SUSPENSION TRAUMA

Suspension trauma, or orthostatic intolerance, is a natural human reaction to being upright and immobile, where a complex combination of blood pooling in the legs and cardiorespiratory restriction leads to unconsciousness. It can be caused by suspension in a harness (deliberate or accidental), when trapped in a confined space, when secured to a vertical stretcher or litter - any situation where someone is forced to stay upright without the ability or room to move. If it is allowed to develop unchecked, it can be fatal in a very short time.

What is suspension trauma?

Suspension trauma is a perfectly natural reaction caused by the body being held in an upright position. It will happen to everyone, and you do not need to be ill or injured - simply standing still and unable to fall over.

Our blood supply and heart cannot cope very well with standing up - gravity pulls blood into the tissues of our legs, and the heart cannot suck it back. Eventually, if enough blood pools in the legs, we will faint. This is fine, so long as we fall over - the blood all rushes back - but if we can't fall over, then we die.

Of course we can stand and walk about in normal life and not risk death, and this is because our leg muscles can pump the blood back upwards, provided you are able to move your legs. When we walk about, this works very well. Standing still it's less effective, and sometimes we faint. If we can't use our legs at all, such as if we're strapped into something or hanging in a harness, then we will faint. The problem comes after that - if you faint, you really need to fall over right away. Stay in the same position, and your brain has no oxygen supply.

Who does it affect?

Anyone who could faint and not fall over. People working in industrial harnesses (using abseiling or fall arrest systems or people in confined space shafts), people using harnesses for sport (caving, climbing, parachuting, parascending, bungee jumping) and people using harnesses for special tasks (stuntmen, theatrical flying, etc) are all exposing themselves to high risk, some more than others. Anyone who is secured to a vertical surface for any reason (a rescue litter or spine board, plank of wood, door, bondage equipment, etc) may also be at risk. The most famous, or infamous, example of deliberate suspension trauma is of course nailing someone to a cross.

In any of these situations if you are not using your legs for support, or are unable to move them, then you will eventually faint. If you live or die depends simply on how quickly you fall over - preventing that from happening will of course kill you.
What exactly happens?

First, let's look at blood, and where you can put it. Your body contains about ten pints of blood, most within your veins and arteries.

Think of these like stockings - they will stretch a lot if you keep pushing more into them, so to fill them to the top you need to squeeze the outsides. Tiny muscles do that to our veins, a process called 'tone'. If these muscles relax a little, then all your blood pours down under gravity, and at the extreme it will all fit below your waist. Naturally this isn't a daily event, but keeping the blood from pooling in your legs is actually a difficult problem. Gravity is strong, and blood is dense, so to suck it back up the four or five feet from your legs to your head would be very hard work - you certainly couldn't do it yourself with a length of tube! Your heart is the pump, and it can't suck that hard. In fact it can't suck at all - it needs blood to be pumped IN under pressure or it just beats on empty.

Now to get that blood back up from our feet, we could increase the pressure - forcing it round like a blockage in a U-bend - but that would need such high pressure our hips would burst. No, instead of turning up the power, we have evolved a much better solution - hearts in our legs. Yes, you read that right. The veins in our legs already have one-way valves in them, so all we need is to squeeze them and we've got ourselves a pump! Since we started walking upright, these leg veins have moved so they are buried in between the muscles, so as we move our legs and walk about, the veins are squashed and released over and over - pumping the blood back up into your abdomen. It's an amazingly good system - when you're running, there's hardly any blood pressure in your feet at all!

Of course you can see the error with this perfect plan - if you don't use those muscles the pumping effect stops and your brain, right at the top of the pile, runs dangerously low on blood very quickly! This can happen if you're standing very still, or hanging in mid-air, or strapped to something. If you're standing still then the brain can fix the problem...

Firstly, when blood to the brain reduces, your brain decides to put you in shock. You must be bleeding somewhere, right? So, it increases your pulse and breathing rates, you feel a little sick, shivery, cold, sweaty and anxious. This doesn't really help much, as what you SHOULD be feeling is a craving for exercise - but never mind, evolution is never perfect. That higher pulse rate shunts blood up to the brain and away from the skin, which helps for a few minutes - but of course it's still pumping blood down into those legs as well. Eventually, your brain realizes its mistake and goes for plan B - the Central Ischaemic Response. You faint.

