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Suspension Trauma 101

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Why are rescue at height plans so important? Why do we talk so much about knowing what to do when sh!t hits the fan? One of the comments that comes up frequently on our feedback form is "Please give us more" in terms of suspension trauma. So here it is. Here is the crash course in suspension trauma. Although suspension trauma can occur in circumstances *other than a fall*, this article will focus primarily on a fallen worker.

Let's start with terms you need to know.

- **Fall Arrest System:** A series of equipment components designed to *stop* the fall of individuals working at heights should they fall.
- **Orthostatic Hypotension:** In suspension trauma, this refers to the pooling of blood in the leg veins of a worker that occurs when individuals fall in harnesses, are suspended in confined spaces, etc. and are forced to hang vertically with their legs relaxed (immobilized).
- **Reflow Syndrome:** The return of pooled, hypoxic blood and its metabolic byproducts from the extremities to the heart (more about this later).
- **Rescue Death:** When related to suspension trauma, this type of death occurs in patients who appear physiologically stable during the rescue and extrication but suddenly die after being freed.
- **Suspension Trauma:** Injuries Sustained from being immobilized in a vertical position when the legs are relaxed and immobile. Injuries include hypoxia (insufficient oxygen reaching the tissues); syncope (loss of muscle strength and/or fainting); hypoxemia (abnormally low levels of oxygen in the blood causing shortness of breath); acidosis (excessive acid in the body fluids or tissues, build up to CO₂); ventricular fibrillation (irregular contractions of the heart where the chambers quiver uselessly instead of pumping blood, generally followed by sudden cardiac arrest); myocardial infarction (heart attack or literally "death of heart muscle"); damage to the liver, kidneys and brain; and possibly death.
- **Suspension Syndrome:** The condition in which a suspended person becomes unconscious due to orthostasis (upright hanging position) *without* traumatic injury.

Scarey stuff right? Still with me? The "good" news is that suspension trauma can only affect someone who is immobile – specifically not using their leg muscles to any great extent. It does not normally affect people who wear a harness who are:

- Actively moving about (climbing, rope access, rescue work, etc.)
- Suspended for only a minute or two (parachutists)

THE DANGER BEGINS WHEN SOMEONE IS UNABLE TO MOVE FOR AS LITTLE AS 3 MINUTES!

So what exactly happens when someone has taken a fall in a harness and is hanging immobilized but is still conscious?

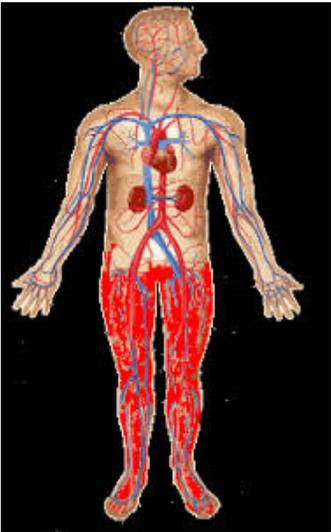
- They will have general feelings of unease (they did just have a fall after all)
 - This can include being dizzy, sweaty and other signs of shock
 - They will have an increased pulse and breathing rates
- They will then experience a sudden drop in their pulse and blood pressure
- This will result in an instant loss of consciousness

- If they are not rescued quickly, **death is certain**
 - Resulting from suffocation due to a closed airway, or from a lack of blood flow and oxygen to the brain



Why does this happen? Let's review a little biology.

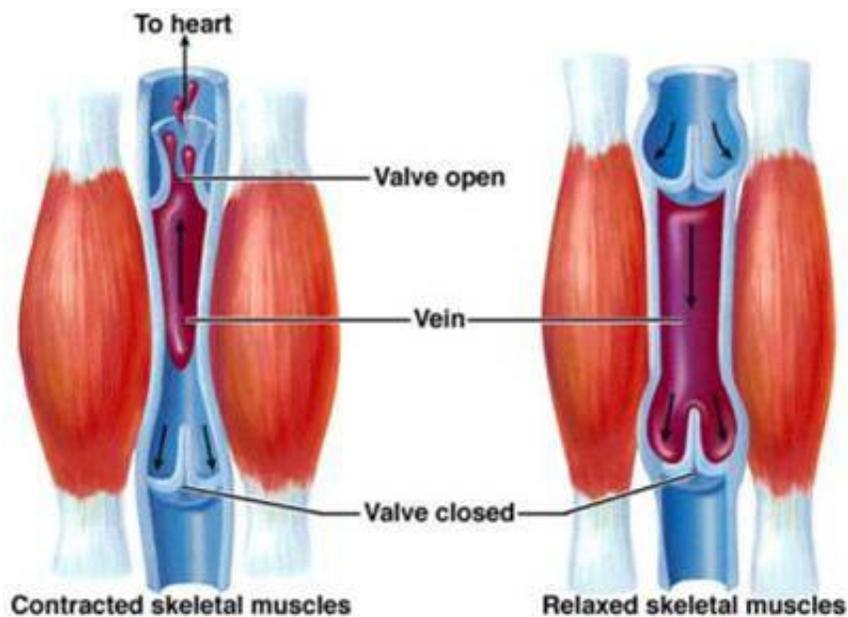
- Humans are not designed to stand upright.
 - Our circulatory system is actually built for life on all fours.
 - Our volume of blood vessels is much greater than that of our blood supply.
- Sooooo, when we stand upright we have a problem.
 - Gravity pulls our blood into our legs!



