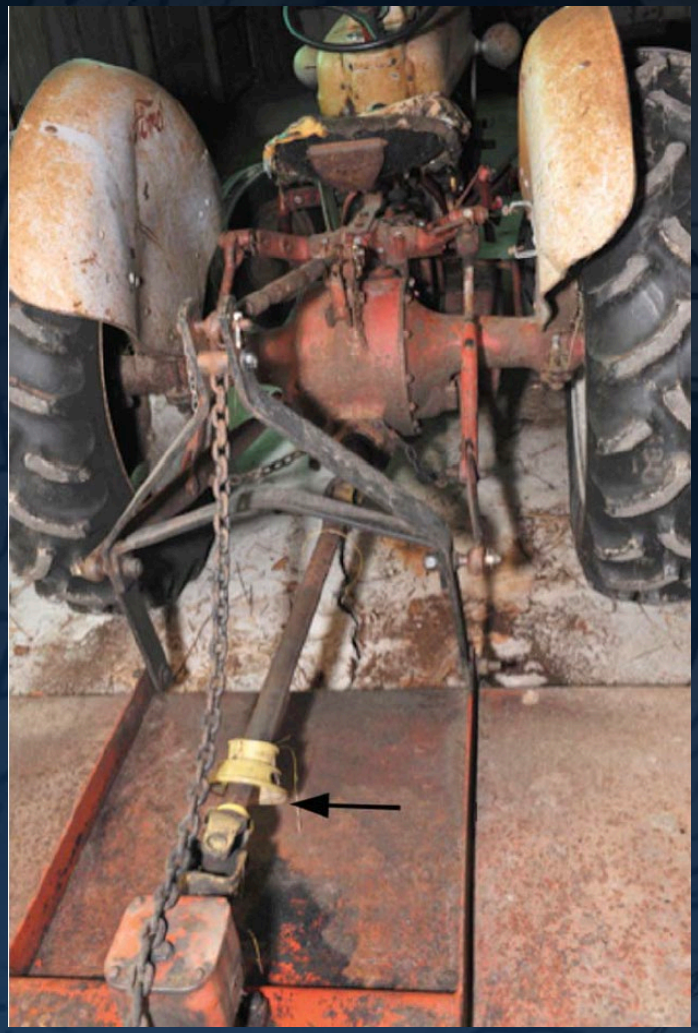
- Inattention
- Complacency
- Rushing
- Carelessness
- Removal of safety mechanisms
- Lack of appropriate PPE

Tractors

- 50% of young males on farms are involved in tractor maintenance
- 30% of young males are involved in tractor operation
- Increased # of hours working with tractors correlated to increased risk of injury

Tractor Mechanism of Injury

- Rollover
- Crush
- Shear
- Thermal injury
- Injury related to power take-off
  - 500-1000rpm
  - Manufacturer shield commonly removed

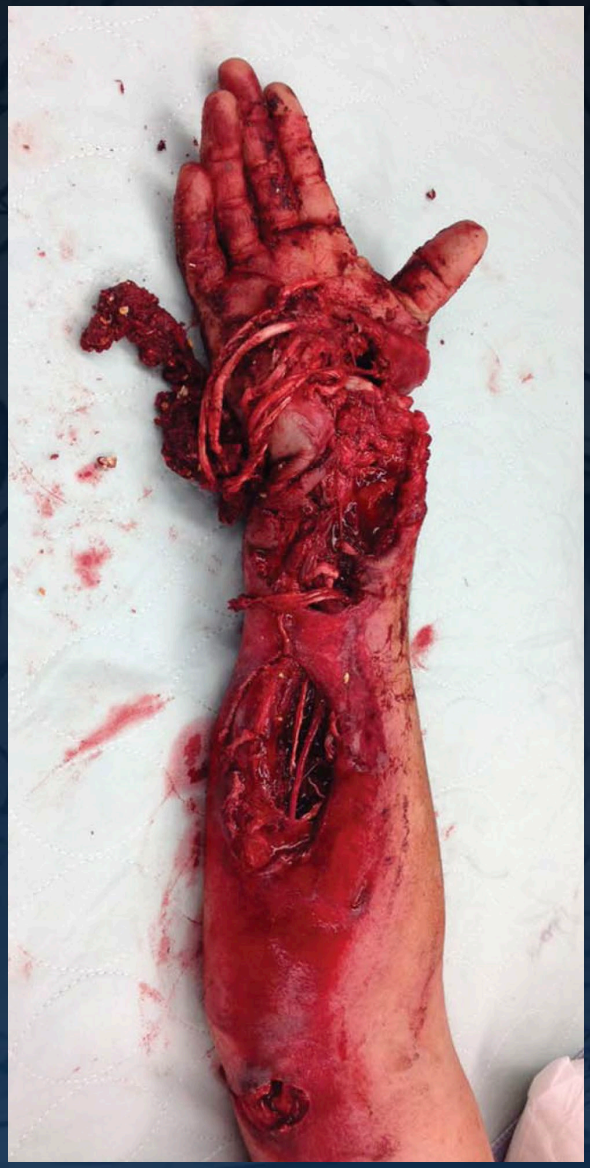


Augers

- Per hour of use, augers are the most dangerous piece of farm equipment
- Typically powered from PTO
- 20-100 feet

Auger Injuries

- Entanglement of the upper extremity
- Limb can be amputated and elevated 5 feet before individual can react

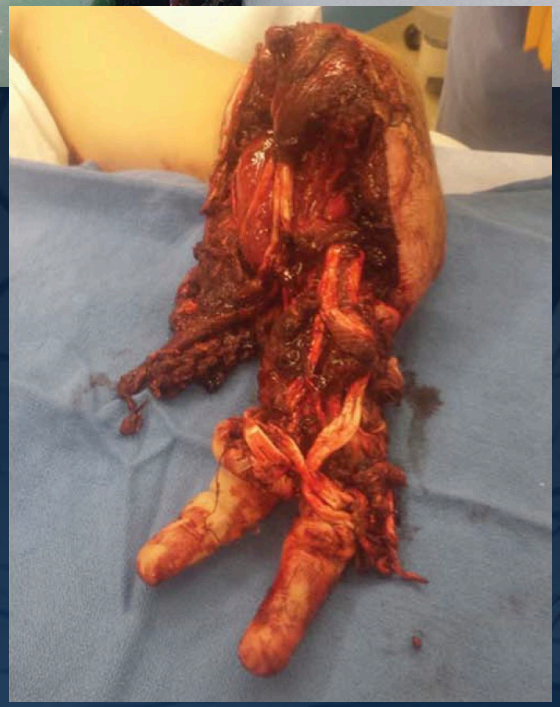


Hay Balers

- Compress and discharge bales weighing up to 2500lbs
- Has rotary fork feeders for hay
- Typically crush and thermal injury

Combine Harvester/Corn Picker

- Steel rollers rotate towards one another at 12 ft/s to snap ears of corn off stalk
- Ears of corn then fed into an auger
- Amputations, large lacerations, degloving injuries



1938 Fair Labor Standards Law

- Enacted to prohibit youths <16 yrs from performing hazardous jobs within agriculture
- 14- and 15-year-olds who receive training and certification can be permitted
- National Safe Tractor and Machinery Operation (NSTMO)
  - Subsidiary of OSHA
  - Trains/Certifies 14- and 15- year olds

cultivate SAFETY

National Children's Center for Rural and Agricultural Health and Safety

National Farm Medicine center

Power Take Off (PTO) Safety

This demonstration uses a work boot and a simulated shoelace to illustrate how far a spinning 540 RPM PTO shaft actually travels in three seconds. This is an easily replicated, visual demonstration to illustrate reaction time and the dangers of entanglement in a PTO shaft.

Top 5 Safety Strategies

1 Keep Kids Away from Tractors

40%

Tractors cause over 40% of accidental farm deaths of children under 15

4 out of 5 farm children regularly ride tractors

It's time to break the tradition.

It's easier to bury a tradition than a child.

cultivatesafety.org/campaigns/tractors

2 Keep young children out of the worksite

Equipment Hazards
- Skid steers
- ATVs
- PTOs

Supervision
- Working in/around grain
- Animals
- Gates, tires, & environmental hazards

Safety Strategies: Child Care, Safe Play Areas - cultivatesafety.org/play

3 Ensure age and ability appropriate work

Teen characteristics:
- Lack experience
- Impulsive
- Risk taking attitude
- Desire to prove themselves
- Susceptible to peer pressure
- Reluctant to ask questions

Work Guidelines:
cultivatesafety.org/aywg

4 Ensure environment is as safe as possible

Eliminate/reduce hazards:

Examples:
- Distractions
- Slippery/uneven surfaces
- Repetitive motion

Provide Personal Protective Equipment:

Examples:
- Non-skid shoes
- Gloves
- Hearing protection

5 Provide training for work/tasks & ensure proficiency

Model safe behaviors

Train youth to do job

Practice until proficient

Supervise

The Plastic Surgeon's World

- Its way easier to prevent an injury than treat it!
- Facial Trauma
- Amputations/Limb salvage
- Degloving injuries
- Open wounds
- Burns

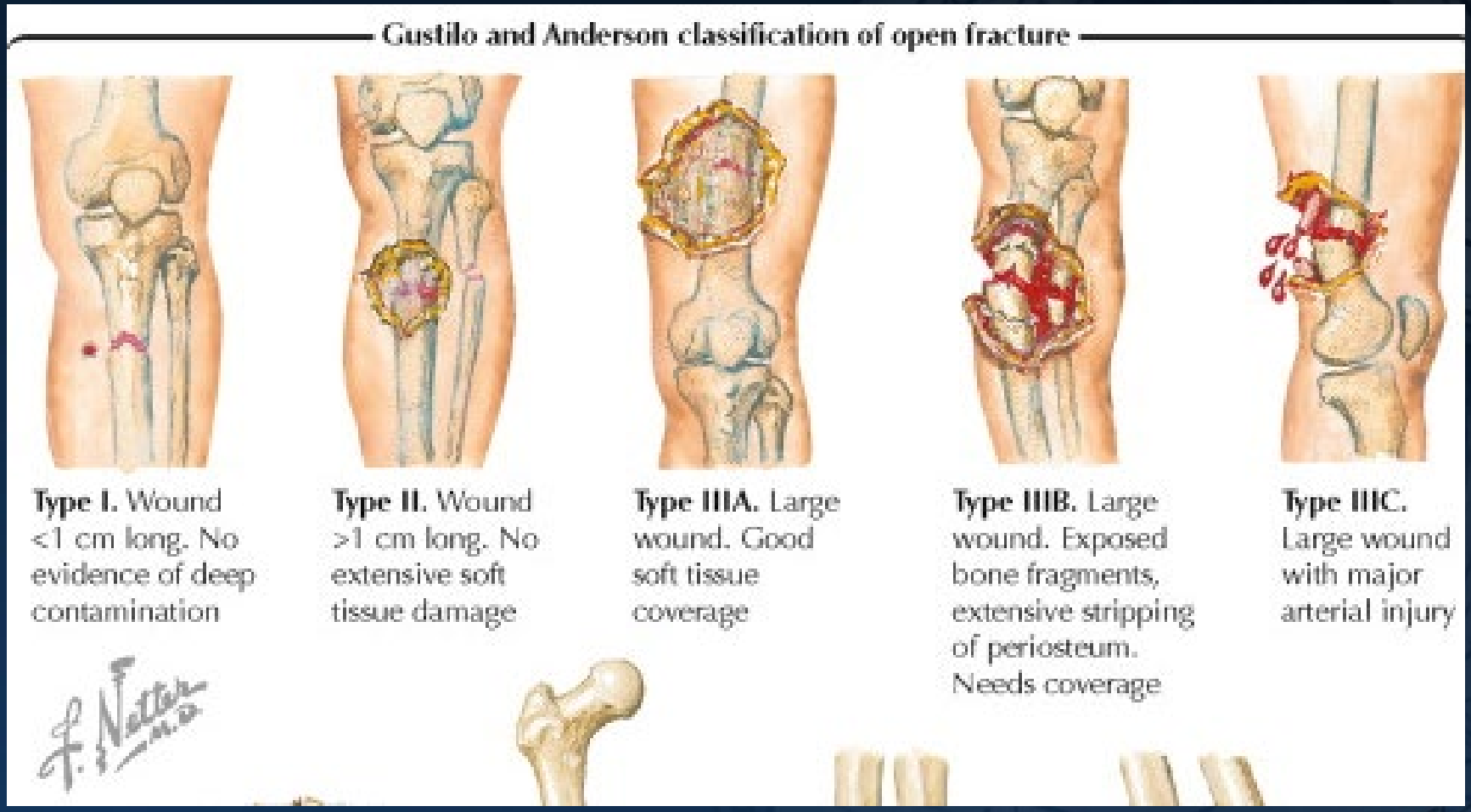
Facial Trauma...Next year?

