Ann. Occup. Hyg., Vol. 57, No. 9, pp. 1180–1188, 2013

doi:10.1093/annhyg/met031

Safety in Alpine Helicopter Rescue Operations—Minimal Requirements of Alpine Skills for Rescue Personnel

THOMAS KÜPPER[1,2*], DAVID HILLEBRANDT[2], JUERGEN STEFFGEN[3] and VOLKER SCHÖFFL[2,4,5]

[1]Institute of Occupational and Social Medicine, RWTH Aachen University, 52074 Aachen, Germany; [2]Medical Commission of the Union Internationale des Associations d'Alpinisme (UIAA), 3000 Bern, Switzerland; [3]Department of Nephrology and Rheumatology, University of Göttingen, 37073 Göttingen, Germany; [4]Department of Trauma and Orthopedic Surgery, Klinikum Bamberg, 96049 Bamberg, Germany; [5]Department of Trauma Surgery, Friedrich Alexander University, 91054 Erlangen-Nuremberg, Germany

Received 21 August 2012; in final form 11 April 2013; accepted 9 May 2013; Advance Access publication 19 June 2013

Objective: There is a lack of data to establish minimal requirements for technical alpine climbing skills needed by rescue teams involved in alpine helicopter rescue operations to perform such operations safely.

Methods: A year of rescue operations (N = 2731) were investigated for the technical difficulties of the terrain. The difficulties were graded according to the Union Internationale des Associations d'Alpinisme (UIAA) scale for rocky terrain and steepness for ice slopes.

Results: For 99.7% of the operations, the terrain could be accurately evaluated. In at least 30.7% of all rescue operations, personal advanced alpine climbing skills were required for the rescue personnel, and in 6.0%, the difficulties of the rocky terrain correspond to UIAA scale grade III with another 2.4% to UIAA grade IV or above. About 1.5% of all operations took place in ice faces steeper than 50°.

Conclusions: To be able to manage 90% of all operations safely, all crew members, except the pilot, must be competent at climbing rock terrain of UIAA scale grade IV and ice of 50° steepness using appropriate rescue, rope, and belaying techniques. These recommendations include a technical safety margin for adverse conditions, such as bad weather.

Keywords: alpine rescue; helicopter; high altitude; minimal requirements; safety; training

INTRODUCTION

Alpine helicopter rescue operations involve complex variables factors, which expose the crews to numerous risks. Some such aspects are already well studied, e.g. noise or cold exposure (Küpper *et al.*, 2003, 2004) or minimal fitness requirements for maximum workload (Kupper, 2006; Callender *et al.*, 2011). Up to 82% of the total operational time in the field showed workload above the respiratory compensation point (Callender *et al.*, 2011). Although the data were obtained during simulated ground rescue operation at moderate altitude and not in helicopter operations, there is a general consensus that alpine rescue operations need well-trained team members to meet the demands (Callender *et al.*, 2011). For high-altitude rescue requiring acclimatization, an international guideline has also been established (Kupper *et al.*, 2009, 2011).

Other aspects are still debated. This includes the minimal requirements of technical alpine climbing,

*Author to whom correspondence should be addressed.
Tel: +49-(0)241-80-88880; fax: +49-(0)241-80-82587;
e-mail: tkuepper@ukaachen.de

experience on steep and difficult rock or ice walls, and rescue rope work, including anchoring (belay techniques). There is currently no systematic data about these aspects available and any discussion becomes very emotive since inadequate skills may pose a threat to the individual, the whole rescue team, and the patient. Until now, any discussion or recommendations concerning the minimal climbing skills of rescue team members has been based on personal opinion. It has been stated that 'safety is the utmost importance and everything possible should be done to minimize risk' (Tomazin *et al.*, 2011), but they do not define the technical skills needed. Instead they focus on logistics, technical (helicopter types), and medical skills. Although they obviously do recognize the special requirements of working in a mountain environment. Based on the data from several studies (e.g. Hotvedt *et al.*, 1996; Frankema *et al.*, 2004; McVey *et al.*, 2010), they clearly point out the advantages of a helicopter compared to a solely terrestrial operation. They also mention the multitude of risk factors influencing rescue crews and which have led to rescuers being killed in action (e.g. Baker *et al.*, 2006; Shimansky, 2008). Despite these comments, until now there has been no data on which to base technical ability recommendations, but experienced mountaineers will acknowledge that competence in the alpine environment is vital.

