Avalanche Victim Trauma

INTRODUCTION

The unmistakable contribution of trauma to mortality and morbidity during avalanche accidents, although clearly overshadowed by asphyxiation as the predominant cause of death, has in the last several years been an area of considerable academic interest in the medical literature around the world. The extensive data derived from several studies demonstrate that trauma accounts for less than 25% of avalanche deaths, ranging widely depending on regional differences as will be discussed.1-3,5,6,7 Basic recommendations supported by the literature are presented and graded using the scheme of the American College of Chest Physicians8 and are applicable to anyone exposed to avalanche terrain (See Table).

GEOGRAPHIC VARIABILITY AND MORTALITY

The mortality statistics relating to avalanche trauma appear to vary significantly with geographic location around the world and the particular characteristic terrain endogenous to the region over which an avalanche victim slides; such as in heavily forested regions in western Canada compared to those predominated by open bowls as in Europe or the western United States.9-10

An early study by Grossman and colleagues,1 who methodologically weakened by the use of mixed data that included both partial and complete burial in Utah and several regions of Europe, reported that traumatic injuries occurred among 25% of the survivors of avalanche accidents. As many injuries in survivors remain unreported, this is almost certainly an underestimate. The most common injuries were major orthopedic, soft-tissue, and craniofacial injuries although chest contusions and rib fractures were reported in some survivors. The overall mortality from multiple trauma and dislocation of the cervical spine; possibly involving other factors. The contribution of such unknown variables to regional trauma rates, such as the long-term prevalent use of air bag systems in Europe compared to North America, mechanized approaches to remote backcountry skiing and snowboarding in Canada, the prevalence of helmet usage and the notable absence of snowmobiling in Europe are unknown but deserve further research.

Recommendation:

Avalanche trauma mortality statistics in the medical literature should only include studies performed in which the cause of death is established by extensive external and radiographic examination or ideally the standard full autopsy.11-13

A) Studies using other than this methodology should be statistically disregarded.

The geographic differences in endemic terrain features, as previously noted, likely dictate the differences in trauma rates discovered between countries and regions, although this remains an area of continued research and could possibly involve other factors. The contribution of such unknown variables to regional trauma rates, such as the long-term prevalent use of air bag systems in Europe compared to North America, mechanized approaches to remote backcountry skiing and snowboarding in Canada, the prevalence of helmet usage and the notable absence of snowmobiling in Europe are unknown but deserve further research.

Recommendation:

Although the practice of wearing helmets is strongly recommended for anyone recreating or working in avalanche terrain, their use would appear even more critical in wooded terrain.

[Grade 1B]

MECHANISM OF INJURY

Avalanche victims can sustain virtually any type of traumatic injury during their often-turbulent descent in the momentum of an avalanche, and certainly if involved in collision with trees, rocks or cliff falls.

Hohlrieder and colleagues reviewed the injuries of 105 avalanche victims in Austria and noted a high incidence of chest trauma, lower-leg fractures, and shoulder dislocations. The orthopedic injuries were felt likely related to attached skis and poles causing mechanical leverage on the extremities although the high rate of chest trauma in this region of low trauma mortality is unexplained. Additionally, spinal fractures were found in as many as 7% of the cohort questioning whether these fractures could actually occur pre-burial during turbulent flow and not always by collision with an object.

Johnson and colleagues reviewed autopsy reports from 28 avalanche deaths in Utah over a 7-year period looking specifically at closed head injury (CHI). Among 22 avalanche victims who died from asphyxiation, one-half experienced mild or moderate traumatic brain injury (TBI), which the authors argued could cause a depressed level of consciousness and contribute to death from asphyxiation. In this study as many as 61% of the victims had evidence of CHI. This important category of combined trauma and asphyxia, since it may be difficult to determine the primary cause, must be considered in studies on the pathophysiology of death in avalanche. All six of the avalanche deaths that were felt to be primarily the result of trauma involved severe traumatic brain injury.

In another review of 56 avalanche fatalities in Utah, all three deaths that were determined to be due solely to trauma involved evidence of head injury.14

Recommendation:

These data again strongly argue for the routine use of helmets in avalanche terrain. Education about the primary prevention of head trauma by the use of helmets in avalanche terrain should be emphasized. [Grade 1B]

Although the data presented clearly demonstrate the role of head and brain injury during avalanche accidents, in the Hohlrieder study it is noted that the only two solely traumatic deaths (5.6%) in their series were caused by isolated fractures and dislocation of the cervical spine; possibly revealing the remarkable forces that an avalanche can apply to the human body and in particular the vulnerability of the cervical spine.

Recommendation:

Since the head and neck appear to be the cause of much traumatic mortality during avalanche accidents, rescuers must adhere to stringent neck stabilization techniques after head exposure, if possible, during even the most difficult of extrications. [Grade 1B]

Long bone fractures should be stabilized and immobilized as best as possible to prevent pain, blood loss, worsening shock or hypothermia.

