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Necropsy study of mountaineering accidents in Scotland

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SUMMARY One hundred and twenty one people died in mountaineering accidents in Scotland between July 1978 and December 1983. Necropsies were carried out on 42, which form the basis of this report. In 21 cases head injury was a major fatality factor, but in 11 of these there were also serious chest injuries. Focal brain damage (haematomas, contusions, or lacerations) was more common (n = 21) than diffuse brain damage (n = 18). Over half of the victims with severe head injury had few other injuries and would probably have survived had the head injury been prevented. Spinal injuries usually occurred with other major injuries. Chest injuries were common, being serious in 18 cases, but abdominal injuries were uncommon. Four climbers with only minor injuries died of hypothermia.

Mountaineering is a dangerous sport. There is, however, little published information on the causes of death. Anecdotal reports from alpine countries have dealt with specific problems such as the exclusion of foul play,[1] the prevalence of pre-existing disease,[2] or the effects of suspension by rope.[3 4] In the United Kingdom a brief summary of six negative necropsies was included in a report on accidental hypothermia.[5] There seems not to have been a systematic necropsy study of mountaineering accident victims.

In Scotland each year there are between 20 and 30 mountaineering deaths. Although all are investigated by the procurator fiscal (a senior legal official in Scotland whose duties include directing the investigation of any sudden death), death in many cases is ascribed to "multiple injuries", and a necropsy is not done routinely. To obtain more detailed information necropsies, including neuropathological examination, were performed on as many cases as possible over five and a half years.

Methods

We studied all fatal mountaineering accidents in Scotland from 1 July 1978 to 31 December 1983. All but four of our cases appear in the reports published annually in the Scottish Mountaineering Club Journal.

The accidents were classified according to whether they occurred in winter (snow and ice) conditions, or during hillwalking, or rockclimbing, the latter being traditionally defined as requiring the use of the hands.

Most of the necropsies were done by one pathologist (HGR) because most of the mountaineering accidents occurred in his catchment area. In each case the brain was fixed in formalin for neuropathological study, and a proforma was completed summarising the information about the circumstances of each accident. The neuropathological findings were passed on to the procurator fiscal for incorporation into the official records.

Results

From July 1978 to December 1983 there were 121 fatal mountaineering accidents in Scotland. Full necropsies were performed on 41 cases, while examination was limited to the head in one further case which was hepatitis B antigen positive. The legal authorities did not request necropsies in the remainder. There were 37 men and five women aged from 14 to 54 years. Twenty four died in winter accidents. Of the accidents in non-winter conditions, seven were rockclimbing and 11 hillwalking. Apart from two crushings, all accidents entailed a fall. Only two people survived long enough to be admitted to hospital.

CAUSE OF DEATH

In many cases multiple injuries made it difficult to ascribe death to any particular cause (table 1). The most commonly identified cause, however, was head

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Table 1 *Main cause of death in mountaineering accidents in Scotland*

	No of cases
Multiple injuries:	
Head and chest and spine	8
Head and chest	3
Single injuries	
Head (mainly)	10
Chest (mainly)	7
Spinal	2
Hypothermia	4
Asphyxia	3
Fractured pelvis	3
Abdominal injuries	1
Pulmonary embolism	1
Total	42

injury either alone (n = 10) or in combination with chest or spinal injuries (n = 11).

HEAD INJURY

Thirty four climbers had evidence of head injury, 17 of whom also had a fractured skull. All the skull fractures except one occurred at the base of the skull (table 2). Head injury was as common in hillwalkers (nine of 11) as in rockclimbers (two of seven) and winter mountaineers (six of 24), the differences between these groups being insignificant because of the small numbers.

Focal brain damage This includes haemorrhages, contusions, and lacerations, and was present in 21 climbers and, as expected, was more common and more severe when there was concomitant skull fracture. The haematomas (10 cases) included subdural, subarachnoid, and intraventricular haemorrhage—often combined. There were no extradural haematomas. Minor subarachnoid bleeding, generally a smear of haemorrhage over both cerebral convexities without gyral flattening, was a common finding (13 cases) of doubtful importance, at least in the context of other injuries.

Table 2 *Head injuries (34 cases)*

	No of cases	
Skull fractures:		17
Vault	1	
Base	4	
Vault and base	12	
Focal brain damage:		28
Haematomas	10	
Contusions and lacerations	18	
Diffuse brain damage		17
Diffuse axonal injury	2	
Brain swelling	7	
Hypoxic damage	3	
Petechial haemorrhages	5	

The categories under each heading are not mutually exclusive.

Diffuse brain damage This includes diffuse axonal injury, brain swelling, hypoxic damage and petechial haemorrhages, and was present in 15 cases. There was little evidence of diffuse axonal injury; only one person had a haemorrhagic tear in the corpus callosum, one a haemorrhagic tear in the dorsolateral quadrant of the rostral brain stem, while none had axonal retraction balls. The brain was swollen in seven cases. Hypoxic damage was uncommon (three cases). There were five cases in which the only sign of diffuse damage was petechial haemorrhage, usually indicative of instantaneous death. The duration of survival of these five cases is not known, but the nature of their injuries suggests rapid death.

SPINAL FRACTURES

In 14 cases there was a fractured spine: eight cervical, five thoracic, and one lumbar, including one case with both cervical and thoracic fractures. All but one of the cervical fractures were at or above C4. Two cases had a pontomedullary tear due to a fracture of the upper cervical spine.

CHEST INJURIES

In 23 cases there were fractured ribs, usually multiple. In 12 cases these were bilateral, eight being paravertebral and four anterior. There were five cases with a flail segment, defined as double fractures of three or more adjacent ribs. Fourteen climbers had a transverse fracture of the sternum, usually the upper body or manubrium. With one exception this was associated with fractured ribs.