Extremity Trauma

Reconstructive Decisions

- Amputation
- Replantation
- Limb Salvage/Reconstruction

What is a bad injury?



Which is a ‘bad’ injury?

High Energy

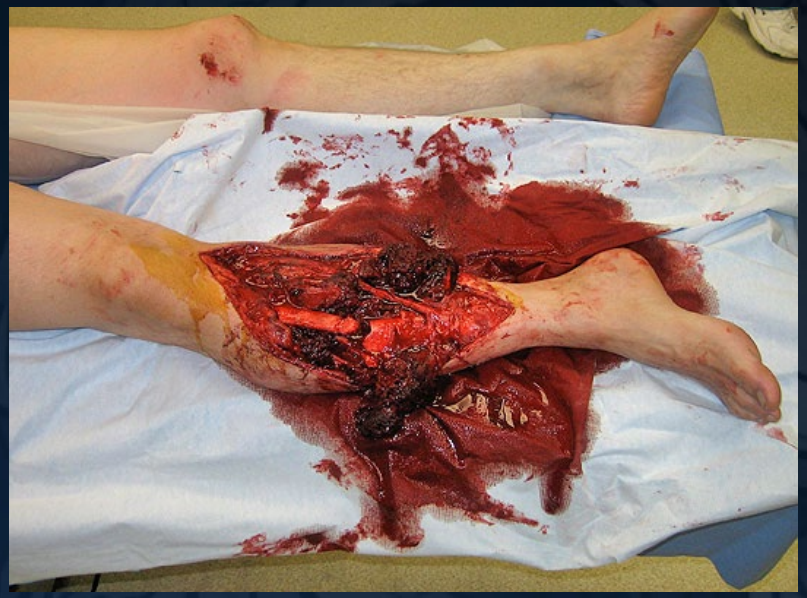
Massive Contamination

Periosteal Stripping

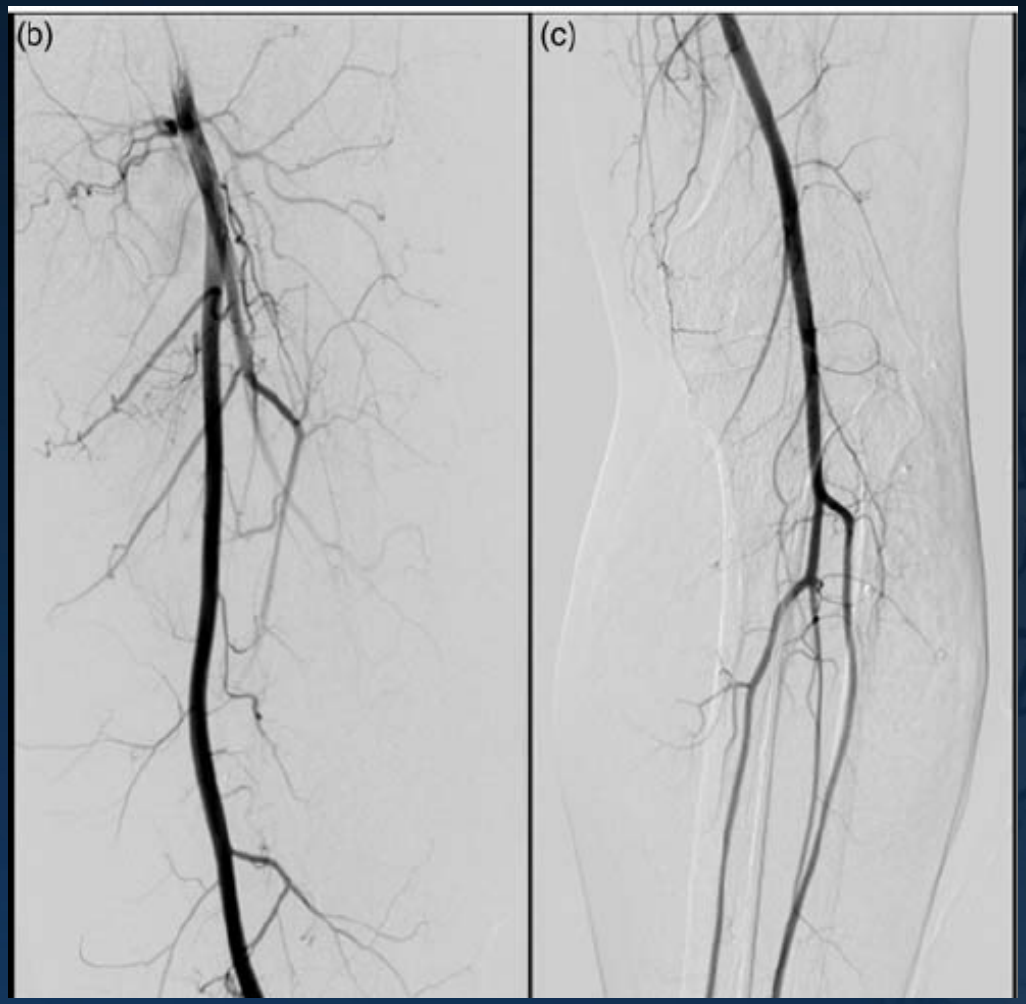
Extensive Soft Tissue Loss

Evaluation

- Vascular integrity?
- What vessels are preserved?
- Is the distal tissue viable?
- Compartment syndrome?
  - 5 P's
- Are fractures reduced?



Status of the Plumbing



Formal Angiogram

MR Angiogram

Bone Integrity

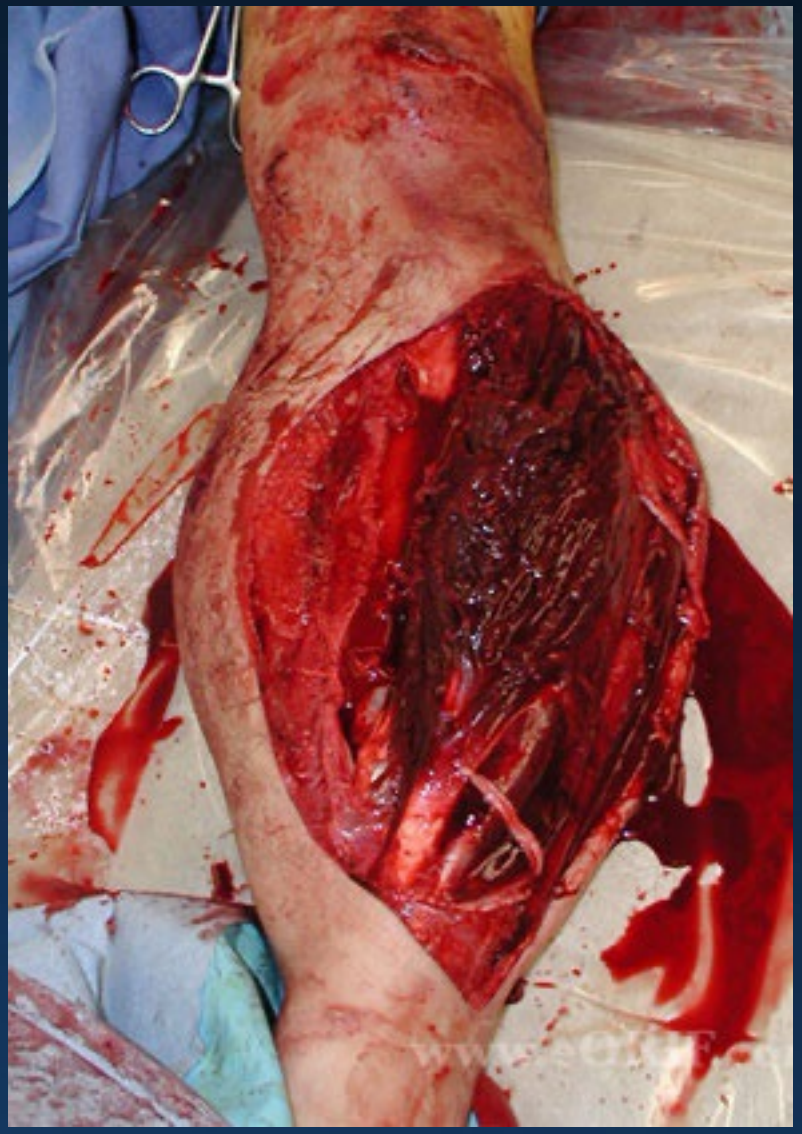
- Severity of the fracture
  - Degree of Comminution
  - Segmental bone loss

- Will this require internal or external fixation?

- Will this defect eventually need vascularized bone?

Bone Integrity

Salvage vs Amputation?



Salvage vs Amputation?

- Severe Injury with life-threatening condition
  - Amputate
  - ”Life over Limb”
- Severe Injury but with functional/sensate limb
  - Attempt salvage
- Severe Injury with de-functionalized limb
  - Gray zone
  - Multiple scoring systems exist
  - MESS, NISSSA, LSI, Hanover fracture scale

Salvage vs Amputation?