Only one paper deals with climbing capabilities, but the lack of data resulted in a vague statement that the rescuer '…must have technical mountain knowledge and experience. … training must include theoretical and practical skills for moving (climbing) in steep terrain in summer and winter conditions, selfbelay and other rescue manoeuvres, patient transport, management of avalanche victims and other specific emergencies.' (Rammlmair *et al.*, 2001).

Acknowledging the general consensus that alpine skills and training must be an integral part of preparation for any alpine rescue but the general lack of data concerning the level of climbing abilities, we investigated the technical alpine skills needed for rescue operations in the central European Alps. To realize this project, we choose two large regions, one in the Eastern and the other in the Western Alps both with access to helicopter bases. These regions cover a large portion of the European Alps and they take into account any possible differences between the Eastern and Western Alps.

MATERIALS AND METHODS

We examined a total of 2731 rescue operations from four helicopter bases over a period of 1 year. Two of the bases were in the Oberwallis region (Switzerland and Western Alps), contributing 1082 operations, and two in Tyrol (Austria and Eastern Alps), contributing 1649 operations. All non-technical alpine rescue operations were excluded [traffic accidents (N = 125), occupational accidents (N = 94), walking in the valleys (N = 160), interhospital transfers (N = 20), etc.]. All accidents or emergencies on resort prepared ski slopes (N = 1097) were also excluded. These exclusion criteria ensured that only alpine rescue operations were included taking place in typical high-altitude terrain of the Central Alps on glaciers, snow slopes, rock and ice faces, ridges, and summits (e.g. Matterhorn 4477 m, Monte Rosa 4639 m).

For any operation, the following parameters were analyzed: altitude of the site of the operation, National Advisory Committee for Aeronautics (NACA) terrain index [National Advisory Committee for Aeronautics, 1960 (rev. 1980); Kohlhammer, 1968], and the difficulty of the terrain rated by Union Internationale des Associations d'Alpinisme (UIAA) scale (Fig. 1; Graydon, 1997; Cox and Fulsaas, 2003; Schoffl *et al.*, 2011) for rock or combined terrain and steepness for ice faces or glaciers. NACA index, UIAA scale, and ice steepness were rated by the investigators by a detailed analysis of the reports, either by personal experience of the respective climb, by personal experience from rescue operations at the same site, by interview of crew or rescue team members, or by the standard guidebooks of the alpine clubs, which give detailed information for most climbs, often with sketchmaps indicating the difficulty for any single pitch (so-called 'topos').

The data were evaluated by descriptive statistics. The subsets Tyrol versus Wallis were compared with non-parametric procedures (Mann–Whitney U-test). $P < 0.05$ was defined as significant.

RESULTS

A total of 452 operations were eventually included in the study, 206 from Tyrol and 246 from the Wallis region. For 99.7% of them, the terrain could be evaluated exactly. For the remaining 0.3% (N = 2), the difficulty was estimated as carefully as possible. Since the location was accurately known, this was possible to within ±1° of difficulty on the UIAA rock scale. According to NACA terrain index, 62.2% of all operations were performed in remote but easy or moderate difficult terrain (NACA d or e), but at least

