TIME IS LIFE

Medical Training in Avalanche Rescue

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CISA-IKAR Air rescue Commission

DVD

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Accompanying oral text

Introduction

In this presentation you will find the most up to date information on the medical aspects of avalanche rescue. By demonstrating the best practices for the on-site treatment of an avalanche victim, we aim to improve your knowledge and expertise. After watching this DVD you will be more familiar with what happens when a person is caught by an avalanche and, hopefully, you will be able to provide your friends or any persons buried by an avalanche with the best treatment possible. All video scenes have been acted but they do reflect real situations in accidents that have happened in the past. Please spread this information as widely as you can; this may improve avalanche survival in the future. However, don't ever forget that triggering an avalanche is one of the most dangerous hazards in mountaineering. Be aware that prevention is the most effective measure to avoid a fatal accident.

The recommendations on the treatment of avalanche victims in this presentation were discussed and approved by the International Commission for Alpine Rescue (ICAR), and the Medical Commission of the UIAA (the International Mountaineering and Climbing Federation). The processing of the data and the medical research were accomplished in close cooperation with the Swiss Institute for Snow and Avalanche Research and the Medical University of Innsbruck.

This presentation is intended for skitourers and off-piste skiers, rescuers, paramedics and physicians. We will show you the basics of the assessment and the proper management of casualties in an avalanche accident. Topics covered include the underlying pathophysiology during a burial, the necessary first aid measures and the medical treatment of avalanche victims. In addition, the importance of self-rescue and the medical aspects of safety equipment are discussed. You can then check your abilities by completing a test!

Winter mountaineering and skitouring are certainly some of the loveliest and healthiest activities one can do.

Apart from the fascination of the landscape, many medical studies have shown that an endurance sport such as mountaineering or skiing in deep powder snow lowers the risk of cardiovascular disease. A healthy heart is of course needed for such activities.

Finally, skiing in deep natural snow hurts our lower joints, particularly the hips and knees, much less than skiing on a hard piste, and a fall is less likely to cause traumatic injuries.

All these points are in favour of skitouring. However there is one perilous hazard; the danger of a fatal accident caused by an avalanche.

Any one who leaves a secured ski area should always keep in mind this risk. Despite the best preparation and being cautious, triggering an avalanche creates a life-threatening hazard. In skitouring, in contrast to other mountaineering activities, the number of experienced mountaineers buried under an avalanche exceeds the number of inexperienced ones.

Epidemiology

In Europe and North America, on average, 140 people die every year under an avalanche.

Between 1984 and 2003, the number of avalanche fatalities in the ICAR-countries in the European Alps has been unchanged. In North America the number has increased, mostly due to snowmobile accidents. Although we don't know the exact numbers, we think that the number of skitourers and off-piste skiers has increased significantly over the same period. So relatively speaking the chance of becoming a victim has reduced. This may be due to advances in the prevention of accidents or to a better survival chance should you be caught in an avalanche.

Pathophysiology

Recently important scientific advances in the field of avalanche medicine have been possible thanks to the work of the Swiss Institute for Snow and Avalanche Research in Davos, Switzerland. They have documented, with the greatest accuracy, all avalanche accidents where people have been involved. This has enabled the crucial factors for survival in an avalanche accident to be identified and the pathophysiology involved to be understood.

Extent of burial

One important factor is the extent of burial. We call it a ‘complete burial’ if the head of the victim is buried under snow, even when other parts of the body stick out. We call it a ‘partial burial’ if the head is out. This is a fundamental difference.

An analysis of about 2000 people caught up in avalanches in Switzerland shows that the overall mortality of an avalanche accident is about 22%. Only 4.4% of people who were not buried or only partially buried died. This compares with a chance of death of 51.3% for people who were completely buried. Most avalanche deaths are associated with complete burial. Measures that reduce the chance this may well be an essential factor for increasing the chances of survival.

It is likely that avalanches with partial burials or “near accidents” go unreported. Frank Tschirky has estimated the number of unreported cases may be as high as the reported ones. This has the effect of reducing the chance of death when the person is partial or not buried to lower than the 4.4% quoted above.

Survival probability

Processing the data from 638 persons that were completely buried whilst in open ski areas, and using a new statistical method, we have calculated the chances of survival. This graph shows the probability of survival is related to the duration of the burial.

