

REVIEW

Suspension trauma

Caroline Lee, Keith M Porter

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Suspension trauma (also known as “harness-induced pathology” or “orthostatic shock while suspended”) is the development of presyncopal symptoms and loss of consciousness if the human body is held motionless in a vertical position for a period of time. It has been described in experiments of personal fall protection, and has been implicated in causes of death in mountaineering accidents, but it seems neither to be widely known about nor to have been presented to the medical profession. This article highlights the potential existence of suspension trauma and suggests that more robust medical research using modern harnesses and healthy volunteers would be beneficial to assess whether this is purely a theoretical risk.

response to the Health and Safety Executive report.⁴ Searches of EMBASE, PubMed and The Cochrane Database of Systematic Reviews 2006, Issue 2, using the same terms, revealed no results. This article aims to raise awareness of the potential medical complications of suspension trauma in patients who may present to the pre-hospital practitioner or to the emergency department.

MECHANISM OF SUSPENSION TRAUMA

Health professionals are all aware of the phenomenon of orthostatic intolerance. The example of the soldier standing motionless on parade (or the medical student standing and observing in theatre for a prolonged period!) who suddenly faints is not uncommon.

In a patient in vertical position, venous pooling occurs in the leg vessels due to gravity, which can lead to a 20% loss of circulating volume and a relative hypovolaemia. If the individual is then also immobile, there will be no muscle pump to provide venous return, with a reduction in cerebral perfusion leading to cerebral hypoxia. When the individual faints and assumes a horizontal position, there is an improvement in venous return and immediate recovery of consciousness.

However, if the patient is a climber hanging in a vertical position supported by a safety harness, is no longer using the muscle pump in the legs to climb and is unable to adopt a horizontal position, the individual will be unable to restore venous return to the brain. Reasons for the individual to pause motionless on a rope include exhaustion, hypoglycaemia, hypothermia, injuries, technical problems or mental problems such as fear.

In addition, it is hypothesised that compression of the femoral veins by harness groin straps will contribute to a further reduction in venous return. Pain from an incorrectly fitted harness may also increase the sympathetic stress on the circulation. Other factors which may increase the risk of suspension trauma include dehydration, traumatic injuries causing pain or hypovolaemia, or any condition causing the patient to fall unconscious.

In experimental work on harness design, patients have been reported to develop presyncopal symptoms including feeling faint, dizzy, palpitations, sweating, nausea and loss of vision. Loss of consciousness has occurred after a variable amount of time from 7 to 30 min. Test subjects have also experienced paraesthesia in their lower limbs with pain. Tachycardia and hypotension have been recorded in subjects who have been suspended vertical and motionless.¹

In other research, symptoms have been reproduced in healthy volunteers using passive tilt table tests with a head-up tilt of 50° from the horizontal,

Suspension trauma (also known as “harness-induced pathology” or “orthostatic shock while suspended”) is the natural physiological response to the human body being held motionless in a vertical position for a period of time, resulting in presyncopal symptoms or loss of consciousness. It is a condition recognised in industries working at height and by manufacturers of personal fall protection, but it does not appear to be widely known about in the medical profession.

A Health and Safety Executive report was published in 2000 as a result of a suspected case of suspension trauma on a training exercise in Australia in 1999.¹ This report summarised the literature from the internet and British Library, and found case reports and examples of experimental test subjects who had experienced the effects of suspension trauma.

The earliest and most famous recorded case of suspension trauma is that of crucifixion. The first medical report was conducted in 1968 at an American medical research laboratory, where five volunteer subjects were suspended in a parachute/torso restraint system for 30 min. One patient lost consciousness during this exercise, but effects of thoracic pressure from the harness might have confounded this event.² Between 1957 and 1968, postmortems were carried out on people killed in mountain-climbing accidents, of which five climbers who were left hanging on the rope had no obvious external or internal injuries to account for their deaths. The explanation was that they may have died from suspension trauma.³

There is little published evidence on the subject. A search conducted of Ovid Medline (R) 1966 to November, Week 4, 2006 using the terms “suspension trauma” or “harness-induced pathology” or “rescue death” found only one reference, which was a letter in