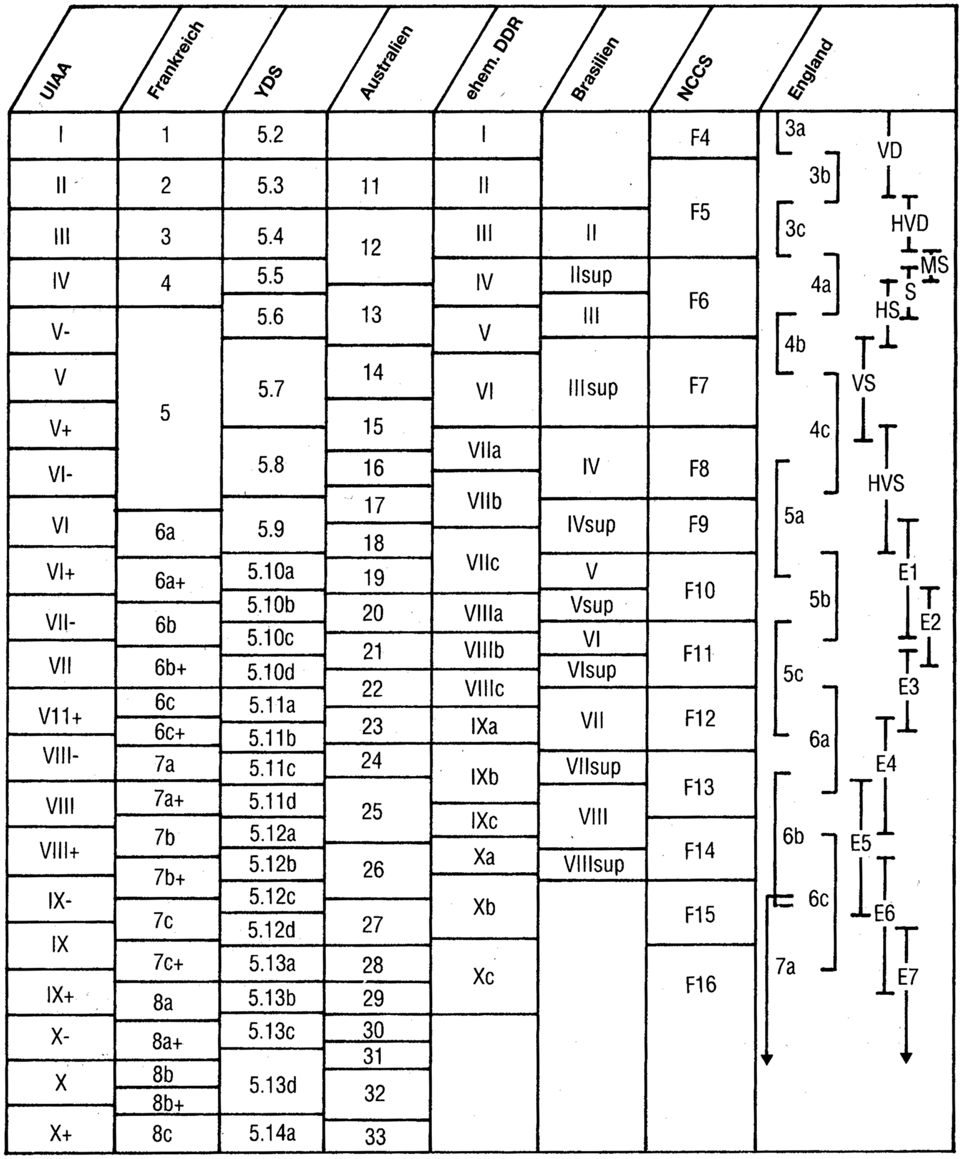

Fig. 1. UIAA scale (and other rating systems to transfer our recommendations to other regions) used for rocky terrain (from Graydon, 1997, with permission of the publisher). Terrain difficulty increases from grade I to X+: experienced mountaineers need a handhold from time to time at grade I. Alpine tour of grade V are for experienced climbers only and include some of the most important and famous alpine climbs. Grade VII and more indicates hard extreme (sports) climbing, which can be done with regular and specific training only. The hardest climbs worldwide so far are rated XII−. In contrast to all the other scaling systems worldwide, the British system includes the risk of a respective climb as an independent part of the rating system. VD (very difficult) describes safe climbs, and E6/E7 at the other end of the scale indicates routes where a climber will not survive if he or she should fall. YDS, Yosemite Decimal Scale (USA/Canada), NCCS, National Climbing Classification System (USA). For details about grading, see also http://en.wikipedia.org/wiki/Grade_(climbing) or http://www.alpinist.com/p/climbing_notes/grades.

5.9% in difficult or extreme terrain (NACA f or g; Table 1). Compared to Tyrol, the terrain difficulties in the Western Alps are significantly higher ($P < 0.001$).

The terrain difficulties were differentiated according to the technical alpine disciplines involved and were rated—where applicable—according to UIAA scale for rock climbing or ice

Table 1. NACA terrain indices of the rescue operations (in percentage of all operations).

NACA terrain score	All regions	Wallis	Tyrol
a	6.2	4.2	7.5
b	3.0	2.6	3.2
c	16.2	5.3	23.2
d	45.0	56.5	37.5
e	17.2	21.7	14.3
f	3.7	2.1	4.8
g	2.3	0.1	3.6

(steepness). Details of the analysis are given in Fig. 2. In at least 30.7% of all rescue operations, personal advanced alpine skills were required of the rescue personnel, and in 6.0%, the difficulties in rocky terrain correspond to III° UIAA with another 2.4% to IV° or higher UIAA. About 1.5% of all operations took place in ice faces steeper than 50°.

