

CASE REPORT

Resuscitation and the Cold

Tariq Hayat Khan, DA, MCPS, FCPS

Consultant Anaesthetist, KRL Hospital, Islamabad

Address for correspondence: Col Tariq Hayat Khan, Dept of Anaesthesia, Pain Management & Intensive Care, KRL Hospital, Islamabad (Pakistan).

Email: tariqhayatkhan@hotmail.com

INTRODUCTION

Numerous cases of cold-water-drowning, followed by resuscitation, are reported each year. In a number of instances, victims of cold water drowning have been revived after up to an hour of clinical death and gone on to lead normal lives. It has been demonstrated that cellular processes in the brain can restart spontaneously after a period of total dormancy. Consciousness returns and memories are preserved. However, in the case of snow burial not much data is available. Recently a case report was documented in which survival was possible with active resuscitation even after twenty minutes of complete burial in the snow. Avalanches are quite common during winters in the Northern Areas and Azad Kashmir areas. The first challenge after someone is buried in the snow is his extrication followed by active resuscitation. Still the chances of survival remain slim. We present a case report of failed resuscitation of a victim of avalanche in the hope to bring this very important issue to limelight.

CASE REPORT

Two soldiers of the signal corps of Pakistan Army were proceeding to their routine duties in the forward localities of Azad Kashmir during the early hours of the day. It had been snowing for many days and they had to walk on foot through a deep nullah to reach their destination on the mountains on the other side of the nullah. When they reached at the bank of the nullah and started descending, a strong avalanche started its journey down from the hill tops at their back and with a roaring sound struck both of them. The soldier in the front was thrown with full force of tons of snow but was only partially buried in the snow.

Although stunned for some time and sustaining multiple bruises, yet he managed to force his way through the snow, searched for his comrade but failed to locate him. He struggled his way back to his post and reported the incident. An immediate search was started for the buried victim that continued the whole day but did not bear fruits. Main Dressing Station (field hospital) of that area was summoned to send medical cover. This medical help was required to resuscitate the victim on his retrieval from the snow as well as to look after the scores of troops and civilians busy in the search. An outstanding conjoint effort ensued lasting almost whole of the day for the next nine days only to be interrupted by bouts of snowfall. An area almost the size of a football field was dug upto many feet. Even many torpedo dynamites, which are normally used by the infantry for clearing the mine fields in their way were blasted, but to no avail. On ninth day about six meter long iron bars were brought in on the suggestion of local civilians. A file of soldiers and civilians started deep probing the snow with these bars from one end of the target area. The search bore fruit and one of the iron bars struck the military shoes of the victim, followed by a frantic digging at that spot. The rescuers soon reached the victim, who was found buried head down about six feet under the snow. The body was shifted to the nearby hut. I examined him and found him to be pulseless. The body was frozen hard, the face was swollen and suffused blue and the corneas were hazy. On the assumption that the extreme cold might help us to revive him successfully, we started active resuscitation. An endotracheal tube was inserted, an intravenous line started, cardiac compression ensued and ventilation with the Ambu© reanimation bag continued. No capnograph or cardiac monitor was

available to assess the results. The only clinical judgment was made by periodically auscultating the heart and by palpation of the internal carotid pulses. Repeated doses of adrenaline were given in an incremental manner. Meanwhile we tried to warm up the body with warmed blankets and warm intravenous fluids. The peripheral body temperature rose to about 34° C in an hour or so. The resuscitation continued for six hours, after which the body was fully warmed, but not the slightest movement of the heart could be ascertained. During this time, we managed to train about ten persons, of which four were army officers. These resuscitators helped us a lot, failing which one could get exhausted in only a few minutes. After six hours, the effort was called off.

DISCUSSION

Snow bound areas very frequently have avalanches during the winters. In Pakistan, Northern Areas and mountain areas of Azad Kashmir fall into this category. The high altitude war between Pakistan and India in the glaciers of Siachin has exposed the troops from both countries to extremes of cold and frequent encounters with avalanches. Often the site of the tragedy is hard to reach and the level of resuscitation training of the troops who might survive or reach the scene of the accident deplorable. There are many factors in the genesis of avalanches but detailed description of these is well out of scope of this case report. Most of the victims are usually travelers or skiers. The victim may well be thrown away, be partially buried or completely buried in the snow. The chances of survival might be dependant upon the speedy start of extrication efforts and the availability of expert resuscitation help.

Complete burial in a snow avalanche has only a 19% survival rate.¹ The median annual mortality from snow avalanches registered in Europe and North America during 1981-1998 was 146 (range 82-226); trend stable in Alpine countries ($r=-0.29$; $P=0.24$), increasing in North America ($r=0.68$; $P=0.002$). Swiss data over the same period document 1886 avalanche victims, with an overall mortality rate of 52.4% in completely-buried, versus 4.2% in partially-, or non-buried, persons. Snow can weigh as much as

800 kg/m³ (water weighs 1000 kg/m³) and may freeze solid around a victim when the avalanche stops; as a result death is usually due to asphyxia.² It is sometimes possible to breathe during burial, depending on factors such as air pockets between blocks of snow and lack of chest compression. This has been experienced by the few survivors who have remained conscious, enduring cold and extreme difficulty breathing.²