Mangled Extremity Severity Score (MESS)

Tissue Injury	Characteristics	Details	Points
1	Low energy	Stab wound, simple closed #, small-caliber	1
2	Medium energy	Opened #, dislocate, moderate crush	2
3	High energy	Short gun, high velocity	3
4	Massive crush	Logging, rail road	4
Shock			
1	Normotension	BP stable	0
2	Hypotensive transient	BP unstable, SBP < 90 mmHg	1
3	Hypotension	In OR	2
Ischemia			
1	None	No signs of ischemia	0
2	Mild	Diminish pulse	1
3	Moderate	Paresthesia, diminish motor activity	2
4	Advanced	Pulseless	3
Age			
1	< 30 y		0
2	30 - 50 y		1
3	> 50 y		2

Score ≤ 6: salvageable limb, Score ≥7: highly predictive of amputation

Initially described in 1990 by Johansen

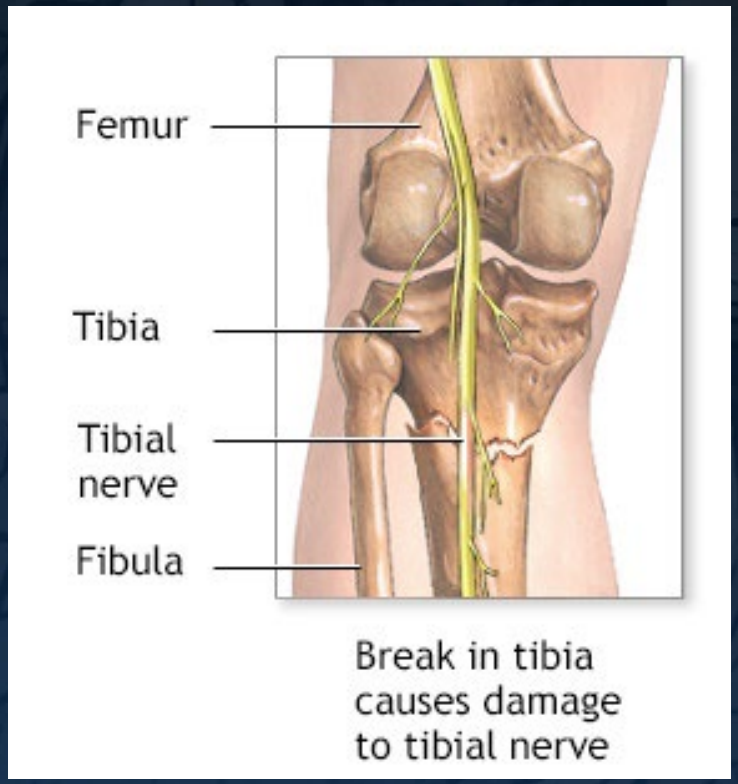
Tibial Nerve

- Controls motor function to lower limb

- Traditional thought was that amputation was better than non-functional foot

- Many patients recover tibial nerve function within 24 months

- Equivalent rates of needing walking device or ankle support



Defining Success

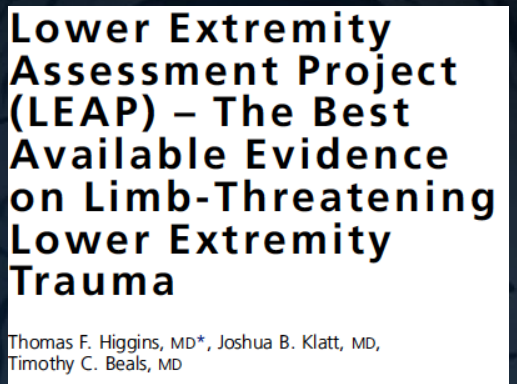
- Salvage and amputation can both be functional or non-functional

- An attached limb that doesn't work is less useful than an amputation
    - Hard for some patients to understand this

- Salvage may be a better option for some patients, and amputation may be better for others

Amputation vs Salvage

- Functional outcomes generally equivalent
- "Self-efficacy" highly predictive of functional outcome
- Functional recovery more dependent on pre-existing factors than injury
- Injury severity indices are not predictive of need for amputation or functional outcome
- Long term costs higher with amputation than salvage



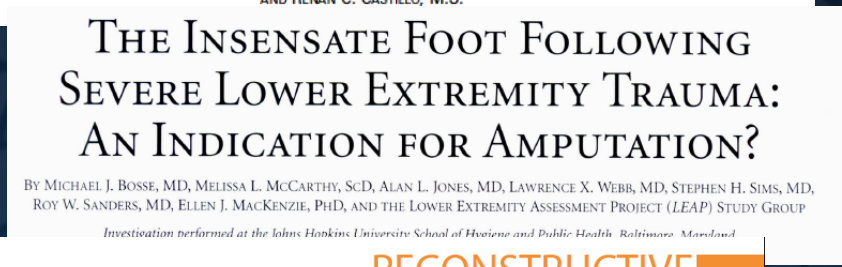
Lower Extremity Assessment Project (LEAP) – The Best Available Evidence on Limb-Threatening Lower Extremity Trauma

Thomas F. Higgins, MD*, Joshua B. Klatt, MD, Timothy C. Beals, MD

The New England Journal of Medicine

AN ANALYSIS OF OUTCOMES OF RECONSTRUCTION OR AMPUTATION OF LEG-THREATENING INJURIES

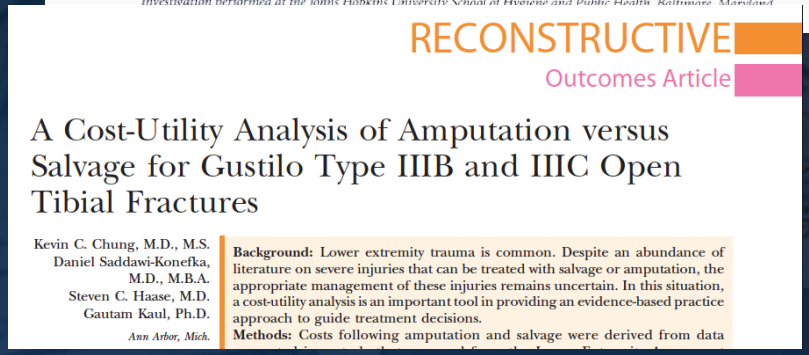
Michael J. Bosse, M.D., Ellen J. MacKenzie, Ph.D., James F. Kellam, M.D., Andrew R. Burgess, M.D., Lawrence X. Webb, M.D., Marc F. Swiontkowski, M.D., Roy W. Sanders, M.D., Alan L. Jones, M.D., Mark P. McAndrew, M.D., Brendan M. Patterson, M.D., Melissa L. McCarthy, Sc.D., Thomas G. Travison, Ph.D., and Renan C. Castillo, M.S.



THE INSENSATE FOOT FOLLOWING SEVERE LOWER EXTREMITY TRAUMA: AN INDICATION FOR AMPUTATION?

By Michael J. Bosse, MD, Melissa L. McCarthy, ScD, Alan L. Jones, MD, Lawrence X. Webb, MD, Stephen H. Sims, MD, Roy W. Sanders, MD, Ellen J. MacKenzie, PhD, and the Lower Extremity Assessment Project (*LEAP*) Study Group

Investigation performed at the Johns Hopkins University School of Hygiene and Public Health, Baltimore, Maryland



RECONSTRUCTIVE

Outcomes Article

A Cost-Utility Analysis of Amputation versus Salvage for Gustilo Type IIIB and IIIC Open Tibial Fractures

Kevin C. Chung, M.D., M.S.
Daniel Saddawi-Konefka, M.D., M.B.A.
Steven C. Haase, M.D.
Gautam Kaul, Ph.D.
Ann Arbor, Mich.

Background: Lower extremity trauma is common. Despite an abundance of literature on severe injuries that can be treated with salvage or amputation, the appropriate management of these injuries remains uncertain. In this situation, a cost-utility analysis is an important tool in providing an evidence-based practice approach to guide treatment decisions.

Methods: Costs following amputation and salvage were derived from data

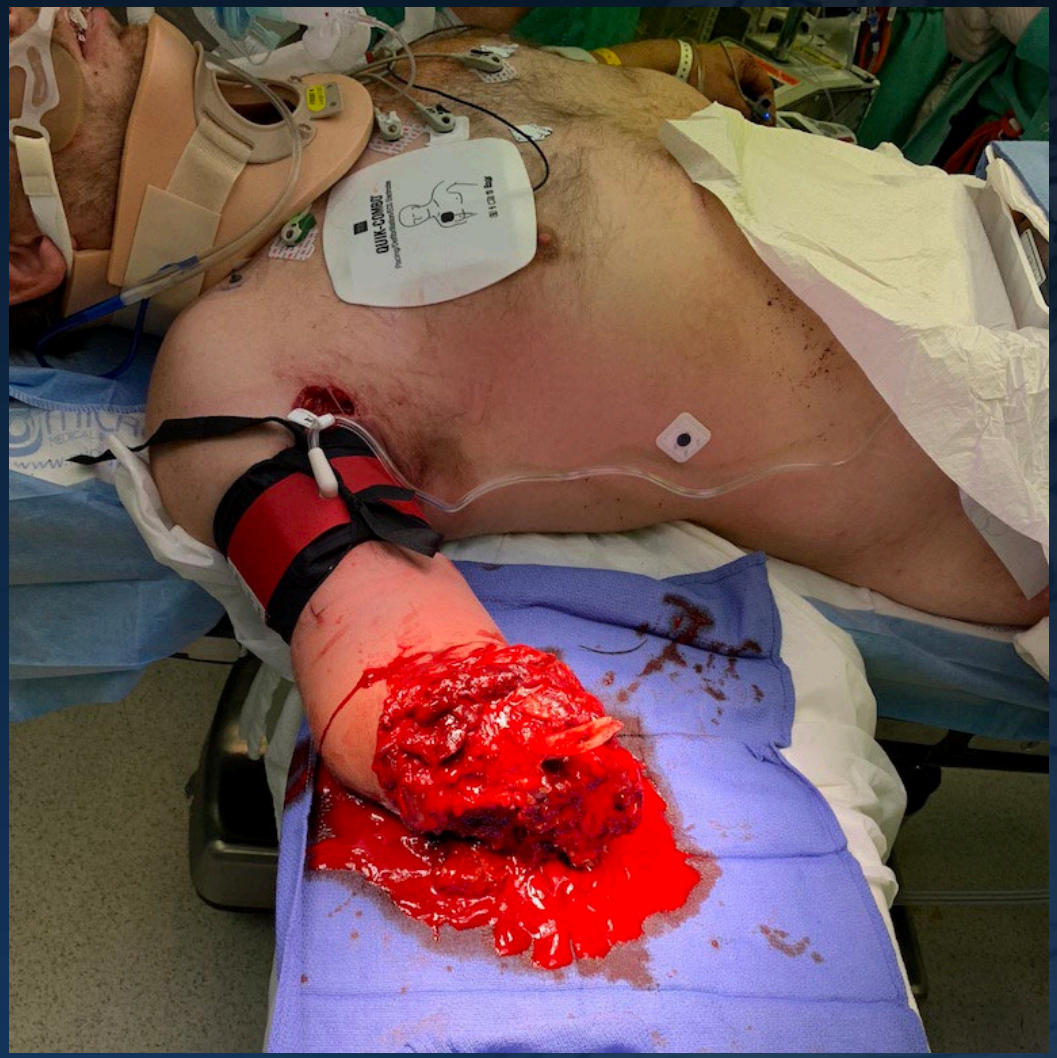
Risk Factors for Amputation

- Gustilo IIIC Injuries
- Sciatic or tibial nerve injury
- Prolonged ischemia (>4-6hrs)
- Crush or soft tissue destructive mechanism
- Significant wound contamination
- Multiple fracture, severe comminution, segmental bone loss
- Severe comorbidities

