

Update on Avalanche Considerations and Treatment of Avalanche Victims

Colorado leads the nation in annual and total number of avalanche victims. Contrary to popular belief these kinds of incidents are not isolated to Summit County nor are avalanches solely caused by back country skiers. Due to multiple weather and terrain variables Colorado is actually susceptible to frequently developing highly unstable snow packs that requires knowledge and skill to successfully navigate. It could be hypothesized that this increase in snow pack variability combined with easy access to technical mountainous terrain from a large population area i.e. the front range lends itself towards Colorado having the largest number of human triggered avalanches in North America¹.

This being the case the medical care of the avalanche victim is actually more complicated then one might suspect. For many years there have been assumptions made in regards to the treatment or resuscitation of avalanche victims. The leading cause of death from an avalanche continues to be traumatic however the survivability of an avalanche is not simply whether trauma is sustained or not. Barring any initial mortal traumatic injuries, survivability is based on multiple variables surrounding burial within the snow pack after an avalanche. These variables and the medical treatment of these patients are what shall be addressed.

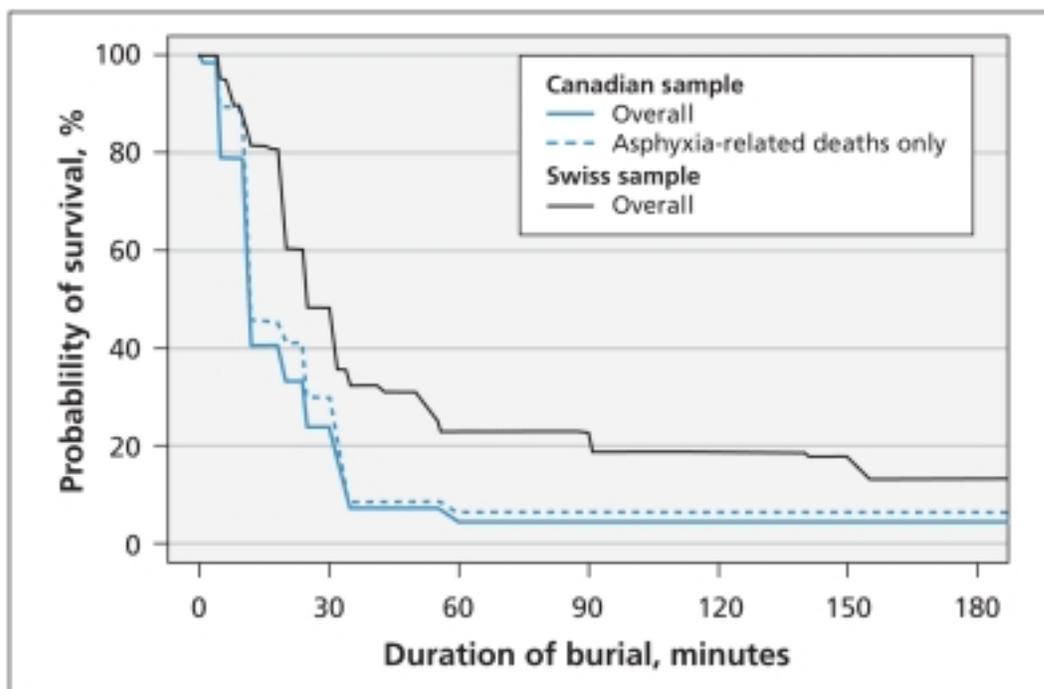
The overall survival rate of avalanche victims is 77%². Mortality is multi factorial in avalanche victims with the initial insult being trauma caused by the avalanche pushing victims into obstacles such as trees and rocks and also over ledges and cliffs. This can further be compounded by the type of avalanche that has stuck the victim. Hard Slab avalanches can create very large, thick pieces of snow that can act similar to concrete in a crushing manner as opposed to Loose Snow avalanches which are more similar to flowing liquid in its movement. There are many different types of avalanches, all with different presentations depending on many different variables. It is an entire field of study unto it's self and will only be minimally explored here.