Lung and pleural injuries generally accompanied rib fractures. In three victims the lung was lacerated and in eight others it was bruised. There was a haemothorax in 14 cases and a pneumothorax in six (four tension), while four further cases had minor degrees of pulmonary collapse. Bone marrow embolism of minor degree was common when fractures were present.

In two cases the aorta was transected, one partly and the other completely, at the junction of the arch and descending portion. This is a classical deceleration injury.[6]

ABDOMINAL INJURIES

Abdominal injuries were uncommon. There were three ruptured spleens, only one of which was associated with clinically important peritoneal bleeding. Similarly, although the liver was lacerated in four cases, in only one (who also had a torn kidney) was blood loss clinically important. Both these climbers with serious bleeding from a ruptured liver or spleen had been wearing a rope. There was considerable intra-abdominal bleeding from a fractured pelvis in two other cases.

OTHER INJURIES

There were eight cases of fractured pelvis affecting the pubic ramus (n = 5), symphysis pubis (n = 2), and sacroiliac joint (n = 2), one person having two fractures. Six climbers had facial fractures; maxilla (n = 2), nose (n = 2), and mandible (n = 2), all associated with skull or spine fractures. There were four fractured femurs, one associated with severe bleeding. A further case had a dislocated hip with a degloving injury of the thigh. Other less serious fractures were of leg or ankle (n = 5), humerus (n = 2), elbow (n = 4), wrist (n = 3) and clavicle (n = 2). There was one dislocated shoulder.

One climber died of chest and thigh lacerations, and one had a torn diaphragm with herniation of the stomach into the chest cavity. Hypothermia seemed to be the main cause of death in four people, all of whom had received minor injuries after a fall in winter.

PRE-EXISTING DISEASE

One person had a superior cerebellar and occipital infarct, thought to have been due to vertebrobasilar arterial insufficiency, and probably the cause of the fall. Two people had an old myocardial infarct, and in another there was an incidental tiny subependymoma at the obex.

ALCOHOL

Of 40 cases measured, alcohol was found in the blood and urine in three. Two of these climbers had been dead for six months and the blood alcohol and urine concentrations of 106 and 38 mg/100 ml and 34 mg/100 ml each were probably due to putrefactive production. In the third, who had died up to two days before the body was found, the blood alcohol concentration of 43 mg/100 ml and urine concentration of 11 mg/100 ml could also have been due to putrefaction.

CRASH HELMETS

Only five climbers had been wearing a crash helmet. One fell 400 feet and had a fractured skull with intracerebral bleeding, severe chest injury, and a torn aorta. One died of fractured pelvis after a fall of 20 feet and had slight brain swelling as the only sign of head injury. Three others, who each fell a considerable distance, had no head injuries. Thirty five climbers had not been wearing a helmet, while in two remaining cases it is not known if a helmet was worn at the time of the accident.

Discussion

A necropsy study has been made of climbing deaths in the Scottish mountains. The commonest main cause of death was head injury. Focal brain damage was more common than diffuse brain damage. Diffuse axonal injury has been found in people who fell from a height[7] but was rare in this study, probably because death was rapid. Prevention of the head injury might have saved six climbers whose other injuries were minor and some who had treatable injuries elsewhere in the body (two with spinal fractures and one with a fractured femur).

How could the head injury have been prevented? Many climbers wear a crash helmet to protect against falling rocks and ice, although in this study only five had been wearing one. A helmet probably offers little protection in a serious fall, if the climber lands on the head, but it may protect against glancing blows. Some of the head injuries could possibly have been prevented if the climber had worn a helmet of satisfactory construction.

Many of the spinal fractures were in the upper cervical region, where they may have caused death. The cervical fractures were also associated with other serious injuries, most of which would have been fatal.

Chest injuries may be directly fatal or may lead to hypoxic brain damage, but because of the rapidity of death no evidence of cerebral hypoxia could be expected in most of the cases in this study. Five cases had a flail segment, although it is difficult to assess how much this contributed to death. Tension pneumothorax seems to have been the main cause of death in four cases.

Rib fractures generally occur when the distance fallen exceeds 70 feet (Siva, unpublished data), suggesting that many of our cases had fallen a considerable distance. The bilateral rib fractures, often associated with fractures of the spine and sternum, were probably due to anteroposterior crush injury. The influence of the rucksack is not known.

Abdominal injuries were not an important cause of death. In only four cases was there clinically important intra-abdominal bleeding, and there were no bowel injuries. The data are insufficient for comment on the effect of a rope or climbing harness.

Blood loss was the major cause of death in two patients with retroperitoneal haemorrhage due to fractured pelvis and in another with a ruptured liver and spleen and fractured femur. Our study, however, is likely to underestimate the importance of blood loss, which in many victims would have been more severe had they survived longer: both the cases with a torn aorta, for example, also had a severe head injury, while several others with potentially serious intrathoracic or intra-abdominal haemorrhage had other major injuries, mainly to the head or spine.

Torn aorta was less common in our study than in those of traffic crash fatalities.[8] In free fall accidents this and other deceleration injuries such as tearing of heart, liver, root of lungs and mesentery are common

in people who fall over 50 feet.[9] In contrast, we found liver lacerations in only four cases. This may be because in some cases a falling climber will tend to bounce off rocks and ice and may fall free for only a short distance. Furthermore, the deceleration of landing may be lessened by falling on to sloping terrain or soft snow.

From the pattern of injuries shown by our study we feel that, although there are many causes of death, head injury is particularly important, even in hill-walkers. Less than one in eight of the climbers in our study was wearing a crash helmet, although because of the variety of circumstances no general conclusion about the value of helmets can be made.

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