RECM 0024 Immobilization and Splinting in Mountain Rescue

Official recommendations of the International Commission for Mountain Emergency Medicine, ICAR MEDCOM

Intended for Mountain Rescue First Responders and Physicians, and Rescue Organizations

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This article reflects the consensus of opinion of the International Commission for Mountain Emergency Medicine, ICAR-MEDCOM, which has full responsibility for the content.

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Abstract

Aims and methods: Immobilization and splinting of fractures is essential to reduce morbidity and mortality in mountain rescue. Therefore, members of the International Commission for Mountain Emergency Medicine (ICAR MEDCOM) debated the results of a literature review carried out by the authors. Focusing on common immobilization and splinting techniques relevant to mountain rescue, a consensus document was formulated.

Results and recommendations: Pain relief of appropriate speed of onset and strength should be available on scene. Spinal immobilization is recommended for all casualties that have sustained head or spine injury. The preferred method is a vacuum mattress with an appropriately sized rigid cervical collar. In such casualties, only those in an unsafe environment or with time-critical injuries should be evacuated before spinal immobilization is performed. In some casualties the cervical spine may be cleared and a cervical collar may be omitted. In the presence of hemodynamic instability and where there is a suspicion of a fractured pelvis, an external compression splint should be applied. Splinting of a femoral shaft fracture is important to limit pain and life-threatening blood loss. If time allows, extremity fractures should be adequately splinted and, if the practitioner is skilled, a displaced fracture or joint dislocation should be reduced on scene with the use of appropriate analgesia.

Keywords: Emergency Medicine; First Aid; Fractures; Immobilization; Mountain Rescue; Splints.

Introduction

The commonest injury that results in a call to the mountain rescue services is trauma to the lower extremity; this can range from a simple ligament sprain to a complex displaced open fracture. In addition, tumbling falls with the potential for spinal and pelvic fractures are frequent (Hearns, 2003; Hohlrieder et al., 2007; Sharp, 2007). Thus, rescuers have to manage fractures ranging from minor to major life threatening conditions, often in a challenging environment, with limited diagnostic and therapeutic equipment. Reducing and immobilizing fractures are the main stay of definitive fracture management; the potential benefits are listed in table 1. It is believed that the earlier immobilization is done the lower the morbidity suffered by the casualty and, in femoral shaft fractures, also mortality (Ellerton, 2006).

Advances in the design of splints have enabled lighter and more compact designs to be brought to the incident site. Of particular note are adjustable splints (for example, adjustable cervical collars) that can be used on most casualties irrespective of body size. These are critical in mountain rescue whether terrestrial– all the equipment has to be carried, sometimes a considerable way– or helicopter based where weight and size are usually at a premium. In 2001, the International Commission for Mountain Emergency Medicine (ICAR MEDCOM) published a short recommendation that, “in general, injured patients in the mountains should be immobilized with a vacuum mattress” (Rammlmair et al., 2001). The purpose of the present paper is to report on subsequent research and expand the prior recommendation to include all immobilization devices for the vertebral column and the extremities.

Methods and Materials

ICAR MEDCOM established a working group in 2007 to update and expand its recommendation (Rammlmair et al., 2001). A Medline search using the keywords “cervical collar”; “femoral fracture”; “femur fracture immobilization not surgery”; “femur splinting”; “immobilization”; “leg splinting”; “pre-hospital or emergency care”; “splints” and “vacuum mattress” was performed (last update 23rd December 2008). The retrieved papers’ references were also scanned for articles. Additional relevant references to pre-hospital or emergency care were identified manually. Thus, 33 articles relevant to mountain rescue were included in this review. The authors presented a draft at ICAR MEDCOM meetings in Lecco, Italy; Chamonix, France; and Bansko, Bulgaria and the manuscript was finally approved.

Results

A primary survey should be carried out on all mountain rescue casualties, and life-threatening injuries managed appropriately, before the immobilization of fractures becomes the focus of the rescuer (Anonymous, 2005). Suspected fractures of the pelvis, shaft of femur and spine, and external bleeding from an open fracture will have been identified during the primary survey and appropriate treatment initiated (Ellerton, 2006). In the mountain rescue setting, only in exceptional conditions would a casualty be evacuated (“scoop and run” without these fractures being immobilized. In contrast, the management of “minor” extremity fractures must be deferred when more serious life-threatening injuries are suspected so as to avoid introducing time delays.

