


# Man in Machine / Machine in Man Rescue

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## Objectives

- Injuries that result from machines
- A systematic approach to rescue and treatment
- Tools and techniques
- Clinical Care of injuries




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# Common Types of Machine Incidents

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## Manufacturing

- Rollers
- Presses
- Packaging
- Cutting
- Injection molding

• May involve any combination of heat, pressure, cutting, electricity



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## Auger Accidents

Home Watch Live News Weather Sports Health Investor

Trauma surgeons take lifesaving measures after man's legs caught in grain auger

October 10, 2017 at 7:29 PM EDT Updated August 16 at 10:27 AM

Farm worker receives life-saving amputation after legs crushed in grain auger



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## "Recreational"



- <https://www.youtube.com/watch?v=UHwqB0L1VWo>
- <https://www.youtube.com/watch?v=DJT0lqYBewg>

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## Chipping, Shredding, Mixing

- Small to big
- Very similar to auger rescue
- Just sharper and / or more complex

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## Agriculture Processing

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## Bins and Hoppers

- Product
- Weights and consistency
- Access
- Air Quality Monitoring
- Dust Creation
- Further ingestion into product
- Danger to Rescue Team

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## Garbage Truck / Waste

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## Carnival / Amusement Incidents

- Electrocutation
- Trapped by position / access
- Fall
- Structural failure
- Debris / shrapnel
- Often multi patient incident with combination of injuries

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## Focal Entrapment

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# UR TRAUMA Tongue Entrapment

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- Initially very time sensitive to vent the bottle before swelling occurs.
- Further options include
  - Lubrication
  - Cold
  - Injection



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# UR TRAUMA Heat and Cold

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# UR TRAUMA Sometimes they are just stuck

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# UR TRAUMA Chinese Finger Trap

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# UR TRAUMA Impalements

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- Trees
- Fences
- Nail guns
- Tools

Consider as penetrating trauma first with high concern of life threatening bleeding



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# UR TRAUMA Scene Sedation vs Facilitated Extrication

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**UR TRAUMA** Facilitated Extrication now "procedural sedation"  
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**2.40 FACILITATED EXTRICATION**

**CRITERIA**  
 Any adult or pediatric patient entrapped, who cannot otherwise be extricated due to extreme pain and/or anxiety

**RSI PARAMEDIC ONLY**

1. Routine Medical Care
2. Assess ECG rhythm (if possible), hemodynamic status, and stability of patient.
3. Identify and treat underlying cause of pain/anxiety as per Protocol 2.24 and/or 2.30, if appropriate.
4. Administer Midazolam 1-2 mg/kg IV/IO or 2-4 mg/kg IM. Additional doses of 2 mg/kg IM or 0.5-1 mg/kg IV/IO every 10 minutes.
5. Consider Midazolam 0.05 mg/kg (max 5 mg) if signs of emergence reaction appear:
  - Delirium
  - Visual hallucinations
  - Fluctuating sensorium
  - Altered body image
6. Consider Atropine 0.01 mg/kg IV/IO or IM (max 1 mg) if hypersalivation occurs.

**NOTE**



- Patient should have oxygen therapy (unless contraindicated) maintained throughout this procedure.
- A medically trained person (initially an EMT) must be able to safely remain close enough to patient during extrication to monitor the patient's respiratory status.
- When possible, ECG monitoring should be continuously in place, unless impractical.

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- Deaths have included electrocutions, falls, crush injuries, construction accidents.
- Over 200 Blade Failures launching blades 4/5<sup>th</sup> of a mile
- Over 100 structural failures
- Over 100 Turbine fires
- Sites of civilian climbing and suicide attempts
- Falling and launching of ice

<https://www.eastcountymagazine.org/dark-side-%E2%80%9Cgreen%E2%80%9D-wind-turbine-accidents-injuries-and-failures-raise-serious-safety-concerns>

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**Initial Response**




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- Pre-Plan
  - Do you have a plan ?
  - Have you been there on a good day ?
  - Do you know who you can call for help ?
  - Do you know who else you can call for help ?
  - What resource are on site ?
  - Who is in charge ?
  - How will you balance the patient care and the rescue ?




