

## Should strategies for care of avalanche victims change?

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∞ See related research paper by Boyd and colleagues, page 507

In an average year, avalanches result in the death of 146 people in North America and Europe.<sup>1</sup> In the European alpine countries (Austria, France, Germany, Italy, Slovenia and Switzerland), there has been no major change over time in mortality due to avalanches; however, there has been a noteworthy increase in mortality in Canada and the United States.<sup>1</sup> It is widely assumed that asphyxia is the main cause of death for those caught in avalanches<sup>2</sup> and that hypothermia and trauma are of lesser importance.<sup>3</sup> Rescue strategies, safety devices and treatment recommendations have been largely focused on the prevention and treatment of asphyxia and hypothermia. However, if trauma is a more important risk factor in some mountain regions or for people involved in a particular outdoor activity, perhaps preventive measures and treatment recommendations should focus more on trauma.

In this issue of *CMAJ*, Boyd and colleagues<sup>4</sup> report the results of a retrospective observational case study of all deaths caused by avalanche in British Columbia and Alberta between 1984 and 2005. The strengths of their well-conducted study include accurate descriptions of the causes of death, methods of postmortem examination, and the inclusion of all fatal avalanche accidents within a defined geographic area and period. The startling result was a high rate of overall trauma mortality (24%) and even higher rates among the subgroups of helicopter skiers (30%) and out-of-bounds skiers (33%). These findings are in contrast with a low rate of mortality from trauma in Austria (5.6%)<sup>2</sup> and Utah, United States (5.4%).<sup>5</sup>

In the study by Boyd and colleagues,<sup>4</sup> the median duration of burial for completely buried victims who died from trauma was 25 minutes, compared with 45 minutes for those who died from asphyxia. This may indicate a negative correlation between the duration of burial and death caused by trauma. In comparison, the median duration of burial for all avalanche fatalities in Switzerland between 1979 and 1999 was 120 minutes.<sup>6</sup> It is possible that the high rate of trauma mortality in the current study was because of an exceptionally high rate of rescue within a short period after avalanche burial when asphyxia has had less chance to occur. This may be expected for helicopter skiers who are all equipped with avalanche transceivers and are accompanied by trained guides able to extricate them quickly in case of burial. In contrast, in Switzerland and Austria, only 56% of people completely buried by avalanche are equipped with a transceiver<sup>7</sup> and about 30% are accompanied by guides.<sup>8</sup> Thus, the higher rate

### Key points

- Mortality caused by avalanches is increasing in Canada and the United States.
- Trauma is a more important risk factor in helicopter skiers and out-of-bounds skiers than previously thought.
- Preventive measures and the on-site management of care for avalanche victims should address trauma.

of early extrication in Canada decreased the overall mortality by reducing the number of deaths caused by asphyxia and proportionally increasing the number of deaths caused by trauma. This could account for some of the discrepancy between Canada and European countries. If this is true, the study by Boyd and colleagues suggests that, in the region of Canada studied, immediate rescue is highly efficient compared with rescue in other countries.

The unexpectedly high rate of trauma among avalanche victims in western Canada raises a number of questions. Previous analyses revealed that the probability of survival depends on the degree and duration of burial, and the presence of an air pocket and a clear airway. In Switzerland from 1981 to 1998, there were 1886 avalanche victims, with an overall mortality rate of 52.4% among completely buried people and 4.2% among partially or nonburied people.<sup>1</sup> The length of time of burial is a decisive factor, because the probability of survival decreases from 91% after 18 minutes of burial to 34% after 35 minutes.<sup>1</sup> That is why all safety devices currently on the market for skiers are designed to avoid acute asphyxiation by reducing the degree and duration of burial or by prolonging survival after complete burial. Three rescue devices are commonly used: an avalanche transceiver, which is intended to increase the speed of locating a completely buried person;<sup>8</sup> an avalanche airbag, which is intended to prevent the person from being completely buried; and a breathing device designed as a life jacket or harness that separates exhaled air from inhaled air, thus prolonging the person's survival under the snow. However, none of these devices is intended to prevent fatal injuries. A retrospective analysis of avalanche accidents in Switzerland and Austria between 1990 and 2004 ( $n = 1504$ ) showed that people equipped with avalanche

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airbags had a lower risk of death compared to those with no airbag (2.9% v. 18.9%, odds ratio 0.009, 95% confidence interval 0.01–0.75,  $p = 0.026$ ). In addition, mortality was lower among people who used an avalanche transceiver than among those who did not use a transceiver (55.2% v. 70.6%, odds ratio 0.26, 95% confidence interval 0.14–0.48,  $p < 0.001$ ).<sup>8</sup>

Boyd and colleagues found that the chest was the most common single site (46%) affected by trauma, followed by the head (42%). Protective measures against injuries to the chest and head are feasible and should be considered in avalanche rescue, at least in mountain regions and for people who are at high risk of dying from trauma. A few such initiatives have been taken. In a retrospective observational case-series of avalanche fatalities from 1992 to 1999 in Utah, United States, Johnson and colleagues<sup>9</sup> reported that 61% of people who died had a closed head injury. Therefore, they recommended wearing helmets in avalanche terrain. In Switzerland, a new backpack with an integrated airbag has recently been introduced. This device, developed from the avalanche airbag, has a shape designed to reduce trauma to the head, neck and chest and is intended to keep the person's head in an upright position in an attempt to avoid complete burial.

In 2001, the International Commission for Mountain Emergency Medicine introduced an algorithm for the field management of care for avalanche victims.<sup>1</sup> The rescue strategy is primarily governed by the length of time of burial and the person's core temperature. With a burial time of 35 minutes or less, rapid extrication and, if necessary, basic life support measures are of the utmost importance. With a burial time longer than 35 minutes and for those with a clear airway, hypothermia management is important. Patients in cardiac arrest should be trans-

ported with continuous cardiopulmonary resuscitation to a specialist hospital for extracorporeal rewarming. Currently, beyond assessment for obvious fatal injuries, there is no consideration of trauma for these patients. Boyd and colleagues show that the on-site management of care for avalanche victims needs to be revised so that trauma management is given more prominence.

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