First Aid

AVALANCHE VICTIM TRAUMA; EVIDENCE-BASED RECOMMENDATIONS

FIGURE 1: A comparison of the Swiss avalanche survival curve (black line) and the Canadian survival curve (blue line) over the same 25-year period. Note the rapid drop in mortality and morbidity during avalanche accidents, although clearly overshadowed by asphyxiation as the predominant cause of death, has in the last several years been an area of considerable academic interest in the medical literature around the world. The extensive data derived from several studies demonstrate that trauma accounts for less than 25% of avalanche deaths, ranging widely depending on regional differences as will be discussed.1-3,5,6,7 Basic recommendations supported by the literature are presented and graded using the scheme of the American College of Chest Physicians8 and are applicable to anyone exposed to avalanche terrain (See Table).

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Long bone fractures should be stabilized and immobilized as best as possible to prevent pain, blood loss, worsening shock or hypothermia.
which is always present to some extent in buried avalanche victims. Potential spine injuries should be treated with common mountain medicine techniques and by following other locally published recommendations including management of potential head injuries and spine fractures. [Grade 1C]

PROTECTIVE GEAR

Protective gear has the potential to limit the extent of trauma from an avalanche accident. In addition to the routine use of a helmet, an avalanche airbag, which specifically has a shape designed to reduce trauma to the head, neck, and chest during collision with objects (Figure 2), may have promise. However, there is negligible meaningful data presently available and with several balloon configurations on the market, prospective comparisons regarding trauma prevention efficacy are difficult. Further research and validation is absolutely required before recommending the use of this device to reduce the risk of head, neck and torso trauma.

Recommendation:
No adequate evidence exists at this time supporting some avalanche air bag system manufacturer’s claims of head, neck or chest protection from a balloon device, although this is an imperative area of further research. [Grade 2C]

TRAUMATIC CARDIAC ARREST

The chances of survival with traumatic cardiac arrest in an avalanche setting are exceedingly low, but may be considered possible if a fast and efficient chain of survival is available.12,13 However, to date no survivor with traumatic cardiac arrest from an avalanche accident has been reported. If CPR is initiated, it may be discontinued after 20 minutes if no response is observed unless there is a strong suspicion of a polytraumatic hypothermic injury. Initiation of CPR, in a traumatic arrest victim, unless possibly consistent with a hypothermic etiology and a clear airway, can be attempted for 20 minutes and ceased if unsuccessful or in such situations where HEMS or rapid ground transport is unavailable, never started. ▲

Recommendation:
In an avalanche traumatic cardiac arrest victim consider starting CPR, only if highly efficient ground or Helicopter EMS (HEMS) transport is available; otherwise strongly contemplate withholding or not continuing CPR as dictated by local, national, and international guidelines. [17,18]

[Grade 1B]

Summary
Traumatic injuries account for the second highest cause of death in avalanche accidents and although variable rates are noted regionally in the literature, asphyxiation has been well shown to be the predominant lethal mechanism worldwide. Non-lethal trauma is probably much higher than the reported 25% in survivors as many don’t seek medical attention and remain unreported. Although long bone orthopedic injuries are not surprisingly common, the often-violent mechanism of injury during avalanche travel and collision has been shown to be associated with a significant rate of head, neck, and chest injury. At this time, preventive equipment that can be confidently recommended is a helmet. Further research will be needed to assess the efficacy of certain avalanche airbags in the prevention of head and neck injury. Initiation of CPR, in a traumatic arrest victim, unless possibly consistent with a hypothermic etiology and a clear airway, can be attempted for 20 minutes and ceased if unsuccessful or in such situations where HEMS or rapid ground transport is unavailable, never started. ▲

References

GRADE OF RECOMMENDATION
DUALITY OF SUPPORTING EVIDENCE

1A. Strong recommendation, high quality evidence
Consistent evidence from well performed randomized, controlled trials or overwhelming evidence of some other form. Further research is unlikely to change our confidence in the estimate of benefit and risk.

1B. Strong recommendation, moderate quality evidence
Evidence from randomized, controlled trials with important limitations (inconsistent results, methodological flaws, indirect or imprecise), or very strong evidence of some other research design. Further research (if performed) is likely to have an impact on our confidence in the estimate of benefit and risk and may change the estimate.

1C. Strong recommendation, low quality evidence
Evidence from observational studies, un系统atic clinical experience, or from randomized, controlled trials with serious flaws. Any estimate of effect is uncertain.

2A. Weak recommendation, high quality evidence
Consistent evidence from well performed randomized, controlled trials or overwhelming evidence of some other form. Further research is unlikely to change our confidence in the estimate of benefit and risk.

2B. Weak recommendation, moderate quality evidence
Evidence from randomized, controlled trials with important limitations (inconsistent results, methodological flaws, indirect or imprecise), or very strong evidence of some other research design. Further research (if performed) is likely to have an impact on our confidence in the estimate of benefit and risk and may change the estimate.

2C. Weak recommendation, low quality evidence
Evidence from observational studies, un系统atic clinical experience, or from randomized, controlled trials with serious flaws. Any estimate of effect is uncertain.

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