See end of article for authors' affiliations

Correspondence to:
Dr C Lee, Academic
Department of
Traumatology, Room 28,
Institute of Research &
Development, Birmingham
Research Park, Vincent
Drive, Birmingham B15
2SQ, UK; drcarolinelee@
hotmail.com

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with the subject supported by a bicycle saddle. This resulted in hypotension, bradycardia and presyncopal symptoms in 69 out of 79 (87%) subjects within 1 h.⁵

INCIDENCE

This condition has not presented to either of the authors of this paper, nor been identified following personal communication with colleagues.

Patient groups in which this phenomenon could occur include industrial climbers and fall-arrest harness users in individuals working at height, climbers and mountain rescue teams, parachutists and military personnel using abseil or suspended access systems, and stunt professionals, theatre or circus performers. There are also implications for patients who are rescued in a vertical position—for example, Search and Rescue using strops, or vertical cave rescue in a confined space.

In 5.8 million recorded “hours on rope” by the Industrial Rope Access Trade Association-qualified rope access technicians (for 11 years till 1999), there have been no reported incidents of presyncopal or syncopal symptoms. This was clarified by Seddon¹ in his report, after placing a questionnaire on the Industrial Rope Access Trade Association website and emailing members between August 2001 and January 2002, with no positive replies. However, this might have been due to these examples being active harnesses used for working, whereas fall-arrest systems are passive harnesses used only for suspension in an emergency. The pathology caused by safety harnesses is applicable only in the context of a person hanging vertically suspended and motionless.¹

PREVENTION

Suspension trauma is probably an unrecognised condition in modern medical practice, as in the majority of cases where an individual is suspended vertically the workers or climbers can keep themselves moving using their legs as muscle pumps, and additionally are rescued relatively quickly. In those who are stranded, for example, on the side of a mountain, other factors probably account for their collapse, including traumatic injury and environmental conditions.

Modern harnesses now use a sitting position with a waist strap and sub-pelvic leg straps for support, which means a shorter vertical distance for blood to be pumped back from the legs. People using this equipment are also taught that if they find themselves suspended vertically, they need to do any of the following: adopt a sitting position, move themselves into a horizontal position or push their legs off from a hard surface to keep their muscle pumps active. Some harnesses also have foot straps to keep the legs mobile for the same reason.

Workers using safety harnesses are not permitted to work alone at height so that a rescue plan can be activated promptly if they come into any difficulty, and so that they will therefore not be suspended for very long. These guidelines are emphasised in the Health and Safety Executive’s *Work at Height Regulations* 2005.⁶

RESCUE DEATH AND MANAGEMENT OF SUSPENSION TRAUMA

In addition to the basic ABC management of a patient who has been involved in a suspended fall, there seems to be controversy regarding the positioning of a casualty after rescue. Authors of several articles on suspension trauma advise that if a person has been suspended in a vertical position motionless for longer than 30 min, then he or she should not be laid in a horizontal position on his or her rescue as this may cause “rescue death”. The aetiology of this has been contributed to a number of suggested factors. These include the hypoxic volume of blood pooled in the legs returning to the heart suddenly causing an ischaemic heart failure; overloading of the right ventricle on horizontal positioning; a reperfusion injury of the vital organs that had become hypoxic during vertical immobility; and a crush-type injury from toxins produced by the accumulated blood in the legs.

For this reason, some authors suggest that the casualty should be positioned in a sitting position with the upper body supported for at least 30 min before being allowed to lie horizontal. Other authors recommend immediate supine positioning, in particular when there are other injuries.¹ There is no consensus opinion regarding this issue.

CONCLUSION

Suspension trauma may indeed be a hypothetical risk, which has been made extinct by modern harness design and health and safety guidelines. However, healthcare providers should be aware of the potential existence of this condition. More robust medical research using modern harnesses and healthy volunteers (representing the climbing population) would be beneficial to assess whether this is purely a theoretical risk.

Authors’ affiliations

Caroline Lee, Keith M Porter, Academic Department of Traumatology, West Midlands, UK

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