Unique Pediatric Concerns

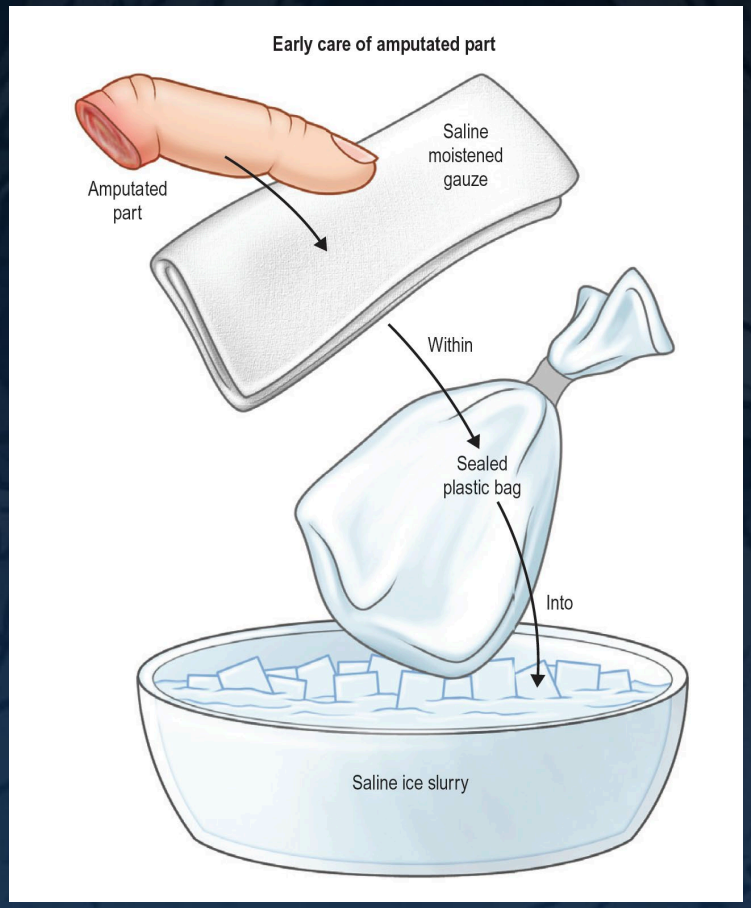
- Future growth potential
- Importance of function
- Aesthetic concerns
- Psychosocial impact
- Ability to tolerate bedside wound care
- Greater ability to heal
- Relative neuroplasticity

What about traumatically amputated parts?



Amputated Parts

- Wrap the amputated part in saline-moistened gauze
- Place wrapped part in a sealed bag
- Put the bag on ice water (4° C)
  - Cooling slows tissue metabolism
- Direct contact with ice can cause thermal injury
  - Frostbite



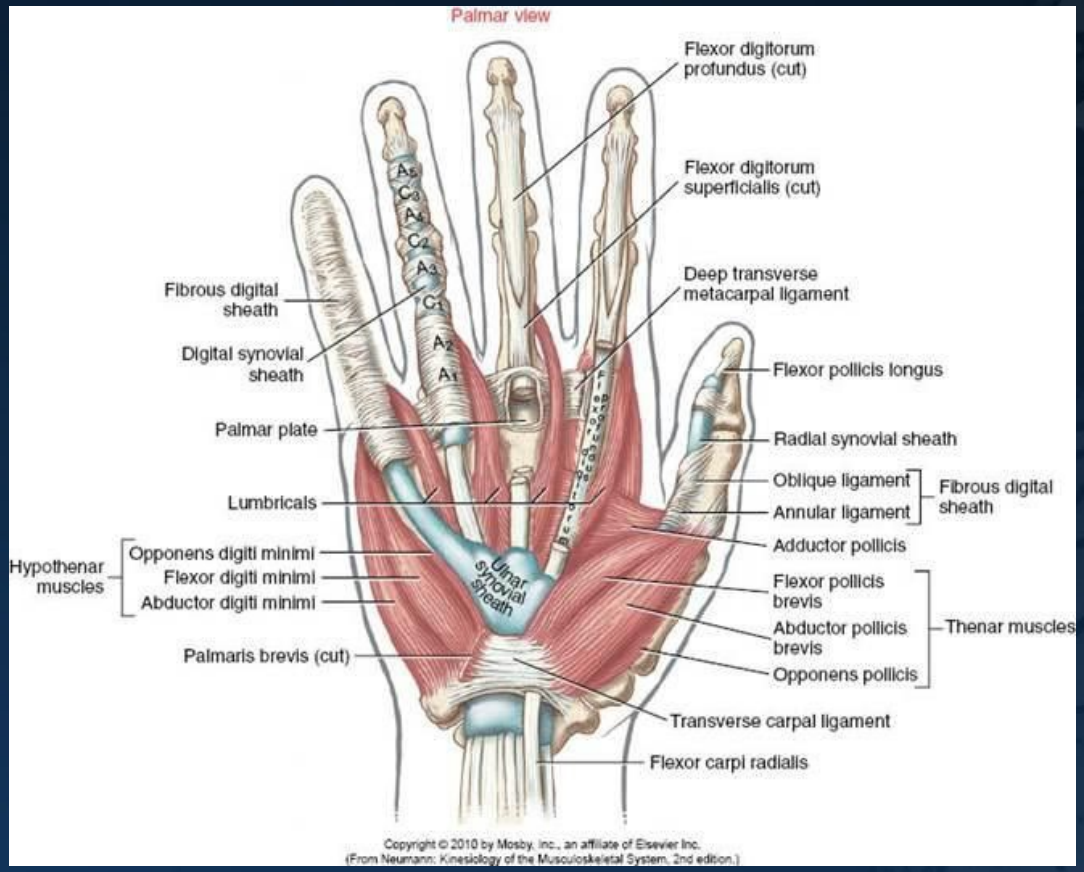
Ischemia Limits

- Warm Ischemia
  - Digit - 10 hours
  - Limb - 6 hours
- Cold Ischemia
  - Digit - 48 hours
  - Limb - 12 hours

- Determined by presence of muscle in amputated parts

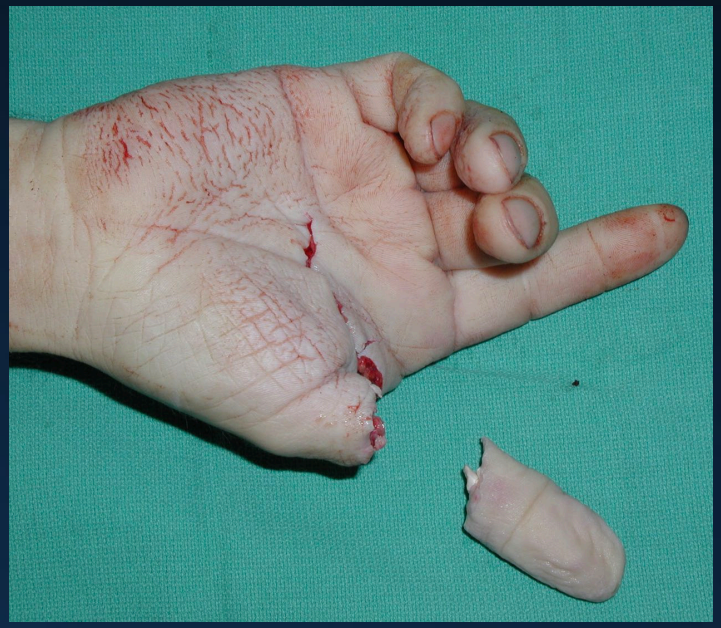
- Muscle has much higher metabolic demands and undergoes necrosis faster

Ischemia Limits



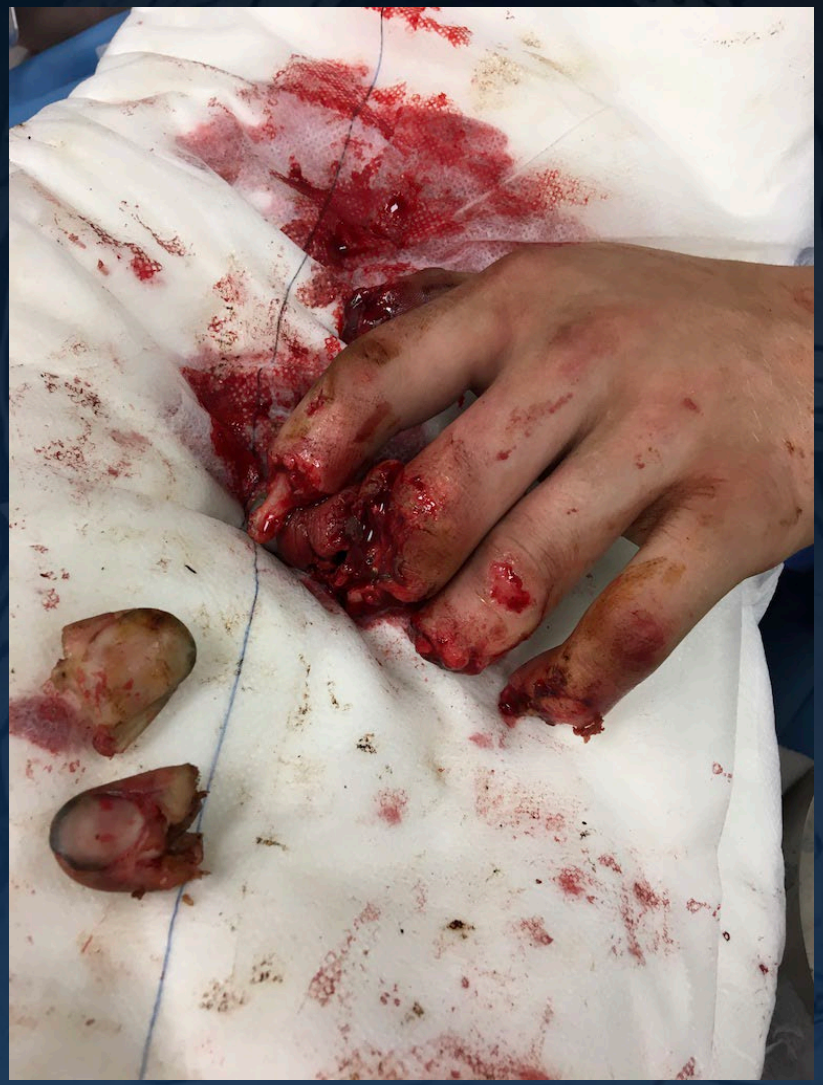
Replantation Criteria

- Any amputation in children
- Thumb
- Multiple digits
- Amputation of hand, wrist, forearm
- Single digit distal to insertion of FDS tendon