Assess the fracture for its site, associated soft tissue injury (e.g. open wounds, skin blanching) and distal neurovascular deficits (e.g. absence of pulses, numbness). In mountain rescue, the casualty may be in a difficult location crammed against boulders or suspended by a rope restricting access. A smooth, progressive immobilization of a fracture is a sign of a good rescue team and minimizes the casualty’s pain.

Discuss the proposed treatment with the casualty, and offer appropriate pain relief (analgesia) bearing in mind that the injury may become more painful during the evacuation. Wound care may be required (Quinn et al., 2006). The extremity is often prepared with soft padding and, if appropriate, deformity corrected. Immobilize the fracture and the joint above and below. Ideally this is done with the primary splint but often a secondary splint is employed. For example, a distal forearm fracture is splinted from the fingers to just below the elbow and then the elbow supported by a broad arm sling. Ensure that the bandage or Velcro strapping securing the splint has sufficient tension to hold it firmly without causing constriction. Check and record the neurovascular status again (Lee et al., 2005). An injury with persistent neurovascular deficit requires urgent evacuation to hospital by the fastest means available. When packing the casualty for evacuation, try to make access to the injured part easy in case this becomes necessary later. In some situations, elevating and cooling the fracture site may be appropriate.

During the evacuation, periodically ask the casualty about discomfort. If it is increasing, the extremity usually needs inspecting. Common problems are: pain from rough handling; a vacuum splint loosing its rigidity; bandaging becoming too constrictive as the injury swells and the initial analgesia wearing off. Rarely a neurovascular problem (‘compartment syndrome’) is developing. In addition, if appropriate, treat any hypothermia induced by the casualty’s relative inactivity and offer reassurance.

It is imperative that on handling the casualty over to the hospital a written statement of your findings and treatment is given. Most importantly, the presence of an open wound should be indicated. Digital photographs of the injury particularly before any manipulation can be of benefit.

Spinal immobilization

In Hearn’s retrospective Scottish Mountain Casualty study, spinal injury occurred in 3.6% of the persons alive when the rescue team arrived (Hearns, 2003). In this and another study of mountaineering accidents in the Sierra Nevada, about 50% of the vertebral column injuries were to the cervical spine (McLennan et al., 1983). As the etiology is usually a tumbling fall, casualties with a spinal injury often have at least one other significant injury (Hearns et al., 2006). Spinal immobilization may minimize secondary damage (Anonymous, 1998). Experimental studies have confirmed that the vacuum mattress is superior to the spinal board in comfort and significantly reduces casualty movement when the device is tipped as is inevitable during the evacuation (Luscombe et al., 2003). In addition, the interface pressure in potential pressure sore sites is lower with the vacuum mattress though can still be high enough to cause skin ischemia in healthy volunteers (Keller et al., 2005). A randomized crossover laboratory study showed that both vacuum mattress and spinal board may reduce respiratory function, though the effect is largely due to casualty’s supine position (Totten et al., 1999). In a review of the use of the spinal board during the hospital phase of trauma management, complications were found in five clinically relevant categories: pressure sore development; inadequacies of spinal immobilization and support; pain and discomfort; respiratory compromise; and quality of radiological imaging and consequently, removal of the spinal board in all patients soon after arrival in emergency departments was recommended (Vickery, 2001).

For these reasons, the vacuum mattress is the preferred device for total spinal immobilization in mountain rescue (Rammlmair et al., 2001). Compared with a spinal board, it is practical to transport and use even in a windy, exposed or confined incident site. The time taken to apply a vacuum mattress is less than three minutes, and is no longer than securing the patient on a spinal board (Johnson et al., 1996). But, some precautions have to be taken when the vacuum mattress is used: a) in the compromised casualty, a smooth wrinkle-free surface with no protruding objects may become paramount to reduce interface pressure, b) over tightening chest straps could have a detrimental effect to respiration and should be avoided, c) external blood loss can be concealed from the rescuer once the vacuum mattress has been applied and d) supplement the vacuum mattress with a rigid external device (e.g. scoop stretcher) to prevent longitudinal flexion and mitigate against vacuum mattress puncture. However, improvements in design have allowed some vacuum mattresses to be used alone for extricating and moving the casualty a short distance or during winching (personal communication, Dr Oliver Reisten, Alpine Rescue Centre, Zermatt, CH).

