Harness Induced Pathology
"The Quiet Killer"

Possible Scenarios

When considering scenarios that involve the implementation of S.R.T. rescues, we quickly conjure up images of cavers hanging mid rope, unconscious due to physical trauma. This of course can be a reality in vertical caving, and is an easily acknowledged and an accepted risk for people of all ability, novices to expert alike. To avoid such scenarios, we can conduct rudimentary, dynamic risk assessments on the stability of the cave or mine to be entered. The likely hood and consequence of a falling object accidents can be ascertained and steps can be taken to minimize the chances of it happening, by using careful movement, good rope work, appropriate route selection, good group positioning and clear pitch communication.

The other options are of course to be hyper cautious and simply abandon any trip or section viewed with any risk.
However there is a less known, equally prevalent, but more insidious form of vertical caving hazard. Harness Induced Pathology or Suspension Trauma. Simply put death from hanging stationary in a harness.

What is Harness Induced Pathology?

Harness Induced Pathology, H.I.P., is essentially orthostatic intolerance (the bodies inability to be vertical and still), which may be defined as "the development of pre-syncope (syncope = unconsciousness) with symptoms such as light-headedness, palpitations, tremulousness, poor concentration, fatigue, nausea, dizziness, headache, sweating, weakness and occasionally fainting during an upright stationary position". This can lead to unconsciousness and death.

A well-known example of orthostatic intolerance is that of a soldier who faints whilst standing at attention for a long period of time. The moment the soldier loses consciousness; he or she collapses into a horizontal position. With the legs, heart, and brain on the same level, blood is returned to the heart. Assuming no injuries are caused during the collapse, the individual will quickly regain consciousness and recovery is likely to be rapid.
The most frequent reports of this condition involve cavers and canyoneers who have lost consciousness and died in their harnesses, while stationary for a prolonged time on a belay or when entangled, or shortly after stopping to rest during a long prussic. Victims have often (but not always) been cold and exhausted.

When suspended in a harness and immobile or suffering with fatigue hypothermia or dehydration the onset of H.I.P. is often sudden and with out assistance usually fatal. This is due to either low blood flow trigging a cardiac arrest or the patient's airway becoming obstructed.
Some venous pooling occurs naturally when a person is standing or sitting for long periods. Venous pooling typically occurs in the legs due to the force of gravity and a lack of movement. In the veins, blood normally is moved back to the heart through one-way valves using the normal muscular action associated with limb movement. If the legs are immobile, then these "muscle pumps" do not operate effectively, and blood can accumulate in the veins. Since veins can expand, a large volume of blood may accumulate.
An accumulation of blood in the legs reduces the amount of blood in circulation. The body reacts to this reduction by speeding up the heart rate in an attempt to maintain sufficient blood flow to the brain. If the blood supply is significantly reduced, this reaction will not be effective. The body will abruptly slow the heart rate and blood pressure will diminish in the arteries. During severe venous pooling, the reduction in quantity and/or quality (oxygen content) of blood flowing to the brain causes fainting.

The major contributing factor to death in cavers and canyoneers is the fact they are suspended in a harness; the person cannot fall into a horizontal posture, so the reduced heart rate causes the brains blood supply to fall below the critical level. The harness keeps the caver suspended in an up right position with legs dangling and the safety harness straps exert pressure on leg veins, compressing them and reducing blood flow back to the heart, which aggravates the problem and regardless of loss of consciousness can lead to the death of the caver. There is also a possibility of increase of toxins in pooled blood. Small amounts of toxins are normal in the veins and are usually carried away safely. Without the action of the muscle pumps, these toxins remain in the pooled blood and begin to build up. Death can occur during or just after rescue caused by the casualty being moved to a horizontal position, resulting in a massive return of venous blood to the heart, which is unable to cope and fails (cardiac arrest). Often referred to as “Rescue Death”. Death can also occur some time after rescue, due to renal failure. This is caused by the lack of blood oxygen to the kidneys due to the effects of venous pooling.

How long can it take for H.I.P to develop?

A 1983 study led France's medical commission to consider the factors relating to H.I.P deaths. In 1984, the first indoor experiments took place. The first two volunteers fainted and experienced serious difficulties, one **after only 6 minutes of hanging**. These experiments due to their dangerous context were stopped immediately. However, the hypothesis is well confirmed in the case of total inertia, (no voluntary muscular action or adaptation), **a healthy caver could die very quickly due to his/her suspension.**
Since these studies further tests have been conducted by assorted organisations using several variances of harness and hang, for example with or without chest harnesses and hanging in hyperextension or not.
In all cases, the subjects experienced **considerable difficulties after only 12 to 30 minutes of hanging**. One of them actually fainted in spite of the medical controls and monitoring.
It pays to remember; all these experiments were conducted in warm, dry laboratory conditions, with medical practitioners near by. Importantly the tests do not take into account other major contributing factors to H.I.P, i.e. fatigue, physical trauma, de-hydration and hypothermia.

