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Original article

Clinical and logistical factors in aeromedical rescue: A retrospective study

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Abstract. *Background and aim:* One of the main reasons for healthcare professionals to intervene with a patient engaged in sports activities is trauma. In the case of severe traumas or incidents that occur in hard-to-reach locations, the preferred method of transport is aeromedical evacuation. Unfortunately, there is limited published evidence regarding this subject. Therefore, an epidemiological analysis was conducted to understand the primary cause of dispatching medical transport to mountainous regions. *Methods:* A retrospective observational analysis was conducted using the HEMS database from 1/1/2009 to 12/31/2019. The database collected interventions carried out through aeromedical services in the italian regions of Lombardy, Veneto, and Trentino-Alto Adige. *Results:* out of 31,063 missions, 14,155 (45.5%) were medical and 11,717 (37.7%) were traumatic. High-altitude rescues (>1,500 meters) involved 4,761 patients (15.3%), with 3,791 (35.7%) from sporting activities. RTS significantly decreased from mission start to hospital arrival (7.2 vs. 6.9; p<0.001). The NACA score indicated that 1,755 (68.8%) patients needed prompt hospitalization. *Conclusions:* This study examines how seasonal variations and activities impact helicopter rescues. Moreover, RTS and NACA score reveal that most rescues involve complex cases needing rapid transport and hospitalization. The research underscores the necessity for specialized strategies and equipment for high-altitude rescues and calls for further investigation into the logistics and clinical management of these missions. (www.actabiomedica.it)

Key words: mountain, aeromedical, emergency medicine, sports, trauma

Introduction

Engaging in sports activities is essential for maintaining a healthy life and avoiding chronic conditions (1,2); however, such activities can also expose athletes to significant emergencies, which may arise from acute medical conditions (3) or traumatic incidents (4,5). The nature of these emergencies can vary depending on the type of sport and the individual's medical history (6,7). In the event of a medical or traumatic emergency, prompt first aid provided by bystanders or those involved in the sporting activity is crucial (3,8). Effective first aid, however, necessitates proper training for both bystanders (9,10) and other athletes (11,12). In Italy, during a medical emergency, it is necessary to contact the emergency medical services (EMS) by dialing the emergency telephone number 112, particularly when the individual's clinical condition requires immediate transportation to a hospital. The dispatch center for emergency healthcare (118) coordinates the dispatch of the most appropriate type of vehicle (13). The EMS-dispatch center can send various

types of vehicles to the scene, including basic life support (BLS) ambulances, advanced life support (ALS) ambulances (14), or helicopters (HEMS) (15,16). The choice of vehicles is based on the severity of the patient's condition and the transport time, with the distance from the nearest hospital being a crucial factor (17). However, there might be situations where logistical challenges, rather than the clinical severity, dictate the choice of vehicle (18,19). For example, during mountain sport activities (20), the Helicopter Emergency Medical Service (HEMS) may be necessary due to the difficulty of ground vehicles in accessing the event site, even for cases of minor traumas (21). In recent years, the number of incidents related to mountain sports has increased (22), despite a significant reduction during the COVID-19 pandemic (23-25) due to stay-at-home policies (26). The rise is primarily due to sports-related traumas such as skiing, snowboarding, and others (27-29). In these cases, the patient might suffer severe trauma, necessitating helicopter rescue for a timely hospital admission due to clinical reasons. Alternatively, the patient could have a lower severity code, and the dispatch of the helicopter may be due to logistical issues as excessive distance from the hospital or inaccessible roads (30). Despite the importance of helicopter emergency services in rescuing individuals involved in sports-related trauma, there is limited evidence on the specific use patterns of the EMS systems. In northern Italy, HEMS are managed by the dispatch centers of the EMS, which have the authority to decide whether to dispatch the helicopter based on logistical reasons or the severity of the patient's condition. The health professionals in the HEMS system are trained in emergency management and retrieval (31). They can perform advanced cardiovascular life support (ACLS) or advanced trauma life support (ATLS) algorithms, even in mountainous areas (32-34). In many cases, trained personnel are involved in missions that focus on simple retrievals. However, there is limited data on the volume of retrieval activities (35). This study aims to analyze the rescues recorded in three major regions of northern Italy to understand the characteristics of these emergency interventions. The study examined the HEMS databases of the Lombardy, Veneto, and Trentino-Alto Adige regions.

