28 CAVING EXPEDITIONS

Andrew Pitkin

Caving activities share some medical hazards with other activities (climbing and diving in particular), but in addition a few are unique to the subterranean environment. Caves are restricted spaces formed by flowing water which present dangers from flooding, restricted air exchange, and unusual flora and fauna. Sections of the deepest caves may be among the most remote places on earth. Intercurrent illness therefore can be, and has been, fatal among cave explorers. Most medical problems are predictable; as data collected by the British Cave Rescue Council (Table 28.1) show, hypothermia and injuries from falls represent the majority of emergencies requiring evacuation from caves in the UK.

TABLE 28.1 **EMERGENCIES REQUIRING CAVE RESCUE IN THE UNITED KINGDOM 1989–98**

Emergency	*Number*	*(%)*
Upper limb injuries	22	(12)
Pelvis and lower limb injuries	38	(21)
Head injuries	13	(7)
Chest injuries	7	(4)
Spinal injuries	19	(11)
Multiple major trauma	9	(5)
Exhaustion and hypothermia	45	(25)
Medical conditions	13	(7)
Drowning	11	(6)

Supplied by the British Cave Rescue Council.

MEDICAL PROBLEMS NOT SPECIFIC TO CAVING EXPEDITIONS

Near-drowning

Cave systems are formed by flowing water and sudden ("flash") flooding is a major hazard to cavers. The medical officer (MO) may have to deal with cases of near-drowning while being trapped in part of the cave system waiting for the water levels to recede. Cave diving is used increasingly to pass sumps (passages completely filled with water) into more distant passages; equipment failure during a cave dive may also require the MO to deal with near-drowning.

The exact sequence of events that occurs in drowning in humans has not been fully worked out. Breath holding occurs on initial submersion. Its duration will vary according to the victim's age, physical condition, exertion, water temperature, etc. Submersion in very cold water can cause a reflex involuntary gasp with immediate water inhalation. If this does not happen, the rising carbon dioxide in the blood will at some point force the victim to breathe in; water in the larynx may cause laryngospasm (reflex closure of the vocal cords) and prevent water entering the lungs. Water in the mouth and pharynx is often swallowed and subsequently inhaled along with stomach contents. Eventually the falling level of oxygen in the blood overrides the "protective" laryngospasm and water enters the lungs. In about 10% of cases laryngospasm persists until respiratory arrest occurs and no water enters the lungs ("dry drowning").

Symptoms and signs of near-drowning

- Difficulty breathing
- Retrosternal chest pain
- Cyanosis
- Coughing frothy bloodstained sputum
- Cardiorespiratory arrest in severe cases
- Convulsions and impaired conscious level maybe to the point of coma.

Hypothermia may complicate matters, but has been associated with survival following prolonged immersion (rarely up to 60 minutes).

In the cave environment the ability to care for a survivor of near-drowning is extremely limited. Follow the guidelines in Chapter 29, page 328. In addition provide resuscitation with basic life support as needed, paying particular attention to the airway, and arrange immediate evacuation to the surface.

Hypothermia

Hypothermia is the commonest single problem requiring rescue from caves in the UK, accounting for a quarter of the callouts for cave rescue organisations (see Table

28.1). Cavers are not exposed to high winds like climbers, but may be unable to avoid immersion in cold water during a caving trip. Conductive heat loss from bare skin immersed in water is approximately 25 times that in air and most textiles lose almost all their thermal insulting properties when wet. Even wetsuits permit considerable evaporative heat loss when removed from water. Heat production must balance heat loss to prevent hypothermia; heat production can be increased by shivering or purposeful activity (ideally to get to a warmer environment), such as climbing a pitch or lifting equipment. Forced inactivity such as waiting to ascend a pitch leaves the wet caver vulnerable to hypothermia. There is marked individual variation in susceptibility to hypothermia and some evidence that resistance to cold can be increased by repeated exposure.

