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REVIEW ARTICLE

Clinical Update: Suspension Trauma

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Objective.—Suspension trauma refers to the pathophysiologic syndrome that occurs when a victim is suspended motionless in a vertical position for an extended period of time. This can occur in sports that use a harness system as well as in various occupational activities including work on high wires or helicopter rescue operations. We reviewed the scientific evidence published to date in order to improve the prevention and treatment of suspension trauma.

Methods.—Medline, PreMedline, the Cochrane Library, and Google Scholar were searched for relevant information about suspension trauma.

Results.—Published data describing the pathophysiology of and the therapeutic approach to suspension trauma are sparse and consist mainly of case reports and a limited number of human experimental prospective studies. The pathophysiology of suspension trauma is related to hypovolemia induced by reduced venous return and by vagal stimulation. It is also influenced by the type of harness used. Chest harnesses may induce severe cardiorespiratory repercussions and have the lowest motionless suspension tolerance. Symptoms of suspension trauma include presyncope and can lead to a loss of consciousness.

Conclusions.—Sports enthusiasts and workers who use a body harness system should never act alone and should not use a simple chest harness. If a victim shows symptoms of presyncope or is unconscious, he should be released from suspension as soon as is safely possible. There is no clear evidence to support the idea that the return to the horizontal position may contribute to the potential risk of rescue death.

Key words: suspension trauma, orthostatic syndrome, harness, orthostatic intolerance

Introduction

Suspension trauma is the pathophysiologic response of the human body being suspended motionless in a vertical position for an extended period of time.[1] Symptoms include presyncope and can lead to a loss of consciousness.[2] Certain sports enthusiasts, as well as various medical and rescue professionals, have a keen interest in this subject.[3] Since the early 1970s, disagreements about the mechanism and management of suspension trauma have sparked debate and controversy among laypersons, as well as professionals in rescue organizations, and elicited a variety of recommendations from experts based mainly upon personal experience and case reports. The medical risks run by suspension victims were outlined in a presentation of case reviews at the Second International Conference of Mountain Rescue Doctors in Innsbruck in 1972. The concept of "rescue death" surfaced, and some specialists advocated against placing the victim in a horizontal position immediately following rescue due to the potential risk of cardiac arrest. This theoretical risk is thought to be tied to a rapid increase in venous return as the body returns to a horizontal position, which can cause a massive volume overload of the right heart chamber or a recirculation of toxic metabolites leading to cardiac arrest.[4]

The aim of our review was to present the most pertinent studies in this area and to synthesize the best scientific data currently available in order to improve the identification and treatment of suspension trauma. Traumatic injuries from the fall itself, as well as the potential delayed complications of crush syndrome from prolonged suspension, will not be discussed here.[5,6]

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Methods and Results

We conducted a literature search using Medline, PreMedline, the Cochrane Library, and Google Scholar, with the following keywords: "suspension trauma," "or-

Figure 1. Motionless suspension in a harness is an emergency, as it can quickly lead to loss of consciousness.

thostatic syndrome," "harness," and "orthostatic intolerance." Over 10,000 articles surfaced and were filtered based on their abstracts. After eliminating irrelevant articles, 39 remained and were read in their entirety. We also checked their respective bibliographies for additional articles of interest.

There is a paucity of scientific data about suspension trauma and what little is available consists of case reports and human experimental prospective studies of which only a few are controlled and randomized. Most of these studies did not measure the tolerance to passive suspension in a modern sports harness such as the sit harness (Figure 1), which is worn around the waist and also encircles the upper thighs. Rather, they used either a whole body industrial harness which encircles the chest and upper thighs, or a body belt which consists of only 1 belt around the waist. We found only 2 studies that used rigorous evidence-based review methods to develop guidelines and recommendations on this topic.[7,8]

Etiology and Prevalence

Suspension trauma can occur in any activity that uses a body harness system. This includes sports such as mountaineering, rock climbing, parachuting, paragliding, via ferrata, canyoneering, BASE jumping, and spelunking. Occupational activities include work on high wires or rescue operations in hostile environments (mountainous or other difficult terrain, helicopter winching in rescues at sea, etc). We were unable to find precise data on the prevalence of suspension trauma. A retrospective review of work on high wires reflecting millions of man-hours of labor did not reveal 1 suspected case of suspension trauma.[9] The currently available literature describes only cases from sports accidents or healthy volunteer studies.

Mechanism

The human body's response to the orthostatic position is pooling of blood in the lower extremities, resulting in functional hypovolemia. The absence of a muscle pump in an immobilized subject diminishes venous return, thereby accentuating this phenomenon. These factors can lead to symptoms of presyncope (nausea, light-headedness, hot flashes, numbness of the extremities) or unconsciousness if not treated in a timely manner. Different types of body harnesses can exacerbate this situation. When a sit harness is used, the leg straps compress the femoral veins, reducing venous return; this is the same mechanism that has also been implicated in the pathogenesis of thromboembolic events.[10] When a simple chest harness is used, as in free suspension, intrathoracic pressure increases, which has been shown to lead to a dramatic impairment of hemodynamic and respiratory parameters.[11]

In addition to hypovolemia due to reduced venous return, a vagal phenomenon (either reflexive or from a nociceptive stimulus) appears to be implicated in the pathophysiology of suspension trauma.[11] Experimental studies in presyncopal subjects have demonstrated that heart rate and mean arterial pressure increase at first but subsequently decrease as presyncopal symptoms develop.[12] In a study of motionless suspension in healthy volunteers, 1 subject experienced bradycardia of 30 bpm followed by syncope. These experimental findings can be explained by a vasovagal mechanism that results in a hypotensive-bradycardic response that, along with orthostasis, leads to syncope.[13]

Timing

In the case of passive orthostasis, the appearance of presyncopal symptoms is the rule and these can develop very quickly. Eight percent of volunteers subjected to a passive head-up tilt of 50° experienced such symptoms after only 5 minutes, and 50% were symptomatic after 27 minutes.[12] These time periods are even shorter when one is suspended in a harness, and depend on the type of harness used. The tolerance for motionless suspension was shown to be greater in a whole body harness (14.38