Materials and Methods

Data collection

This retrospective observational study was conducted on the HEMS database from 1st January 2009 to 31st December 2019. We analized 31,063 registered HEMS interventions.

This analysis examined missions conducted in three Italian regions: Veneto with 4 helicopters (Pieve di Cadore, Treviso, Padova, and Verona), Trentino-Alto Adige with 3 helicopters (Bolzano, Bressanone, and Lasa), and Lombardy with 5 helicopters (Sondrio, Como, Bergamo, Brescia, and Milan). The orographic characteristics of these regions differ significantly. Lombardy (total 23,864 km²) comprises 9,650 km² (40.4%) of mountainous terrain, 2,968 km² (12.4%) of hilly land, and 11,246 km² (47.1%) of plains. Trentino-Alto Adige (total 13,606 km²) consists entirely of mountainous terrain, covering 13,606 km² (100%). Meanwhile, Veneto (total 18,407 km²) encompasses 5,346 km² (29.0%) of mountainous terrain, 2,656 km² (14.4%) of hilly land, and 10,405 km² (56.5%) of plains. The database is a tool promoted and managed by the HEMS association (Mountain Hems Association). Every rescue base can participate in the data collection by entering their rescue mission data in the database. Data collection began on 1st January 2009 and continued until 31st December 2019. Additionally, the collection was interrupted due to the COVID-19 pandemic. The Lombardy region was the first region involved, followed by Veneto and Trentino-Alto Adige. The various bases progressively joined the data entry process over the ten-year period.

Each helicopter rescue base affiliated with the HEMS association has a database manager responsible for verifying the accuracy and completeness of the entered data. Informed consent is not required from patients because sensitive patient data is not entered in the database, and the helicopter's departure base is not recorded within the system. Therefore, it is not possible to link individual interventions to a specific base. The database contains logistical data of the rescue (rescue altitude, external temperature, weather) and clinical characteristics of the patient.

Statitical analysis

Categorical variables are presented as frequencies and percentages, while continuous variables are expressed as means and standard deviations (SD). The average number of rescues for sports-related and non-sports-related events was analyzed using a one-way ANOVA test. Differences were considered statistically significant when $p<0.05$.

Results

Out of 31,063 registered interventions in the HEMS database, 14,155 (45.6%) were medical events, 11,867 (38.2%) were traumatic events, and the remaining 5,040 (16.2%) were unclassified events. The average age of patients was 49.8 (SD: 22.8), and 21,068 (67.8%) subjects were male. Out of the total, 22,286 (71.7%) patients were of Italian nationality. The number of rescues for individuals engaged in recreational, sporting, or excursion activities is 10,603, 34.1% of the total. Among these, 2,162 (20.4%) cases involved an acute medical event.

4,159 (47.1%) cases were classified as a major traumatic event and assessed through the Revised Trauma Score (RTS). Among these, 3,402 (81.8%) patients had a RTS <9 at the beginning of the rescue mission, which represents an indicator of severe clinical impairment. A reduction in the RTS was observed from the one measured during the beginning of the mission, to the one assessed at hospital arrival (7.2 (3.0) vs 6.9 (3.1); $p<0.001$). Among the patients rescued during sporting activities, 3,791 (35.7%) were rescued at an altitude higher than 1,500 meters. If we analyze the clinical characteristics of these patients, 52 were intubated with an endotracheal tube (IOT). There were 74 subjects with an altered level of consciousness; among these, for 24 patients the loss of consciousness was unwitnessed. ACLS maneuvers were initiated in 46 subjects. Return of spontaneous circulation (ROSC) was achieved in 16 patients.