TABLE 28.2 **FEATURES OF HYPOTHERMIA**

Core temperature (°C)	*Manifestation*
37–35 "Mild"	Feeling cold, pale skin, shivering, "goose bumps", disinterest in group activities, impairment of precise hand movements
35–32 "Moderate"	Uncontrollable shivering, generalised inco-ordination, mental slowing, lack of co-operation, memory impairment
< 32 "Severe"	Cessation of shivering, confusion, strong desire to sleep, incoherent speech, visual disturbances, urinary incontinence, coma. Slow, possibly irregular pulse, low blood pressure, slow shallow breathing, "fruity" odour of acetone on breath

Management of the hypothermic casualty depends entirely on the expedition scenario and the severity of the hypothermia, as well as many other problems (such as injuries resulting in immobility and/or shock)(see Chapter 25). No single symptom or sign is diagnostic of hypothermia other than an accurate measurement of core temperature. For symptoms of hypothermia see Table 25.2, page 286. In practice, mild/moderate and severe hypothermia are different problems, the latter being a medical emergency requiring intensive care, mainly because of the ease with which life-threatening cardiac rhythm abnormalities can be provoked. See Chapter 25 for full details.

TABLE 28.3 **MANAGEMENT OF COMMON CAVING INJURIES (SEE ALSO CHAPTERS 13 AND 14)**

Fracture	*Symptoms/signs*	*Treatment*
Feet/toes	Pain in foot (may follow "insignificant" impact). Pain from heel (calcaneus) fractures may prevent weight bearing	Usually splinted by well-fitting shoe or boot. Give painkillers
Ankle/lower leg	Deformity, crepitus (grating of bone ends), pain, swelling (latter may be greater with sprains). Minor fractures (e.g. lateral malleolus) may allow limited weight bearing	Immobilise with a splint. Straightening may be necessary first. Treat sprains as fractures until excluded by X-rays. Give painkillers
Thigh	Pain, deformity, haemorrhage (into fracture), painful muscle spasms	Immobilisation and traction (which controls haemorrhage and spasms) ideally with dedicated traction splint (e.g. Thomas splint). Avoid non-traction splints. Give painkillers
Hip	Pain, deformity (shortening and rotation of leg and foot to the outside) if displaced	Splint by binding to the other leg. Do not allow to walk. Give painkillers
Pelvis	Pain (especially with front-to-back or side-to-side pressure), major blood loss, damage to bladder (no or bloodstained urine) or other pelvic organs	No splinting required (pelvic muscles hold fragments together). Treat for major haemorrhage. Evacuate supine on stretcher; do not allow to sit or stand. Give antibiotics (if available)
Spine	Pain, tenderness along spine. Pain, tingling, weakness, numbness, loss of bladder control suggests nerve injury	If unconscious, assume cervical (neck) spine injury. For all cases, immobilise using rigid board or similar (e.g. ladder, rigid stretcher). Move casualty only by "log-rolling", keeping all sections of spine aligned. Consider waiting for specialist help and equipment
Chest (ribs)	Pain aggravated by breathing or movement. Breathlessness if pneumothorax (air leak in chest), haemothorax (blood in chest) or "flail chest" (section of ribs moving in the "wrong" direction with breathing). Extreme breathlessness and low blood pressure (tension pneumothorax). Open "sucking" chest wounds	Oxygen, antibiotics (if available). In extremis drain air from tension pneumothorax (both sides if unsure) – insert a large-bore cannula through the second intercostal space in the mid-clavicular line. Immobilise a flail segment with padding and adhesive tape (lie patient on flail segment in emergency). Seal "sucking" wounds immediately (e.g. with a square of polythene secured with tape)
Head	Unconsciousness, bleeding from ears and/or nose; 15% have broken neck. Lesser injuries cause drowsiness, confusion	Evacuate as emergency. If rescue of unconscious casualty is impossible, consider waiting a few hours in case consciousness returns. Maintain airway (recovery position). Search for other injuries; assume broken neck until proven otherwise in hospital

Trauma

Most fatal caving accidents result from falls causing multiple major injuries. Lesser injuries also occur and are not unique to caving. The lower limb and pelvis are most commonly affected, with upper limb, spinal and head trauma accounting for most of the remainder.