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**UR TRAUMA** Site hazards  
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- Uncontrolled chemical release
- Electricity
- Loaded PTO Systems
- Falls
- Fire / Explosion






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## UR TRAUMA Initial considerations


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- Gain access
- Get a proper brief from subject matter experts
- Six (7) sided size up
- Discuss and execute lock out / tag out and power procedures :
  - First consider any advantages : opening power doors / hatches / ventilation / raise / lower
  - Make sure the device wont move or return a "start up" position
- Determine what product may be involved.
  - Look up the product : consider acid / base properties, state it is in ( dust, particle , liquefied)
  - Will it create dust? , will it react with water? Sparks ?




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## Patient Care

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## UR TRAUMA Systematic Approach

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- **Patient : Stable / unstable**
- Risk of future / ongoing / progressive injury
- Was there a fall or force first ?
- Objective findings of limb in jeopardy ( 5 Ps)
- Burns, asphyxiation, contamination
- Suspension trauma
- Compression / reperfusion injury
- **Position : Vertical / Horizontal / Other?**
- **How :** Entrapment or Entrained :
  - Focal / general
- **Type :** Compressive / penetrating / Entrained

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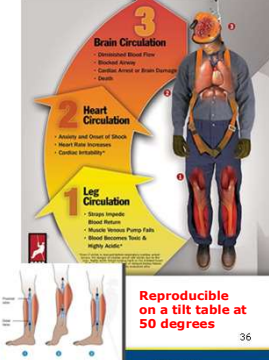
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## UR TRAUMA Suspension Trauma


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- **Causes**
  - Immobility
  - Venous blood return needs muscle contraction
  - Gravity
  - Constriction by harness
  - Dehydration
  - Blood anoxia and acidosis in limbs
- **Effects**
  - 20% loss in blood volume
  - Risk of syncope during rescue
  - Risk of acute ischemic injury or acute RV load injury post rescue
- **Considerations**
  - Drugs that change vascular tone and hydration
  - Post rescue position : 30 minutes supine / sitting



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## Crush injuries : Compartment vs Crush syndromes

### Compartment Syndrome

*"increased pressure within a confined space that leads to micro-vascular compromise and ultimately to cell death as a result of oxygen starvation"*

- Progressive swelling of tissues inhibits crush syndrome by preventing adequate circulation .
- BUT ; compartment syndrome can lead to limb loss, disability and death

### Crush Syndrome

An injury of reperfusion as a result of toxic cell waste and traumatic rhabdomyolysis


- Cell disruption
- Compressive ischemia
- Vascular compromise

Three criteria

- Muscle mass
- Prolonged compression 1-4+ hrs
- Compromised circulation
- **\*\*presence of blood in tissues**

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## UR TRAUMA Crush Injuries

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**(2-16) General Crush Injuries**

- ABCs and vital signs every 5 minutes, if practical
- Cervical immobilization and appropriate oxygen therapy
- Consider EMS physician response, if available, or early physician consultation for medical management

**EMT STOP**

- Rescuer cannot safely or 2 rescuers more than one RSI
- Transported within 1 hour of injury
- Rescuer has "Controlled Risk Management" protocol, as indicated

**ADVANCED STOP**

- Cardiac monitor, if possible, with 12-lead ECG repeated at 30 minute intervals

**EC STOP**

- If hemodynamic compromise is evident : 3 hours, or 2 rescuers are needed : 1 hour
- Subtle tachycardia 50 and 60 bpm (slow) every 30 minutes
- If available, one rescuer great to continue: Subtle tachycardia 50 and 60 bpm

**PARAMEDIC STOP**

- If hypotension is suspected and ECG changes, obtain at least 12-lead ECG every 5 minutes. Repeat in 10 minutes, if there is no resolution of the ECG changes or if hypotension
- Administer two boluses
- Consider application of a tourniquet for prolonged management placed as close as possible to the injury (may prevent the return of the contents)


**Any Paramedic Consideration**

- A second EMS physician involved in the scene, if practical, instructed to prioritize
- A transport of 100% of oxygenation should be given between the time of release of the patient and the time of patient transport
- Hypotension is indicated by PVS, peaked T waves, or widened QRS complexes
- After evaluation, immobilize the extremity and apply cold therapy, do not elevate the extremity

- Confirmed Crush injury ?
- Assess
  - Absence of circulation
  - Pain Pallor Pulseless Paresthesia Pressure
  - Waveform Oximetry
  - Cap Refill ( trended)
  - **"Completely Crushed"**
  - Not trapped.
  - If Hyperkalemia **AND** ECG changes
- **New evidence that "smiling death" is arrest from anoxic blood bolus or massive exsanguination or RV failure or embolic event**