Figure 1 shows the number of rescues per month. During the winter months of January and February, the overall number of rescues decreases. However, the ratio of rescues for sports-related and non-sports activities remains similar during those months. During the summer and spring, the number of missions increases, particularly for non-sport events. Table 1 shows the number of subjects rescued above 1,500 meters and their activities before the rescue. 4,761 patients were rescued above 1500 meters, 15.3% of the total rescues.

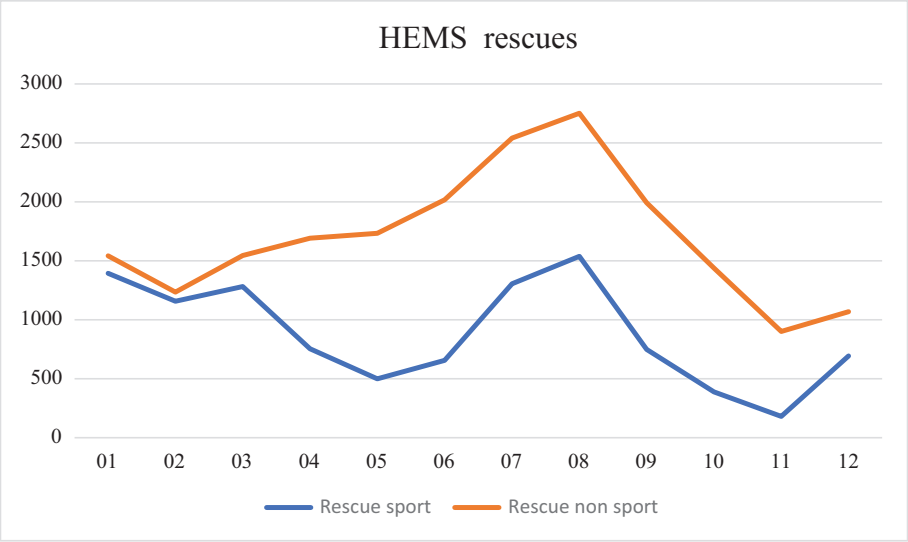

Figure 1. Number of rescues per month conducted by HEMS. ANOVA test F (1ù,22)=16,24, $p<0.001$.

Table 1. Type of sport practiced by the subject rescued at an altitude higher than 1500 meters.

Sport	Altitude >1500 m	% sport
Alpine skiing	1532	40.4%
Hiking	886	23.4%
Mountaineering	443	11.7%
Other	157	4.1%
Mountain biking	102	2.7%
Snowboarding	216	5.7%
Ski mountaineering	177	4.7%
Off-piste skiing	91	2.4%
Motorcycle riding	31	0.8%
Sledding	25	0,7%
Paragliding	24	0,6%
Ice climbing	23	0,6%
Mushroom picking	18	0,5%
Road cycling	13	0.3%
Hunting	12	0,3%
Snowshoeing	13	0,3%
Cross-country skiing	15	0,4%
Horseback riding	5	0,1%
Rock climbing gym	3	0,1%
Hang gliding	3	0,1%
Ice hockey	1	0,0%
Ice skating	1	0,0%

Table 2 shows the comparison of the Revised Trauma Score (RTS) at the beginning and at hospital admission for patients with traumatic conditions rescued at more than 1500 m altitude. The RTS was assessed for 1,177 patients and it remained stable for the majority of patients (977, 83.0%); it decreased for 128 (10.9%) and increased for 72 (6.1%) patients, as reported in Table 2.

Figure 2 shows the National Advisory Committee for Aeronautics (NACA) score of patients rescued above 1,500 meters. The NACA score was assessed for 2,549 patients.

The NACA score is related to the initial assessment of the patient. Based on the subjective severity observed in the patient, the health professional decides on a code to determine whether the patient requires immediate transport to the emergency department or

Table 2. RTS of patients rescued at more than 1500 m altitude.