Our heart is a positive-pressure pump only. It cannot suck. The only way to get the blood back out of the legs is to pump it using another method. We rely on the muscular pumps in our skeletal system to assist with circulating the blood.

How do muscular pumps work?

- The veins in your legs are entwined within the skeletal muscles, and when you move your legs, these muscles squeeze the veins, pushing the blood out of the way
- We have one-way valves in these veins, so each squeeze can pump the blood a short distance towards the heart



- Providing you are walking around, this process makes a 'heart in each leg' – and it's very effective!

But what happens if we're not pumping? What happens if a worker has fallen and their legs are immobile?

- As mentioned earlier, if the muscles are not pumping the blood upwards, it pools in your legs
 - You can 'lose' several pints of blood and go into shock
- Your brain tries 'shock' for a while (heart beating faster), but of course it doesn't help – the blood is stuck in your legs
- After a few minutes, it goes for the last-ditch method and tells itself:

"If I faint, I fall over and I will get the blood back."

The Syncopal (Fainting) Response

- The brain assumes that you must fall over. If you stay upright (without the blood pumping):
 - Your brain has no oxygen supply
 - Your airway is at risk
 - **You will probably die within 10 minutes**

But how long do you really have? I personally have heard everything from 3 minutes, 30 minutes, to it's all a conspiracy theory to sell fancier harnesses. Good thing people have done some pretty hardcore research on the subject. In the most recent study done on the effects of suspension trauma:

- Uninjured volunteers felt dizzy in as little as 3 minutes
 - Typically 5 - 20 minutes
- Loss of consciousness in as little as 5 minutes
 - Typically 5 - 30 minutes

It is difficult to put a timeline on deaths, however from research it is clear that death can result in as little as 10 minutes, more typically between 15 - 40 minutes post-suspension. Death is more rapid with existing injuries, but can happen to anyone.

ANYONE IMMOBILIZED AND SUSPENDED IN THEIR HARNESS IS IN IMMEDIATE DANGER OF DEATH

Signs and Symptoms that May be Observed in Someone Reaching Orthostatic Intolerance

Faintness	Dizziness
Breathlessness	Unusually Low Heart Rate
Sweating	Unusually Low Blood Pressure
Paleness	"Greying" or Loss of Vision
Hot Flashes	Nausea
Increased Heart Rate	Numbness in Lower Extremities

Factors that Can Affect the Degree of Risk of Suspension Trauma

Inability to move legs	Hypothermia
Pain	Shock
Injuries during fall	Cardiovascular Disease
Fatigue	Respiratory Disease
Dehydration	Blood Loss

What other factors matter?

- All designs of harnesses (even those without constrictive leg loops) show almost identical results
- Patient age, weight, height, sex and fitness seem to make little difference to the time it takes before you faint
- Stress, panic, injury, smoking/drinking, extant cardiac conditions and illness increase the risks

Remember! **THERE MAY BE NO VISIBLE TRAUMA!** All that matters is that the legs are lower than the heart and the leg muscles are immobilized. No other injury is needed.

Ok. So we rescue them!

Whoa Nelly! Not so fast! There is something very important that we need to deal with first:

- The blood that is trapped in the legs may not be in very good condition, and may even kill the person if we let it all pour back into their heart and brain!
- This is called the 'reflow syndrome' and is medically very complicated – you will not be able to control it once it starts, and the person will most likely die. Luckily you can slow the process it down if you handle them with care!

What causes reflow syndrome?

- The blood that we now understand has been pooling in the legs becomes 'stale' after 10-20 minutes
 - This means it has been drained of oxygen and is saturated with CO₂
 - The blood is also now loaded with toxic wastes from the body's fat burning process
- Re-elevating the legs will return this blood to the rest of the body in a massive flood.
 - This can stop the heart
 - This can result in damage to the internal organs, particularly the kidneys
- You have to slow the return of this stale blood, but still keep enough blood flowing to the brain to keep the person alive. (Good thing you have a rescue plan - and have practiced it!)

Emergency Response for a Fallen/Suspended Worker

- Whatever plan you have written, it is vital that the lowering system can be controlled to prevent the worker's body from being laid flat as it reaches the ground.
- Anyone released from immobile suspension should be kept in a sitting position for **at least 30 minutes**
- Keep the harness on and do not release the leg straps
- Try to get the person to sit in the 'W' position (legs pulled towards chest) if possible



- KED boards should be used if spinal precautions are needed – and if trained to use!
- Let EMS know it is a fallen worker and that the worker should not be layed flat. They should be transported in the sitting position to the nearest hospital unless in cardiac arrest

As I am sure you have now realized, dealing with falls is something you have to prepare for just like everything else. Every second counts, but it is not something you can rush.

Investing in quality emergency first response training and rescue training as well as using the tools such as your working at heights rescue plans, job safety analysis, and safety talks, can all help if an emergency occurs.

If you would like assistance with any of your plans, or are interested in further training - please feel free to drop us a line! We are always here to help!!

References

- Robertson, David. Orthostatic Intolerance. Vanderbilt University, Nashville, Tennessee
- Seddon, Paul. Harness Suspension: Review and Evaluation of Existing Information. Health and Safety Executive. Research Report 451/2002, 104 pp.
- Weems, Bill and Bishop, Phil. Will your safety harness kill you? Occupational Health and Safety. 72(3): 86-88, 90, March, 2003.

Comments