

PREHOSPITAL CARE

Aero-medical Retrieval in Extreme Environments: The Zermatt Experience

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Objectives: 1) to describe the challenges inherent in high-altitude rescues, 2) to discuss and apply the injury scoring system developed by the National Advisory Committee for Aeronautics, and 3) to review strategies employing land and air resources for rescue and retrieval missions in mountainous terrain.

Abstract

The Air Zermatt medical rescue service was established in 1968. The service has both land and air-operated retrieval and rescue abilities covering the upper Rhone Valley in Switzerland. This region is of outstanding natural beauty but has extreme mountainous and climatic conditions. There are 29 mountains more than 4,000 m high, including the Matterhorn at 4,478 m. The service runs 1,000 rescue flights per year on average. There is a clear seasonal variation in activity, with two peak seasons: about 30% of missions are conducted during the winter high-season months of February and March and 25% during the summer high-season months of July and August. The majority of rescue victims (55%) are skiers, with mountaineers making up the second most common group. The geographic and meteorologic conditions pose unique difficulties. Rescues are made using two specially equipped helicopters, with back-up helicopters available during high season. The dispatched crew includes an experienced pilot, paramedics, and a medical officer with anaesthetic training. The service rescued 2,851 victims between January 1998 and November 2000.

Key words: Emergency medical services, Emergency treatment, Resuscitation, Trauma

Introduction

The Swiss mountain village of Zermatt, located in the south of Switzerland near the Italian border, is dominated by the Matterhorn Mountain. The Matterhorn and the surrounding mountains have attracted mountaineers for more than a century, and their activities have resulted in numerous successes and accidents. The original mountain rescue service was

established in Zermatt, but rescue operations were difficult due to the problems of accessing and extricating victims. Air Zermatt started to operate its first helicopter in 1968 and in many ways the crew members were pioneers in alpine helicopter rescue. Today the service runs 10 helicopters from 3 airbases with the assistance of 45 staff members. Rescue flights make up 15% of the work, while 85% of the duties are scenic flights or helicopter carriage of food and construction material to remote huts and cable car stations. The helicopter service has thus become indispensable for the local community.

The service operates in the eastern part of the upper Rhone Valley, where 29 of the peaks have altitudes of more than 4,000 meters above sea level. Two helicopters are specially equipped and reserved for rescue operations with 24-hour coverage. Each is staffed with an experienced pilot; a winch operator, who is also a trained paramedic; and a medical officer, who is usually an anesthetist. The victims are taken to one of two regional hospitals, which can be reached within less than 15 minutes from all sites within the area. Alternatively, the major trauma centers with neurosurgical and cardiothoracic coverage are situated at the University Hospitals of Bern and Lausanne, with a flight time of around 35 and 45 minutes, respectively.

Materials and Methods

The study period was from January 1998 to November 2000. The data were extracted retrospectively from the statistical data sheets, which were completed by the attending medical officer after each emergency flight.

The study population consisted of people transported during clearly defined rescue flights.

The population in the service areas varies with the seasons. Air Zermatt covers the upper Rhone Valley with a variable population due to seasonal difference. During holiday periods, the covered population in some villages can increase in some villages as much as two-fold.

The Air Zermatt operates in general in cooperation with three other organizations. Primary medical service on ski slopes is provided by the local ski patrol. If accidents happen in a difficult environment, the technical support is provided by the regional terrestrial mountain rescue organizations. Responses to incidents on roadways are run primarily by the local emergency services.

On average, more than 90% of the medical officers are specialists in anesthesia, who have completed a special training program (e.g., winch operation, rescue net, rescue bag). They must be experienced in Advanced Trauma Life Support (ATLS™). All of them have experience in ground medical service before being appointed. In addition, special knowledge of medical conditions associated with high-altitude medical conditions is required.

In this study, our interest focused on site of incident in terms of access to the patient and flight operation required to retrieve the patient. Concerning patients, we reviewed victim activity and severity of medical condition. We graded according to the seven-level scoring system of the National Advisory Committee for Aeronautics (NACA) (Table 1) (1960, rev. 1980).^{1,2} With this score, trauma patients and patients with medical emergencies were classified at the end of the emergency mission.

Figure 1. Yearly distribution of rescue flights from the air base in Zermatt in 1998.

