ORIGINAL RESEARCH

Changes in Injury Patterns and Severity in a Helicopter Air-Rescue System Over a 6-Year Period

Marc Kaufmann, MD, HEMS; Berthold Moser, MD; Wolfgang Lederer, Prof, MD, HEMS

From the Department of Anesthesiology and Critical Care Medicine, Innsbruck Medical University, Innsbruck, Austria

Objective.—To study the influence of current trends in alpine sports on the frequency and types of injuries handled by a helicopter-based emergency medical system (HEMS) in a wilderness mountain region.

Methods.—A retrospective review of medical reports at a single emergency helicopter port (Christophorus-1 air rescue) in Innsbruck, Austria, was conducted for comparison between two 3-year periods (1998–2000 and 2001–2003).

Results.—Comparing the two 3-year periods, the proportion of leisure-time injuries leading to HEMS activation increased, whereas the frequency of life-threatening injuries significantly declined ($P = .001$). There was significant increase in injuries during mountain hiking and rock climbing ($P = .002$), during swimming ($P = .013$), and in avalanches ($P = .019$). Most injuries (70.1%) were recorded for skiers, and 68.3% involved tourists. During the investigation period, the high National Advisory Committee of Aeronautics scores showed a decreasing trend, whereas Glasgow Coma Scale scores and low National Advisory Committee of Aeronautics scores tended to increase ($P = .048$).

Conclusions.—For the HEMS in this study, there has been an increasing number of calls for help from persons involved in outdoor leisure activities. As the number of life-threatening injuries declines, HEMSs more frequently serve as means of rescue rather than as providers of emergency treatment.

Key words: high altitude and climbing, HEMS, air-medical transport, medicine in remote environments, wilderness trauma management, helicopter

Introduction

The availability of a helicopter-based emergency medical system (HEMS) in a wilderness region has been shown to significantly reduce mortality by extending rapid rescue and emergency medical care to victims.^{1–3} Physicians for a HEMS must be familiar with basic emergency care for all age groups and across several specialties.² With new and more adventurous activities promoted as part of a healthy lifestyle, HEMSs must react to new trends in outdoor sports such as skiing with carving skis, paragliding, canyoneering, trekking, and rafting. Rescue strategies need to be designed to respond to various medical challenges in extreme surroundings (eg, hypothermia and asphyxia resulting from avalanches).⁴ The development of rescue techniques is ongoing, as demonstrated by the use of stand-by search parties

and technical assistance with Recco tracing systems for avalanche rescue. In the case of glacier crevice falls, a “tripod” brace—a 3-legged rescue support placed on both sides of the crevice—and an ice cutter composed of a hydraulic chisel are used to free and extricate victims from a crevice.

Innsbruck is the capital of Tyrol, Austria, and has about 129 000 inhabitants. There are plenty of sporting and leisure facilities in Innsbruck’s surroundings, including skiing and snowboarding, paragliding, mountain climbing, trekking, and canyoneering. Leisure centers in high-altitude alpine regions, such as North Park and the Stubai Glacier (3300 m), are within a 1-hour drive.

During peak season in winter 2003–04, there were approximately 335 298 tourists per day in Tyrol in addition to the 646 809 residents. This number, however, does not include persons in transit through Tyrol. Over the past 10 years there was an increase from 5 to 14 HEMSs operated by 3 different providers in Tyrol. This equals approximately 1 HEMS per 70 150 persons and

Corresponding author: Dr Marc Kaufmann, Department of Anesthesiology and Critical Care Medicine, Innsbruck Medical University, Anichstr 35, A-6020 Innsbruck, Austria (e-mail: Marc.Kaufmann@uibk.ac.at).

provides one of the highest densities of emergency helicopters in Europe. In addition, 3 more helicopters without flight physicians are available during the winter months for rescue of victims with minor or no injuries. At present, all helicopters are coordinated by 6 dispatch centers.