Replantation Contraindications

- Associated life-threatening injury
- Multi-level extremity injury
- Massive contamination
- Co-morbidities precluding general anesthesia
- Psychosis
- Single digit proximal to FDS (adults only)



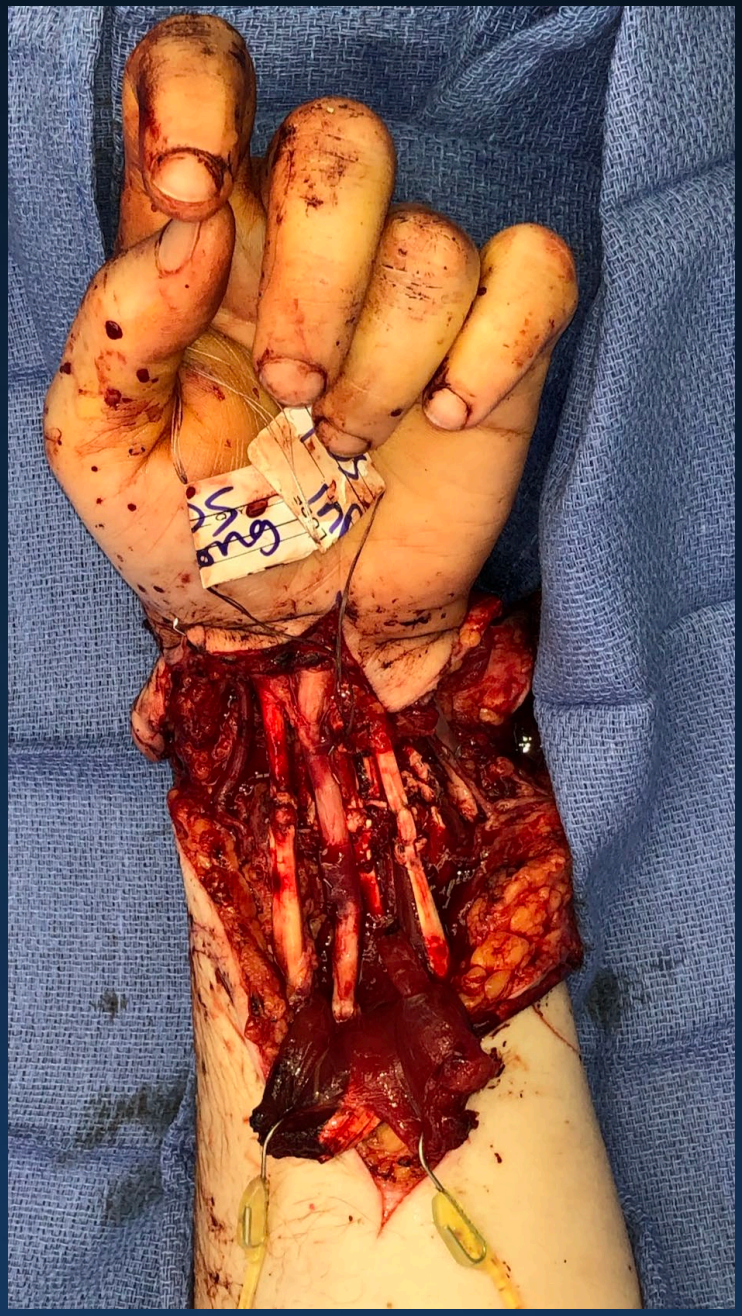
ORIGINAL ARTICLE

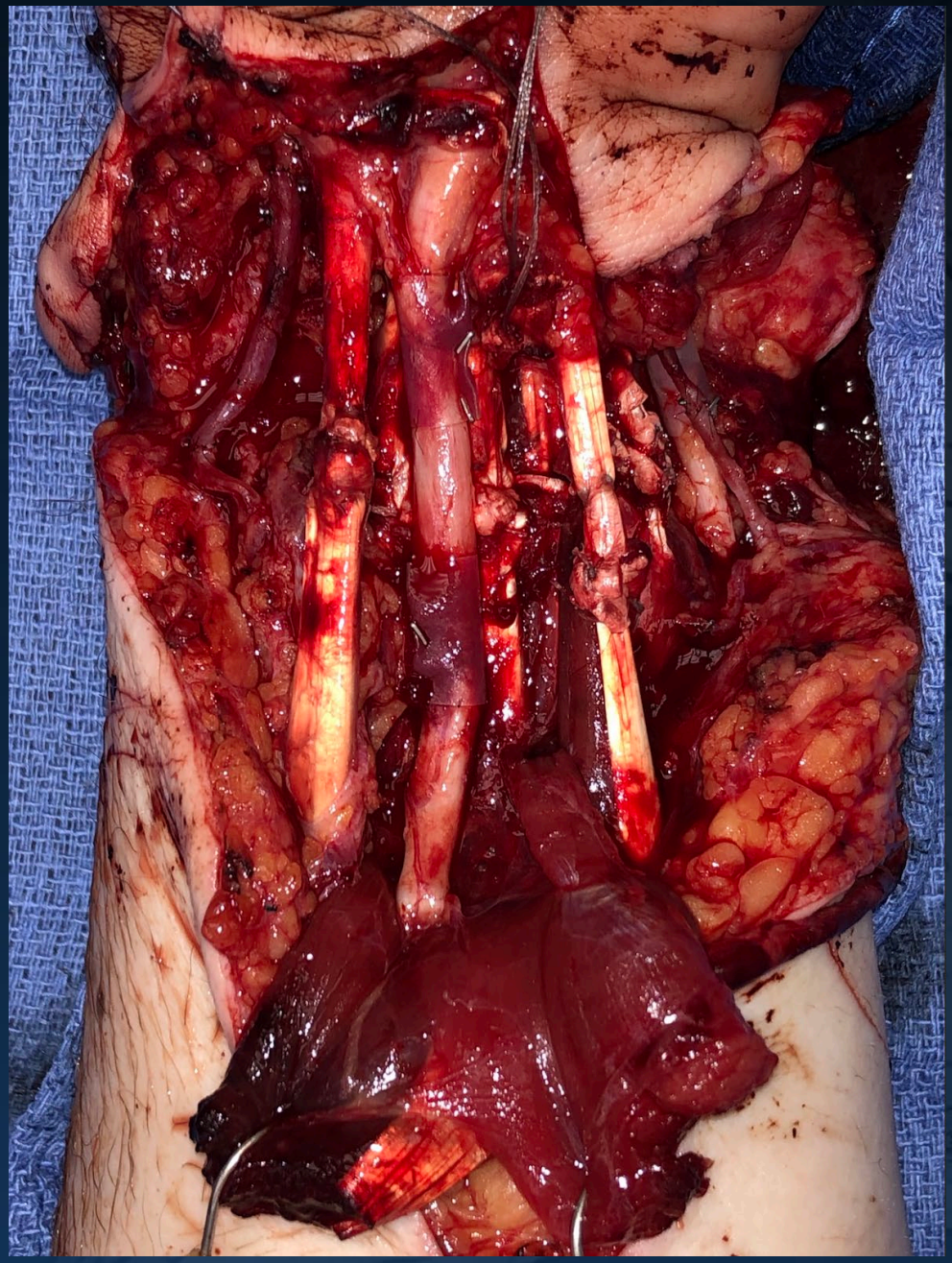
Farm-related Limb Amputations in Children

Shannon K. McClure, MD and William J. Shaughnessy, MD

Patient #	Sex	Age	Device	Level	Reimplantation?	Infection	# of Initial Surgeries	Time to Close (days)
1	M	10+7	Logsplitter PTO	L BEA	Yes, failed	Yes, Gp D strep, yeast	7	12
2	M	13+1	PTO	Bil AEA	Yes L, failed; No, R	Yes (L), Serratia Marcescans, Klebsiella Oxytoca, Pseudomonas Maltophilia, Gp D strep, Enterobacter cloacae, Flavobacterium Odoratum, Fungus (Mucor and Geotrichum)	8	33 R 88 L
3	F	7+1	Auger	L BKA	No	No	10	14
4	M	12+0	Farm wagon, conveyor belt	L AEA	Yes	Yes, Gp D strep, Enterobacter cloacae, osteo	11	7, 24
5	F	2+11	Corn auger	R AEA	Yes, failed	Yes, Gp D strep, Serratia liquefaciens	7	10
6	M	4+6	Farm auger	L AKA	Yes	Yes, GP D strep, Acenitobacter calcoaceticus, Staph aureus, Proteus vulgaris	11	30
7	M	11+2	PTO	R AEA	No	No	2	2
8	M	4+11	Corn auger	R AKA	No	No	5	12
9	M	7+7	Grain auger	L foot (ankle disartic)	No	No	3	4
10	M	12+2	PTO	L AEA	Yes, failed	Yes, Alcaligenes Xylosoxidand, Enterococcus, Xanthaomonas Maltophilia	8	28
11	F	5+4	Corn auger	L elbow disartic	No	No	3	3

Replantation considered in all, attempted in 6, successful in 2 (16%)