The only result that leads to optimism is the high probability of survival - about 90% - if the duration of burial is less than 18 minutes. We call this phase the ‘survival phase’, and every skitourer and off-piste skier should know it. If we were able to rescue every buried person within this period of time, 9 out of 10 could be retrieved alive. In this phase every minute counts because from 18 to 35 minutes, the probability of survival drops from 91% to 34%. In this second phase, the so called ‘asphyxia phase’, all persons without an air pocket die. This is because the person cannot breathe and so rapidly becomes asphyxiated - the snow suffocates them. Obstructive asphyxia accounts for more than half of the total causes of death in buried persons. Though efficient basic and advanced resuscitation can be helpful, it is linked with the risk of a permanent hypoxic damage; the body is not yet hypothermic in this phase. Severe trauma also accounts for many deaths in this phase.

After 35 minutes, the steep fall in the probability of surviving reduces. The survivors are not dying at the same rate. This is called the ‘latent phase’. What is happening to account for this change? The survivors are buried persons with a clear airway and a closed air pocket - that is a hollow space around the mouth

and the nose without any connection to the outside. In this situation a person can survive for about 90 minutes.

Of course even these buried persons cannot survive forever. Between 90 and 120 minutes the survival curve shows a second drop from 28% to 7%. In this period deaths of buried persons with a closed air pocket are probably due to a combination of slow asphyxia and hypothermia, the so-called “Triple-H-Syndrome”.

A small number of buried persons are fortunate enough to survive longer than two hours under an avalanche. This is only possible if the person continues to get sufficient oxygen from either an ‘open air pocket’ - a pocket that connects with the outside air - or from a big closed air pocket. Under these conditions, a buried person can survive for many hours before they cool down to a critical core temperature. So it would be wrong to stop the rescue operation at 120 minutes, and to give up hope, though the chance of survival is very small.

In 1972, in Italy, a woman survived under an avalanche for 44 hours. In 1951, a mining worker, in Austria, was recovered after being totally buried in a building for 13 days!

The depth a person is buried is an important factor in survival. On average, the head is buried about 70 cm under the surface. However, we could not find a relationship between the depth of burial and survival when the time of burial is taken into account. As you might expect there is a strong correlation between the depth of burial and the time taken to release the person. The more deeply buried are generally retrieved later and so the survival chance is smaller. It is not clear whether the pressure of the snow above the person affects the survival.

Air pocket

As shown before, the existence of an air pocket is a decisive factor for surviving an avalanche. Indeed there are numerous impressive case reports where buried persons have survived for hours under an avalanche without permanent damage, even with a small air pocket. This has sparked many research groups in Europe and the US to study the pathophysiology of buried people with an air pocket.

For rescue teams, the definition of an air pocket, as a decision criterion, must be simple and concise. An air pocket is any hollow space, no matter how small, around the mouth and the nose in addition the upper air passages of the person must be open. The critical finding ‘no air pocket’ can only be reliably stated if the mouth and nose are blocked by snow or debris as the external air pocket may have been

missed during the snow clearing procedure. That means that if the air passages are definitely free of snow and debris, the person is counted as having had an air pocket.

In the US, a team lead by Colin Grissom and Martin Radwin made several tests to study the effectiveness of the rescue vest, AvaLung. The subjects were buried under 1 m of snow. Some of the volunteers had to breathe into a small air pocket of about a half litre. Within a few minutes, severe hypoxia and hypercapnia - that is an accumulation of carbon dioxide- developed. All the tests had to be stopped within 19 minutes.

At the same time, a European study group lead by Brugger, Sumann and Falk let non-buried volunteers breathe into artificial air pockets of one or two litres in volume, and compared the effect of different snow densities.

During the study, several respiratory and circulatory parameters were recorded as well as the changes in oxygen and carbon dioxide levels in the subjects and the air pocket.

The findings were similarly to Grissom and Radwin; after a few minutes, all subjects developed hypoxia and hypercapnia. This was followed by a respiratory acidosis with a decrease of the pH level and an increase in serum bicarbonate. Some of the volunteers were able to complete the 30 minutes of the experiment.

The hypoxia was more severe in the small air pockets and the decrease in oxygen saturation showed a negative correlation with the snow density. That means that the denser, that is the wetter the snow, the faster oxygen deficiency develops. Cold and dry snow is less dangerous than wet and heavy snow.

