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FIRST RESPONDER CARE FOR CAVE ACCIDENT VICTIMS

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Abstract

Although cave accidents are fairly rare events in New South Wales there is need for Police, Ambulance and V.R.A. personnel to be aware of the problems presented by cave rescues and to be able to act should a cave accident occur. The N.S.W. Cave Rescue Group is available to provide advice and training in cave rescue and, in the event of an accident taking place, can be mobilized through the Police Disaster and Rescue Branch. Like most members of the caving community, the Cave Rescue Group is a largely Sydney-based organization and its response time for an authentic call out is likely to be between 3 to 5 (or even more) hours. In the event of a cave accident there will be a delay of at least an hour before initial reporting, (members of the victim's party must leave the cave and summon help, or a party is reported overdue). As caving areas are some distance from major centres the first responders are not likely to reach the accident scene in less than two hours after the accident has taken place. With some N.S.W. cave areas it is reasonable to assume that an accident victim may be 24 hours or more away from first responder care.

It is vital that the first responders to a cave accident are aware of the type of care required by cave accident victims and of the hazards that caves present.

THE HAZARDS OF CAVES

Caves are foreign and dangerous to ill-equipped and/or disabled humans. The major dangers in caves are:- 1. lack of light; 2. thermal conditions; 3. noxious atmospheres; 4. the physical shape of caves; 5. flooding; 6. rock falls; 7. physiological and psycho logical effects.

Since all caves are different, some are wet, some cold, some have foul air, and others deep shafts, there is a great need for first responders to be aware of the conditions found in caves in their area of responsibility.

1. Lack of Light

Caves are totally dark. Complete loss of light is a serious threat to cavers since any attempt to move without light is likely to result in injury. Cavers are advised to carry three independent sources of light and it is common to see less well equipped caving parties completing trips using their, often quite inadequate, back up lighting. Total light failure means that cavers have to stop, and so an overdue party may simply have run out of light. Total or partial light failure will increase the possibility of trauma. First responders themselves need to be very aware of the need for reliable light. Since cave rescues can be protracted affairs, their normal handlights may be quite inadequate for the task.

2. Thermal Conditions

Caves have a fairly stable thermal environment. Cave air temperatures remain close to the annual average air temperature for the area in which the cave is situated and so cave air temperatures are fairly pleasant in most N.S.W. caves. It is, however, the thermal environment that poses the greatest threat to a cave accident victim, particularly an immobilized one.

While involved in strenuous activity cavers may become quite warm, however, on resting they rapidly lose heat due to wet clothes, strong draughts and most importantly through contact with the rock.

For an immobile accident victim heat loss through physical contact with the rock poses a serious threat. Victims trapped in confined spaces will rapidly lose heat to the rock. If measures to conserve their body heat are ineffective they may become hypothermic, a serious condition that can result in death.

3. Noxious Atmospheres

The chemical composition of cave atmospheres is rarely identical with that of the outside air and in many N.S.W. caves it is sufficiently different to pose a threat to the

health and safety of cavers. The main atmospheric problem affecting cavers is foul air.

Foul Air

Foul air is enriched in carbon dioxide and/or depleted in oxygen relative to normal air. In most, although not all cases, the enrichment in carbon dioxide is the factor that most affects cavers.

In so-called "normal foul air" oxygen is replaced by carbon dioxide almost volume for volume and its effect on cavers is for carbon dioxide to build up in the blood (hypercarnapia) which will in severe cases result in acidosis and could eventually be fatal. The symptoms and signs of hypercarnapia are:

Increased pulse and respiration
Lips, ears and face becoming red (peripheral vasodilation)
Skin hot to touch
Headache (often first symptom)
Decreased mental ability and coordination resulting in a drunken-like state (carbon dioxide narcosis).

Normal air contains 0.03% carbon dioxide and the threshold limit value for carbon dioxide is 0.5%. Most people can tolerate up to 2% carbon dioxide for extended periods. Experienced foul air cavers can work in up to 4.5% carbon dioxide for short periods but will suffer after effects (nausea often with vomiting) due to acidosis. Normal foul air containing above 6% carbon dioxide is potentially fatal. Some caves in N.S.W. contain foul air with up to 13% carbon dioxide.

A more dangerous, and fortunately more unusual form of foul air is "stink damp". Stink damp contains increased carbon dioxide and very significantly reduced oxygen, with the oxygen being replaced by nitrogen, methane and hydrogen sulfide. An extreme example of stink damp collected from the lowest part of Grill Cave at Bungonia Caves contained 1% carbon dioxide and only 10.8% oxygen. In such an atmosphere the threat of anoxia is immediate. Since the low carbon dioxide concentration won't elicit a physiological response - (increased pulse and respiration rate) - in the victim a rapid loss of consciousness, followed by death could ensue.