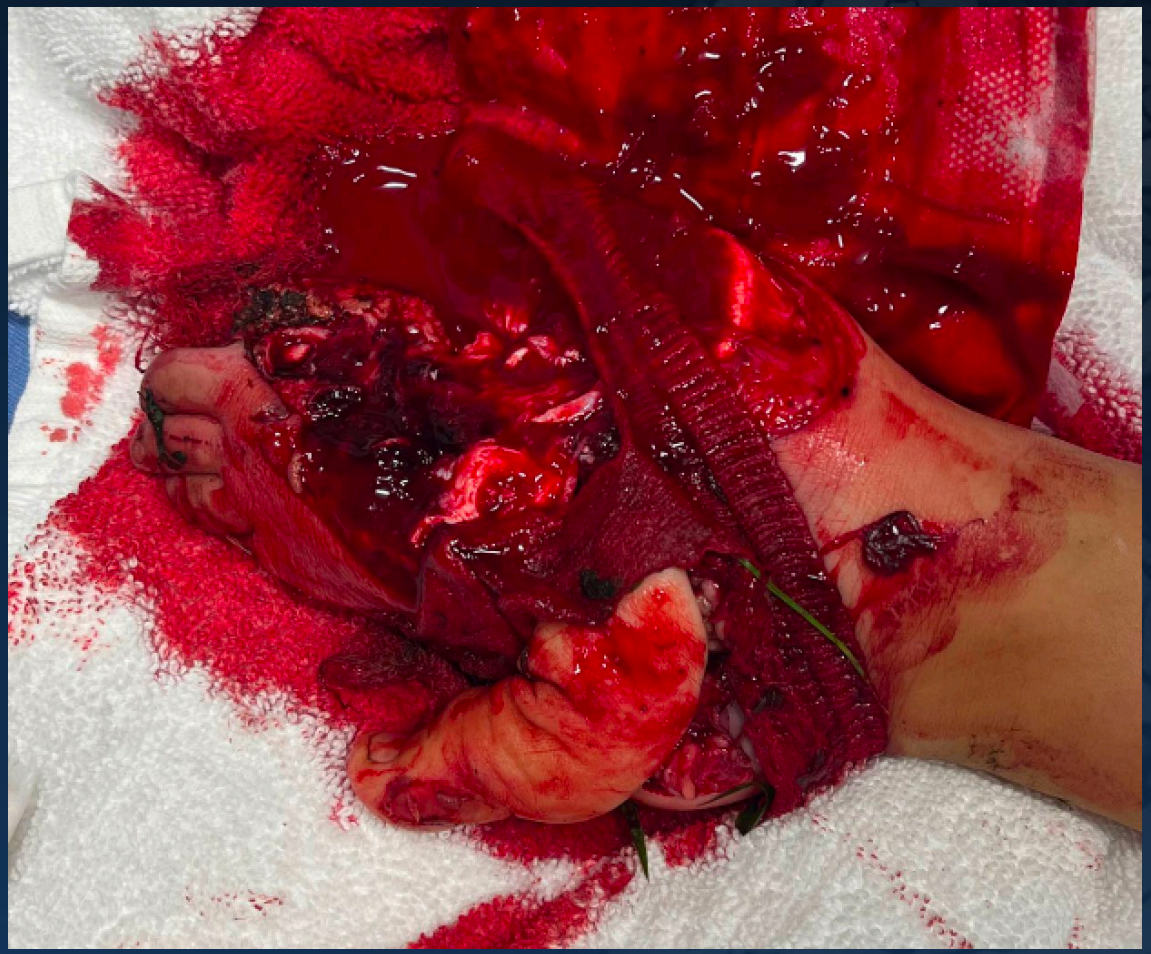
Principles of Management

The Solution to Pollution is Serial Dilution

- 2-6L of antibiotic irrigation
- Removal all gross contamination
- Requires manual ‘finger’ agitation of wound
- Don’t just assume the wound is completely opened
- Soaking in a bucket is not the same as power irrigation

The Solution to Pollution is Serial Dilution

The Solution to Pollution is Serial Dilution



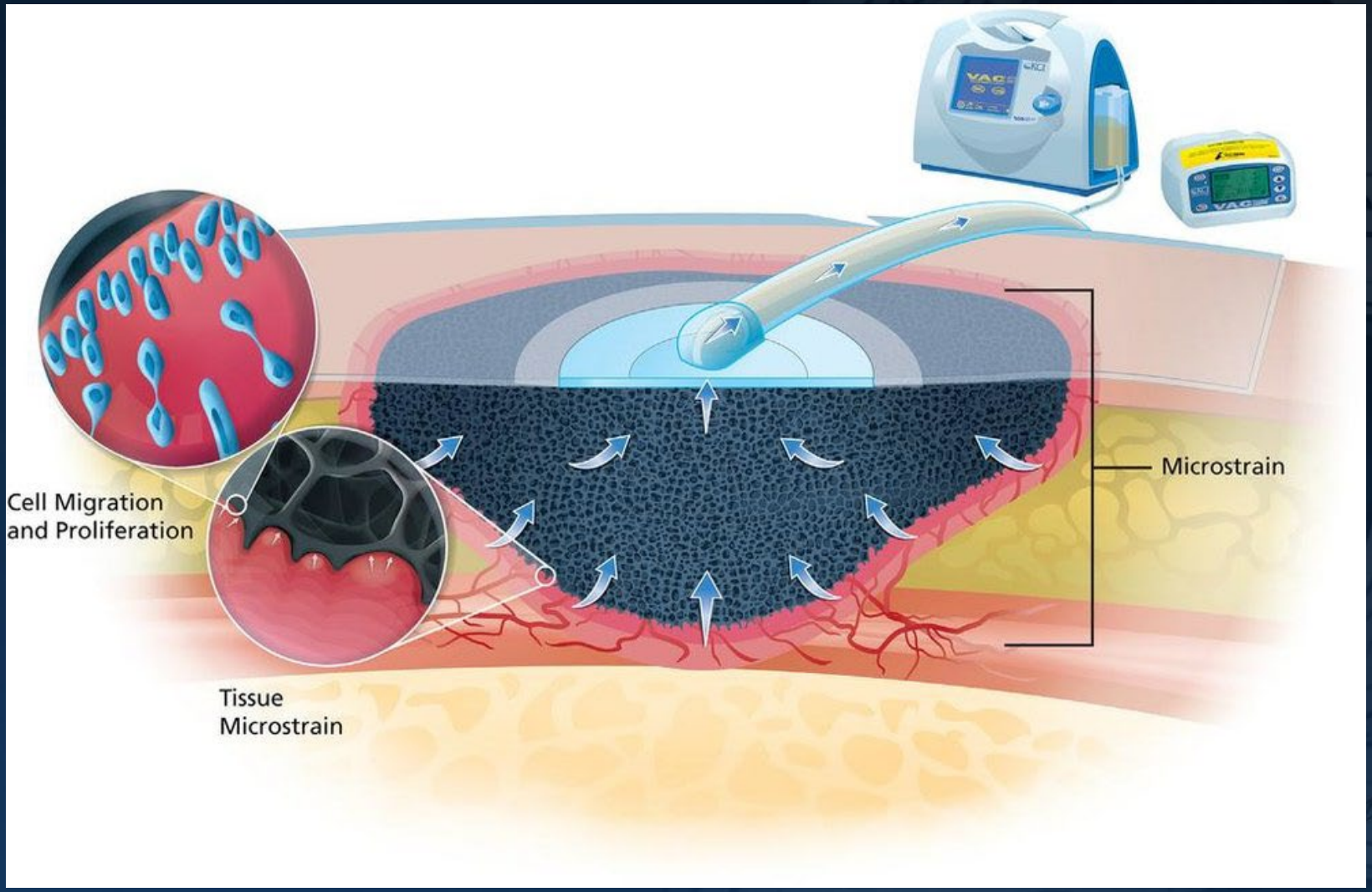
Remove what is dead, but don't rush to radically removal tissue

There is no value in leaving obviously dead tissue

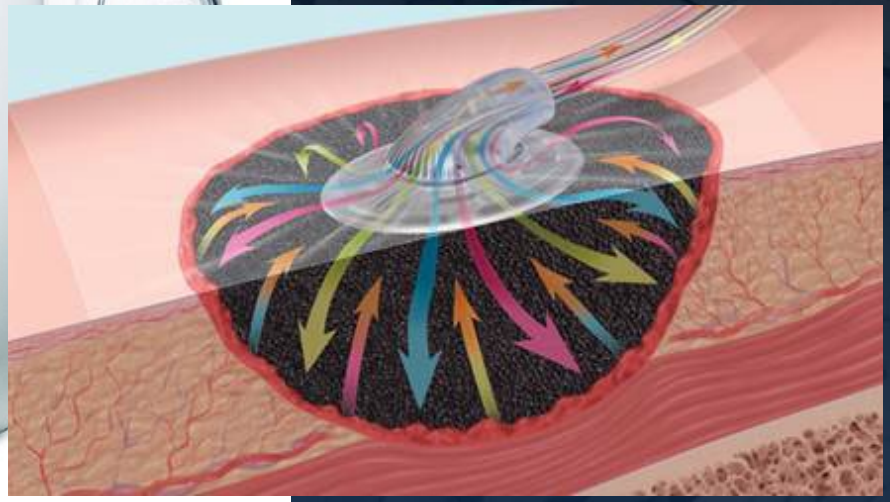
- The end point of debridement is punctate bleeding tissue
- If there is no clear demarcation, leave the tissue to declare


MEDLINE

Negative Pressure Wound Therapy



Negative Pressure Wound Therapy



Irrigants


1000 mL
Baxter
Not for Injection
0.9% Sodium Chloride
Irrigation, USP


NDC 0436-0672-16
DAKIN'S
SOLUTION
quarter
strength
CENTURY
Pharmaceuticals, Inc.
473ml (16 fl oz)


vashe
Skin – Wound – Burn
Cleansing Solution
• Debridement Irrigation
• Physical Disruption of Biofilm
• Removal of Microorganisms

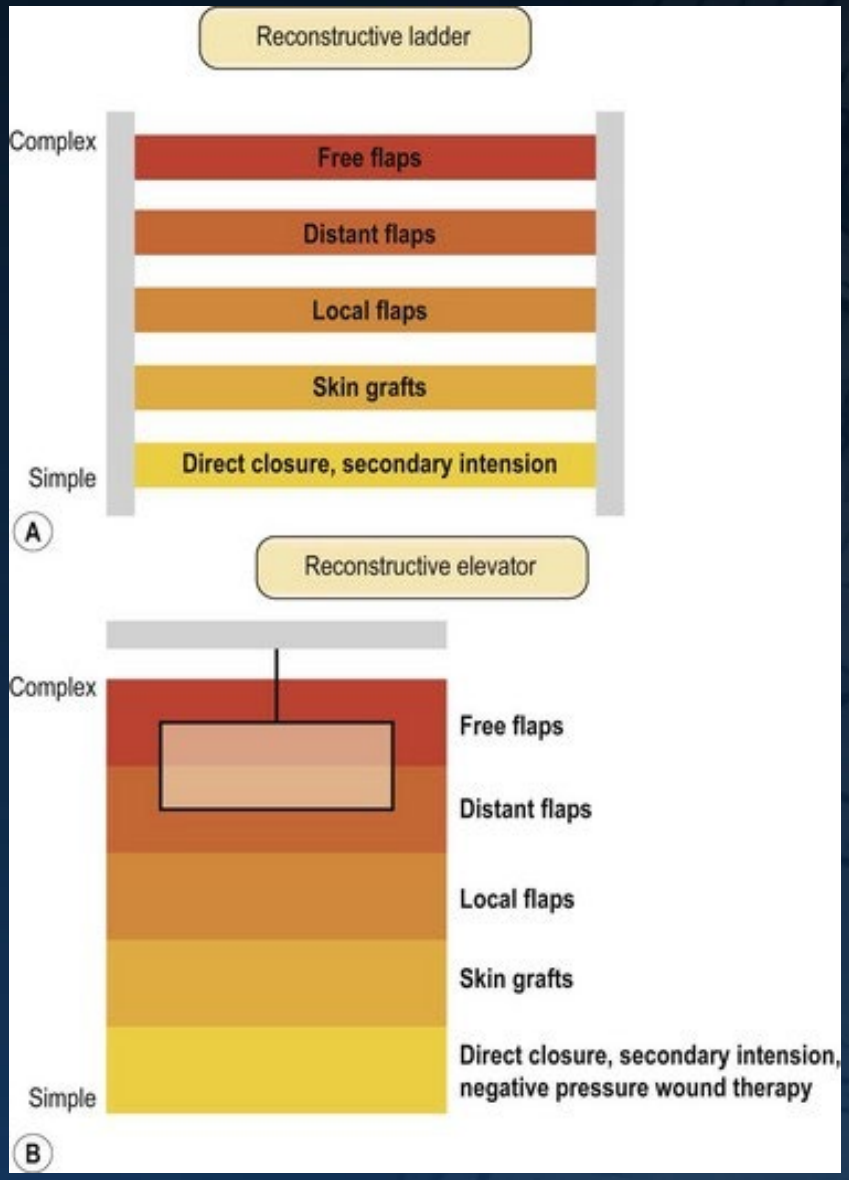
Washout, Debride, Washout, Debride, Washout, Debride

Be Patient!