Prevention of Harness Induced Pathology

In relation to the Casualty
All harnesses should fit well to the body i.e. not too slack to assist efficient movement and not too tight help maintain circulation.
All S.R.T, foot loops, safety cords and cow tails should be tied to the correct length for the individual. This increases the chances of good vertical efficiency and therefore reduces the chances of fatigue.
Caver’s individual level of fitness and health should be considered before any pitch ascent.
If they’re showing any signs of fatigue, dehydration, hypothermia or mild trauma, then immediate

action must be taken. Re-hydrate if possible - oral warm sweet fluids if conscious.
If exhausted, provide some easily digestible energy source - glucose sweets etc and remove any excessive equipment or bags they may be carrying.
Ensure cold patients are adequately insulated with dry and waterproof clothing, or a plastic bag / blankets / group shelter - do not forget the head must be insulated and the patient must be insulated from the ground.
Ensure any significantly cold or exhausted persons are closely monitored and sheltered and, if possible, hoisted horizontally in a stretcher rather than allowed to climb or be hoisted in a harness only. If this means a cave Rescue call out… then do it.
When a caver is attempting a pitch ascent under their own steam, and is beginning to tire mid pitch, ask the conscious caver to do leg contractions. The caver should be trained to "pump" his/her legs frequently to activate the muscles and reduce the risk of venous pooling. Footholds can be used to alleviate pressure, delay symptoms, and provide support for "muscle pumping." To assist circulation ask them to place their feet in the foot loops taking weight off their thighs and major leg arteries. An under the knee strop can be considered to hold the patient more horizontally, allowing better blood flow toward major organs and the brain.
It is often easier to go with gravity i.e. down.
If a vertical hoist is unavoidable, minimise the lift time. Ask the patient to assist if possible. This will help their blood pump around the body and allow you to judge their physiological state it may also make the rescue easier. If you are close to the patient monitor vital signs. Ask the patient how they feel and if possible check pulse rate as often as possible. Changes may give you warning of impending collapse. Do not let this detract you from implementing a safe swift rescue.

In relation to the Rescuers
The absolute golden rule is “Never put yourself in danger”. Another injured or dead person will not help the casualty. Do not attempt any vertical rescue unless you are competent to do so. (See above)

Take adequate fluids and food. Look after yourself. You are very important to the casualty. Keep warm but avoid excess sweating and heat exhaustion, because dehydration will dramatically reduce your performance. Rest and recover before a long prussic or other vigorous exertion. Do not push yourself to the point of exhaustion - especially on long prussics Avoid prolonged stationary suspension in a harness - take turns at the job, consider a Bosun's chair or alternative belay position. If it is necessary to hang in your harness, change position as necessary to keep comfortable and try to regularly tense your calves to maintain circulation. Always wear a chest harness so that you can lean back without risk of inverting or falling from your harness if consciousness is reduced. If you feel at all faint or unwell at any time, let others know immediately, tense your legs repetitively and try to lower your head and raise your legs. Move to a location where you can take the weight off your harness.

Treating Harness Induced Pathology

Get the patient to a level firm surface as soon as possible, consistent with safety for rescuers.
If collapse occurs mid hoist or lower and intervention is not possible on the rope, complete the hoist or lower of patient rapidly - whichever will get the patient to a stable position with at least one rescuer to provide care.

Don’t lay the patient flat on the ground (Not even in the “Safe Airway Position) due to the possible build up of toxins (as above)

Advice in *Rescuing people who have fallen and first aid following suspension in a safety harness*

by:
M Lieblich and W Rensing (1997) is:
"The victim should be positioned with the upper body very well raised, i.e. in a seated, or possibly squatting or crouched posture. All restrictive belts and clothing should be unfastened. A doctor should be called immediately. Laying the victim down horizontally could be life threatening. The blood that has accumulated in the legs flows abruptly into the heart creating a risk of heart failure due to overstrain. Transfer to a horizontal posture should take place only gradually. Continuous monitoring of the respiration and circulation is necessary. In the event of unconsciousness, the air passages should be kept open"

Scharfetter and Flora (1972) is:
"Orthostatic shock and typical respiratory obstruction may lead to death when hanging on a rope; the probability of survival after hanging two hours is small; death may occur during hanging or after detachment from the rope when rescued. The cause of this death, generally occurring suddenly, soon or some time after detachment from the rope, is ascribed to protracted shock, but also to acute heart failure. The latter can perhaps be explained by the inability of the heart to cope with the blood which had sunk into parts of the body in orthostasis, but flows back in excess to the heart after the victim is laid flat. Failure of the kidneys damaged by shock may lead to death much later."

Stabilise the patient as best as possible then call out cave rescue.

Conclusions:
Harness Induced Pathology is a complex medical matter, but we can come to the following conclusions: Whatever the type of harness, motionless suspension is not physiologically safe and will eventually lead to very serious blood circulation problems, which leads us to the following advice:

Prevention is better than cure.

- Undertaking comprehensive training in vertical techniques, reduces the chance of entanglements or prolonged hanging in harnesses.
- Cavers ideally should have a progressive introduction to vertical caving. Time should be taken learning skills and developing the physical and psychological fitness needed for protracted vertical trips.
- Purpose made quality-caving equipment should be worn and the minimum of an extra layer and warm hat should be carried, to stave off the on set of hypothermia.
- Groups of cavers should consider, theirs and other people's position within the cave, and the likely hood and consequence of dislodged loose material. In high-risk venues a set of call signals should used to advise others of safe passage and position, so reducing the chance of injury whilst suspended.
- Cavers should be aware that static suspension in a harness puts them at risk of orthostatic intolerance. Be aware of the signs and symptoms.
- Cavers should be aware of factors that can increase the risk of suspension trauma, hypothermia, fatigue etc.
- Cavers should be aware that orthostatic intolerance is life threatening. Suspended cavers with head injuries or those who are unconscious, are particularly at risk.
- It is advisable that before each trip, adequate food and fluids should consumed, and small amounts should be carried underground.
- A tired caver should refuse to begin a long and difficult ascent, especially on a wet pitch, without recovering first. He/she must carry and use his/her survival food and emergency shelter correctly.
- A caver in difficulty on a rope, due to exhaustion or to technical problems, must be helped very quickly.
- A caver hanging completely inert, must be unhooked by other team members immediately.
- A team should never let one of its members begin a rope ascent alone, even if they are in very good shape.
- Several members of the team should be conversant with and carry the necessary equipment for quick effective vertical rescues.