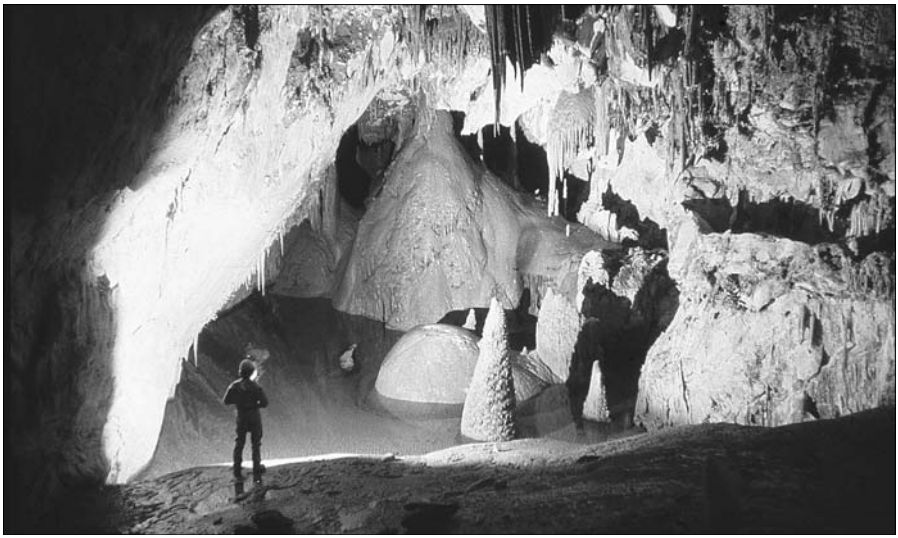

Figure 28.1 *Moulin Rouge Passage, Mulu, Sarawak (A. Eavis/RGS)*

SPECIFIC MEDICAL PROBLEMS OF CAVING

Histoplasmosis

Histoplasma capsulatum is a spore-forming fungus that is found in caves containing dry, dusty, bat or bird guano. Cavers may breathe in the airborne spores, resulting in a range of clinical manifestations depending on the individual's previous health and the quantity of spores inhaled. The disease is called histoplasmosis, but other names include cave fever and Darling's disease. It was identified in 1983 as a specific cave-related health hazard after a number of visitors to Church Cave in Wee Jasper, Australia and scientific investigators contracted the disease.

Several clinical varieties of this rare disease exist; members of caving parties are most likely to suffer from acute (epidemic) pulmonary histoplasmosis. After a latent period of 12–21 days, symptoms of tiredness, fever, dry cough and chest pain develop. Pain that migrates from joint to joint often occurs; occasionally a rash (erythema nodosum or erythema multiforme) appears. Chest X-rays show hilar lymphadenopathy and diffuse

patchy consolidation. Skin tests may be negative; a rising antibody titre in an individual with a history of exposure is the best confirmation of the diagnosis. In most cases no specific therapy is required, but if symptoms are prolonged or lung function is significantly affected treatment with intravenous amphotericin B may be needed.

Leptospirosis (Weil's disease)

Leptospira interrogans causes a variety of disease states from a subclinical infection to jaundice and liver failure in the severe form known as Weil's disease. Rats and other rodents are the major reservoir of infection and excrete the organism continuously in urine. The organism can enter through skin abrasions or the mucous membranes of the eyes, nose and mouth, and infection can also occur through swallowing infected water. Cavers are obviously at risk from prolonged immersion in stream water and the abrasive nature of the cave environment. Cave divers are particularly at risk.