Reconstructive Considerations

- Dimensions of wound, including depth
- Quality of the wound bed
  - Exposed tendon/nerve/bone/hardware
- Quality of surrounding tissue
- Unique functional role of that skin/tissue
- Adjacent tissue laxity
- Availability of adjacent tissue
- Target vessels for microsurgical anastomosis

Reconstructive Principles



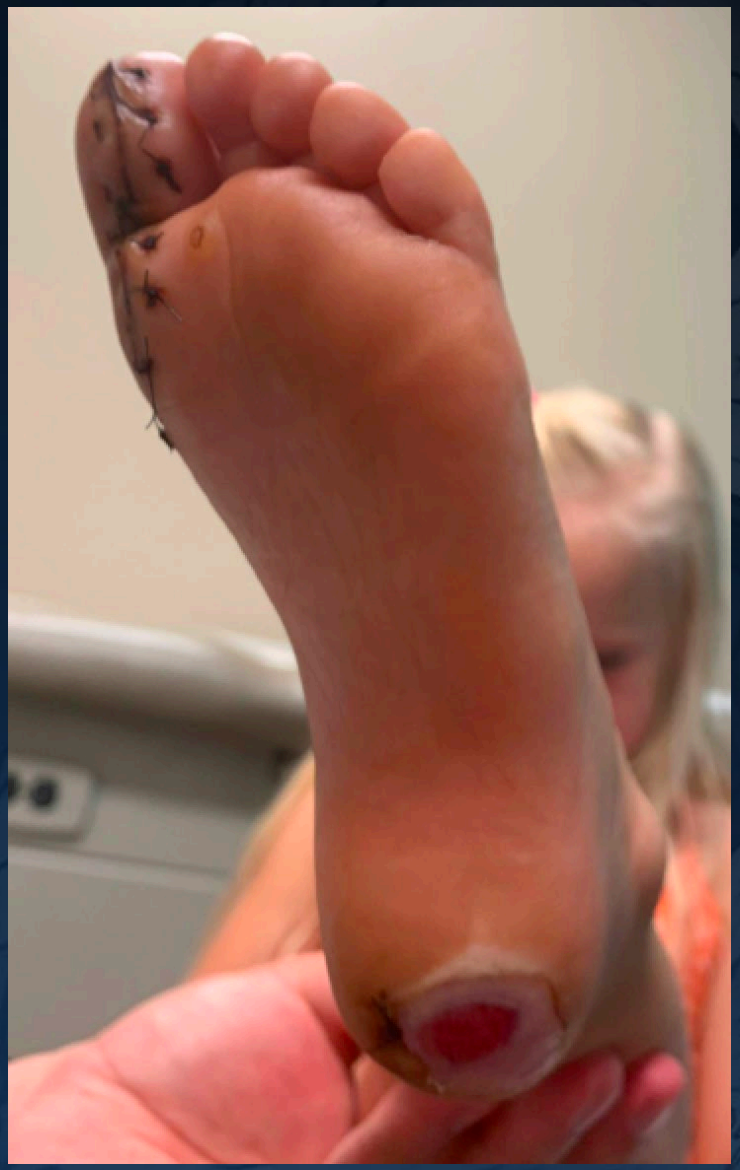
Trauma 5 Ways

Washout and Debride

Close what you can

Reconstructive Ladder

Primary Closure



Secondary Healing

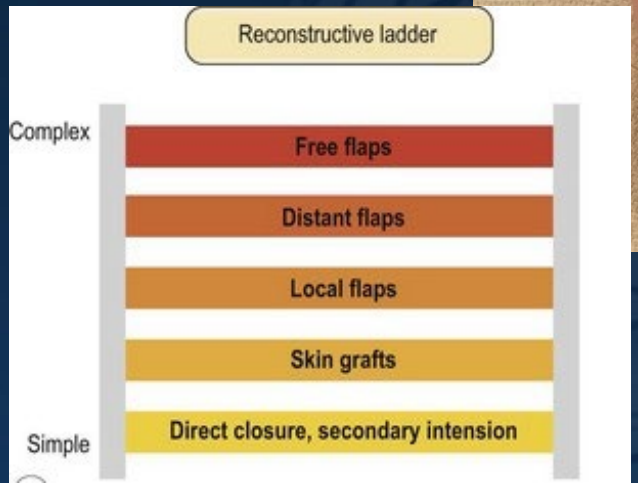
Close what is easy

Washout, Debride, Washout, Debride, Washout, Debride

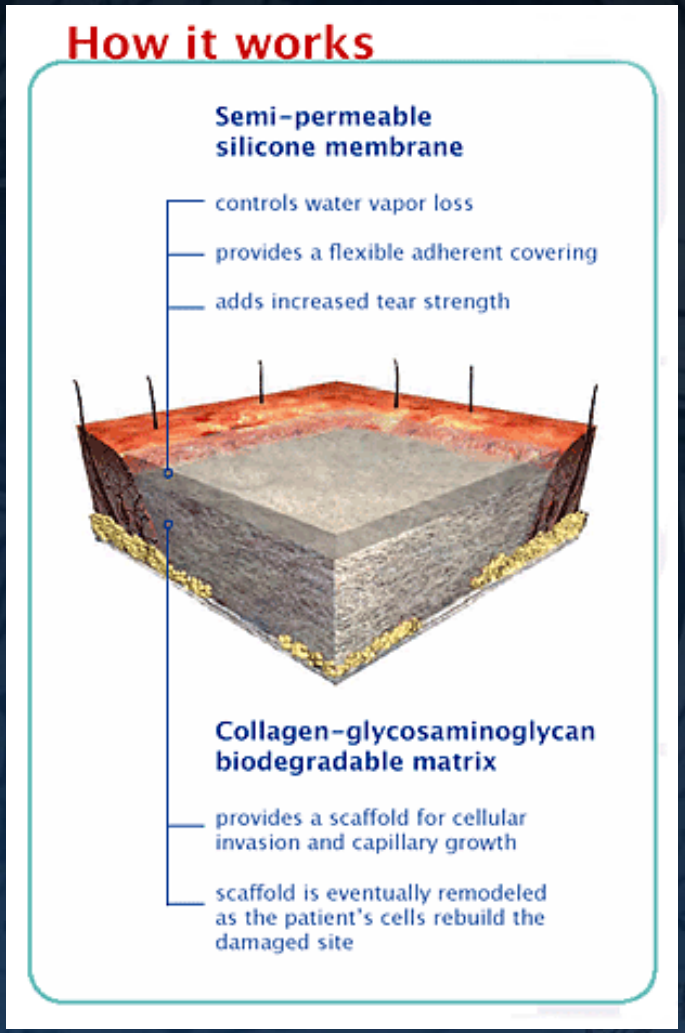
Washout, Debride, Washout, Debride, Washout, Debride

Reconstructive Ladder

- Too large to heal secondarily
- Unable to close primarily (sutures)
- Tissue quality too poor to use a skin graft
- No exposed bone/large amount of tendon that requires more robust flap