RTS at the beninning of the rescue \ RTS at hospital admission	3	4	5	6	7	8	9	10	11	12
3		1								
4		2								
5		2	432		1	1	16			
6										
7					2	22			3	10
8		1	1		2	250	3			1
9			74	2		4	150			
10					1		1			2
11					3	2			7	12
12					1	32			2	134

not. In our analysis, 1,755 patients (68.8%) had a score greater or equal to 3, thus indicating a high-risk patient that requires prompt hospitalization. 127 patients had a NACA score of 7, so were assessed as dead.

Discussion

This study aims to analyze the recorded helicopter rescues of three northern italian regions to better understand the characteristics of these emergency interventions. Our analysis utilized the HEMS database, a tool used by rescue bases to collect intervention logistics and mission outcomes. The database is valuable for epidemiological investigations. The timing of providing rescue during the management of a medical emergency is crucial (36,37). It is directly linked to patient outcomes and their chances of survival. Furthermore, numerous factors, such as environmental conditions, can influence the patient survival rate and affect the patient's outcome during the management of an emergency (38,39). This aspect is particularly pertinent during high-altitude rescues managed by helicopters. Activities performed by individuals can also have significant clinical outcomes. For instance, sports can lead to urgent medical situations in otherwise healthy individuals, even though such events are less frequently related to acute medical reasons (3) and more frequently to traumas (40,41). According