Furthermore there is a significant variation between the subjects. It is not clear whether this is due to psychological factors, different ventilatory responses or other, as yet, unknown factors.

In summary, survival in the presence of a closed air pocket depends on: the volume of the air pocket, the snow density and other unknown individual factors.

From the results of these studies, we conclude that buried persons with an air pocket will suffer from hypoxia and hypercapnia quite quickly. When the burial lasts longer hypothermia may occur. The combination of these three factors is designated the “Triple-H-Syndrome”.

At extrication of a buried person with an air pocket one should always keep in mind that on the one hand hypoxia and hypercapnia might reduce the state of consciousness of the victim and on the other hand the same parameters considerably stimulate respiration. There are many case reports in which a buried

person becomes apnoeic, that is stops breathing, immediately after extrication. We assume that this is due to the decrease of carbon dioxide in the blood and the normalisation of hypoxia when the victim comes in contact with the outside air.

So when a person with air pocket is being extricated from the snow, always monitor carefully and be ready to start artificial respiration should apnoea occur. Remain vigilant during the recovery and transportation phases.

It is not known how many persons buried under an avalanche die from fatal injuries because autopsy reports are few. It is assumed that many severely injured people die from suffocation before they would die from trauma. Altogether we estimate that approximately 20% of the casualties die from fatal injuries though it is possible that this percentage varies depending on the terrain and regional factors. In the last few years, fatal injuries may have increased because many avalanche accidents now occur in arduous and rocky terrain.

Thus, the crucial factors for surviving an avalanche are the extent of burial, the duration of burial, the presence of an air pocket and the presence of severe injuries.

In conclusion, deaths by avalanches are due to acute asphyxia in about 65%, to the Triple-H-Syndrome in about 15%, and to fatal injuries in about 20%.

On-site treatment

Based on the fundamental research as described in the earlier chapters, the International Commission for Mountain Emergency Medicine (ICAR MEDCOM) has produced guidelines for the medical management of avalanche accidents and an algorithm for the management of casualties. It was published in the journal Resuscitation in 2001.

The shape of the survival function indicates two time goals for a successful recovery: uninjured companions should try to locate and extricate their colleagues within the first 15 minutes by all possible means, since 90% of victims who were extricated within this time span survive. Organised rescue teams have about 90 minutes to save the victims with a closed air pocket. In this latent phase, which extends to about 2 hours after burial, the organised rescue team has a real chance of finding a buried person alive using electronic transceivers, the RECCO device, dogs and probing.

In the following chapter we look at actions that uninjured companions should take and compare it with the actions of organised rescue teams.

In principle, we differentiate between two different strategies for the extrication of completely buried persons in relation to the length of burial. With a short burial time, i.e. up to 35 minutes, a rapid extrication is essential for a successful recovery to prevent death from suffocation. Every second counts. The existence of an air pocket is of secondary importance. However, if the time of burial exceeds 35 minutes, an open airway and the presence of an air pocket are a prerequisite for survival. At extrication of the victim the rescuer should always pay attention to a possible air pocket and take care of the airway. Since hypothermia is expected, large movements of the victim should be avoided.

Immediate rescue

The first goal of all the uninjured companions is to free all the victims of the avalanche by what ever means are available within the first 15 to 20 minutes. If you consider that you need about 3-5 minutes for the search with an avalanche transceiver and then an additional 10 minutes for digging with a shovel, you can see that there are natural limits to this first goal.

If you have a mobile phone connection, you should make an emergency call immediately after the avalanche. If there's no such possibility, all uninjured companions should participate in the search for about 20 minutes and only afterwards should one member of the party go for help. Only if the group is very large compared with the numbers of members missing should one or two persons, depending on the terrain, leave immediately and go for help.

To successfully locate a completely buried person you should use an electronic avalanche transceiver. In addition, you should always search the surface of the avalanche simultaneously with your eyes and ears. In this example, the snowboarder has no avalanche transceiver and no shovel. Digging by hand or with a snowboard is not efficient and is very time consuming. A recovery within the first 15 minutes is, in most instances, not possible.