There are significant differences between Tyrol and Wallis (Figs 3 and 4): while advanced alpine skills are necessary in 30.1% of the operations in Tyrol, this is 36.9% in the Wallis region ($P < 0.01$). These data do not include avalanches, accidents involving aircraft of various types, e.g. where parapenters may have to be rescued from inaccessible places, and some other rescue operations in inaccessible mountain terrain. If these cases were included, a portion of at least 40% of the analyzed rescue operations needed advanced alpine skills.

DISCUSSION

We investigated the difficulties of the terrain, which have to be managed safely by the crews of alpine rescue operations in the Central Alps. The helicopter bases included in the study represent typical mountaineering regions comparable to others investigated in previous studies (e.g. Marsigny *et al.*, 1999). Furthermore, the range of the rescue operations of these bases covers most of the central alpine mountaineering [not included is the Montblanc region (France) and the Hohe Tauern in Austria]. Although there were some significant differences between the operations in Tyrol and Switzerland, most of them are not relevant for a discussion about minimal technical requirements and operational safety. Therefore, the following recommendations are based on both regions. The only difference with consequences for occupational health and safety is the significant longer time of noise exposure in Austria, which has been discussed extensively in an earlier paper (Küpper *et al.*, 2004).

Although intensely discussed using case studies, there is currently no hard data available to establish the minimal requirements for personal climbing skills when rock and ice climbing, safe movement on crevassed glaciers or on steep snow terrain. Such skills imply the ability for safe belaying and other so-called ‘alpine and ropework skills’. Such skills are learnt during a mountaineering apprenticeship and are also included in the

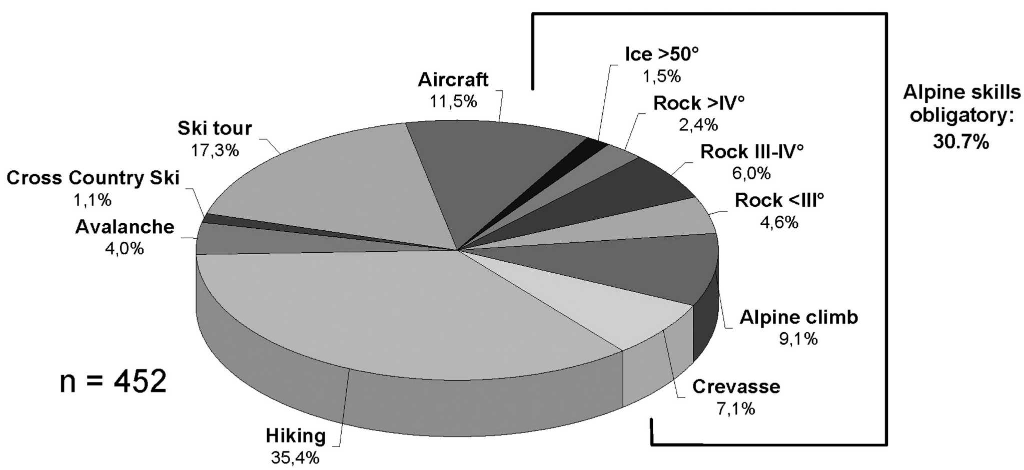

Fig. 2. Alpine rescue operations (all helicopter bases and regions) according to different sport disciplines and—where applicable—differentiated according to UIAA scale for rock climbing and steepness of ice. ‘Aircraft’ indicates accidents with any type of flying system used for sports (parachutes, gliders etc.). ‘Avalanche’ indicates accidents on ski tours, where the victim was buried or injured by an avalanche. This category was included because it requires tactical and technical skills, which differ significantly from those of a ‘normal’ accident on ski tours.

