Suspension Trauma Revisited

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

http://www.wemjournal.org/article/S1080-6032(10)00320-0/fulltext
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 - rhabdomyolysis 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

- 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.
<table>
<thead>
<tr>
<th>Activity</th>
<th>Age/Sex</th>
<th>Time to Death</th>
<th>Autopsy</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training</td>
<td>25/M</td>
<td>6 minutes</td>
<td>No</td>
<td>18</td>
</tr>
<tr>
<td>Mountaineering</td>
<td>18/M</td>
<td>&gt; ½ hour</td>
<td>Plethora of lower vena cava</td>
<td>3</td>
</tr>
<tr>
<td>Mountaineering</td>
<td>17/M</td>
<td>24 hours?</td>
<td>Not available</td>
<td>34</td>
</tr>
<tr>
<td>Mountaineering</td>
<td>19/M</td>
<td>½ hour</td>
<td>Not available</td>
<td>34</td>
</tr>
<tr>
<td>Mountaineering</td>
<td>25/M</td>
<td>2 hours</td>
<td>No</td>
<td>34</td>
</tr>
<tr>
<td>Caving</td>
<td>15/M</td>
<td>&lt; 2 hours</td>
<td>No</td>
<td>4</td>
</tr>
<tr>
<td>Caving</td>
<td>NA/M</td>
<td>20 minutes</td>
<td>No</td>
<td>4</td>
</tr>
<tr>
<td>Caving</td>
<td>NA</td>
<td>&lt; 1 hour</td>
<td>No</td>
<td>4</td>
</tr>
<tr>
<td>Caving</td>
<td>50/M</td>
<td>Unclear</td>
<td>No</td>
<td>4</td>
</tr>
<tr>
<td>Caving</td>
<td>24/M</td>
<td>Unclear</td>
<td>No</td>
<td>4</td>
</tr>
<tr>
<td>Caving</td>
<td>NA</td>
<td>Unclear</td>
<td>No</td>
<td>4</td>
</tr>
<tr>
<td>Caving</td>
<td>NA</td>
<td>&lt; 1 hour</td>
<td>No</td>
<td>4</td>
</tr>
<tr>
<td>Caving</td>
<td>25/M</td>
<td>Unclear</td>
<td>No</td>
<td>4</td>
</tr>
<tr>
<td>Caving</td>
<td>20/M</td>
<td>Unclear</td>
<td>No</td>
<td>4</td>
</tr>
<tr>
<td>Caving</td>
<td>23/M</td>
<td>Unclear</td>
<td>No</td>
<td>4</td>
</tr>
<tr>
<td>Caving</td>
<td>29/M</td>
<td>Unclear</td>
<td>“Hypothermia”</td>
<td>10</td>
</tr>
<tr>
<td>Caving</td>
<td>26/M</td>
<td>&gt; 2 hours</td>
<td>“Hypothermia”</td>
<td>6</td>
</tr>
<tr>
<td>Caving</td>
<td>28/M</td>
<td>Unclear</td>
<td>No</td>
<td>7</td>
</tr>
<tr>
<td>Mountaineering</td>
<td>18/M</td>
<td>2–3 hours</td>
<td>“Asphyxia by hanging”</td>
<td>14</td>
</tr>
<tr>
<td>Mountaineering</td>
<td>16/M</td>
<td>35 minutes</td>
<td>Suffocation by Aspiration</td>
<td>13</td>
</tr>
<tr>
<td>Canyoneering</td>
<td>24/M</td>
<td>Unclear</td>
<td>Mechanical asphyxiation</td>
<td></td>
</tr>
<tr>
<td>Caving</td>
<td>20/M</td>
<td>&gt;45 minutes</td>
<td>Hypothermia, Suspension Trauma</td>
<td></td>
</tr>
<tr>
<td>Caving</td>
<td>~19/M</td>
<td>&gt;45 minutes</td>
<td>Hypothermia, Suspension Trauma</td>
<td></td>
</tr>
</tbody>
</table>
What’s happening?

- 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 Followup

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

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

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

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.
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.
So is it safe to lay them down?

- At least 3 independent medical reviews say no evidence for the original recommendation.
- OSHA says “Ensuring 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

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