Although numerous methods exist for measuring the oxygen and carbon dioxide composition of air, the simplest tests using flame extinction offer the best protection to the non-specialist. A match is extinguished in about 1% carbon dioxide and a candle in about 4% (normal foul air). Only personnel wearing breathing apparatus or experienced foul air cavers should enter an atmosphere that extinguishes candles.

4. The Physical Shape of Caves

Dangers to cavers related to the physical shape of caves fall into three main groups; falls and climbing incidents, entrapments and becoming lost.

Falls and Climbing Incidents

Many caves contain deep shafts and almost all caves have irregular floors making falls the most likely initial cause of injury to cavers. In the United Kingdom in 1982 11 out of 47 underground incidents involved falls, being the most common of 15 classes of cave rescue incidents. Experience in the U.K. has shown that most falls occur on short drops (probably due to less care being taken).

As well as falls the presence of shafts in caves can result in cavers being trapped on ropes and ladders, hanging suspended on safety lines or being unable to ascend a rope they have descended. With the increasing popularity of Single Rope Techniques (S.R.T.) it seems likely that the prevalence of these types of incident will increase.

A person hanging on a rope for any length of time is in danger of suffering from crush syndrome-like effects due to the restriction of circulation in their legs by harnesses. Such incidents should be treated very seriously.

Entrapment

Caves contain many narrow rifts and tight passages resulting in a real, but probably exaggerated, risk of cavers becoming physically jammed and unable to extricate themselves either by their own efforts or those of their companions. A jammed caver faces five main dangers:-

1. Becoming more jammed
2. Loss of body heat to the rock
3. Physical inability to breathe
4. Shock due to the trauma of the situation
5. Suffocation in their own exhaled breath.

There have been cases in the U.K. and the U.S. where victims have not been able to be extricated and death has followed due to hypothermia, asphyxia, and heart attack due to congestion of the blood vessels.

Becoming Lost

It is fairly rare for cavers to be unable to find their own way out of a cave. It is common for even experienced cavers to be "uncertain of their position" for 30 minutes or more. The main danger is that a party may run out of light while trying to find their way. Although some caves are quite complex, most are fairly simple. Major problems in direction finding in caves are that cave passages look quite different when viewed in the opposite direction (it is good practice to look behind regularly when moving through a cave), large blocks of rock or formation may be passed on different sides, and junctions may be missed.

5. Flooding

Cavers being trapped underground by flooding is the second most common cause of cave rescue incidents in the U.K. Although there have been no incidents of this type in New South Wales there are a number of caves where the potential for such incidents exists. Once underground, cavers have no knowledge of surface weather conditions and so flash flooding can easily catch them unawares.

Water levels in caves may be affected by large falls of rain in distant catchment areas adding to the danger of flooding in caves. Cavers trapped by flood waters can only move to the highest point and sit it out. As flood waters will take some time to fall they can be expected to run out of both light and food.

6. Rock Falls

The main danger of rock falls in caves comes from rock piles formed from old rock falls, and rubble filling shafts. These may be moving naturally, or move by being disturbed (in some cases only accidentally kicking a loose rock may cause a pile to move). As with any rubble pile, moving the wrong block can have serious consequences. Specialist advice from geologists and mining engineers may be required should a caving party be trapped by a rock fall.

It is rare for falls to occur from cave roofs as caves, unlike artificial tunnels and mines, have existed long enough to allow the rock mass to adjust to having a cavity formed in it. Most roof falls occur fairly early in the history of a cave.

7. Psychological and Physiological Factors

Caves are dark, cold, and wet, and caving is hard work being both mentally and physically demanding.

Cold, wet, and tired people (particularly if they have been exposed to foul air or have inadequate lighting) will make mistakes and have accidents. Due to the stresses to which they have been subjected injured cavers will rapidly succumb to shock and eventually hypothermia. It is important to remember that a cave accident victim is likely to spend many hours in the cave before any evacuation is attempted and may have been already in the dark for many hours before first responders arrive.

On occasions cavers will reach their psychological limits and "freeze" on ladders and climbs while others may become so physically tired that they cannot continue. Experienced cave party leaders are usually able to deal with these situations without outside assistance. When a member of a poorly experienced party gets into these types of difficulty, problems can arise.