To quickly recover a buried person you need full equipment: an avalanche transceiver, a shovel and a probe. After locating the person, the exact point of burial should be marked with a probe and the depth should be determined. Digging should be as fast as possible with several shovels. Do not dig from vertically above but diagonally from the lower side. When reaching the area around the head, try to create an air passage to mouth and nose of the buried person and free the head as fast as possible.

If the buried person is unconscious and not breathing, you should clear the air passages while he or she is still partly buried by cleaning the mouth of snow and other material. Open the airway by performing a jaw thrust, or if necessary, bearing in mind the possibility of a neck injury, a careful head tilt manoeuvre

If the buried person is unconscious but still breathing, dig him out and place him in a stable lateral position. When calling the emergency service it is crucial to give accurate information on the location of the accident and the state of the casualty. Some one should remain with the injured person at all times. They should constantly monitor the vital functions, i.e. respiration and circulation, until the rescue team arrives.

If there are no signs of breathing or circulation, you should call the emergency service and start cardiopulmonary resuscitation. This should be continued until the arrival of the rescue team. All skitourers and off-piste skiers should be familiar with the techniques of basic life support.

As an alternative to mouth-to-mouth resuscitation a Pocket Mask® is recommended, not only for hygienic reasons but also for its high ventilatory efficiency.

When buried under snow the cooling rate of an avalanche victim is rather low. However, after extrication, the heat loss of the body is considerable particularly in conditions of low temperature and high wind. For this reason the victim should be put on a dry underlay and insulated with clothes and a hat.

Accidents in the mountains are always very special and, by nature of the terrain, may require you to take tough decisions. So what do you do when you can't get through to an organised rescue team while resuscitating an avalanche victim? In this case it is perfectly acceptable to stop resuscitation after some time. However, if you are expecting a rescue team, try to keep resuscitating the victim until the care can be transferred to the rescue personnel.

Furthermore, you may be alone with one or more injured or hypothermic victims and you have to decide whether to stay with them or to leave and call for help. As a rule, it is better not to leave but to wait with the injured and to try to look after them in a snow-cave or a bivouac until help arrives. We will now look at the management of the incident by an organised rescue team.

Organised rescue

For organised rescue teams and the emergency medical team, an avalanche accident is a great logistic, organisational and professional challenge. Specific equipment, a detailed knowledge of the medical problems of an avalanche burial as well as physical fitness are required.

In every decision the benefit of a rapid rescue of the buried person should be balanced with the risks to the rescue team. The hazards from secondary avalanches, poor weather, darkness and the topography of the accident site should always be considered.

Thinking ahead should be a guiding principle.

An avalanche accident is always a medical emergency and indication for helicopter assistance, if this is possible. Finding the buried person is as important as immediate medical care. That's why it is so relevant to get the avalanche dog with its handler and the physician – let us say 'docs and dogs' - to the accident scene as fast as possible. Using two or more helicopters could be justified.

In addition to your standard medical equipment you should bring chemical heat bags, aluminium foil sheets, blankets, a thermometer to check the core temperature and, don't forget, hot sweet tea.

The rescue team should be physically fit and carry their full winter equipment including waterproof boots to allow them to move around the avalanche site. In some cases, snowshoes can be helpful.

If the buried victims aren't already recovered, establish an emergency depot to store the medical equipment. Do not allow medicines and metallic laryngoscopes to freeze; carry them under your clothes or keep the emergency kit warm with chemical heat bags.

If a buried person is to be found in a critical condition after a short burial time, i.e. within 35 minutes of burial, the likely causes are an obstructive asphyxia from suffocation secondary to closed air passages, thoracic compression or aspiration, or traumatic injuries but NOT from hypothermia. However, after recovery, any rescued person is at risk of cooling down quickly.

During the first 35 minutes every single minute counts. Locating and recovering the buried victim should be done as quickly as possible by all means available.

The most important initial medical measure is the management of the airway whilst the victim is still trapped by the snow. If appropriate early basic and advanced life support follows as soon as practical. For cardiopulmonary resuscitation the victim should be placed on a hard surface, such as a board, skis or snow compacted by trampling. After extricating the victim from the snow, he should be adequately insulated from the cold. Furthermore all appropriate advanced life support (ALS) measures should be carried out following the international ILCOR guidelines.

The target hospital can be the nearest one with an intensive care unit or, if more appropriate, a specialised hospital able to deal with the victims' injuries such as one with a neurosurgical centre. A specialised trauma centre may be the most appropriate hospital.