Christophorus-1 air rescue was established in 1983. Today, its fleet includes 24 new, double-engine Eurocopter EC 135s that are especially equipped for high-altitude rescue. The service offers adult and pediatric emergency medical care and provides interhospital air-medical transport. Availability is ensured every day from dawn until nightfall unless bad weather prevents flying. The average response time from receiving call information to arrival on scene is about 13 minutes.⁵ With some overlap to neighboring HEMSs, the Christophorus-1 air-medical service covers an operational area of up to 450 km² with a diameter of approximately 150 km. Because of its special geographic location, Christophorus-1 serves 9 hospitals (5 in Austria, 1 in Italy, and 3 in Germany) all within a 15-minute flight distance. The 25-minute catchment area includes 17 hospitals (7 in Austria, 6 in Italy, and 4 in Germany). The total HEMS crew of Christophorus-1 consists of 3 pilots, 16 rescue technicians, and 25 physicians (21 from the Department of Anesthesiology and Critical Care Medicine, 2 specialists in internal medicine, and 2 surgeons).

Each year more persons travel from nonmountainous areas to the mountains of Tyrol, seeking recreation and relaxation. With an increasing focus on leisure sports, recreational injuries are on the rise. The tense financial situation of the Austrian national health insurance system can no longer cover the total HEMS costs unless the victims have supplementary leisure accident insurance. The purpose of this investigation was to determine the influence of recent trends in alpine sports on the frequency and types of injuries handled by our HEMS.

Methods

STUDY DESIGN AND STUDY ENVIRONMENT

A retrospective review of data from our HEMS program for two 3-year periods (1998–2000 and 2001–2003) was conducted by the senior author (W. Lederer). All patients who were treated and transported by the HEMS team of Christophorus-1 air rescue in Innsbruck between January 1, 1998, and December 31, 2003, were enrolled in this study. Type of incident, type and location of injuries, environmental factors, fatalities, and type of medical services provided for all patients were analyzed. We retrospectively evaluated the computerized emergency-care charts used by the Christophorus-1 emergency physi-

cians. Completion of data was compulsory, and the computer indicated to the users whenever data were lacking.

The on-duty flight physician determined the emergency category classification for individual cases. Patients who were employed were classified as occupational injuries when injured during work hours (eg, a ski instructor was classified as an occupational injury when injured on the job but classified as a leisure injury when injured off the job). In the case of missing scores (eg, in the Glasgow Coma Scale), missing data were indicated as “not specified.”

SCORING AND SCALING

Severity of disease and injury was classified according to the 7-point scoring system of the National Advisory Committee of Aeronautics (NACA). This allows ranking of injury severity and correlates with patient outcome (1 = minor, no transport; 2 = moderate, outpatient management; 3 = serious, hospital admission; 4 = severe, potentially life threatening; 5 = severe, immediately life threatening; 6 = critical, survival uncertain; 7 = death). Scores were pooled into minor (0–1), serious (2–3), severe (4–5), and critical (6–7). Head injury was classified by using the Glasgow Coma Scale for patients older than 4 years of age. These scores were pooled into mild-moderate (15–13), severe (12–9), and critical (8–3) injuries.

The terrain involved in the mission was classified on an 8-point scale according to topographical distinctions and accessibility (A = authorized landing place, B = highway, C = lanes, D = slopes, E = mountain huts, F = steep areas, G = rocky declivity, H = extreme overhanging). Both G and H were considered difficult terrain. In steep terrain, the medical crew either disembarks from the hovering helicopter or is lowered by rope to the site.

Statistical analysis was performed with the SPSS, v11.0, statistical package (SPSS Inc, Chicago, IL). The association among dependent variables (eg, pattern of injury) was analyzed by linear regression. Statistical significance was indicated at $P < .05$. Multivariate analysis of the interrelationship among dependent variables (eg, pooled NACA scores) was performed by logistic regression. Results were deemed significant when $P \leq .01$.

