



Suspension Trauma Revisited

International Technical Rescue
Symposium
Fort Collins, CO
November 6, 2011

Objectives

- Describe physiology of Suspension Trauma.
- Define the terms crush syndrome, rhabdomyolysis, and compartment syndrome.
- List two consequences of prolonged passive suspension.
- Describe the controversy over laying patients down.
- List two implications for patient packaging and transport.

Suspension Trauma

- Also known as Harness Pathology, Harness Hang Syndrome, Suspension Intolerance.
- Probably should not use a term with harness as the harness is not the problem.
- Identified as early as 1972.



Is it real?

- Some don't believe in it.
- Rare things are hard to study.
- Lack of a commonly accepted definition makes it hard to study.

Suspension Trauma

- **What it is**
 - A state of shock from blood accumulating in the legs from **passive suspension**
 - Early fainting with death
 - Late muscle damage
-
- **What it is not**
 - Death from sitting in a harness

Terms

- Rhabdomyolysis-muscle destruction leading to muscle enzymes in the blood. Can lead to kidney failure.
- Compression-rhabdo from compressing muscles from not moving, like passed out drunk
- Crush-rhabdomyolysis from external pressure on muscles e.g. building debris.

Terms

- Compartment syndrome—swelling inside one of the non-elastic compartments of the body. Leads to no blood flow and muscle destruction (and rhabdomyolysis.)

Image of a cross section of the lower Leg showing compartments

Terms

- Rhabdo is a general term for muscle destruction by any cause
- All crush syndromes have rhabdo but not all rhabdo is crush.
- All compartment syndromes have rhabdo, but not all rhabdo is compartment
- Compression may cause rhabdo, but not all rhabdo is compression

Suspension Trauma

- 1972 conference, Series of Alpine mountaineering accidents. Deaths on rope without trauma.
- French series of cavers who died on rope of “hypothermia” but faster than expected.

Suspension Trauma

- The French tried to replicate this.
- Told to act unconscious on rope.
- In 3 and 6 minutes they were.
- Re-examined their protocol.
- Replicated in a hospital in 9 minutes.



Activity	Age/Sex	Time to Death	Autopsy	Ref
Training	25/M	6 minutes	No	18
Mountaineering	18/M	> ½ hour	Plethora of lower vena cava	3
Mountaineering	17/M	24 hours?	Not available	34
Mountaineering	19/M	½ hour	Not available	34
Mountaineering	25/M	2 hours	No	34
Caving	15/M	< 2 hours	No	4
Caving	NA/M	20 minutes	No	4
Caving	NA	< 1 hour	No	4
Caving	50/M	Unclear	No	4
Caving	24/M	Unclear	No	4
Caving	NA	Unclear	No	4
Caving	NA	< 1 hour	No	4
Caving	25/M	Unclear	No	4
Caving	20/M	Unclear	No	4
Caving	23/M	Unclear	No	4
Caving	29/M	Unclear	"Hypothermia"	10
Caving	26/M	> 2 hours	"Hypothermia"	6
Caving	28/M	Unclear	No	7
Mountaineering	18/M	2–3 hours	"Asphyxia by hanging"	14
Mountaineering	16/M	35 minutes	Suffocation by Aspiration	13
Canyoneering	24/M	Unclear	Mechanical asphyxiation	
Caving	20/M	>45 minutes	Hypothermia, Suspension Trauma	
Caving	~19/M	>45 minutes	Hypothermia, Suspension Trauma	

What's happening?

Image of venous pump with valves in vein
Between muscles

- For blood to return to the heart, muscles have to contract.
- With no contraction, the blood just pools in the legs.

Really?

- In the lab one sees...
- 1. Swelling legs
- 2. Shrinking heart
- 3. Decreased trans-thoracic impedance
- 4. Increasing heart rate
- 5. Decreasing pulse pressure
- 6. Decreasing blood flow to kidneys

Fainting Response

- Think of the soldier on the parade ground.
- Standing with knees locked, not moving a muscle.
- If the brain isn't getting enough blood, it goes to ground.

Image of soldiers at attention with One fallen down, fainted.

Fainting Response

- Sometimes called a vaso-vagal response.
- Parasympathetic discharge.
- Blood pressure drops.
- Heart rate drops.
- Response to heat, emotion, low volume.
- Once flat, volume returns to the heart and can be pumped to the brain.

Fainting Response

- What happens if you can't fall down?
- Blood volume at the heart already low.
- Blood pressure drops.
- Heart rate drops.
- You might die.

The Madsen Case

- Soldier in training situation told to simulate unconsciousness.
- Trainer went to get trainees.
- Came back 6 minutes later.
- Soldier dead on rope.

Madsen et al. Aviat Space Environ Med 1998; 69:781-4

Madsen Followup

- Madsen put 79 people on a tilt table
- 69 were presyncopal in a median of 27'
- No harness involved

Image of a tilt table

Seddon

- Seddon for HSE summarized what was known.
- Concern raised for “Rescue Death”
 - Concluded “Don’t lay them down after rescue”
 - Concluded “Don’t take off the harness”

“Rescue Death”

- In the 1972 series, one of the patients died as soon as she was rescued.
- At that conference several warned about laying anyone down “abruptly” after rescue.
- Many explanations of the phenomenon exist, usually citing “toxins” or rapid return of volume.