Cavers are encouraged to think in terms of self-rescue in all but the most serious situations. This is one reason for the small number of cave rescue incidents reported. Experienced trip leaders of both caving clubs and youth organizations take their responsibility towards their party members very seriously, and many are quite competent in cave rescue procedures. It is likely that a first responder group may arrive and find the situation fairly well under control. Responsible cavers may call on outside help "just in case" even if they feel they can deal with their situation and should not be discouraged from doing so.

FIRST RESPONDER CARE

The first responders to a cave accident are likely to be the local Police, Ambulance and the nearest P.R.S. or V.R.A. units. The actions they take will be the MOST IMPORTANT in determining the outcome of a cave rescue incident. The management of cave rescue incidents can be divided into six distinct stages:-

1. Surface assessment
2. Reaching the victim
3. Underground assessment
4. Protection
5. Stabilization
6. Evacuation

It is the first four of these activities that will always be the responsibility of

the first responders.

1. Surface Assessment

This involves establishing the history and nature of the incident, the location and state of the victim and making an initial decision as to the likelihood of needing outside assistance. It is important to find out what has already been done and to get as much information as possible about the location of the victim, as names used for parts of caves can vary considerably.

In the case of a person being believed to be lost in a cave, or of an overdue party whose position is totally unknown, outside help should be called without delay. This is because searches of caves and cave areas take days to complete and require large numbers of skilled personnel.

2. Reaching the Victim

Once the victim's likely status and position has been established the next aim is to reach the victim with a small assault party (4-6 persons) who can render immediate aid and make an underground assessment. This party should ideally consist of members of the first responder rescue organization, an Ambulance Officer, and at least one person with a good knowledge of the cave.

In popular caving areas it is likely that there will be competent cavers close to the scene who can be used to make up members of this party. If possible use a member of the victim's own party as a guide. Care is required as such a person may be in a disturbed state.

The first party should carry first aid equipment, blankets, extra lighting, food, tackle and hardware as the situation suggests.

It cannot be stressed too strongly how difficult it may be to find the victim's location from interviews with witnesses on the surface. Cave maps (frequently not available) can assist but are of varying quality and reading them is more an art than a science. Good local knowledge of the cave is most important at this stage.

3. Underground Assessment

There are three types of assessment that need to be made on reaching the victim; medical, hazard, and rescue. In cave rescues the principle of not becoming the next victim is most important and the assault party must be aware of the likely hazards to themselves before attempting to assess the status of the victim.

(a) medical assessment
The medical assessment of a cave accident victim differs little from that required by any trauma victim except that particular attention should be paid to checking for signs of shock, loss of body heat, effects of foul air, and to establishing the mental state of the victim.

(b) risk assessment
Before attempts are made to treat the victim it is essential that a good assessment is made of the risks that the victim faces. Most of these have been mentioned before but it is important to stress hypothermia, foul air (or air becoming foul), falling further, flooding, entrapment, and being suspended on a rope. These are hazards which require immediate attention.

(c) rescue assessment
Rescue assessment is deciding what resources and methods will be needed to execute the eventual evacuation of the victim. Can the victim walk with assistance when treated or is stretcher transport necessary? Are tight passages, vertical lifts or difficult traverses involved? Will the cave itself need to be modified by simple "gardening" of loose stones or by more drastic methods? These decisions need to be made early in the piece as they will determine what extra assistance, if any, is required.

4. Protection

The protection stage begins with the initial treatment of the victim and continues throughout the remainder of the rescue. It should be clear to rescue and ambulance personnel what is required to protect the victim, however, caves present some special problems whose management requires special mention.

(a) shock
Unlike road trauma victims, cave accident victims may have to wait many hours before receiving initial treatment. During this time they are likely to be exposed to cold, wet conditions and so the onset of shock is likely. Since first responders may be responsible for the care of the victim for a protracted period proper diagnosis and treatment of shock is essential.

(b) loss of body heat
Cave accident victims, even those who are uninjured, will lose body heat. Once basic first aid is completed retention of the victim's body heat is a priority. The victim must

be insulated from contact with the rock, have wet clothes removed and be protected from draughts. With immobile, trapped, or badly exposed victims hypothermia can occur.

Ingenuity may be needed to prevent the victim from cooling. Heating by body contact, air blowers, and low voltage electric blankets may all form a part of the management procedure.

(c) foul air

Rapid removal of a victim from foul air, or if not completely possible to air that is less foul, is the first priority. Rescuers need to be aware of the effects of foul air on themselves. Oxygen therapy is the treatment of choice for those exposed to foul air and can be used to sustain the life of a victim who is trapped in foul air. Persons exposed to foul air for any length of time or at high concentrations will be suffering from acidosis and will vomit on receiving oxygen therapy. Rescuers must expect this and be able to act accordingly.

