



ORIGINAL RESEARCH

Static Rope Rescue Operations in Western Norway: A Retrospective Analysis of 141 Missions

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Introduction—The Norwegian national standard for rescuers describes medical and rescue requirements for helicopter emergency medical services (HEMS) technical crew members, but there is a lack of scientific data supporting these requirements and their safety relevance. The study aims to analyze the rescue profile of Norwegian HEMS static rope human external cargo operations, emphasizing terrain challenges and additional safety measures utilized on-site.

Methods—We conducted a retrospective descriptive analysis of static rope missions performed in daylight by 3 HEMS bases in Western Norway in the period 2015 to 2019. The analysis measures evacuation methods, terrain, on-site safety measures, and medical treatment.

Results—Out of 8352 primary HEMS and search and rescue missions, a total of 141 (2%) static rope missions were performed by the 3 HEMS bases in Western Norway. The most commonly used evacuation method was triangle harness (62%) and a static rope length of 30 m (81%). Ninety-two (65%) missions were completed in simple terrain, 38 (27%) in challenging terrain, and 11 (8%) in complex terrain. There were no reported accidents, but a small number of adverse events were registered. The most frequent medical intervention administered on-site was pain management, followed by spinal immobilization.

Conclusions—Thirty-five percent of the static rope missions performed by HEMS in Western Norway were completed in challenging or complex terrain, requiring additional safety measures on-site. The most common safety measure needed was the ability to operate in a mountain or alpine environment. Our findings support the safety relevance of a national standard for rescuers.

Keywords: air ambulance, rescue work, safety management, wilderness medicine

Introduction

Previous studies on human external cargo (HEC) rescue have indicated that HEC missions can be a useful means to reach and evacuate patients from areas where access is difficult, as compared to ground-based rescues.^{1–4} Currently, 2 different HEC methods are applied in the helicopter emergency medical service (HEMS): hoist and

static rope. Both are accepted as equivalent HEC rescue methods by the European Union Aviation Safety Agency when landing is not a safe option.⁵ A recent study from Norway showed that static rope HEC missions can reduce time to treatment and time to hospital by providing early access to medical treatment and evacuation.⁶ Although most patients evacuated in HEC missions have suffered minor injuries, medical treatment is frequently required, and pain management is the most regular treatment given.^{6–8} More advanced treatment options such as endotracheal intubation are rare.^{6,8–10}

Static rope missions have been a part of the Norwegian HEMS mission profile since the late 1970s. There is a well-established consensus within the HEMS service that static rope missions require rescuers who are physically capable and skilled in rescue techniques like

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mountaineering and swimming, but there is a lack of scientific data supporting this notion. A government-approved national standard for rescuers in the air ambulance service, the rescue helicopter service, and offshore search and rescue gives a good overall outline of the required competences for rescuers in HEMS, but it is quite general in its competence descriptions, leaving room for individual interpretation.¹¹⁻¹³

The main objective of this study was to identify the typical features of static rope missions in Norwegian HEMS, focusing on terrain challenges, rescue methods, and on-site patient care. This knowledge could allow us to postulate on the competence and skills needed for rescuers in Norwegian HEMS to perform HEC missions and on whether additional safety measures are required in these missions.

STATIC ROPE IN NORWEGIAN HEMS

The Norwegian HEMS utilizes only the static rope HEC method, with the HEMS technical crew member as the rescuer. None of the helicopters are equipped with a hoist. The HEMS technical crew members are emergency medical technicians, paramedics, or nurses with additional training and competence in rescue techniques, operational concepts, medicine, and flight operations, as specified in the national standard.^{5,12} The pilot maneuvers the helicopter visually during the static rope mission and is supported by the emergency physician, who is positioned on the starboard side of the cabin with the door fully opened. The physician acts as a load observer, indicating directions in all 3 dimensions, based on visual observations, standardized hand signals from the HEMS technical crew member, and standardized communication. National rules and risk analyses stipulate that static rope missions only be performed during daylight. Depending on terrain and operational conditions, static rope missions can be carried out with different rope lengths, from 10 to 60 m. Missions requiring a hoist are often performed by or in cooperation with helicopters from the rescue service, which are equipped with a hoist.

All static rope missions are conducted in accordance with a standard operating procedure, and all missions include standard safety measures (Table 1), both hard defenses (eg, harnesses, helmets, dual hooks, static rope) and soft defenses (eg, human performance, standardized procedures, communication, manual helicopter handling skills).¹⁴ When the HEMS technical crew member operates at the target site, there is frequently a need for additional safety measures, most often soft defenses such as basic mountaineering skills if the crew member disconnects from the static rope, but there is currently no established system for registering this aspect.¹²

There are 2 main static rope methods in the Norwegian service: static rope over land and static rope over water. In static rope over land, the HEMS technical crew member is lifted from a preparation site to and from the target site, hanging from the static rope. In static rope over water, there are 2 procedures. The primary procedure for static rope over water is an adjusted variant of a military helocast technique, called “ihopp.”¹⁵ The HEMS technical crew member is attached to the rope, sits on the starboard side of the helicopter, and jumps into the water from approximately a 3.5-m hover; thereafter, he or she is lifted ashore, together with the victim, hanging from the 10-m rope (Figure 1). The secondary static rope over water procedure is a traditional water pickup, where the HEMS technical crew member is lifted to and from the target site hanging from the rope. All crew members are required to do static rope training every 90 d and static rope over water training every 180 d.