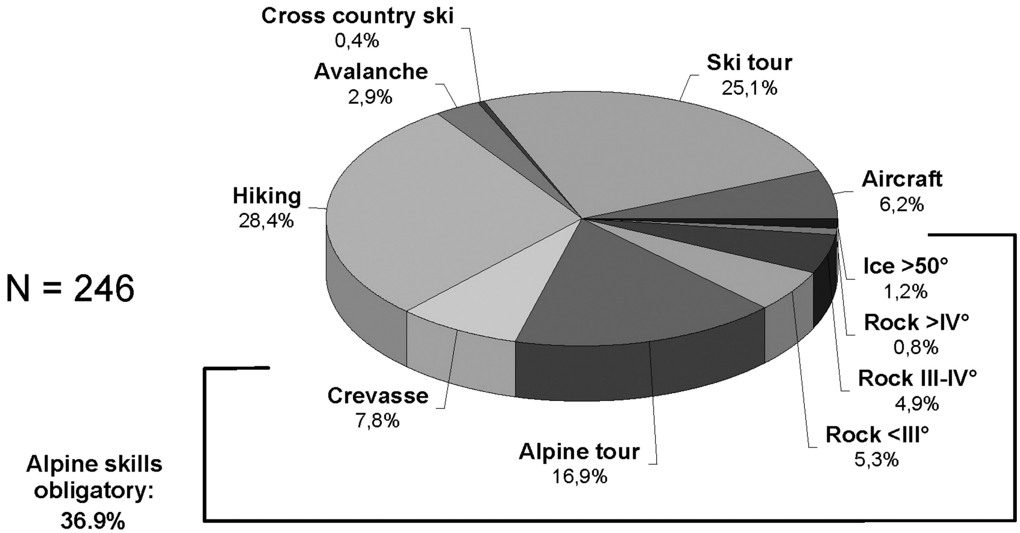

Fig. 3. Rescue operations in the Wallis region according to different sport disciplines and—where applicable—differentiated according to UIAA scale for rock climbing and steepness of ice. For 'aircraft' and 'avalanche', see Fig. 2.

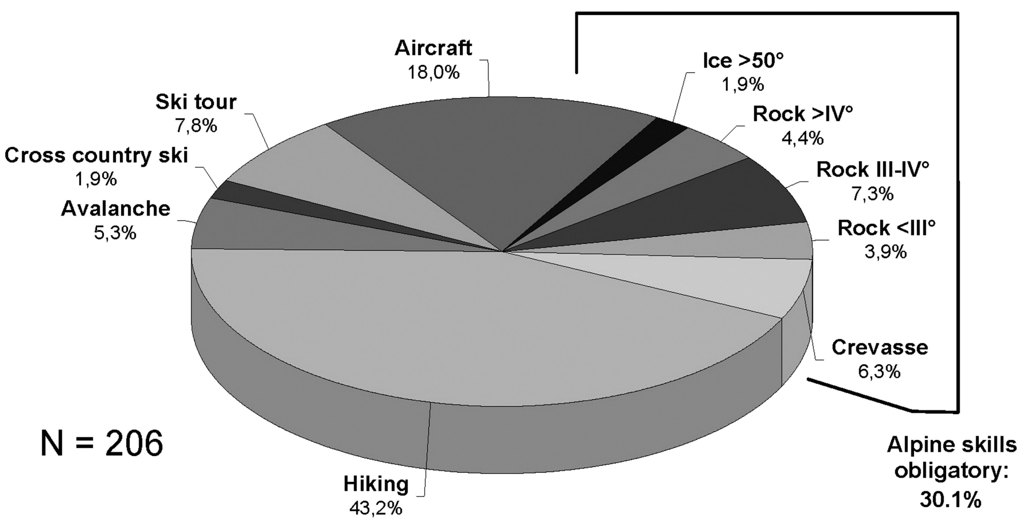

Fig. 4. Rescue operations in Tyrol according to different sport disciplines and—where applicable—differentiated according to UIAA scale for rock climbing and steepness of ice. For 'aircraft' and 'avalanche', see Fig. 2.

list of learning targets of any mountain rescue organization worldwide. In addition to both physical and psychological fitness, it is mandatory that rescuers have specific training in climbing, mountain rescue, and mountain medicine to be relaxed and able to work safely in these potentially hostile environments (Jenny, 1994). Our data show that, depending on the region, specific alpine training and knowledge are necessary in 30–40% of the alpine rescue operations.