Oxygen therapy equipment most suited to cave rescue work consists of a "C" cylinder fitted with a dial type regulator and flowmeter (e.g. C.I.G. Regulator 518503 and Flowmeter TM 17). Oxyviva type equipment, although effective, is difficulty to carry in caves.

In extreme situations rescuers can breathe oxygen enriched foul air through a therapy mask. This is a risky procedure and should only be used in an emergency.

It is important to monitor the air near the rescue scene, as in poorly ventilated caves the air could become foul due to the respiration of the rescuers.

The comments made so far apply to so-called "normal" foul air. In the case of "stink damp", removal of the victim to good air is urgent and unless this has been accomplished by the victim's own party the prognosis is grim. One particular problem with carbon dioxide narcosis is that its symptoms may mask those of concussion or other serious illness. Where a victim is found lying on the cave floor under foul air conditions the possibility of concussion should not be ignored and the victim's condition monitored appropriately.

(d) entrapment

The cave accident victim trapped in a tight passage or rift is rapidly losing heat to the surrounding rock, afraid, anxious, uncomfortable, and in danger of suffocation in their own breath. The only solution for a trapped victim is their release.

The longer a victim is trapped the worse their condition will become. The first response will be to maintain the victim's body heat by placing blankets around the victim and if the space is enclosed applying oxygen therapy as a matter of course.

Simply methods of extracting the victim can then be attempted. Pulling on limbs, rope loops or air bags under the feet, in fact, any method that might work should be considered. Remember to check for jamming by ruffles of clothing or equipment attached to the victim's body.

If the victim is unable to be easily removed then a major emergency exists and outside help must be called. In any event every effort should be made to maintain body heat and air supply.

5. Stabilization

This stage of the rescue becomes important if the victim is not able to be quickly evacuated from the cave. It involves the use of medical and paramedical personnel to stabilize the victims condition prior to their movement. In its most developed from it involves in-cave hospitalization where treatment is effected (over an extended period) and the victim leaves the cave under their own power.

6. Evacuation

The evacuation of a stretcher patient from a cave can be a very difficult procedure. Being moved through a cave on a stretcher can be quite frightening.

Evacuations from difficult caves can require many skilled cavers and may take days. In many cases it will not be possible to avoid aggravating the victim's condition in order to evacuate them.

Cave rescue practices are probably a poor indicator of the amount of time required to evacuate a real victim from a cave due to their use of a cooperative victim and the need in a real rescue to modify the cave in order to fit the stretcher through.

Evacuation should only be attempted by the first responder organization when it is either imperative for the victim's survival or when it is clearly going to be a simple procedure. In most cases involving stretcher cases extra assistance will be required.

SOME POINTS OF PROCEDURE

This paper has been written assuming that the first responder organization to a cave rescue incident will not be the Cave Rescue Group. The procedures outlined do not exactly follow those of the Group who would, as well as following the basic steps outlined above, have use of special equipment and extra personnel.

In a completely Cave Rescue Group manned rescue, a communications team would follow the assault team and lay telephone lines from the surface HQ to the accident scene. At the same time lighting crews would be running 240 volt light along the proposed evacuation route while other groups, under the supervision of the underground coordinator, would be removing hazards and constrictions from the evacuation route and setting up hauling equipment where required.

CONCLUSIONS

Cave accident victims are best assisted by rapid and efficient first responder care. The care given by the victim's own party and the first responder organization will in many cases determine the outcome of an incident.

In order to make their vital contribution to the survival of cave accident victims, first responder must not be afraid of caves or believe that cave rescues are beyond their ability. It is not necessary for rescue groups near cave areas to be proficient in the more specialized and technical aspects of cave rescue as these services are available through the Cave Rescue Group. It is, however, essential that groups likely to be called to a cave accident are proficient in first responder care and are able to reach an accident victim in order to give that care.

To do this rescue groups need to be familiar with the caves in their area and with simple caving techniques.

The Cave Rescue Group's aim is to ensure that an efficient rescue system operates for all members of the caving community throughout New South Wales and is happy to assist any organization whose members may be called to a cave accident with information or training. Regional exercises involving Police, Ambulance, and V.R.A. units are organized where there are caves with significant visitation, or at the request of local rescue groups.

Cave rescues are difficult, but not impossible, and with proper first responder care their outcome can be viewed confidently.

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