Regardless of the initial trauma sustained from the avalanche, asphyxia remains the leading cause of death in avalanche victims. In a 21 year review of deaths from avalanche it was found that 75% of victims died from asphyxiation. Of the victims that had mortal traumatic injuries 48% of those victims were also completely buried³. This study was isolated to

British Columbia, Canada. However it has proven to be indicative of similar studies completed in Europe.

Should the victim not sustain any mortal trauma, the largest factor in survivability is the burial characteristics. These primarily involve the grade to which the victim is buried and the overall length of time buried. The grade of burial is the strongest factor in survival. Burials which include the chest and head have a survival rate of 47.6% compared to only a partial burial with a survival rate of 95.8%⁴.

The length of time spent buried is the second factor in survivability. As you can see below, there is a non-linear decrease in survival as length of time buried increases.



(Source: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3080528/figure/f1-1830789/>)

The length of burial time contributes to mortality in two major phases. The initial medical issues that affects the victim is asphyxiation. The two pathway roots this entails is whether the victim has a patent airway or not and whether the victim has an air pocket around their face or not. The density of the snow plays a direct factor in this regard. Mortality drops much

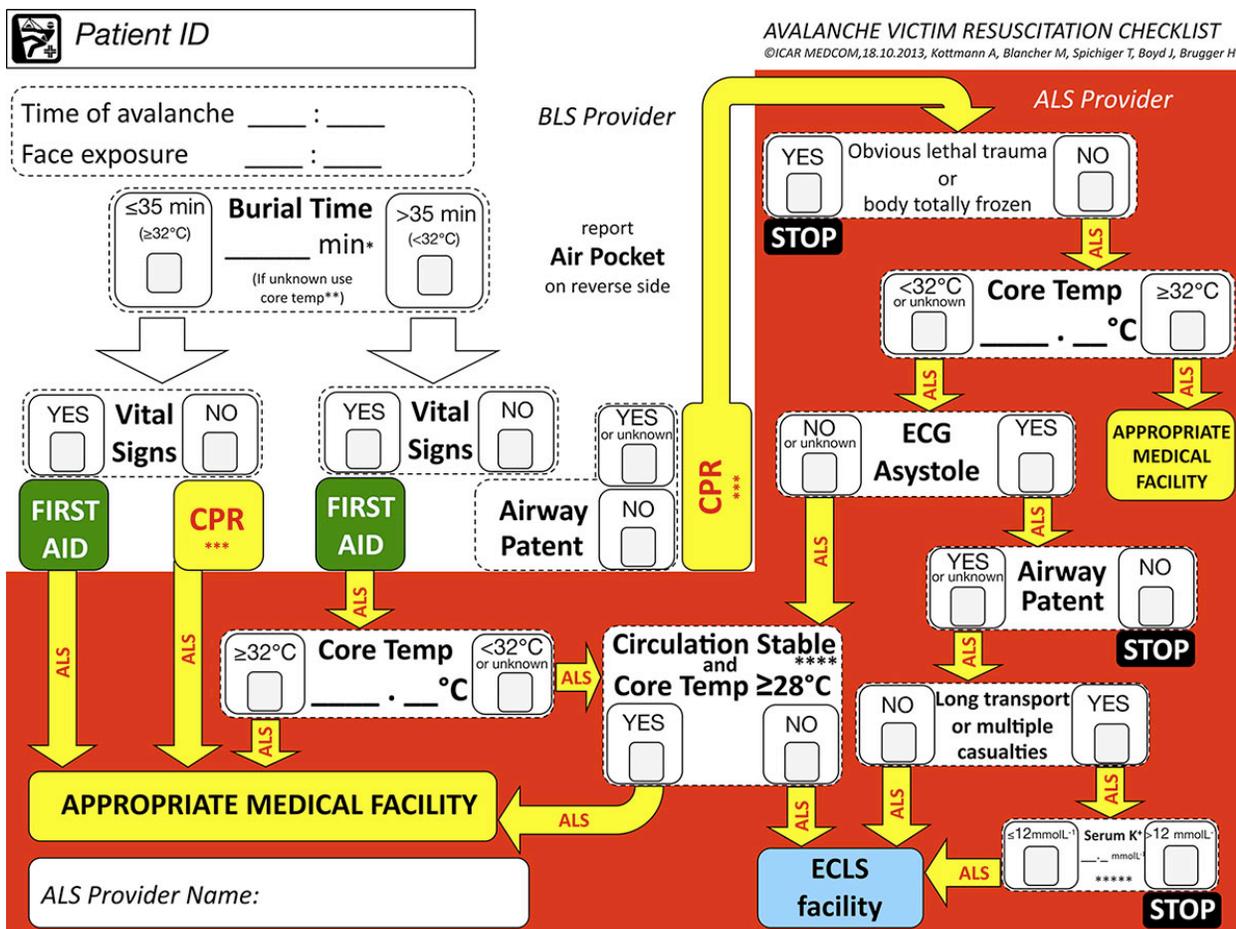
more precipitously in the Canadian study and is reported to be due to denser snow in this area than in Switzerland⁵. The prolonged burial time with asphyxia can lead to a fatal hypoxia and hypercapnia. Survivability is potentially prolonged if the patient has a patent airway and a facial air pocket or able to breath around large block of slab snow in particular types of avalanches. One study was completed showing that in a simulated air pocket victims were able to reach a steady state of survivable hypoxia lasting at least 20min⁶.