If the transport time is long, the victim should be insulated. Though a hypothermic victim can't be rewarmed by insulation alone, further cooling can be avoided.

If the burial time exceeds 35 minutes, the victim's survival depends upon the existence of free air-passages and an air pocket. The search should occur as fast as possible, however the extrication should be gentle allowing for the assessment of the air pocket before it is destroyed. Large movements of the victim should be strictly avoided.

The period between extrication and the admission to hospital is called the rescue phase - a phase during which the patient is at increased risk. During extrication there's the risk of destroying an air pocket; the patient could suddenly become apnoeic or have a circulatory arrest with ventricular fibrillation or cool down quickly and develop severe hypothermia.

Dig out the buried person diagonally from the valley side rather than vertically from above along the probe. The width and depth of the cave should be such that the person can be extricated with minimal changes in posture. The greater the depth of burial, the larger the cave will have to be. When reaching the buried you should take your time to excavate around the head and pay attention to a possibly existence of an air pocket and ensure that the airway is kept clear at all times. An air pocket and free air passages indicate that the victim was still breathing after the avalanche and is a reason for hope. Observations of air pockets show that most are small, sickle-shaped and frozen up on the inner surface and easily seen if the rescuer pays enough attention to look. When teaching rescue teams the importance of this finding should be pointed out.

If the mountain rescuer, paramedic or physician can rule out the existence of an air pocket, and the air passages are blocked by snow or ice, survival beyond the 35 minutes burial isn't possible. In this case, the physician can certify death by suffocation at the scene of the accident.

If the air passages are free, you can consider a Triple-H-Syndrom, .i.e. that the buried person isn't only hypothermic, but also hypoxic and hypercapnic.

In this case, large movements of the patient's body and the limbs are to be avoided during the extrication and transfer in order to prevent the mixing of cold blood from the periphery with somewhat warmer blood in the central organs. Therefore it is very important to make the excavation hole as big as

needed to get the buried victim out without any large movements. If movements of the body or the limbs cannot be avoided they should be conducted as slow as possible.

When recovering a number of buried people in a critical situation at the same time, patients with vital functions should have be given priority over patients without any signs of life.

Too rapid an extrication of a patient with large movements and without taking much care can lead to a sudden cardiac arrest! Also respiratory depression or even arrest can occur during or after the extrication, probably due to the loss of hypoxic and hypercapnic stimuli to ventilation. Many reports on the so called 'rescue deaths' may be traced back to this cause. Accurate monitoring and constant preparedness to start basic life support during recovery and transportation are very important.

For a staging hypothermia at the site of the avalanche we recommend the Swiss Classification. This is based upon basic clinical parameters and can also be used by non-medical personnel. The stages are: stage 1, the hypothermic patient is still responsive with shivering from the cold; stage 2 the patient is semiconscious, i.e. hardly rousable and without shivering; stage 3 he's not responsive and at stage 4 there's no signs of breathing at all. A measurement of the core temperature, i.e. the temperature inside the body, is not absolutely necessary for determining the stage of hypothermia but is desired because the clinical symptoms can vary considerably between the subjects. For example, while one hypothermic patient can be conscious at a core temperature of 30°C, another one may not be responsive at the same temperature.

How can the core temperature be measured in the field? There are two useful sites: in the ear canal (epitympanic) or in the oesophagus, i.e. in the external auditory canal or in the gullet.

To measure the core temperature with the epitympanic measurement a soft probe with a sensor is placed in the ear canal near to the eardrum.

An epitympanic measurement can read too low when: the environmental temperature is very low; or during a circulatory arrest; or when the auditory canal is blocked by snow or debris. The epitympanic measurement can definitely not be used to establish whether the patient is dead. It is most useful to measure the patient's temperature trend during the rescue phase and for triage because false low readings will not disadvantage the patient. With intubated patients, we recommend using an oesophageal probe in the lower third of the oesophagus. As this measures the true core temperature directly, it is not subject to the potential errors of the epitympanic site.

Every patient suspected of having the Triple-H-syndrome should have oxygen therapy started as soon as possible. They should be extricated without any large movements and insulated from the cold and wind. ECG monitoring should be started as soon as is practical as malignant arrhythmias can occur at any stage. The core temperature should be measured. If the rescue phase is long, heat packages should be applied.