Why? Because of course if you faint, you must fall over. Your brain has learnt that from millions of years of... falling over. When you hit the floor, the blood trapped in your legs returns, and all is well. You wake up, feel sick, and if you're a soldier on the parade ground you prepare for the punishment of your life. The problem is when you don't fall over. Your brain has no comprehension of that idea - so if you are physically held upright after you've fainted - by a harness, litter or cross - your brain is in deep trouble.
It's turned off its own blood supply to get you to faint, and it still needs the blood in your legs. So, it waits. You're unconscious of course, so you aren't aware of all this.. but you wait. You do not 'wake up and try something else' - you wait. **You die waiting.**

**How long have you got?**

If your legs are perfectly still, then you can start feeling the first signs of shock in as little as three minutes. The average is between five and twenty minutes. You will faint a few minutes after that, and if you are not allowed to lie down straight away then your brain can start to die a few minutes later.

**So, worst case scenario you can be dead in ten minutes.** Actually, less than that - because once you faint, you lose control of your airway and if your body is upright you can choke on your tongue and suffocate in a matter of seconds.

Not everyone will be pushing death inside of a quarter hour though - the time it takes is random. Some people will last ten, some sixty. Age, height, weight, fitness, sex, race - none make any difference. The same person will react differently from one day to the next. In short, it's unpredictable. Very old people suffer first, as their muscles are less able to control the blood flow, and very young children are immune as their bodies are just too short! Nobody's sure at what age you become 'at risk', but certainly anyone over about 5 feet tall is capable of feeling the effects.

Luckily, we're telling you all this because there are lots of simple ways to prevent it from happening.

**Preventing suspension trauma**

Without being too obvious, the best way to prevent suspension trauma is never to get into a position where it can start! Working with suspension in harnesses is perfectly OK, provided you PLAN to prevent suspension trauma. The same goes for medics and rescuers using litters, and for those who enjoy tying each other up. The risks come from failing to predict the dangers, and so allowing the casualty to develop problems without anyone else noticing, and from not knowing how to react should they suddenly faint. *Almost all deaths from suspension trauma could have been prevented*, had colleagues, friends and rescuers known what was going on.

Assuming you've read the Introduction you'll know how and why the condition develops, and that it's all started by blood pooling in your legs. If you're going to be held in an upright position for more than five or ten minutes, then you will be at some degree of risk. A rock climber is usually safe because he or she is using their legs all the time - but if they fall off, stop for lunch, or just get bored and 'dangle', then it's a different matter. Parachutists are never 'under canopy' for long enough to see problems until they get stuck in a tree, in which case it's too late to start asking for advice.
Prevention techniques

Preventing suspension trauma can take one of two approaches - either we stop the blood pooling in the first place, or we make sure it's pumped back out. Which you choose depends on what you're doing, and it is very important that you pick the right method. Some sources of advice, even some government publications, get this bit very wrong and you could end up very dead if you follow the wrong advice.

Plan 1: Sitting up, chilling out

You're probably sitting in a chair reading this. You haven't moved your legs in a while, but you're not dead. It's all down to the fact your thighs are almost horizontal - they are where most of the blood pools, and so if they are kept elevated then suspension trauma is almost impossible. Think of how many times you've heard of someone fainting to death in an armchair.

For anyone suspended in a harness and who doesn't need to move about all the time, or who can't (for example someone who has fallen and is injured, tired or just lazy) then the best, most effective and easiest way to keep them safe is to lift them into a sitting position. Looping something under their knees, or sitting them on a swing-seat, is all you need to do - the person can often do that themselves if they've got something to hand. It's very important to do this as soon as possible - within a few minutes of suspension - so the blood has no time to begin pooling.

The trick is to lift the knees, and to use your legs as little as possible - the more you use them the more blood is sent down to the muscles. Sit down, relax, chill a little.

Now, there is an obvious problem with this advice, good though it is. You can only lift your knees up if you're allowed to by the design of whatever you're being suspended from. In a stretcher it's impossible. In a rock-climbing or parachute harness it's easy, and in parascending or paragliding harnesses there's an inbuilt seat precisely for the purpose. With other designs of harness you may find the angle of your torso or the way the leg loops are connected prevents you from being able to lift your knees more than a few inches. Clearly this is a stupid idea, but we're stuck with it, as many harnesses are designed to comply with standards and laws which were written long before suspension trauma was recognised.