Extrication devices, such as the Kendrick Extrication Device®, or a spinal board may be used when specific circumstances occur. For example, a technique using an extrication device along with an additional pelvic support has been advised for the rapid removal of a casualty trapped in a confined space, such as a narrow crevasse (Winterberger et al., 2008).

Cervical collars

A rigid cervical collar, properly fitted, should be used in conjunct with the vacuum mattress as this has been shown to improve the immobilization of the neck in a laboratory study (Hamilton et al., 1996). However, two controlled prospective studies show that a cervical collar can raise intracranial pressure by a combination of noxious soft tissue pressure and venous obstruction (Kolb et al., 1999; Mobbs et al., 2002) and, if poorly fitting, can even reduce airway patency (Dodd et al., 1995). Cervical collars applied for long periods are uncomfortable and can also cause pressure sores. Clothing needs adjusting and necklaces removed to ensure the collar abuts the skin. From a retrospective study on selective cervical spine immobilization it was concluded that, having assessed the casualty to be fully conscious and non-intoxicated with no neurological symptoms, no posterior midline tenderness, and no distracting injury, the cervical collar could be omitted (Stroh et al., 2001). This may be particularly helpful if the evacuation time is going to be many hours. Adjustable cervical collars have been an important development. The number of collars carried to the incident can be reduced without compromising fit. Very few studies have been published comparing collars (Alberts et al., 1998; Tescher et al., 2007). The studies all assess the collars in isolation without full spinal immobilization, which is not relevant to current clinical practice. Experience with the recently introduced vacuum cervical collars (using the same principle as the vacuum mattress) is limited (Ransone et al., 2000) and their value in mountain rescue has yet to be assessed.

Pelvic splints

A major pelvic fracture with disruption of the bony ring is rare– less than 1% in the Scottish Mountain Rescue Casualty study (Hearns, 2003). Uncontrolled hemorrhage contributes to a significant number of deaths. This may be arterial, venous or from the distracted bone ends and may, in the latter two, be minimized by reducing and immobilizing the fracture. Therefore, recent guidelines suggest that, in a hemodynamically unstable casualty with a pelvic fracture, reducing and splinting a fractured pelvis may reduce blood loss (Heetveld et al., 2004). As a result, Lee and Porter state that “If there is any suspicion of fracture, immobilize the pelvis using an external compression splint (commercial or modified, e.g. sheet)” (Lee et al., 2005). In addition, they maintain that ‘springing the pelvis’ (moving the bony fragments) should be abandoned; clinical assessment should be based on suspicion from the mechanism of injury, a complaint of pain (in the conscious) and observed signs around the pelvis alone (Lee et al., 2005).

Once the pelvis has been reduced and splinted, the external compression should only be released after a full assessment of the casualty in the hospital (Qureshi et al., 2005). This may be difficult if a vacuum mattress was used as the sole compressive force. It is paramount that the casualty is evacuated with the greatest urgency to a medical facility capable of managing the injury.

Femoral shaft splints

In the Scottish Mountain Rescue study there was one case amongst the 333 live casualties (Hearns, 2003). Reflecting the seriousness of the injury, the casualty died from hemorrhagic shock during evacuation. In another study of an urban population, femoral fractures occurred in only 16 out of 4513 patients (0.35%). Traction splints were applied in two of the 16, whereas 14 were managed with total immobilization only without sequelae. From this study it was concluded that a traction splint might not be essential equipment. (Abarbanell, 2001).