Dermal Wound Matrix

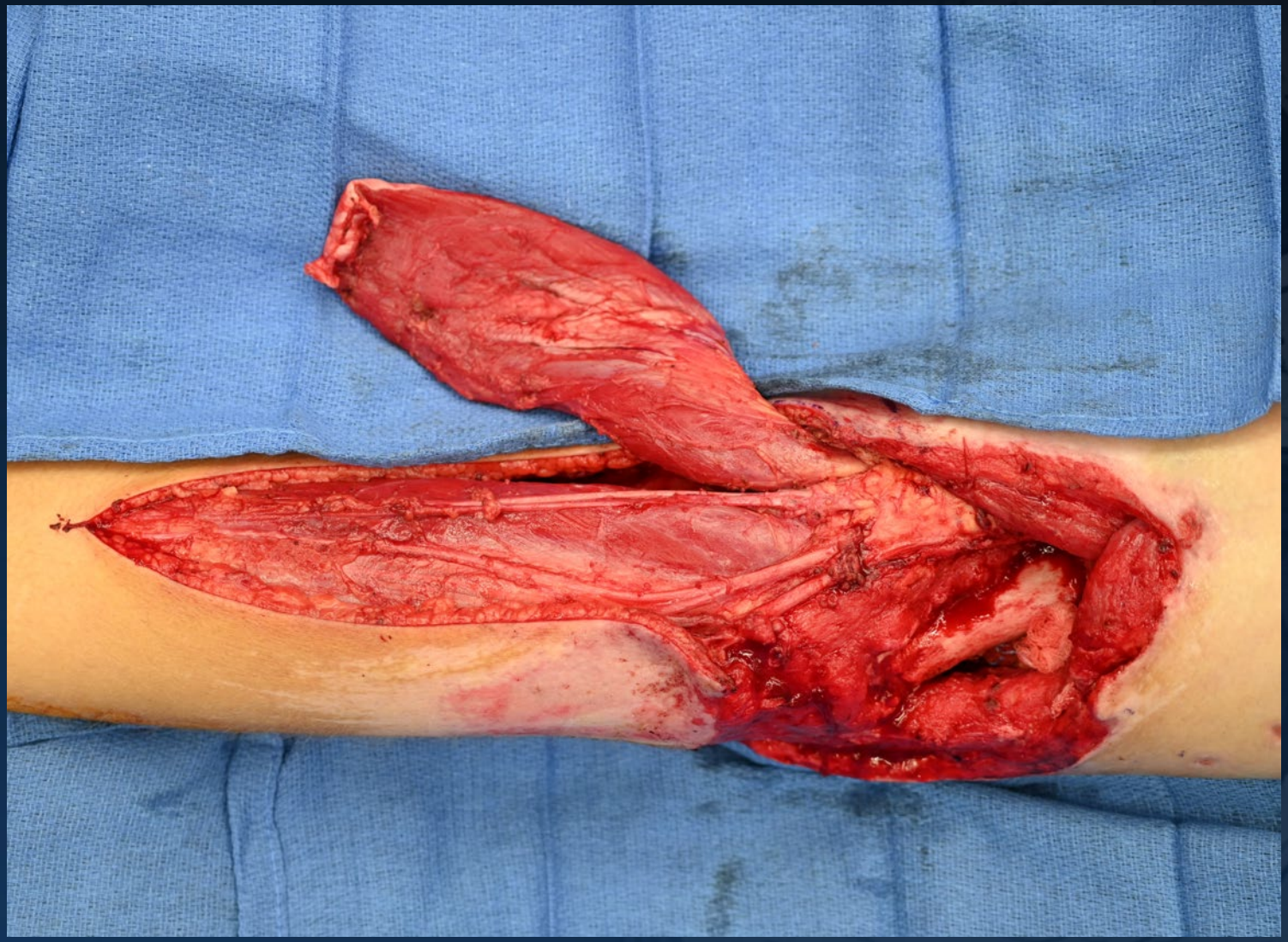


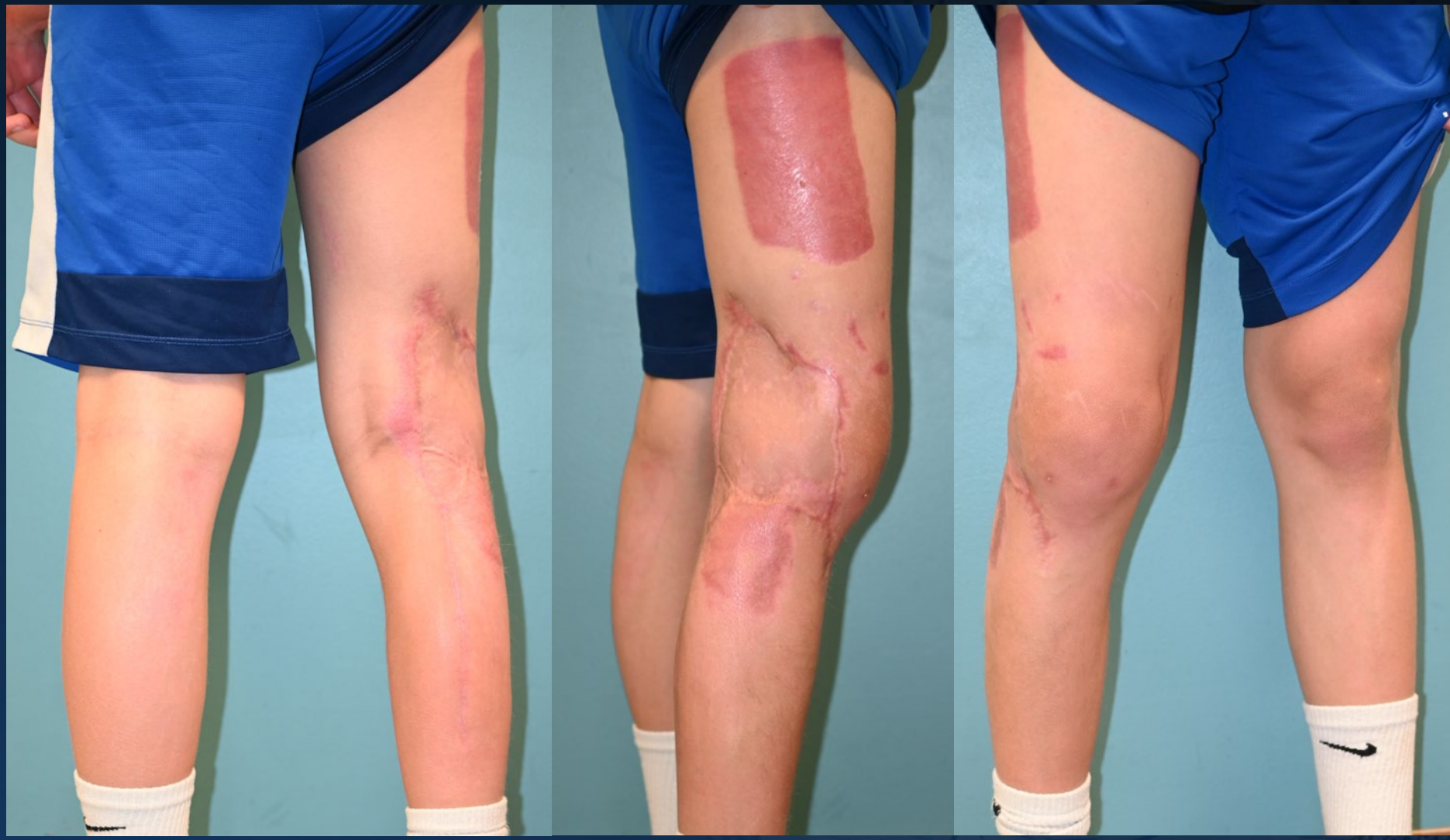
Debridement

Wound Vac Therapy

Post- Debridement

- Too large to heal secondarily
- Unable to close primarily (sutures)
- Depth of wound and bone exposure prohibits skin graft or dermal substitute
- Needs bulky, well vascularized tissue



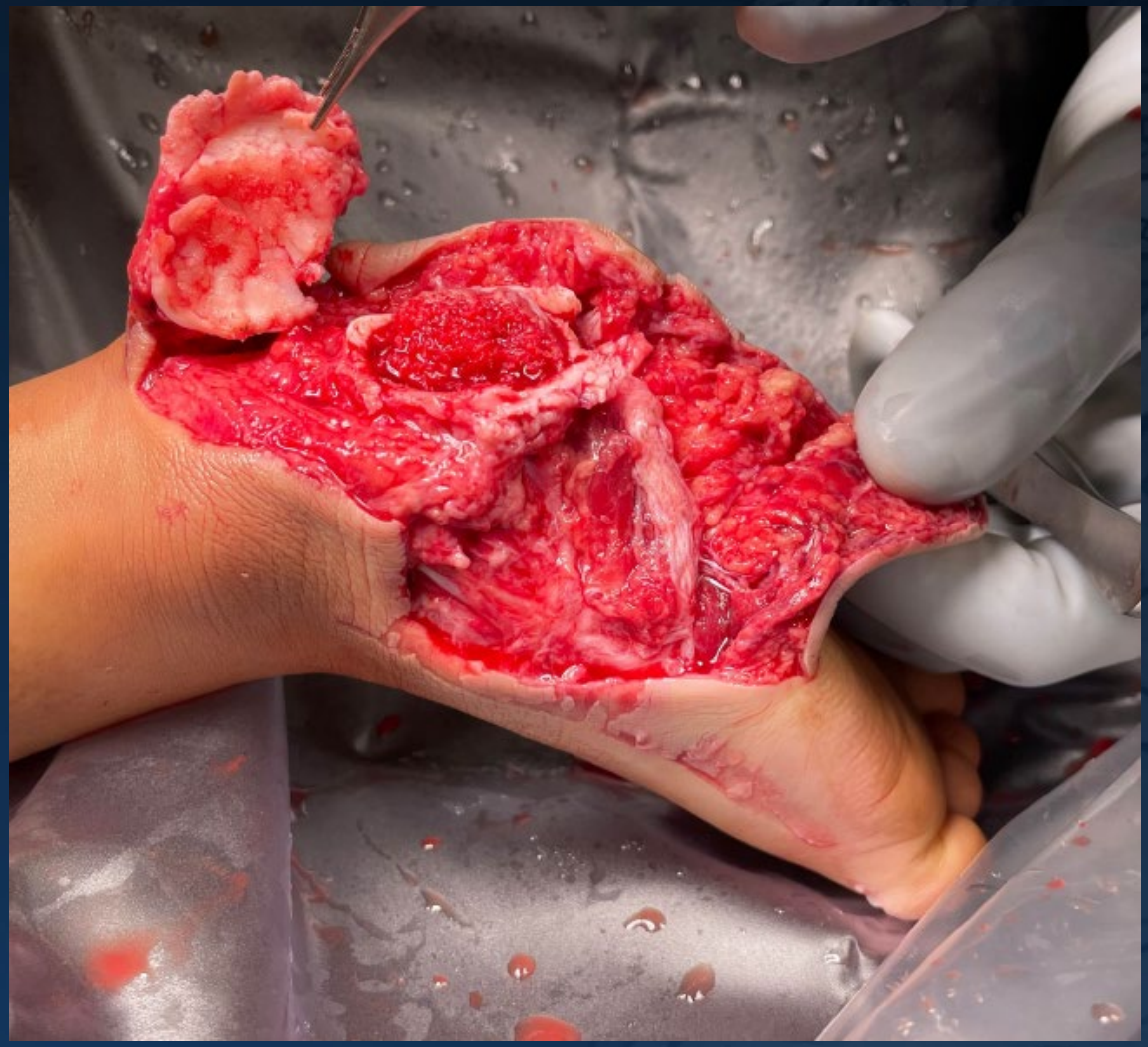


Flap Atrophy

Case #3

Case #3

Washout



Close what you can

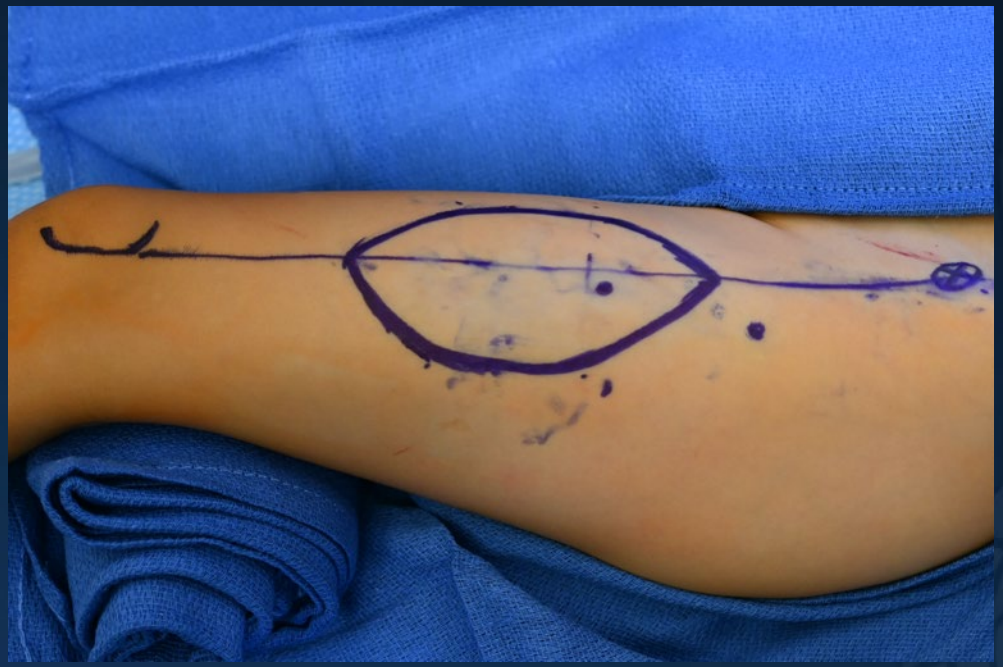
Wound Vac Therapy

Reconstructive Ladder

- Too large to heal secondarily
- Unable to close primarily (sutures)
- Tissue quality too poor to use a skin graft
- Exposed bone and Achilles tendon requires more robust flap

Free Flaps

- Fasciocutaneous
  - Anterolateral thigh
  - Scapula/Parascapula
  - Radial forearm
  - DIEP
- Muscle flaps
  - Latissimus
  - Rectus abdominis
  - Gracilis




MEDLINE

Case #5

Amputated Parts

Debridement

Debride, Close what you can, Wound Vac

Skin Graft

Flap Reconstruction

Thenar Flap

Thenar Flap

Thank You!