Results

Although the number of HEMSs providing air-medical rescue in Tyrol doubled over the 6-year study period, the total number of emergency calls received by the dispatch center also increased, leaving the average annual number of calls per HEMS within a comparable range. Between January 1, 1998, and December 31, 2003, there

Table 1. Overall distribution of patterns of injury and medical treatment and monitoring patterns during helicopter-based emergency medical system missions from 1998 to 2000 and from 2001 to 2003

	1998–2000 (n = 2639)		2001–2003 (n = 2679)		P value
	n	%	n	%	
Pattern of injury					
Skull	555	21.0	558	20.8	.968
Chest	318	12.1	400	14.9	.035*
Abdomen	149	5.6	97	3.6	.021*
Pelvis	101	3.8	115	4.3	.429
Spine	418	15.8	294	11.0	.066
Upper extremity	416	15.8	510	19.0	.015*
Lower extremity	637	24.1	858	32.0	.017*
On-site medical treatment and monitoring					
Airway management					
Oxygen	730	27.7	711	26.5	.521
Intubation	310	11.7	199	7.4	.024*
Pulse oxymetry	1843	69.8	1617	60.4	.104
Capnometry	124	4.7	50	1.9	.009*
Circulation management					
Intravenous access	1745	66.1	1705	63.6	.628
Circulatory drugs	301	11.4	275	10.3	.577
Electrocardiogram	1328	50.3	1140	42.6	.067
Noninvasive blood pressure	770	29.2	994	37.1	.029*

*Statistically different values.

were 5318 emergency calls involving 5417 persons, of whom 5075 needed medical treatment. There were 462 (8.7%) interhospital flights and 265 (5.0%) false alarms.

Calls related to trauma to the upper extremities ($P = .015$), lower extremities ($P = .017$), and chest ($P = .035$) significantly increased during the study period, whereas calls involving trauma to the abdomen ($P = .021$) declined. Injury to the skull was diagnosed in one fifth of the patients and did not increase during the investigation period. Comparison between the two 3-year periods revealed significant decline in the number of emergency intubations ($P = .024$) (Table 1). A total of 2017 persons were injured during leisure activities, not including traffic accidents on the way to and from leisure resorts. The average annual frequency of missions attributed to leisure-time injuries from 1998 to 2003 grew by 38.6% each year. Of all injuries, 70.1% involved skiers. Victims were more commonly older than 14 years (89%), male (65.1%), and tourists (68.3%).

During the 6-year study period, the frequency of injuries related to mountain hiking and rock climbing ($P = .002$), swimming ($P = .013$), and avalanches ($P = .019$) significantly increased (Table 2). The number of emergency calls initiated by victims and relatives increased significantly ($P = .032$). Within the same period,

the mean injury score declined, showing a trend toward decrease in victims with high NACA scores and an increase in those with high Glasgow Coma Scale scores. Accordingly, the number of low NACA scores tended to increase as well ($P = .048$) (Table 3).

Mission terrain was classified as easily accessible (A, B) in 29.9%, moderate (C, D) in 25.9%, steep (E, F) in 36.2% (Figure 1), and difficult (G, H) in 8.0% of cases (Figure 2). Rope rescue including standard procedures with 10- to 50-m lines was performed in 7.1% of cases and did not change in frequency during the investigation period. Since 2003, long-line missions (exceeding 80 m) have been introduced and were performed in 4 cases.

Four rescue helicopter crashes occurred in Tyrol during this investigation period. These did not involve patients but resulted in 2 injured crewmembers and 1 emergency physician killed.

Discussion

During the 6-year study period, we observed a rise in the number of HEMS calls for leisure-related injuries. There was a significant increase in HEMS calls for mountain hiking, rock climbing, swimming, and avalanche incidents. At the same time, we observed a sig-

Table 2. Comparison of frequency of injuries according to various categories of leisure-related incidents from 1998 to 2000 and from 2001 to 2003