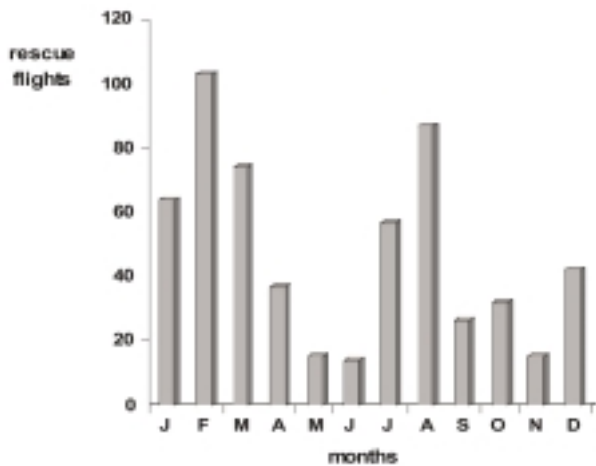


Table 1. NACA score (National Advisory Committee for Aeronautics, 1960, rev. 1980)

NACA 1	Minor injury or minor medical condition
NACA 2	Ambulatory treatment required
NACA 3	Hospitalization necessary
NACA 4	Condition that is possibly life threatening
NACA 5	Life-threatening condition
NACA 6	Condition after successful cardiopulmonary resuscitation
NACA 7	Death at scene

base at Zermatt for 1998 shows a seasonal variation with two peaks: one in winter and the other in summer (Fig. 1). To provide additional helicopters during these busy times, several sets of medical equipment are held in mobile containers and additional rescue helicopters can be provided within

minutes. Skiing is possible all year round (during the winter, the majority of rescue victims are skiers). During the summer, most of the victims are rock climbers and trekkers. Overall, 54% (n=1,539) of those rescued in the study period were skiers or snowboarders and 23% (n=656) were mountaineers (Fig. 2). In both categories, the rescue teams had to manage major trauma victims, many of them located in very difficult environments.

Severe or life-threatening injuries (NACA grades 4 and 5) were seen in 16% (n=438) of victims, while 1,336 patients (47 %) were NACA grade 3. Minor injuries (NACA grades 1 and 2) were seen in 28% (n=800) and 4% (n=125) of those rescued had no injury. Overall, 5% (n=134) of the victims were dead at the scene (Fig. 3).

The estimated accessibility to the site of accident by non-aeronautic means of transport is classified into five groups (Fig. 4).

Only 13% (n=352) of the accident sites were accessible via a roadway. Unsealed roads (n=1,603), which include ski slopes, represent the biggest group (59%). However, 28% (n=738) of accident sites were difficult or very difficult to access. During rescue operations in these difficult areas, highly trained mountaineers provide technical assistance with the rescue.

Special helicopter flight operations were often required to gain access to the patient in this alpine environment (Fig. 5). In 64% (n=1,736) of the cases, landing near the incident site was possible, but in 35% (n=970) of cases, complex flight operations were required. This included 419 rescue flights where in-and-out hover was required. In-and-out hover is performed on a sloping surface where it is impossible to land the helicopter because of the incline. In this situation, the pilot wedges the front of the helicopter skis in the snow and the rescue team disembarks and reloads with the helicopter in a hover. Because of more severe inclines or difficult access, winch operation were required in 521 rescue flights. On 17 occasions (0.6%) during the 35-month period described, terrestrial runs by local mountain rescue guides were the only possible route of access.

Figure 2. Victim activity statistic: (2,851 patients between January 1998 and November 2000).

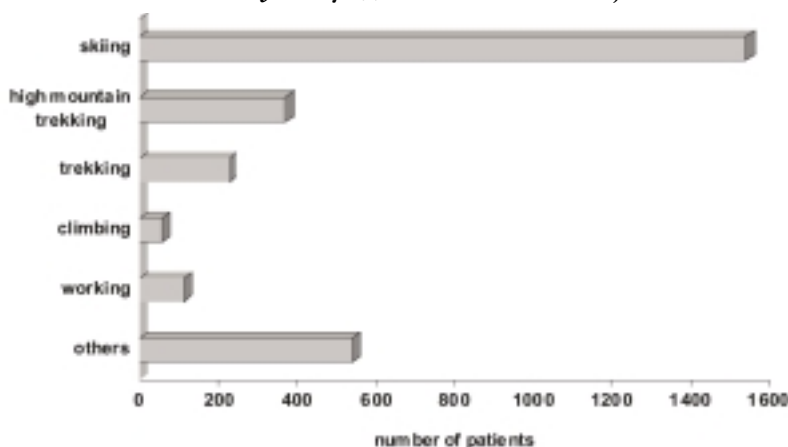
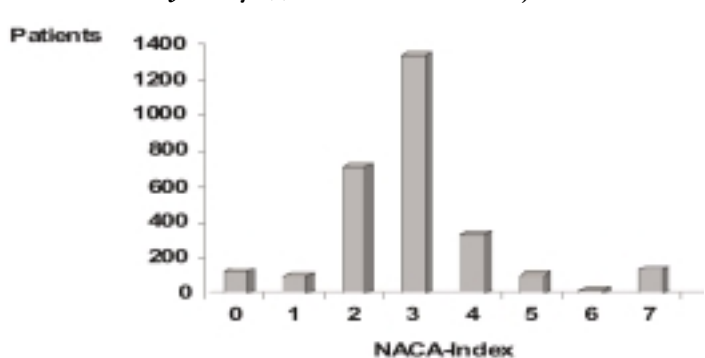


Figure 3. NACA Index (2,851 patients between January 1998 and November 2000).