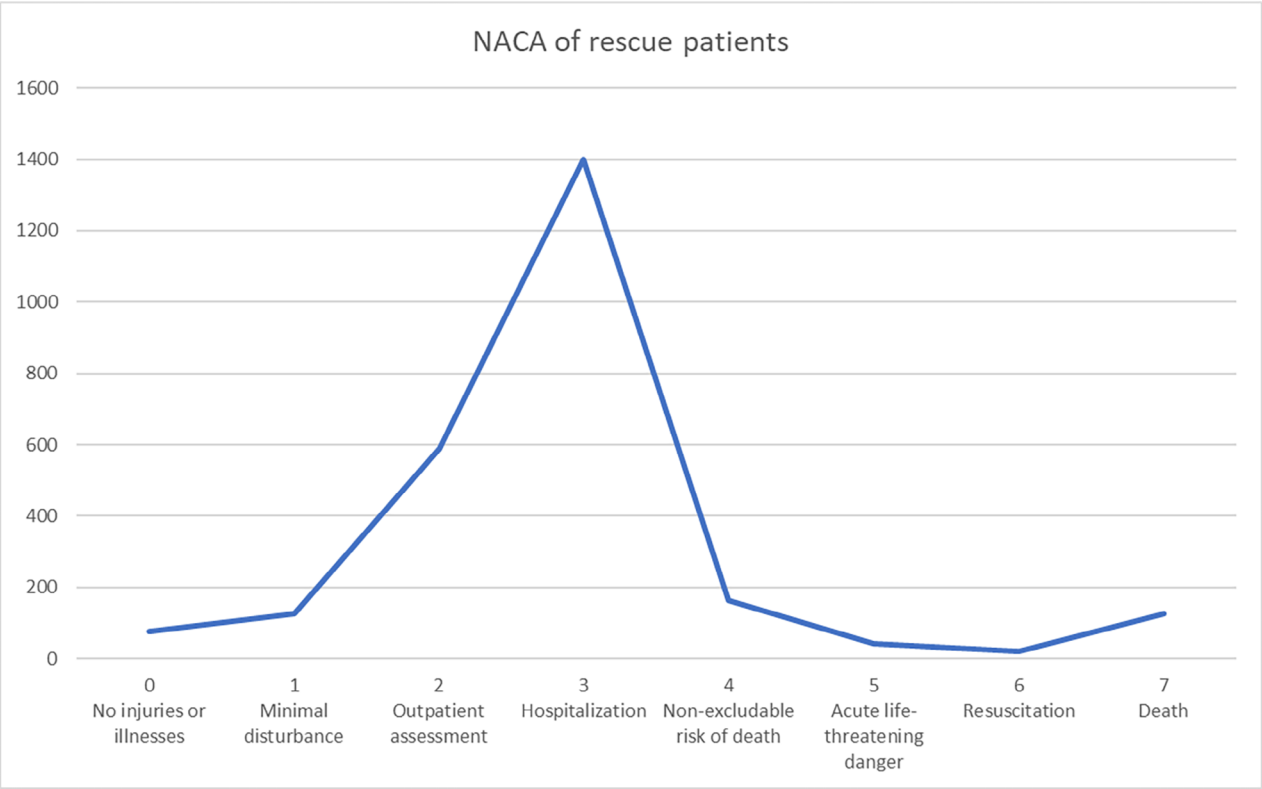

Figure 2. NACA score.

to our analysis, during the winter months of January and February, the overall number of rescues decreases. However, the ratio of rescues for sports-related and non-sports activities remains similar during those months. During the summer and spring, the number of missions increases, particularly for non-sports events. This phenomenon may be related to the seasonality of human activities, specifically the ski season, which unfolds during the winter months and thus increases the proportion of rescues carried out for sporting reasons. This study explores interventions that occurred at high altitudes during sports activities, highlighting the impact of rescue through two different scales, the RTS and the NACA score. In particular, the NACA score can be performed also on patients with acute medical events, whilst the RTS can only be applied to traumas. Among all the subjects, 34.1% patients were engaged in a sport activity before the rescue. Of these patients, 20.4% experienced an acute medical event, while the remaining cases were related to traumatic events. Between all the subjects with trauma, 47.1% had a major traumatic event according to the RTS assessment. Additionally, we observed a significant decrease of the RTS from the beginning of the rescue mission to the time of arrival at the hospital (7.2, SD: 3.0; vs 6.9, SD: 3.1; $p<0.001$). This finding is crucial as it underlines the importance of patient management during helicopter transportation, as there may be significant physiological changes for rescued and trauma patients during transportation. Currently, there is a lack of studies on the topics of transportation and logistics involved in these situations. The NACA score is assessed at the rescue scene and was performed on 73.9% of patients rescued above 1500 meters. In this scenario, around 39.7% of patients faced a high clinical risk and required immediate hospitalization. It should be noted that among the individuals who were rescued while participating in a sporting activity, 15.3% were engaged in an activity at an altitude higher than 1500 m. This is related to the areas that were examined, as the

three regions under analysis are considered popular touristic destinations in Italy, and skiing was the main activity for 40.4% of the rescued individuals. For recoveries at high altitudes, it is often unclear whether the rescue is primarily motivated by clinical factors, transport time, or logistical aspects. For example, it is particularly challenging to transport patients at high altitudes using ground-based vehicles. These analyses are indeed crucial for understanding the necessary medical equipment and for planning high-altitude rescues. One of the primary limitations of this study is the lack of clarity regarding the date of initial entry of data by the rescue bases. This inconsistency results in non-uniform data collection across different bases during the 10 years under analysis. The heterogeneity in data collection may affect the reliability and comparability of the study's findings, potentially limiting the generalizability of the results.

Conclusion

This study provides a comprehensive analysis of helicopter rescues in northern Italy. Utilizing the HEMS database, the research highlights that the percentage of rescues performed by helicopter is greatly influenced by the seasonal and the activity performed. High-altitude rescues present unique challenges, with a notable percentage of patients experiencing major trauma or acute medical events. The RTS and NACA assessments both highlight that, in most cases, rescue occurs on complex patients who need rapid transport to the emergency department and then hospitalization.

This research underscores the need for specialized strategies and equipment for high-altitude rescues, advocating for further investigation into the logistics and clinical management when performing high-altitude helicopter rescues.

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Ethic Committee: The study was conducted following the principles of the Helsinki Declaration and was approved by the HEMS Data Protection Officer in January 2023.

Conflict of Interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement, etc.) that might pose a conflict of interest in connection with the submitted article.

Authors Contribution: AG, SR, and FB designed the study. LG defined the statistics and tables. AL, MF, and GC collected the data. FB wrote the first draft of the manuscript. All authors reviewed and approved the final version.

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