Category	1998–2000 (n = 787)		2001–2003 (n = 1230)		P value
	n	%	n	%	
Skiing (on piste)	381	48.4	664	54.0	.101
Skiing (off piste)	7	0.9	15	1.2	.103
Snowboarding	94	11.9	148	12.0	.139
Avalanche	9	1.1	27	2.2	.019*
Glacier crevice falls	2	0.3	10	0.8	.058
Mountain hiking or climbing	159	20.2	214	17.4	.002*
Paragliding	26	3.3	32	2.6	.238
Aircraft	2	0.3	1	0.1	.135
Biking	31	3.9	29	2.4	.556
Roller skating	2	0.3	1	0.1	.573
Swimming	3	0.4	9	0.7	.013*
Diving	1	0.1	0	0	.805
Canoeing	3	0.4	1	0.1	.158
Canyoneering	0	0	1	0.1	.441
Rafting	1	0.1	0	0	.441
Horseback riding	9	1.1	4	0.3	.132
Other	57	7.3	74	6.0	.201

*Statistically different values.

nificant downgrading in NACA scores, whereas the tendency to call for medical assistance for minor injuries increased.

In the catchment area of Christophorus-1, there has been a considerable increase in the number of HEMS programs, providing one of the highest densities of HEMSs in Europe. By comparison, South Tyrol, Italy, has almost the same combined number of inhabitants and tourists and accessible alpine resorts as does Tyrol, yet there are only 3 HEMSs coordinated by 1 dispatch center. In light of the increasing availability of HEMSs

in Tyrol, the number of missions related to leisure-time incidents also increased. We attribute this to the growing use of mobile phones. In 2003, about 80% of all emergency calls in our catchment area were made from mobile phones. It may be that mobile phones offer persons a sense of safety and could be used as an attempted substitute for limited experience and inadequate equipment. In addition, the ready accessibility of HEMSs could encourage persons to take more risks than they would in the absence of rapid-rescue systems.

Many of the tens of thousands of tourists who come

Table 3. Multivariate analysis of pooled National Advisory Committee of Aeronautics (NACA) scores and pooled Glasgow Coma Scale (GCS) scores in leisure-related injuries from 1998 to 2000 and from 2001 to 2003

Category	1998–2000 (n = 787)		2001–2003 (n = 1230)		P value
	n	%	n	%	
NACA 0–1	29	3.7	39	3.2	.568
2–3	556	70.6	956	77.7	.012*
4–5	178	22.6	205	16.7	.450
6–7	24	3.1	30	2.4	.824
GCS 15–13	687	87.3	1133	92.1	.006*
12–9	15	1.9	21	1.7	.866
8–3	45	5.7	54	4.4	.597
Not specified	40	5.1	22	1.8	.229

*Statistically different value.

Figure 1. Helicopter-based emergency medical system mission in steep terrain. Photograph by T. Widerin, Christophorous-1.

Figure 2. Helicopter-based emergency medical system providing mountain rescue to a victim of rock climbing mishap in difficult terrain. Photograph by T. Widerin, Christophorous-1.

to alpine regions each year expose themselves to a multitude of risks and are often naïve of the dangers.² In the catchment area of Christophorus-1, most injuries prompting HEMS assistance were attributed to skiing, mountain hiking, rock climbing, snowboarding, and biking. The pattern of skiing injuries has changed over time as different ski, boot, binding, and slope-grooming technologies have evolved. An increase in injuries of the lower extremities and the knees has been partially attributed to the use of super sidecut skis.⁶ A rising trend in snowboarding was reflected in a higher incidence of emergency injuries necessitating immediate intervention and mostly involving the upper extremities.⁷ In our study, we observed a high frequency of injuries to the head, in agreement with findings in other studies.^{8,9} Severe injuries to the skull and spine were more frequently diagnosed during the low-snow seasons.¹⁰ Shorter et al⁹ have suggested that the use of helmets should be encouraged for skiers.