Two approaches to splinting a femoral shaft after manual reduction of the fracture have been described. Differing countries are polarized in their preferred practice; no studies were identified that could be used to inform on the optimal management. The consensus opinion of ICAR Medcom is that both approaches are acceptable.

a) Use a femoral traction splint (Rowlands et al., 2003; Ellerton, 2006). No comparative studies of the commercially available splints have been identified so the choice will be based on personal preference. As an alternative, an improvised splint using e.g. extendable ski sticks and strapping may be more likely to be available when required. It is important to consider how the splint fits with other rescue equipment as its protruding structure inevitably extends below the foot of the casualty and is particularly vulnerable. Contra-indications to the use of femoral traction splints include dislocation of the hip, fracture dislocation of the knee, and ankle injuries (Lee et al., 2005). In one series of multi-system trauma patients, 38% were judged to have a contraindication to applying a traction device (Wood et al., 2003) making this method unusable.

b) Use a vacuum mattress or large splint– vacuum or box (Forster et al., 2001). Manual traction is applied to the lower leg to reduce the fracture. Then the vacuum mattress/splint is firmly moulded around the fractured leg and deflated. Secondary splinting to the uninjured leg or maintaining manual traction, if practical, is frequently required to maintain the reduction.

Other extremity splints

Splinting extremity injuries is one of the most common interventions performed by most mountain rescue teams (Hearns, 2003; Elsensohn et al., 2009). Unfortunately, very little has been published on extremity splints except the potential harm caused by inflatable splints (Shakespeare et al., 1984). Despite this lack of data, there is no doubt that effective splinting is much appreciated by the casualty. There are many different splints designed for the extremities each with its advantages and disadvantages (Table 2). In mountain rescue, the bulk, weight, reliability, flexibility of use and cost will determine which are carried. Even in organized rescue the art of improvisation, including using mountaineering equipment, has a role and can provide very effective splints. Reducing deformity is desirable under certain adverse conditions. These include a long transit time to definitive care (e.g. > 2 hours), confined spaces (e.g. cave rescue), open fractures with exposed bone and intractable pain. If the rescuer is suitably trained, lower extremity fractures with a subluxation or dislocation of the ankle, a patella subluxation or shoulder dislocation can be reduced at the scene of the incident with benefit to the casualty and evacuation plan.

Recommendations

All mountain rescue casualties should have a primary survey performed and priority given to treating and evacuating those with suspected life threatening injury without introducing time delays. Pain relief, with an appropriate speed of onset, should be available at the incident site. Effective immobilization of fractures to minimize morbidity should be carried out and a written record of the treatment passed to the hospital. In general, spinal immobilization is recommended for all mountain rescue casualties injured in a fall. The preferred method is a vacuum mattress with an appropriately sized rigid cervical collar. Any helicopter likely to be performing in a mountain rescue environment should be equipped with a vacuum mattress and a range of extremity splints. Only in exceptional circumstances, where a time-critical injury or unsafe environment takes priority, should spinal immobilization not be performed prior to evacuation. The cervical collar may be removed in a casualty who is fully conscious, non-intoxicated, without neurological symptoms, posterior midline tenderness, or distracting injury. In the presence of hemodynamic instability and a clinical suspicion of a fractured pelvis, an external compression splint should be applied to the pelvis. Splinting a femoral shaft fracture is an important component of its management. Extremity fractures should be adequately splinted. If the rescuer is trained, displaced fractures, joint subluxation and dislocations should be reduced on scene after giving an appropriate analgesic.

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Table 1. Benefits of reducing and immobilizing a fracture, adapted from (Lee et al., 2005)

Reducing pain
Reducing blood loss
Minimizing neurovascular complications
Reducing risk of fat embolism
Reducing risk of further tissue damage and facilitating healing
Helping transportation

Table 2. Types of extremity splint

	Advantages	**Disadvantages**	**Uses**
Box-shell or gutter-type	Effective if extremity is aligned. Equipment will not fail	Bulky to carry. Poor splinting if extremity distorted or grossly swollen	Lower leg fracture, knee injury, forearm fracture
Improvised	Infinite possibilities depending on your imagination. For example, camping mat, ski poles and ‘duct tape’	Can be time consuming and may destroy equipment. Often less good than commercial splints	May be the most appropriate splint even in an organized rescue team
Inflatable	Light	Pressure applied can be excessive and potentially harmful. Equipment failure common. Affected by changes in altitude and temperature	Out dated– rarely recommended in organized rescue
Malleable splints e.g. SAM®	Light, compact, flexible. Equipment will not fail	Multiple units required for lower extremity, longitudinal rigidity less good than box and vacuum splints	Most extremity fractures
Vacuum	Moulds to the extremity. Very adaptable	Moderately bulky, expensive, can deflate and equipment failure occurs. Remember the pump! Affected by changes in altitude and temperature	Most extremity fractures