So far, most studies about alpine emergencies focus on medical topics and technical aspects or safety after the emergency has happened are neglected (Shimanski, 1998) and the limited reports available are anecdotal and often written by victims (e.g. in Shimanski, 1998; Litch, 1999). Both, Shimanski (1998) and Litch (1999), point out, that in addition to the external factors, which cause significant strain on the rescuers and which may impair the monitoring of the patient (Myers *et al.*, 1995), there is an additional specific risk factor identified as 'human error' or 'human factor' (Shimanski, 1998; Litch, 1999). Shimanski (1998) concludes: 'Rescuers must be mountaineers first, rescuers second,' a situation that has been summed up by B. Yelk (mountain guide and officer in command of the mountain rescue division in Zermatt, Switzerland): 'I don't need a doctor for whom I need two guides just to prevent him from falling down the mountain!' (personal communication, 1998). The data presented should now enable the responsible bodies to establish minimal requirements for rescue crews (except mountain guides who are independently trained and assessed).

Technical mountaineering difficulty at the location of the emergency is one important factor that defines the risk/safety balance for the rescue crew, but there is little data available. An old study from the region near Innsbruck (Austria) reported 7.9% of all operations in difficult or extreme terrain (Bonatti *et al.*, 1992). But the data in the paper are not detailed enough to support any minimal requirements. The same problem exists in the study from the Ennstal region (Steiermark, Austria), where 24% of all operations had to be performed in undefined: 'not easy conditions' (Fasching and Pretscher, 1992). The German Alpine Club statistics also indicate that a significant number of rescue operations are performed in again undefined: 'demanding terrain'. For the period 1989–2003, there was an average of 19.2% of operations in terrain of III° UIAA scale or harder with additional 16.9% on glaciers or alpine tours and 12.6% on ski tour, all together 48.7% (Schubert, 1990, 1991, 1992, 1993, 1998, 2000; Randelzhofer, 2002, 2004). In 1991, 57% of the mountain accidents in Switzerland were rated according to NACA d, 32.9% NACA e, 7.8% NACA f, and 1.3% NACA g (Durrer, 1993b). However, because there is no correlation between the NACA terrain index and any 'alpine' scale, the data cannot be used to establish minimal alpine requirements. Nevertheless, Durrer (1993b) summarized that 'with such an amount of difficult terrain advanced alpine skills are mandatory for any crew member of alpine rescue operations, physicians included.' Special circumstances have to be taken into account operations where the winchman or rescuer is often left alone on scene. In his study, there were 15% winch operations and another 5% so-called 'hot loading' (patient, material, and crew are loaded while the helicopter is hovering with the engines running full power on moderate steep slopes). A comparable report was published with 17.3% winch operations and 2.1% 'hot loading' in the Western Alps (Kupper, 2006). It should be pointed out that >75% of the patients of Durrer's study were rated as 3–6 according to NACA injury index with the consequence, that therapy by a physician was required on scene, even in difficult terrain (Durrer, 1993b). These data were confirmed later by Küpper's study with 56.8% of NACA 3–6 patients (Kupper, 2006). According to others, Durrer himself characterizes the ideal mountain physician as 'active mountaineer and climber who has at least some knowledge in emergency medicine' (Jacomet, 1991; Durrer, 1993a; Shimanski, 1998).

This statement is in complete agreement with the data of our study. In contrast to urban emergencies, the deployment of a helicopter in alpine regions is often dictated more by the terrain than by the medical condition of the patient (Jacomet, 1991; Kupper, 2006). The large percentage of patients with moderate or high medical risk increases the need for a rescue physician rather than reduces the need as was claimed by earlier authors (e.g. Schwitzer, 1994). Because of the long transport times and distances from the mountains to the nearest hospital, a 'take and run' policy is not an option. For severely ill or injured patients (NACA ≥4), there a is a well-established international consensus that the patient benefits from on scene treatment by a emergency physician (Zäch, 1974; Riedinger and Sefrin, 1980; Rhee *et al.*, 1986; Fasching and Pretscher, 1992; Sefrin and Sellner, 1993). Consequently, technical alpine skills are essential for rescue physicians and several authors. Fasching and Pretscher (1992) confirm this and it has also been included in the recommendation of the International Commission for Alpine Rescue (IKAR), but here, as in other papers, without specific data about the requirements in alpine techniques and the difficulty of the terrain (Rammlmair *et al.*, 2001; Tomazin *et al.*, 2011). The data presented here defines the minimal recommendations for alpine skills in more detail and should apply to all crew members excluding the pilot.