Risk-taking behavior, poor physical conditioning, lack of preparation, and underestimation of altitude and terrain are likely contributing factors to the increasing fre-

quency of injuries during mountain hiking and rock climbing. Limited safety awareness has been more commonly observed in middle-aged men.¹¹ A recent study of helicopter-rescued paragliders showed that too little experience and too many judgment errors are the most common factors contributing to incidents.¹² Adolescents are an age group particularly eager to engage in extreme sport activities and accept higher risks. For some, the risk taking becomes pervasive.¹³ Röggla et al¹⁴ found that attempts to induce a higher performance level by pharmacological means were not uncommon in leisure mountaineering. The frequency of injuries associated with alcohol, however, is underassessed.¹⁵ We assume that greater risk taking and the availability of rapid medical assistance by HEMSs may prompt an increase in HEMS missions. The decline in on-site emergency procedures (eg, intubation and capnometry) observed in our study can be attributed to the increasing number of HEMSs providing medical assistance to an increasing number of patients with less severe injuries. In his study on the effectiveness of HEMSs, Powell et al¹⁶ applied 4 categories of different risk levels evaluating patient cri-

teria (critical intervention, expected major deterioration of vital signs) and logistic criteria (possible transport by ground services, remote locations) in 400 consecutive missions. Although we might argue the indication for HEMS missions in some cases, Powell et al,¹⁶ however, judged the use of HEMSs as appropriate and reasonable in 91% of their reviewed cases.

The use of high-technology equipment in recreational sports demands intense training and skills but could give a false sense of security, contributing to underestimation of extreme situations and acceptance of higher risks. Extreme sports such as white-water rafting and kayaking are growing exponentially in popularity.¹⁷ There is little information on the safety and hazards of these activities. In our study area, with many rivers and gorges, only 1 rafting and 3 canoeing incidents required HEMSs. The number of victims of extreme sports was low in our study; therefore, the majority of rescues took place without the need for extra rescue technology. Considering this, it might be argued that special equipment, such as a tripod brace for glacier crevice rescues, Recco tracing systems for avalanches, or long-lines for canyoneering rescues, is not really justified because these rescue techniques demand ongoing and repeated training for all helicopter crews. However, we believe that though this special equipment adds to take-off weight and may limit HEMS operations at high altitude, the extreme conditions during rescue in the alpine environment necessitate the training and development of special rescue techniques that might rarely be needed.

Tyrol has 5 emergency rescue dispatch centers running a 24-hour service. In an emergency, each call is automatically allocated to the nearest dispatch center. Proper assessment of medical urgency, logistic facilities, hospital capacities, and coordination of rescue personnel is crucial during each operation. Although many leisure activists may expect accessibility to immediate rescue, HEMSs should not be dispatched before specific issues are evaluated, such as weather, location, and visibility.³ This necessitates a competent dispatch center to provide the specific preflight information mandatory for HEMS missions and to select indications for HEMS missions by urgency. Alternatives for evacuation and transport by snowmobile and on-foot teams should be utilized for patients with low-urgency injuries. To improve decision making and to increase dispatching sensitivity, Gijzenbergh et al¹⁸ recommended the implementation of medically supervised and standardized dispatching protocols.

Despite the increased risk of injury inherent in sports such as snowboarding, mountain biking, and rock climbing, many persons involved in these activities still lack formal medical insurance coverage.¹⁹ Such individuals should arrange for travel insurance before embarking on

their trip and should make sure that their health insurance policy specifically includes ambulance and helicopter rescue.

Also important to consider is the real risk of medical-helicopter incidents when HEMSs transport patients with minor injuries.²⁰ The risk of incidents is greater for HEMSs than for ground services and has to be taken into consideration whenever a HEMS is requested. During the investigation period, 4 rescue-helicopter crashes occurred in Tyrol. On the other hand, even minor injuries in high altitude and difficult terrain may become potentially life threatening and necessitate HEMS assistance unless such patients can be safely rescued by other means.

The results of our study are limited because we investigated the data for only a single HEMS station. Furthermore, evaluation of computed data was not blinded and was conducted by the authors themselves.

Conclusions

Injury pattern and severity have changed during the 6-year period of our investigation. The easy availability of HEMSs and the ability to rapidly access help with mobile phones may be responsible for an increasing utilization of HEMSs for leisure-time injuries with lesser degrees of severity. As the number of life-threatening injuries declines, HEMSs more frequently serve as means of rescue rather than as providers of emergency treatment.

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