We recommend insulating the patient with an aluminium foil sheet, woollen blankets and a hat, and using chemical heat bags to add some external heat.

When the patient is responsive and has a core temperature above or equal to 32°C, thus at stage 1, he can be given warm sweet drinks if he can swallow. Wet clothes can be changed for dry ones and the patient can be transported to the nearest hospital for observation.

However if the patient is semi-conscious or not responsive, he has critical hypothermia and must be managed with the utmost care. ECG monitoring, measuring the core temperature and, extrication without large movements are advisable. Intubation should be considered to protect the airway; the risk of provoking ventricular fibrillation is negligible. Administering fluid or ALS drugs have not been shown to benefit hypothermic patients. Peripheral intravenous access can be established only if it doesn't take more than 5 minutes to do. Central venous access is not recommended because it may trigger ventricular fibrillation. The target hospital should have some experience in the treatment of hypothermia. If circulatory instability or malignant arrhythmias occur, the target hospital should have cardiopulmonary bypass facilities.

An unconscious patient with stage three hypothermia, is a strong indication for endotracheal intubation if the skills and equipment are available.

Ventricular fibrillation is resistant to electric defibrillation in a hypothermic patient when the core temperature is below 28°C. However, the prognosis after re-warming with a cardiopulmonary bypass is favourable. Up to three defibrillations using the maximum energy setting should be performed. If unsuccessful, the cardiopulmonary resuscitation should be restarted and continued until the patient has been re-warmed with cardiopulmonary bypass.

In organised rescue operations, approximately 85% of victims are being recovered in circulatory arrest and show asystole (a flat line) on the ECG. In most of these cases, the cause is asphyxia or fatal trauma. However, in some cases it is because of stage 4 hypothermia.

Given a victim unconscious with asystole, the emergency team should perform an assessment at the site of the accident to define those patients that have a realistic chance of successful re-warming. To do this we need to differentiate between the diagnoses of asphyxia and hypothermia.

The criteria for the assessment are: asystole on the ECG, data about an air pocket and the condition of the air passages supplemented, if possible, with a core-temperature.

Victims with a burial time of less than or equal to 35 minutes and/or a core temperature above 32° are treated according to the International Resuscitation Guidelines with Basic Life Support and Advanced Life Support for at least 20 minutes. If resuscitation is successful, the patient is transported to the nearest hospital; if unsuccessful, death from asphyxiation can be established.

If the duration of the burial exceeds 35 minutes, the further management of the victim depends on the presence or absence of an air pocket and the patency of the airway. If the air passages are closed, the physician can establish death by asphyxia. In the presence of a clear airway and an air pocket, or if these findings are uncertain, the victim is assumed to have reversible hypothermia. Cardiopulmonary resuscitation should be continued until re-warming by cardiopulmonary bypass in hospital has been achieved. If transport to a specialist unit with cardiopulmonary bypass is not possible, the victims should be taken to the nearest hospital to measure the serum potassium. This parameter determines the irreversibility of the cardiac arrest after an avalanche accident. If the potassium exceeds 12 mmol/l, resuscitation can be stopped. With values lower than or equal to, 12 mmol/l, the patient should be transferred, with continuing resuscitation, to a hospital with cardiopulmonary bypass facilities for re-warming.

In conclusion, in the presence of an air pocket, there is always a reason for hope. If obvious fatal injuries are excluded, all hypothermic avalanche victims with an air pocket and a clear airway should be managed optimistically with an attempted re-warming in a specialist unit with cardiopulmonary bypass facilities.

Post-traumatic stress disorder

An avalanche accident cannot only lead to death or severe injury but can also cause mental disorders that impair the quality of life of the victim. These disorders are grouped under the term ‘post-traumatic stress disorder.

A study of 60 survivors from avalanche accidents showed that, overall, 28% of victims suffered from an acute post-traumatic stress disorder. If the victim had been completely buried the figure rises to 41%. The symptoms include compulsive memories; sleep disturbance; loss of appetite; panic attacks; nausea; vomiting and a feeling of guilt. In 18% of victims, these symptoms lasted longer than a year.

Though stress disorders are not life threatening, they affect the daily life of the patients and have been underestimated for a long time. Therefore we recommend, in the case of an avalanche accident, activating a crisis intervention team to advise and treat the survivors, their relatives and also the rescuers.