In these cases, you may have no option but to use the second plan below. It's not as good as plan 1 and we really would prefer you to avoid those situations at all costs, for example by changing your activity so that accidental suspension is no longer a possibility. There are however some unfortunate cases where plan 2 is going to be your only option...
Plan 2: Invisible Bicycles

Just as with a rock climber struggling up a cliff, or you when walking to the kitchen, using your legs keeps the blood flowing. Even hanging in a harness, if you are using your legs to climb about, you will be safe. The problem comes when you're in mid-air, or you're injured or tired, and that movement is a bit less forceful. Now, the pumping effect is reduced but your leg muscles are exercising, so they need blood! The arteries feeding your legs open wide, blood pours into your legs, and eventually... well you can see the result. The 'keep your legs active' plan works great if you have surfaces to kick against, like our rock climber.

So why are we saying that plan 2 is so terrible?

It's useless for anyone who physically cannot move (strapped into something, or injured), as of course it needs the casualty to exercise (and exercise very hard). If you, as a casualty, have just fallen off a cliff and smashed yourself to pulp on the way down, you won't be in a fit state to start running on the spot. If you're gently hanging there and start feeling faint, you won't be able to exercise fast enough to stop yourself fainting, as by driving more oxygen into your leg muscles you momentarily reduce the supply to your brain even more, and so you're likely to pass out anyway.

The main reason for plan 2 to rate as a stupid idea is that once you start madly pedalling that invisible bicycle in mid-air, you cannot stop. All that exercise has increased the oxygen demands of your leg muscles, and so if you get tired and stop using them, the venous pump stops instantly. Blood is still rushing into your legs to feed your muscles, and so the world goes dark around the edges.

Leg-pumping is advocated by many 'official' advice but we simply cannot condone it - for the reasons given above. The only possible situation you should try it is if there is absolutely no other option. If you think about what 'preventing suspension trauma' is trying to do, it makes perfect sense. You're trying to get as much blood as possible to your head, and as little as possible to your legs. Lifting them and relaxing them achieves that. Using them like crazy doesn't.

We often like to remind our students of the old joke about a traffic cop who stopped a woman driving a battered old station wagon at 150mph through downtown Detroit. When asked why she was going so fast, she said "My brakes don't work. I gotta get home fast before I have an accident!"
Unplanned suspension

If your job, hobby or personal preferences mean you're potentially at risk from suspension but in reality aren't expecting it, then being aware of the above techniques is the best single thing you can do. It would be nice to have a trained rescue team on standby, but in many cases that isn't an option - someone parachuting for sport will probably never get hung up in a tree in their lives, but if they do, a 5-minute talk from the instructor will save their lives. When the risks start increasing, you can start to take equipment with you. Military paratroopers often expect to jump into trees, and so carry ropes so they can abseil out of them. If you're going caving and there's a huge 1200ft shaft to descend, it makes sense to carry spare equipment so you're less likely to get stuck - and if possible make yourself a swing-seat from webbing so you can abseil in a safe position, or take rest stops on the way back up.

Workers who may be suspended as a result of a fall onto personal fall arrest harnesses should always plan for it happening, even if it rarely does. You should have very carefully-thought-out rescue plans for every possible scenario, including the equipment and people needed to perform the rescue. In many countries this provision is required by law - but even if it's not, it may be the only thing stopping you from attending the funeral of your best friend - or from them attending yours. Rescue plans and training are not difficult, and may be a 'business overhead' but when spread over the hours of a contract can cost less than the coffee in the canteen. Remember - you all expect an office to have a fire extinguisher, even though most of you will never be in a building that catches fire. Why not expect to be rescued from a harness?

Intentional suspension

There are many situations where prolonged suspension is intentionally planned, such as in theatrical performer flying, bondage, parascending, access into confined spaces, etc. and although it's sensible to try and adapt your activities to reduce the time spend in an at-risk position, it's not always possible.

1. **If there is no way to avoid being suspended**, you should attempt to do so with your knees raised into a sitting position. This may be by use of a climber's seat, or by using something on which you can rest your feet, but by placing your thighs horizontal the risk of suspension trauma is reduced to negligible levels. You may not be able to stay in the sitting position all the time, but if you can move into and out of it every few minutes it will help a lot.

2. **In a sit-harness (for rock climbing, caving, rope access etc.) it's possible to swing your entire body upside-down**, and although it seems (and feels) silly, doing that every few minutes will literally pour the blood out of your legs.

3. **If you cannot adopt a sitting position** then you should restrict the time in suspension to no more than five minutes at a time, and have immediate rescue in place so that the casualty can be removed from suspension instantly if they show any signs of discomfort or distress.
It's important to plan for the rescue delay - if for example you are lowering a worker into a narrow shaft using a winch and harness, they may develop problems near the bottom, where it might take another three or four minutes to winch them back out again. In cases like that it can be more sensible to carry on lowering them to the bottom, so at least they're out of suspension.