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## Crush Treatment

- Coordinated rescue
- Oxygen, hydration
- WARMTH
- Pain control
- Sodium Bicarb: keeps myoglobin in serum
- D50 / Insulin: put K back in cells
- Albuterol : puts K back in cell
- **ALL PHARMACOLOGIC MEASURES ARE TRANSIENT**

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## Patient Assessment / Treatment : WARNING


**GRAPHIC CONTENT**

- ABCDE
- Recovery / Rescue / or Limb Rescue
- Prepare for prolonged patient care in Hazardous environment
- IV Access / Volume replacement
- Crush Syndrome
- Pain / Comfort / Sedation / Nerve Block
- Temperature control
- Limb Preservation
- Language Barrier



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## Patient assessment

- Patient assessment and care should be brief and simple
- Do not impede a 10 minute rescue with 20 minutes of patient care



BATMAN (Battlefield Air Targeting Man-Aided Knowledge)  
BATDOK (Battlefield Airmen Trauma Distributed Observation Kit),

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Tools and techniques

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## Rescue Tactics

- Disentangle vs./ and / or Extricate
- Reverse
- Relax
- Disassemble
- Cut / Lift / Spread
- Transport w partial rescue



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## Know your enemy

- Aluminum (element)
- Iron (element)
- Steel
  - Carbon Steel: Carbon steel is dull and matte in appearance and is vulnerable to corrosion.
  - Alloy Steel
    - Alloy steels are a mixture of several metals, including nickel, copper, and aluminum. Alloy steels tend to be cheaper and are used in mechanical work, car parts, pipelines, and motors
  - Stainless Steel (chromium)
    - Stainless steel is strong and can withstand high temperatures. There are more than 100 grades of stainless steel
  - Tool Steel
    - Tool steels are hard and heat and scrape-resistant. They are named tool steels because they are often used to make metal tools, such as stamping, cutting, and mold-making tools




Tungsten

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## Iron Vs. Steel

- Cast iron is not truly pure iron.
- Steel has a carbon content of less than 2.1% by weight. More carbon makes the mix harder, more brittle
- Cast iron contains MORE carbon than that rough upper limit of 2.1% for steel.
- Carbon prevents dislocations from forming when you try to deform (bend) the cast iron. The cast iron simply won't bend. Instead, it shatters under stress.

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## Cutting Tools

- Saws
- Grinders
- Ratchet or Chain Cutter
- Torch / Thermal Cutting
- Right tool, right method, right metal, right way**





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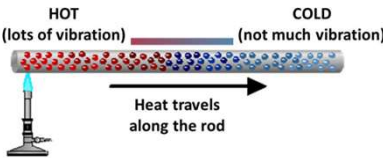
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## Heat Transfer

- Transfer of heat during close quarter cutting can burn a patient
- Use of a heat sink, heat trap
- Patient protection from sparks



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## Man in machine kit




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## Specialized Equipment



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**UR TRAUMA** "an axe always starts"  
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**UR TRAUMA** **Techniques : Ring Rescue**  
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- Lubrication
- Cold & Constriction
- Fishing line
- Umbilical Tape (spiral wrap )
- Rubber Band

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**UR TRAUMA** **Techniques : Cutting**  
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- Running grinders / augers in reverse will likely complete a partial amputation
- Grinders are an ideal cutting tool.
  - Heat transfer
  - **Cuts must be 1/2 the ID to remove the auger**
  - Consider machine disassembly and transfer to a controlled environment

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**UR TRAUMA** **Techniques : limb in a space**  
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- Rarely injured just "trapped"
- **Excellent case for selective relaxation**
- Challenge is patient is never in a good position to receive sedation
- Rarely limb threatening but edema and muscle tetany will make situation worse over time.
- Tools & technique
  - Micro camera
  - Lubrication / Drain holes
  - Relax and remove
  - Chip and cut

<http://www.firststretackle.com/2016/05/19/hand-stuck-floor-drain-prog/>

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**UR TRAUMA** **Technique : Rollers**  
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- Electrically powered vs PTO Powered
- From commercial machine to pasta makers
- Rollers generally steel
- One or both rollers may be powered or geared
- Easy solution is a slight spread
- Disassembly removal and release
  - Release may roll the entrapment forward, block and chock
  - Still spread as you release
- A sure thing is a torch ( very destructive to the machine)

Cincinnati Rescue 9 and <http://www.firststretackle.com>

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# Techniques : Amputation

- The role of amputation should be a last resort
- Indications would be
  - Imminent circulatory collapse