Leptospirosis is a rare disease, symptoms typically appearing 1–2 weeks after exposure. Most cases consist of non-specific fever with muscle pains (especially calf and lower back muscles) and nausea. In a few the disease progresses with abdominal pain, rashes, vomiting and conjunctivitis (septicaemic phase). Headache is usually intense and occasionally the patient becomes delirious. Jaundice indicates severe infection, and renal failure should be suspected. A tendency to bleed (e.g. nose bleeds) is also a sinister sign. The third (immune) phase occurs a week later and includes meningitis, nervous system problems and visual disturbances. Treatment is with appropriate antibiotics; benzylpenicillin (1.2g 6 hourly), doxycycline (200mg daily) and erythromycin (500mg 6 hourly) have all been used successfully. Maintenance of fluid and electrolyte balance is important, particularly when the patient is febrile. Most recover; kidney function may need to be supported temporarily (hence hospitalisation is mandatory). Prevention is best achieved by protective clothing; doxycycline 200mg weekly has also been used. Vaccination is impracticable for humans as numerous serotypes (strains) of the organism exist; however, this may be useful if repeated exposure to a known serotype is necessary.

Harness hang syndrome

Also known as compression–avascularisation–reperfusion (CARP) syndrome, this problem may be easily misdiagnosed as hypothermia or exhaustion while on rope. It occurs when a caver hangs immobile in a harness that occludes the blood supply to and from the legs. Tests using a variety of harnesses and body positions have shown that hypotension occurs in minutes and that reperfusion injury to the lower limb may result in the caver being unable to ascend further. The affected caver must be rescued from the rope; subsequent treatment is supportive.

Altered atmosphere ("bad air")

Sections of cave close to the surface tend to be well ventilated; deeper caves and sec-

tions sealed by water may not be sufficiently ventilated to prevent an alteration in atmospheric contents. "Air bells" in or between sumps are very often affected. The two components of most importance are oxygen and carbon dioxide.

Oxygen is essential for life and is produced by photosynthesising plants exposed to sunlight; no oxygen production therefore occurs in caves. Oxygen is used by the metabolic processes of the body and by combustion (e.g. carbide lamps). Exertion increases the body's use of oxygen. Features of hypoxia (lack of oxygen) *at normal atmospheric pressure* do not usually occur until the atmospheric concentration falls to below 12%. Symptoms of acute hypoxia include breathlessness, weakness, lack of coordination, euphoria and apathy, with the victim typically being unable to recognise his or her impairment. Unconsciousness may occur suddenly with no warning whatsoever. The traditional method used by cavers to detect "bad air" is the naked flame test, which is useful to prevent hypoxia as it has been shown that matches and butane lighters will not stay lit at oxygen concentrations below 14%.

The naked flame test does not reliably indicate high levels of carbon dioxide. This gas is produced by combustion, metabolism and also by the cave itself as water containing carbonic acid evaporates releasing carbon dioxide into the cave atmosphere. Being about 1½ times heavier than air it tends to sink into shafts and other low areas of the cave; particular caution should be observed by the first caver down a new pitch. The carbon dioxide concentration in normal air is 0.03% and levels of up to 0.5% are harmless. At carbon dioxide levels above 1% symptoms appear, which consist of headache, breathlessness (worse if there is associated hypoxia), sweating, vasodilatation, fatigue and, at sustained levels of more than 6%, unconsciousness. Provided there is no shortage of oxygen, carbon dioxide levels of up to 15–20% can be survived for periods of several hours.

Treatment for exposure to such an atmosphere consists of removal to a normal atmosphere. The principal danger is the likelihood of sustaining an injury (e.g. a fall) while incapacitated by an altered atmosphere.

Caving beyond sumps

Cave divers should be aware that any injury or equipment malfunction that prevents them from returning through a sump is extremely hazardous and potentially fatal. A very high degree of caution should therefore be used when caving beyond a sump that requires a significant dive. There are no hard-and-fast rules about rescues from beyond sumps; these depend on the limit of what may be achieved with any degree of safety. It is now generally agreed that it is better to try to assist injured cavers (with analgesia, splints and so on) to dive through the sump themselves than to try to stretcher them through with attached breathing apparatus, although the latter approach may be necessary with severely injured casualties. Any risk of loss of consciousness necessitates a full-face mask and such casualties should be taken under water only if there is no alternative.