Prevention and safety equipment

Preventive measures to avoid an avalanche accident are much more important than all therapeutic efforts. Although assessing the snow and risk of avalanche by skitourers and off-piste skiers is not the main topic of this presentation, we want to draw attention to preventive measures in this chapter.

What can a person do, when caught by an avalanche, to help himself? Can he improve his chances of survival during the fall of an avalanche?

A survey of 60 skitourers and off-piste skiers who survived an avalanche showed that only 18% could get rid of their skis and only 8% their skis and ski poles. Approximately half of the survivors were not able to perform swimming movements during the fall of the avalanche; it is not known if this affected the extent of burial.

However, 50% of those who were completely buried were able to put a hand in front of their mouth before the avalanche stopped and to build up an air space around their mouth and nose. All of them were able to keep breathing.

Therefore when you are completely buried, you should try as a priority to protect your face with your hands and to keep the air passages clear. We think that this might be the only effective measure of improving survival.

Safety equipment provides another opportunity to improve the probability of survival.

We think there are three ways to reduce mortality. These are: decreasing the degree of burial, decreasing the length of time the victim is buried and prolonging survival should the victim be completely buried.

1. The avalanche airbag is the only technical device that can reduce the risk of a complete burial. It is a buoyant system that must be activated by the user when they are caught in an avalanche. Two balloons, integrated in the backpack of the user, are inflated with air keeping the skier on the surface of the avalanche. The buoyant effect will only work if the victim is in a flowing avalanche and carried by the avalanche over a certain distance. If, for example, he is standing at the bottom of an avalanche slope or caught by a second avalanche, the airbag may not be effective.

From 1991 to 2004, 77 reports of airbag inflation during an avalanche have been received. 76 survived and one person died. 10 people with an inflated airbag were completely buried but could be freed from the avalanche by their companions quickly because the balloons were easily visible on the surface. In 9 cases the balloons were not inflated due to technical failure or because the user did not activate the balloons. The same avalanches caught 25 people who were not wearing an airbag. Of these 12 were completely buried and 9 were found dead.

Comparing those with an airbag with those without showed that the airbag lowered the probability of a complete burial from 47.1% to 13% and the mortality from 35.3% to 1.3%. Both these reductions are highly significant.

The second possible method to reduce mortality is by decreasing the length of time the victim is buried. However, the effect on mortality will depend on when the time is saved. If the time saved is in the flat period of the survival curve from 35 to 120 minutes, the reduction of mortality is lower than if the time saved is in the steep decline of the survival curve from 18 to 35 minutes.

The avalanche transceiver is the only technical device that can be used to help localise a completely buried person. A study of 135 buried skitourers in the Austrian Alps showed that the use of an avalanche transceiver decreases the median burial time significantly from 170 to 20 minutes. The mortality reduced from 79 to 50%.

Though the time to localise a buried person can be reduced by using a good search device, the depth of burial is the limiting factor, as most time is needed for digging the victim out. It has to be stressed that training in the use of a transceiver must be regular and that you should always carry a shovel too. Otherwise the device is unlikely to be effective.

The third possible method to reduce mortality is by prolonging the survival time when completely buried. This can be done through a fortuitous or self-created air pocket or by an artificial breathing device. In effect it is hoped that the flat part of the survival curve is raised artificially.

The AvaLung consists of a tube system that is incorporated in a rescue vest or a harness. When breathing into the tube through a mouthpiece, a valve separates the exhaled from the inhaled air. The exhaled air passes round to the back of the skier, whilst the inhaled air comes, via a membrane, from the snow lying in front of the user. It is proposed that this mechanism prevents the accumulation of carbon dioxide in the body and so the buried person may survive longer. By 2005, 33 tests have been reported and 3 accidents where the AvaLung has been used are known. In the accidents, all the victims survived. However, from the available data, we do not know how often the user is able to put the mouthpiece into the right position and keep it there during the burial process. We are also concerned that the device does not reduce the chance of a complete burial with all its attendant risks. The victim is still dependent on how other people can locate and retrieve them.

How much security can we achieve from these techniques? Only reliable statistical data can help us to form an opinion. Collecting reliable data is most importance in this matter. Having considered the available data, we can recommend the following classification.