Original article

**Man or machine? An experimental study of prehospital emergency amputation**  
Caroline Leech,<sup>1</sup> Keith Porter<sup>2</sup>

**OPEN ACCESS**

**ABSTRACT**  
**Objective:** Prehospital emergency amputation is a rare procedure, which may be necessary to free a time-critical patient from entrapment. This study aimed to evaluate four techniques of cadaveric lower limb prehospital emergency amputation.  
**Method:** A guillotine amputation of the distal femur was undertaken in both frozen and unfrozen cadavers. A prehospital doctor conducted a surgical amputation with Gigli saw or hacksaw for bone cuts and firelighters carried out the procedure using the reciprocating saw and Holmatro device. The primary outcome measures were time to full amputation and the number of...

**Key messages**  
**What is already known on this subject?** Prehospital emergency amputation is a rare but potentially life-saving procedure. There is little evidence about which technique or equipment may be effective. This cadaveric study aimed to assess four different techniques of amputation using equipment, which may be carried by a prehospital doctor and the UK fire service.  
**What might this study add?**

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Original article

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Figure 2: An arena table saw



Figure 3: Reciprocating saw



Figure 4: Holmatro distal cut



Figure 5: Girth the prisoner with hip saw

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# Amputation Considerations

2 & 2 Rule

- 2 rescue specialists
- 2 Physicians (may be consultation)

Scenarios

- Stable patient, Viable Limb & a rescue option.
- Imminent threat to the patient & limb not viable & no rescue option
- No imminent patient threat & limb not viable & no rescue option
- Imminent threat to patient & viable limb & no rescue option
- No imminent patient threat & limb not viable & moderate to long rescue option

Table 1 Results of amputation techniques

	Gigli saw	Hacksaw	Reciprocating saw	Holmatro
Time (s)	91	88	22	38+15
Number of cuts	1	3	2	2+
Risks to rescuer or survivor	Sharp knife, sharp Gigli saw	Sharp knife, saw blade injury	Significant spray/plattering of blood and tissue Aerosolisation of tissue would require FFP3 mask	Manual handling. Audible loud splintering sound
Practicalities of use in entrapment	Elbow room for Gigli	Need to support/protract leg. Difficult to angle hacksaw	Some angulation required. Difficult to see when cut completed	Would be difficult to encircle leg if within vehicle
Quality of skin cut	5	5	4	4
Quality of soft tissue cut	5	5	4.5	3
Quality of bone cut	4	5	4.5	2.5


Leech C, Porter K. *Emerg Med J* 2016;32:1-4. doi:10.1136/emermed-2015-204881

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# Pre Hospital Communication

- Try to paint an accurate picture or
  - Time
  - Depth
  - Location of injury
  - Size
  - Patient co-morbid conditions
- We often get :
  - "it was big... large... heavy"
  - "Impaled by metal"
  - "Amputation of arm"



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**COUNTY OF LOS ANGELES FIRE DEPARTMENT**

**USC University of Southern California**

Marc Kevin Eckstein, MD  
• LACoFD Med Dir.

Elizabeth Benjamin, MD, PhD  
• Trauma Surgeon

• RN, Resident and a Fellow



LAC+USC HERT team lauded for astonishing rescue

He was trapped. And the fire department couldn't get him out. Hector Ruiz had climbed into a confined space inside a hopper at the iron foundry where he works...

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## "Yeah...that looks swollen"

- Even small brief entrapment can create isolated late compartment syndrome
- Diligent assessment of function, sensation and circulation should be frequent and trended





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## Patient Care

- Open fracture care
  - Antibiotics
  - Cef & Gent / Vanc
  - Zosyn
- Vascular injury
  - Post rescue assessment
- Skeletal injury
- Hypoxia
- Secondary injury
  - Thermal
  - Metabolic

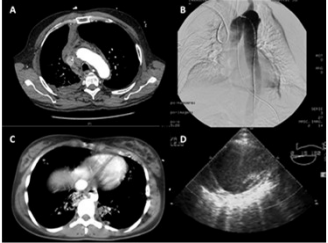


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## Central Crush Injuries

- ATAI
- Acute Traumatic Aortic Injury
- Prevalent central vessel injury associated with blunt force different that deceleration injury
- Injury of the aorta between sternum and thoracic spine (osseous pinch), and direct load causing aortic wall strain and medial tears.



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