Results

During the study period, 2,851 patients were transported in 2,693 rescue flights.

The yearly (1998) distribution of rescue flights for the air-

Figure 4. Estimated accessibility to the incident sites with non-aeronautic means of transport. (2,693 rescue flights between January 1998 and November 2000).

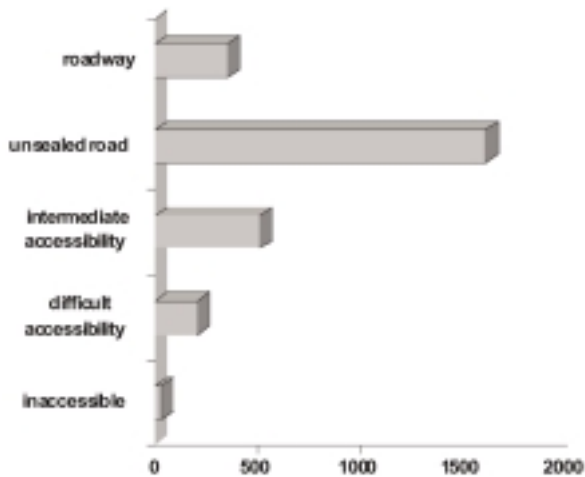


Figure 5. Flight operations to the incident sites. (2,693 rescue flights between January 1998 and November 2000).

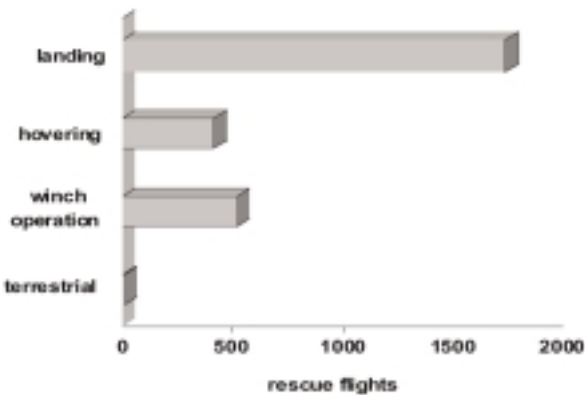


Figure 6. Accident site on the north face of Liskamm Mountain (4,200 m above sea level).



Case Report

To illustrate the sort of work carried out by the rescue service, the following case is described. The incident took place in the area southeast of Zermatt on a fine day in March. Two mountaineers were climbing the 4,527-m high Liskamm Mountain. They were walking on a narrow crest, approaching the peak from the east, when suddenly one of them slipped and fell into the north face of the Liskamm Mountain. A rope connecting them to each other was pulled down as well. The incident was observed by other mountaineers, who saw them disappearing down the north face and notified the alarm center immediately by radio.

Four minutes later, a Lama helicopter with the mountain rescue team started from the air base in Zermatt. Twelve minutes after takeoff, the helicopter approached the north face, where the mountaineers were discovered on a very steep ice field at an altitude of 4,200 m (Fig. 6). After a 200-m fall, an ice block had caught their rope and stopped them from falling another 700 meters to their certain deaths. They were hanging in a loop from each side of the ice block. One was waving but the other victims showed obvious grand mal seizure activity.

The mountain guide of the Zermatt rescue service was lowered down with the helicopter winch. He installed a central fixation device for himself, the patients, and the rescue teams to follow. The medical officer was the second to be lowered. The initial assessment showed one patient was alert and orientated but had chest trauma. He was stable enough to maintain a conversation and was left to be rescued by a second team. He suffered from pulmonary contusion and required intubation for respiratory distress in the intensive care unit of the regional hospital. The other patient was unconscious with a Glasgow Coma Scale score (Table 2) of 4, extending to a painful stimulus. He was cyanotic with partial airway obstruction and was tachycardic with a weak pulse. The likely extrication time was discussed with the mountain rescue guide and was estimated to be 20 minutes; therefore, the decision was made to intubate the patient. The patient was intubated on scene with a 7.5-mm tracheal tube, and 500 ml of colloid solution (Haemacel®) was infused. Inline stabilization and cricoid pressure were applied according to the rapid-sequence induction protocol. Anesthesia was provided using etomidate, fentanyl, and suxamethonium. After a hard collar was applied, the patient was log rolled on a rescue net and airlifted with the medical officer to a nearby landing area, where the patient

Table 2. Glasgow Coma Scale (Neurologic Assessment of Impaired Consciousness)

		Points
Eye opening	Spontaneous	4
	To speech	3
	To pain	2
	Nil	1
Best verbal response	Oriented	5
	Confused	4
	Inappropriate	3
	Incomprehensible	2
	Nil	1
Best motor response	Obeys commands	6
	Localizes to pain	5
	Withdraws to pain	4
	Abnormal flexion	3
	Extensor response	2
	Nil	1

was lowered on a vacuum mattress and further immobilized. A limited secondary survey was performed before take off, which confirmed the patient was now hemodynamically stable with good oxygenation. Bleeding from the tracheal tube and multiple hematomas of the chest wall suggested chest trauma. After additional monitoring (electrocardiogram, blood pressure, SpO₂, and EtCO₂) was initiated, the patient was transferred to the trauma center of the university hospital of Bern.