The data from avalanche accidents show that the avalanche airbag can significantly reduce the probability of a complete burial as well as the mortality rate. The statistical evidence is good to very good. The device is surely efficient and would be classified in the 2a-category following ILCOR; it is the device of choice.

The use of an avalanche transceiver also showed a significant reduction of the mortality. The statistical evidence is good to very good, the device is surely effective and would be classified in the 2b-category. However, even with the transceiver, the mortality remains very high at 50%, in contrast to the airbag.

For an evaluation of other safety equipment like AvaLung or the avalanche ball we still lack statistical evidence. This equipment would be placed in the category “indeterminate”. The results look promising but, at the present, there is insufficient data available to allow us to give any recommendations.

However do not forget that if a piece of safety equipment which enhances security induces a false sense of safety and misleads the user to take greater risks, the skier may be no better, or even worse, off. Taking higher risks, mitigates against any gained security!

Reinhold Messner says: “Risk is part of mountaineering. But I never climb to die. Risk assessment is necessary to counterbalance ambition. Discipline means being able to set a limit to your abilities.”

From our understanding of the science, a combination of strategies to reduce the risk has been proposed. This includes using proven safety technologies and seems to be the best strategy to avoid an avalanche death.

Ten possible mistakes in avalanche rescue

In the following chapter we highlight 10 practical mistakes in avalanche rescue that occur time and time again.

1st possible mistake: Leaving the avalanche site immediately after an accident is a grave mistake in rendering aid to one's companions. Because the odds of survival are very good in the first 15 minutes, all group members must help dig out the victim during this period. A member of the group should only leave after this time in order to give the alarm. Never forget to search on the surface; there have been many cases in which buried victims were already dead when dug out by the rescue team, although body parts or pieces of equipment were clearly visible on the snow surface.

2nd possible mistake: When the rescue team reach the avalanche site, only those team members whose job it is to locate, rescue and take care of the avalanche victims should enter the site. Always remember that a buried victim could be just under the snow and surviving only with the aid of a fragile air pocket. Trampling on the avalanche area could destroy it. For the same reason, rescue equipment should be placed outside the avalanche area, and helicopters should avoid landing directly on the avalanche site until the last victim has been dug out.

3rd possible mistake: If a rescuer thinks he or she has found something by probing, the probe must not be removed but left in the snow as a marker until the victim is dug out. If the probe is moved and a second attempt made, it may take a different direction, and so delay the rescue.

4th possible mistake: Don't dig vertically but obliquely from the side, in order not to destroy a possible air pocket. When the victim is found, determine the orientation, free the head using your hands, and protect the victim's face during the extrication so that snow cannot block the airway. The rescue pit must be large enough to allow at least one rescuer to work in it and begin the first life-saving measures.

5th possible mistake: Often the emergency physician is called only after the buried victim has been successfully dug out. Ideally, the emergency physician should be present during the extrication, in order to determine if an air pocket is present and the airway clear. On the basis of these findings, if the victim is in cardiac arrest, the physician can decide whether to proceed with or to discontinue resuscitation.

6th possible mistake: Evaluation of an air pocket and of the airway is primarily a question of paying attention during the extrication. An "air pocket" refers to any space – no matter how small – in front of the mouth and nose in the presence of a free airway. Rescue teams must be trained about the importance of these findings. It has been neglected in the past.

7th possible mistake: While extricating hypothermic victims, large body movements should be avoided, in order to prevent the cooling of the core by influx of cold blood from the periphery. Even when this is difficult to do in practice, unavoidable movements of the limbs should be made as slowly as possible.

8th possible mistake: Hypothermic victims who are not intubated should be placed in a stable position on one side and evacuated in this position. There is no sound reason not to adopt this practice.

9th possible mistake: Prolonged resuscitation of a dead victim without an air pocket cannot be recommended and can pose an additional risk to the rescue team. If the ICAR criteria for establishing death are met, the emergency physician can discontinue resuscitation at the site of the accident.

10th possible mistake: If the victim is found with an air pocket, hope should not be lost: "hypothermic victims with an air pocket are not dead until they are warm and dead". This means that resuscitation of a hypothermic victim with an air pocket who is in cardiac arrest must be continued until active re-warmed in a hospital.

You can find out more about the medical aspects of avalanche-accidents on this website: www.provinz.bz.it/avalanche

Official ICAR website

www.ikar-cisa.org