Death after Rescue

Activity	Age/Gen	Time Suspended	Time to Death	Autopsy	Reference
Caving	17/M	Unclear	5 hours	No	4
Caving	NA/M	"Rapidly"	20 hours	No	4
Mountaineering	25/M	3 hours	11 days	Rhabdomyolysis	34
Mountaineering	18/M	6.5 hours	1.5 hours	Unknown	34
Mountaineering	24/F	7 hours	32 hours	No	34
Mountaineering	21/M	4 hours	2 hours	No significant trauma	34
Mountaineering	33/M	3 hours	19 hours	Not available	34
Mountaineering	23/F	4 hours	"Few minutes"	Circulatory collapse	2,34
Mountaineering	19/?	8 hours	17 hours	Not available	34
Caving	?/M	4 hours	Minutes	Not Available	11

Myoglobin

- As muscle cells die they release myoglobin into the blood stream.
- It can be toxic to kidney cells and is the cause of kidney failure.
- It does not affect cardiac rhythm.

Acid

- Limbs are routinely tourniqueted for surgery.
- pH after two hours is 6.9 (pretty acidic)
- Tourniquets are released with no special precautions and no consequences beyond a few minutes of hyperventilation.
- pH affects contraction but not rhythm.

Potassium

- Released from damaged muscle cells.
- Elevated levels can change heart rhythms or even stop the heart.
- Bicarbonate can reduce potassium levels.

How to prevent “Rescue Death”

- According to Seddon
 - Don't lay them down
 - Don't take off the harness

http://www.hse.gov.uk/research/crr_htm/2002/crr02451.htm



What to do about "toxins"?

- Get them down NOW!
- IV Fluid appropriate if available (normal saline alternated with 1/2NS with 1 amp of bicarbonate)
- Don't wait for fluids to get someone down.
- At risk for renal failure if hanging >2 hours. Take to an ER.

Volume

- Concern expressed that the act of laying someone flat returns blood from legs so fast that it distends the heart and causes it to stop beating.

Image of girls cartwheeling

Volume

Image of man upside down on
Olympic rings

- If you infuse a heart with saline rapidly you can get see some abnormalities, but the same ones that you see if stressed

Volume

- Hard to find any other activity in which changing heart volume by changing position is lethal.

Image of two women diving into A pool.

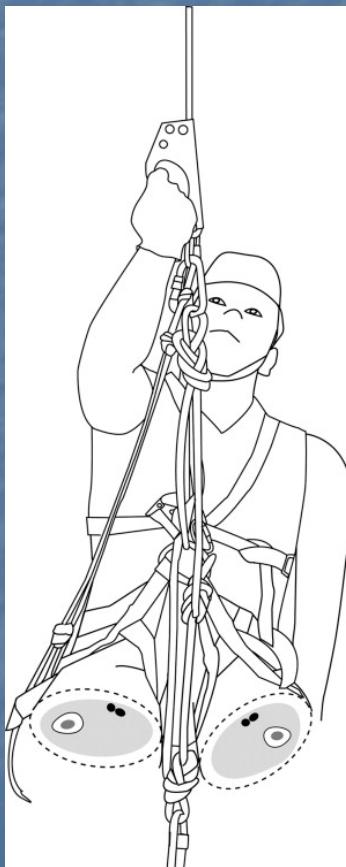
So is it safe to lay them down?

- At least 3 independent medical reviews say no evidence for the original recommendation
- OSHA says “Ensuring(e) that a worker receives standard trauma resuscitation once rescued”
- The organization that published Seddon’s recommendation as theirs has since retracted that.
- MRA says treat like any other.
- IKAR going to say the same thing

Could it harm to wait 30 min?

- Remember that Madsen's lab subjects got suspension symptoms from simply being at an angle.
- Evidence from vascular surgery shows that waiting depriving muscles longer increases the chance of muscle death, swelling, and compartment syndrome.

What about the harness?



- Seddon says take off slowly
- But great vessels not actually affected by the harness
- Take off or leave on based on comfort and evacuation needs

Death after Rescue

Activity	Age/Gen	Time Suspended	Time to Death	Autopsy	Reference
Caving	17/M	Unclear	5 hours	No	4
Caving	NA/M	“Rapidly”	20 hours	No	4
Mountaineering	25/M	3 hours	11 days	Rhabdomyolysis	34
Mountaineering	18/M	6.5 hours	1.5 hours	Unknown	34
Mountaineering	24/F	7 hours	32 hours	No	34
Mountaineering	21/M	4 hours	2 hours	No significant trauma	34
Mountaineering	33/M	3 hours	19 hours	Not available	34
Mountaineering	23/F	4 hours	“Few minutes”	Circulatory collapse	2,34
Mountaineering	19/?	8 hours	17 hours	Not available	34
Caving	?/M	4 hours	Minutes	Not Available	11

Rescue Implications

- Know your rope work. Practice it.
- Horizontal position unless there's a darn good reason not to.
- Vertical lift of an unconscious patient is dangerous!
- Leg loops for every good leg to push against.

Rescue Implications

- In SRT training situations, use a releasable anchor so someone in trouble can be lowered quickly.
- (In other situations too???)

Image of tied off rack

Summary

- Short term death by fainting while suspended
- Potassium levels can be high enough to harm
- Medium term muscle death by starving it of oxygen
- Long term kidney failure from muscle components

Summary

- Get them down
- Lay them down
- Fluids if possible
- Don't worry about the harness