The initial hospital assessment showed systolic blood pressure of 130 mmHg and a pulse rate of 50 beats per minute. Both pupils were wide and did not react to light; the corneal reflex was negative. The initial computed tomography scan showed a severe cerebral edema with brainstem coning. A subdural hematoma of 2 cm with midline shift was noted as well. The patient died the following night from his severe head injury. The other patient made a good recovery.

CLINICAL ISSUES

Care of the Burn Patient: A Review

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Objective: To discuss burn patient management during the various phases of care in the prehospital environment, emergency department, operating room, and critical care unit, with emphasis on airway management.

Burned patients are probably the sickest patients a physician will ever see.¹ Major burns are associated with a high rate of multisystem failure and mortality.² Survival rates have improved over the past five decades due to improvement in many aspects of burn therapy, including emergency care, critical care, surgical care, anesthetic care, rehabilitative care, and, most importantly, the development of specialized burn centers operated according to guidelines from the American Burn Association (ABA).

Survival rates are still inversely affected by three risk factors: age >60 years, burn size >40% of total body surface area (TBSA), and the presence of inhalation injury.³ Predicted mortality is ~0.3% with no risk factors, 3% with one risk factor, 33% with two risk factors, and 90% with three risk factors. The relation between age and survival is biphasic, with mortality rates being lowest among patients 5 to 20 years old.⁴

Emergency Care of the Burn Patient

The burn patient is a trauma patient.⁵ The incidence and severity of inhalation-induced acute (or adult) respiratory distress syndrome (ARDS) is related to the number of breaths of smoke inhalation. At the scene, the priority is to isolate the

Summary

Over the past 30 years, Air Zermatt has developed a helicopter rescue service, that provides advanced trauma life support in even the most hostile and remote areas of the Swiss Alps. The service relies on teamwork and coordination among various dedicated professionals.

References

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patient from the heat source. Once rescued, the patient is provided with 100% oxygen and examined for associated trauma.

The “6 Cs” approach is applied for wound care: removing nonsticking clothing, cooling with water, cleaning with chlorhexidine, chemoprophylaxis, covering with a layer of gauze impregnated with petroleum jelly wrapped with absorbent gauze, and comforting (pain relief).⁶ Chemical wounds, particularly of the eyes, are irrigated immediately and continuously with water until arrival at a hospital.⁷ Neutralization of acids or alkalis is not attempted because it produces heat.⁸ Chemical burns caused by phosphorus, as in certain military burns, must be kept wet until complete surgical debridement.⁸ Burns caused by phenol are cleansed with polyethylene glycol in addition to prolonged irrigation with water. Burns caused by hydrofluoric acid are treated with topical calcium gluconate gel (2.5% q 2 hr) and calcium gluconate (1–3 g IV) to prevent a potentially lethal hypocalcemia. Esophageal alkali burns are treated subsequently with systemic steroids.⁹

At the hospital, the primary and secondary surveys of trauma are implemented, including toxicology screen and head computed tomography (CT) when indicated. Wound care continues by providing tetanus prophylaxis, analgesia such as morphine, topical antibiotics such as silver sulfadiazine, and elevating and cooling the burned area while protecting the patient from hypothermia.¹⁰

High-voltage (>1000 V) electrical burns cause deep tissue injury requiring escharotomy, fasciotomy, or amputation in 30% of cases.¹¹ Low-voltage (120–140 V) electrical burns cause minimal skin damage relative to the associated internal injury.¹² Lightning injuries cause all the complications of electrical injury, including fatal cardiac arrest.¹³ Continuous electrocardiographic monitoring and serial myocardial enzymes are indicated in electrical injury. Tetanic contractions may cause spinal cord injury, bone fracture, and rhabdomyolysis. The latter leads to hyperkalemia, hyperphosphatemia, hypocalcemia, and myoglobinuria. Myoglobinuria manifests as very dark “Coca-Cola-like” urine with no red blood cells on urine analysis. Treatment consists of lactated Ringer’s (LR) solution, with NaHCO₃ (50 mEq/L) and mannitol (12.5 g IV, every hour), with the goal of maintaining a urine output (UO) ≥ 2 ml/kg/hr and a urine pH ≥ 6.5.