4. **A stretcher patient** lifted in a vertical position is at extreme risk, especially if they already have compromised circulation due to illness or injury. It should be done only where absolutely necessary, and only for the minimum amount of time and with continual patient monitoring. Many people have been killed by vertical stretcher lifts, and some of them were just people doing training.

**In summary...**

So, what have we learnt so far?

- Unless you're planning on moving about or are forced to stay upright for some other reason, lifting your legs into a sitting position while suspended is the best plan, and the easiest.
- Try to avoid being 'upright and immobile' for more than a few minutes at a time, and if you feel ill, get out of the position straight away!
- *Never* leave anyone alone who may be at risk of suspension trauma

Of course if it does happen, you'll want to know how to treat the victim safely!

**Training for those at risk**

Clearly everyone at risk of suspension trauma should be aware of what it is, how to prevent it and what to do in an emergency. Typical user groups include:-

- Industrial climbers, abseilers, rope access and fall arrest harness users
- Climbers, cavers, parachutists and parascenders
- Stunt professionals
- Theatrical and circus flying system operators and performers
- Professional and amateur performance artists and practitioners working with human suspension and bondage
- Mountain and cave rescue teams
- Military and special forces operatives using abseil or helicopter access systems

In addition, those who may be called in to handle a suspension incident need training in what medical and rescue procedures to use, and importantly what NOT to do. They should be aware of the information on our treatment pages and how to apply it safely. Normal First Aid, EMT and even paramedic training does not include suspension trauma, and what they know about 'fainting' can be dangerous as they will want to lie the patient flat. It is often up to the worker or his colleagues to advise medical staff as to what to do.
At-risk users should plan their work with suspension trauma in mind. Trying to avoid it in the first place is all-important, and so people planning jobs need to be mindful of the risks of accidents, how and when a worker could be placed in suspension, and how long it will take for them to be rescued. The critical things for workers to remember are:-

1. Hanging immobile in suspension is a life-threatening emergency
2. You must never work in suspension unless you are sitting on a workseat or actively using your legs
3. If someone falls into suspension and cannot be rescued, lifting their knees into a sitting position is very important and may save their life
4. When rescuing someone, avoid them laying flat on the ground. Keep them sitting up for 30 minutes
5. Explain all this to the emergency services, paramedics or hospital doctors - most will not know it

If you are working in the EU, then your national version of the EU Temporary Work at Height Directive makes it law that you plan for, and educate your workers in, the risks of suspension trauma. You also have to have effective and fully trained rescue plans and equipment in place for all work.

**Suspension trauma treatment**

*Treating someone with suspension trauma is not standard First Aid.* If you follow the normal advice for ‘fainting’ then you can easily kill your patient. If you haven't read our section on Reflow Syndrome then please do so now.

**Reflow syndrome in suspension trauma**

Anyone who has developed suspension trauma is also at risk from reflow syndrome - caused when the pooled blood in their legs is allowed to flow back into their body. It is potentially fatal.

The exact details of what happens and why are dealt with in our medical treatment section, but the idea is simple enough to summarise. The blood that is pooled in the legs starts off perfectly normal, with oxygen and nutrients dissolved in it. Over time, the cells in the legs use up the oxygen and nutrients - even though they may not be moving much, they still need to stay alive. When all the oxygen is used up, the cells start to burn fats. This process, called anaerobic metabolism, is usually only seen in extreme exercise, and relies on a fast blood flow to keep the process safe. As the blood in the legs is not moving, toxic byproducts of fat burning start to build up in the blood. After quite a short time they can reach dangerous levels.

If the blood is allowed to rush back into the rest of the body then these toxins, and the lack of any oxygen, can cause very serious problems. The heart can stop, the liver, kidneys and brain can be damaged, and in many cases they will die. **This will happen if the patient is allowed to lie flat on the floor.**
It's therefore very important that they stay in a safe position until they reach hospital, or until the blood has had time to gradually clear the toxins. A 'safe position' is the same as for the rest of suspension trauma - sitting upright with their legs bent at the waist. During a rescue, transport to hospital or even when they arrive, they have to be kept in this position and NEVER allowed to lie down. Our guideline is that they should stay sitting for 30 minutes after being released from suspension. It does not matter if they have fainted or not.