Anecdotal reports of survival after short periods of burial-for example five minutes are numerous, but longer burial times, for example, 20 hours-are exceptional.² Asphyxia is the most common cause of death after avalanche burial. A device that allows a person to breathe air contained in snow by diverting expired carbon dioxide (CO₂) away from a 500 cm³ artificial inspiratory air pocket may improve chances of survival in avalanche burial. ⁹ Standardised guidelines are introduced for the field management of avalanche victims. Strategy by rescuers confronted with the triad hypoxia, hypercapnia and hypothermia is primarily governed by the length of snow burial and victim's core temperature, in the absence of obviously fatal injuries. With a burial time $< \text{or } = 35$ min survival depends on preventing asphyxia by rapid extrication and immediate airway management; cardiopulmonary resuscitation for unconscious victims without spontaneous respiration. With a burial time > 35 min combating hypothermia becomes of paramount importance. Thus, gentle extrication, ECG and core temperature monitoring and body insulation are mandatory; unresponsive victims should be intubated and pulseless victims with core temperature $< 32^{\circ}\text{C}$ (89.6°F) (prerequisites being an air pocket and free airways) transported with continuous cardiopulmonary resuscitation to a specialist hospital for extracorporeal re-warming.⁴ Self-rescue and rescue by friends are the most important to the victims who survive.⁵

Comparisons of surviving burial in an avalanche and immersion in cold water, when respiratory arrest and cooling also occur, can be made. Survival after as long as 40 minutes' immersion⁶ has

Resuscitation and the Cold

been attributed to the protective effect of generalised hypothermia and the diving reflex. Hypothermia often occurs in burial in an avalanche, but the process is slow as compared to drowning in cold water. The face is often the only area unprotected by clothing and in direct contact with the snow, which may be important as it is the face that triggers the diving reflex. This is unlike immersion in cold water, when cooling is more uniform. During immersion water may enter the nasopharynx, causing cooling of the brain, or may be inhaled, causing rapid cooling of the heart and brain before circulation stops. Although this would not occur during burial in snow, snow has been found packed in the mouth and nose and may be inhaled, possibly with similar effects.

Very low temperatures create conditions that can preserve tissue for centuries, possibly including the neurological basis of the human mind. Through a process called vitrification, brain tissue can be cooled to cryogenic temperatures without ice formation. Damage associated with this process is theoretically reversible in the same sense that rejuvenation is theoretically possible by specific foreseeable technology. Injury to the brain due to stopped blood flow is now known to result from a complex series of processes that take much longer to run to completion than the 6 min limit of ordinary resuscitation technology. Reperfusion beyond the 6 min limit primarily damages blood vessels rather than brain tissue. Apoptosis of neurons takes many hours. This creates a window of opportunity between legal death and irretrievable loss of life for human and animal subjects for cryopreservation with possibility of future resuscitation.⁷ This is the basis of the science of cryonics.

However, there is yet another complication that may have adverse effect on the outcome, and it is the development of pulmonary edema. The pathogenesis of this complication involves respiratory and hemodynamic factors which are responsible for the development of a hydrostatic pressure gradient between capillaries and alveoli. The resulting transudation requires some time after the victim has been buried and probably the appearance of pulmonary edema directly precedes death. This might

be one of the reasons why pulmonary edema has rarely been observed. However, such an event can, theoretically, be considered part of the pathophysiological processes in buried avalanche victims.⁸

In our case the victim remained buried for full nine days, was buried deep down with tons of snow over and around him producing immediate asphyxia. The head down position might well have led to rises in intracerebral as well as intrathoracic pressures. The swelling of the face indicates increased hydrostatic pressures in the head. The onset of core hypothermia may theoretically have taken place a few hours due to water proof, protective clothing the victim used. The failure of the resuscitation might well be due to many factors, the prime factor being delayed in extrication, lack of adequate monitoring and lack of advanced facilities at hand including extracorporeal warming and oxygenation. Still it seems prudent to continue resuscitation for an extended time in the hope of reviving a victim, especially if extreme cold weather is at our side, e.g. drowning in cold water or burial in snow.

REFERENCES:

1. MacInnes H. International mountain rescue handbook. 2nd ed. London: Constable, 1984.
2. Fraser C. The avalanche enigma. London: John Murray, 1966.
3. Grissom CK, Radwin MI, Harmston CH, Hirshberg EL, Crowley TJ. Respiration during snow burial using an artificial air pocket. *JAMA*. 2000 May 3;283(17):2266-71.
4. Brugger H, Durrer B, Adler-Kastner L, Falk M, Tschirky F. Field management of avalanche victims. *Resuscitation*. 2001 Oct;51(1):7-15.
5. Rostrup M, Gilbert M, Stalsberg H. A snow avalanche in Vassdalen. [Medical experiences] *Tidsskr Nor Laegeforen*. 1989 Mar 10;109(7-8):807-13.
6. Siebke H, Breivik H, Rod T, Lind B. Survival after 40 minutes' submersion without cerebral sequelae. *Lancet* 1975;i:1275-7.
7. Best BP. Scientific justification of cryonics practice. *Rejuvenation Res*. 2008 Apr;11(2):493-503.
8. Schmid F. The pathogenesis of pulmonary edema after being buried by an avalanche] *Schweiz Med Wochenschr*. 1981 Sep 26;111(39):1441-5.