Two other factors that need to be taken into account are as follows:

1. On extreme terrain or in extreme weather, it may be impossible to perform any medical procedures. Initial analgesia may be needed, e.g. ketamine or morphine, injection into M. femoris through the clothes whenever there should be problems to establish an intravenous line or if there is a high risk for frostbite in extreme weather conditions (e.g. Küpper, 2010). Surely, intranasal diamorphine or ketamine or fentanyl

lozenges are much better because in cold environment with a shocked patient intramuscular route frequently does not work until the patient arrives in a warm receiving hospital. In extreme terrain, technical rescue must come first.

2. It is not realistic that all the medical crews are trained as fully qualified mountain guides although occasionally some physicians may be dual qualified.

It should be noted that the phrase 'relatively easy terrain' is well established within the mountaineering world and is only 'relatively easy' for experienced alpinists. It would be considered dangerous or even life threatening for inexperienced people. Any recommendations must take this into account and also acknowledge that many rescues, by necessity, take place in adverse weather, which make any technical movement over wet or icy rock more difficult and complex. In these conditions, a skill reserve is essential.

Our data show a group of technical rescues consisting of 7.1% glacier accidents, 9.1% (high) alpine tours, 4.6% rocky terrain <III° UIAA scale, 6% III–IV°, 2.4% >IV°, and 1.5% ice walls >50°. Theories of risk management and risk acceptance (Kupper, 2006) demand that the alpine experience and training of the rescue crew should cover 90% of all operations. Therefore, any crew member (pilot excepted) should be technically proficient on all categories of rock to UIAA grade IV and on ice up to 50°. Although unroped 'solo' climbing should never be normal practice during a rescue, alpinists with this degree of experience will often be able to solo UIAA grade III rock and ice to 40°.

In technical terms, the medical crew must be able to safely manage winch operations or long line operations where rescuer and equipment are suspended under the helicopter but also the terrain detailed above and any belaying or ropework technique needed on such terrain. Medical treatment is impossible on truly extreme terrain or in extreme mountain weather. In these cases, the only option is to perform a two-stage rescue. First, a winch or long line to remove the patient from the extreme situation, and then to stabilize the patient in a more secure environment where rescuers can operate with their hands free. As previously stated, this may not be an area considered 'safe' to an inexperienced alpinist.

Most rescuers have considerable alpine experience and skills prior of joining a rescue team; however, all European rescue organizations do assess aspirant members skills and have learning targets and lists of expected essential skills. It is interesting to compare our data-based recommendations with the minimal requirements for aspirants of the Bavarian Mountain Rescue ('Bergwacht Bayern'). These requirements were previously established as armchair decisions, but the listed minimal requirements are nearly identical to ours, e.g. safe travelling in terrain of UIAA grade III (e.g. http://www.kvberchtesgaden.brk.de/index.htm?/bergwacht.php). Historically, several organizations have copied the Bavarian recommendations and still work with them. For other international areas where other grades are used for rock difficulties, Fig. 1 may be used to easily convert our data. Additional knowledge of rock and ice fall, avalanches, snow pack formation, load capacities of anchors, and safe moving on crevassed glaciers is also vital.

CONCLUSION

By an analysis of rescue operations in the Central Alps, it is now possible to establish minimal requirements for alpine skills for the medical crew members of helicopter rescue operations. To be able to manage 90% of all operations safely, they must be competent in climbing rock terrain of UIAA scale grade IV and ice of 50° steepness (both at good conditions) with the appropriate ropework and belaying techniques combined with knowledge of additional alpine hazards such as avalanches and rock or ice falls. This recommendation includes a safety margin for the crew members if the weather conditions should deteriorate.

Recommendations and future work

Currently, some helicopter rescue team members do not fulfill these recommendations and we acknowledge the valuable work currently done by them with their extensive experience. It would be dangerous to suddenly implement our recommendations, but future members should be fully assessed and current active members encouraged to do everything possible to come up to standard, partly for their own safety and for operational safety.

In this paper, we have only investigated helicopter rescue. Up to now, there are no data available concerning the 'alpine' requirements of ground rescue operations. It may be assumed that they may be even harder, at least for aerobic (endurance) fitness.

FUNDING

'Research Award' of the Austrian Society for Alpine and Altitude Medicine (ÖGAHM); 'E.W. Baader Award' of the German Society of Occupational and Environmental Medicine (DGAUM).

Acknowledgements—The investigation is subproject of the research project 'Demands on Rescuers at Alpine Accidents.'

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