**First Response**

Anyone who has developed suspension trauma to any extent will have reduced blood flow to their brain. This initially causes symptoms of shock, and if untreated will lead to loss of consciousness. This in itself could kill by preventing the patient controlling their own airway, but eventually the reduced cerebral blood supply will lead to brain damage and death. The goal of the first responder is to return oxygen to the brain while preventing Reflow Syndrome. Never allow the patient to lie down, even for an instant, unless there is a life-critical need to perform CPR. Normally, suspension trauma makes the legs feel numb. If the patient has no other injuries and yet complains of severe pain in their legs, especially when you try to move them, then they may have developed a severe condition called compartment syndrome. You should place them in a sitting position and summon an ambulance with great urgency. The patient may deteriorate rapidly. There is nothing you can do for compartment syndrome as a first responder.

If managed correctly, patients with suspension trauma - even severe cases - will make a full recovery and have no long-term complications. Normally patients who do not require hospital treatment will be well enough to return to normal duties within 24 hours.

**If the patient is conscious**

If removal from suspension is not going to happen instantly, and you can reach the casualty or they can follow your instructions, lift their knees into a sitting position using a rope, sling, hose, items of clothing etc.

Your first action when they are released from suspension should be to place them in a sitting position with their body upright and their legs flat, or bent at the knees. This will reduce the pooling effect of gravity, but will keep most of the pooled blood in the legs, preventing reflow. The patient must not be allowed to stand up, exercise, drink or eat. If possible keep them as calm and relaxed as you can, to reduce the effects of stress on the heart rate. There is no difference in the angle of the knees - the critical issue is that their body is upright, and their legs are no longer dangling.

Obviously they need to be removed from suspension, and kept in the same sitting position at all times. They may feel faint, and so you will have to stay with them and prevent them collapsing onto the floor. **If you have oxygen available, administer it at**
100%. Do not give the patient any other medication or fluids unless you have been trained to do so, and are aware of a pressing need. Summon medical help as soon as possible - a fully conscious and aware patient may be taken to hospital in a private vehicle, but remember that everyone suspended for more than 10-20 minutes should be sent to hospital for routine blood tests, even if they are not injured.

If you cannot reposition the patient or remove them from suspension, then you must expect them to faint at some point. Providing 100% oxygen will help a great deal, but your priority is maintaining their airway and arranging urgent rescue.

If the patient is not conscious

If removal from suspension is not going to happen instantly, and you can reach the casualty, lift their knees into a sitting position using a rope, sling, hose, item of clothing etc.

Loss of consciousness due to suspension trauma itself indicates that the pooling of blood has had time to develop, and that laying the patient flat will probably be counterproductive - maybe leading to death. You will have to manage the airway while keeping the patient in a sitting position. Suspension trauma rarely leads to cardiorespiratory arrest in the short term, but if the patient requires CPR then this overrules the posture policy, and you must of course lay them flat. This specific situation is allowable because without a heartbeat, the reflow effect cannot happen - and the circulation caused by normal CPR is not strong enough to kick-start any reflow issues.

A patient who has been rendered unconscious by another event (such as impact in a fall or electrocution) and who is reached within the first 10 to 20 minutes of suspension can be allowed to lay flat. If you are trained in the use of artificial airways then these may assist in supporting the airway even in a sitting position, but there is no need to use the sitting position unless the casualty has been suspended for a longer time.

EMT / Paramedical PHLS treatment

The following advice is aimed at trained medical and EMT staff

Note that suspension trauma (orthostatic incompetence) is not part of your standard training program. You should approach the incident as similar to a crush injury in terms of immediate management though there are critical differences in both pre-release and post-release therapy. If the condition is advanced or the patient has lost consciousness, urgent transport to a trauma center is required.

The patient will be cerebrally hypoxic due to gravitational pooling of venous blood in the legs, the majority being in the thighs. The initial presentation after 5 to 10 minutes of suspension will be of distributive shock leading to tachycardia and tachypnea. Local
PP02 from fingertip sensors will be normal, but saturations from earlobe sensors will be reduced. There need be no other injuries. The patient may complain of general symptoms of shock, heat or absence of sensation in the legs. Patients reporting **severe pain** in the legs with the absence of orthopedic insult are of great concern as it suggests formation of *compartment syndrome*.