The second phase in the burial that contributes to mortality is hypothermia. Hypothermia can develop quickly in buried victims due to light clothing, sweating prior to burial and exhaustion. In some cases the maximum rate of cooling was 9 degrees Celsius an hour⁷. However, this quick cooling can also act as a cerebral protectant in the case of cardiac arrest, prolonging the survivability of the brain. Resuscitation of these victims is dependent on the victim having a patent airway upon being freed from the avalanche⁸.

Advances in severe hypothermia with cardiac arrest treatment have led to ideal victim care being delivered at tertiary care centers which can provide either extracorporeal membrane oxygenation or cardiopulmonary bypass rewarming.

These techniques combined with appropriate and gentle care in the field can change outcomes for even extreme cases. Part of the challenge then lies within providing that care in the field. This care has recently been updated by the International Commission for Alpine Rescue (ICAR).

ICAR has produced an updated and revised algorithm for decision making in the field by advanced providers. This includes both the best practice for providing and guiding care but also when to terminate resuscitation efforts. ICAR has also released an educational presentation on how best to use this new information with multiple scenarios for self education.



Part of the new addition is the use of serum potassium as an end point for either termination of resuscitation efforts or transportation to an ECMO capable facility. Serum potassium was found to be predictive of survival in the hypothermic cardiac arrest victim⁹. A serum potassium greater than 8 mmol/L has not been found to be survivable in the cardiac arrest patient after burial.

This short review mechanism in cardiac arrest for avalanche victims is only a small summary of the new algorithm used to guide response efforts. ICAR has freely published both research and best practice algorithms which are attached in their entirety for further self education.

Colorado will continue to experience the heavy loss of back country travelers and users. It is the duty of advanced providers to know and understand the transport and care of these critical patients.

External Links

[AVALANCHE VICTIM RESUSCITATION CHECKLIST](#)

[The Teaching Presentation - ICAR](#)

References

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¹ <http://avalanche.state.co.us/accidents/statistics-and-reporting/>

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⁹ Boyd J, Brugger H, Shuster M. Prognostic factors in avalanche resuscitation: a systematic review. Resuscitation 2010;81:645–52.