As soon as possible after suspension has begun, the patient should have been repositioned into a sitting posture with the thighs horizontal or slightly elevated with respect to the pelvis, and the spinal column vertical. If this was done within a few minutes, then it is unlikely that a sufficient volume of blood has pooled to cause loss of consciousness, however it can still present a hazard if permitted to return to the core in bulk. A patient who has not been repositioned in time is likely to have progressed beyond distributive shock and lost consciousness via the central ischaemic response. Barometric trigger pathways will produce enforced syncope via bradycardia, leading to decreased cerebral perfusion and an instant LOC. If the patient falls into a prone position at LOC then blood returns to the brain and they recover without artifact, however in suspension the patient is usually unable to fall over, and remains held upright. In this position the LOC persists, as does bradycardia and almost negligible cerebral perfusion. This is in itself fatal within a matter of minutes, but of course the patient is also unable to maintain a patent airway and so primary cause of death is often suffocation.

Stabilisation is possible on scene, but great care should be taken to monitor PP02 and ECG during release and transport, as the patient will be electrocardially fragile.

- Do NOT allow the patient to lie flat (unless CPR is required) or to stand up
- Provide oxygen at 100% for all patients
- Prior to release, manually stabilise the airway via all possible means
- During release, be particularly cautious of the patient entering a prone position by accident, for example when transferring between stretchers or being passed across an obstruction
- Minimise fluids to those required for unrelated trauma. The patient is not hypovolemic and adding IV will lead to hypervolemia when the patient is repositioned. You may start a keep-open line for future access but operate on minimal flow
- The patient may also be hypothermic if suspended outdoors, and external rewarming may be necessary. Do NOT give warmed IV fluids at this stage.
- Monitor ECG carefully - peaked T waves, prolonged QRS or HTN indicates hyperkalemia and the onset of crush syndrome. If detected, direct and agressive action is needed. This is beyond current PHTLS training but via direction will require IV bicarbonate, calcium chloride, albuterol or insulin via large-bore IVs running normal saline. **This contradicts the earlier fluid restriction policy but is only to be initiated under direction if compatible ECG artifacts are identified.**
- Transport the patient, in the sitting position, to the nearest hospital

**Hospital ER treatment**
If the patient has been in suspension for a prolonged period (variable, but between 5 and 40 minutes is the typical point at which symptoms develop) then venous pooling in the legs will have lead to cerebral hypoperfusion and hypoxia. This may have been treated on scene with O2 or by repositioning into a sitting posture. **DO NOT ALLOW THE PATIENT TO LAY FLAT for at least 30 minutes unless there is a priority need for life support.** Pooled venous blood in the lower extremities has been static for some time, and will be entirely hypoxic. Anaerobic metabolism within the legs will result in toxic levels of metabolites in the pooled volume, and on release into core circulation, it can result in cardiac arrest, dramatic ETCO2 and PP02 fluctuations and transient hypercarbia. Cytochrome-C release and transient renal hypoxia will result in renal artery spasm, tubular necrosis and potential acute renal failure within 60 to 80 hours of the incident. Increased serum certainine with reduced output, uremia and acidosis are diagnostic. Dialysis would be required in such cases to prevent mortality.

In most cases of suspension in a purpose-designed harness, confined space or litter then the patient will *not* have experienced soft tissue insult sufficient to cause crush syndrome, however extended suspensions (in excess of 2 hours) or those with thin ropes or straps may initiate the syndrome. It manifests as release of potassium and myoglobin, and can contribute to renal insult. Serum K should be monitored, as hyperkalemia is diagnostic in these cases. Treatment of crush syndrome is based on volumetric support, renal protection and serum K management. Once local reflow has been corrected then IV support may be required to manage hypovolemia, bicarbonate and mannitol are indicated to control acidosis and hyperkalemia. Monitor ECG and regular urine myoglobin, CPK and full chem panel.

In severe cases of vertical immobile suspension where pooled blood has become cytotoxic, a split-form full blood transfusion is possible and effective, with surgical interruption of the femoral arteries and veins placing the lower limbs on bypass, enabling a localised transfusion and management regime for reflow and crush syndrome to be applied while the remainder of the body is managed in isolation. If successful this can remove the need for amputation, though the procedure is complex.

Patients are considered equally susceptible to suspension trauma in terms of gender, age, fitness, body mass or race. Those taking tricyclic antidepressants will have increased susceptibility as they contribute to orthostatic hypotension. There is no difference in treatment or medication required for patients on TcaDs.

Patients involved in enforced vertical posture but not caused by a harness can also present with suspension trauma. Potential candidates include those entrapped in vehicles, buried in snow, sand or grain, etc.

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