Methods

All operational data from the Norwegian HEMS missions are entered in an operational database, the Norwegian air ambulance occurrence logging and administrative system (NOLAS), developed in FileMaker (Filemaker Inc, Santa Clara, CA). For the purpose of this study, we chose to collect data from the 3 HEMS bases in the Western Norway Regional Health Authority: Førde, Bergen, and Stavanger. These HEMS bases carry out approximately 22% of all HEMS missions in Norway, and the region has a slightly higher rate of static rope missions compared to other regions.¹⁶ The Western HEMS bases are all located in urban areas but cover a mixed urban and rural population of approximately 1.2 million with a geography varying from coastline to high mountains. We limited data extraction to the period from January 2015 through December 2019 to obtain data from the most recent missions and incorporate a period after the “ihopp” procedure was reintroduced by the service in 2012. Initially, we identified primary missions and search and rescue missions in which the static rope on the helicopter was used (Figure 2). Quantitative data from the static rope missions concerning rope lengths, evacuation methods, rescue equipment, geographic area, target accessibility, adverse events, and accidents, combined with the mission report written in free text by the HEMS technical crew member, were retrieved from NOLAS by the system administrator.

Different definitions and classifications of terrain exist, but few are specific to HEMS and helicopter rescue. The Union Internationale des Associations d'Alpinisme grading scale for mountaineering and

Table 1. Definitions of central words and concepts used in the study

Safety measure	A hard or soft defense planned to prevent, mitigate, or control an undesired event or accident. A hard defense is a safety measure passively preventing an accident from taking place (eg, attachment to an anchor or rope). Soft defense refers to human performance safety measures actively preventing an accident from taking place (eg, use of mountaineering or swimming skills to operate safely). ¹⁴
Additional safety measure	Additional hard or soft defenses required on-site by the rescuer.
Simple terrain	Terrain with a low risk severity, no injury potential. Safe to operate unaided on-site.
Challenging terrain	Terrain with a medium risk severity, minor injury potential. Active use of soft defenses as additional on-site safety measure is required.
Complex terrain	Terrain with a high risk severity, severe injury potential. Active use of both soft and hard defenses as additional on-site safety measures is required.
Adverse event	Undesirable event without personnel or material damage.
Victim	Unharmed person not admitted to a medical facility.
Patient	Person admitted to a medical facility.
Fatality	Person deceased at target site.
Primary mission	Mission dispatched by an emergency medical communication center to patients located outside of a medical facility.
Secondary mission	Interhospital transfer mission.
SAR mission	Search and rescue (SAR) mission dispatched by the joint rescue coordination centers.
Rescue mission	A primary or SAR mission where a registered rescue technique or method is utilized, such as static rope, light on skid, ground-based rescue, water rescue, or aerial search exceeding 5 min.

descriptions of slope angles or accessibility are used in several studies to specify terrain.^{11,17-21} To include the on-site risk severity in rescue missions, a system for classifying simple, challenging, and complex terrain was developed for the intent of this study by the Norwegian air ambulance rescue technical department (Table 2). The main purpose of the system was to incorporate the physical characteristics of the terrain and to identify whether the HEMS technical crew member could operate unaided on-site (low risk severity), actively had to use additional soft defenses (medium risk severity), or actively had to use both

additional hard and soft defenses (high risk severity). This system was used to accurately classify the terrain in retrospect. At first, terrain data from the mission reports were categorized according to Table 2. Then, mission data and the terrain classifications were validated by each of the HEMS technical crew members, respectively.

Missions reported as physically demanding were registered to provide insight into the physical requirements of static rope missions. Medical treatment given on-site by the HEMS technical crew member, registered in NOLAS, was also quantified.



Figure 1. Ihopp: the primary static rope over water procedure in Norwegian HEMS (courtesy of Fred Sirevaag).

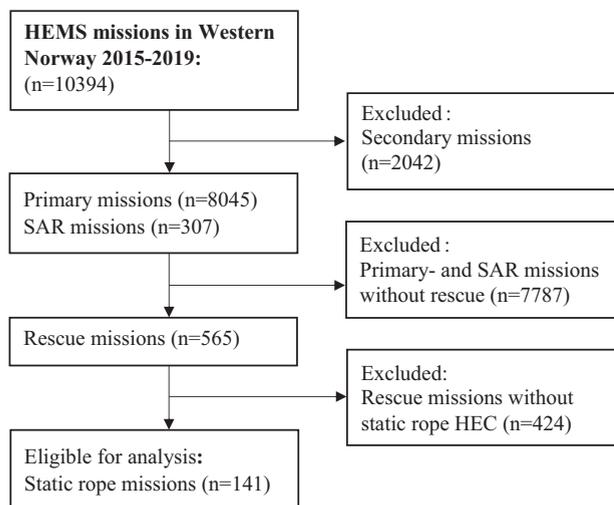


Figure 2. Flowchart showing selection of static rope missions qualified for analysis.

The study was exempted from ethical review by the Norwegian Regional Committee for Medical and Health Research (REK Helse Vest) after a preliminary review, since the study does not collect patient identifiable data or impose experimental treatment (reference number 255231). The study was approved by the Norwegian air ambulance data collection officer in accordance with the rules from the Norwegian Social Science Data Services. Voluntary consent from all HEMS technical crew members was collected before proceeding with data collection from all potentially involved participants in the study.

Results

We identified 8045 primary HEMS and 307 search and rescue missions in the 5-y period for which data were collected. Of these, 565 (7%) were rescue missions, with 141 (2%) fulfilling the criteria of a static rope mission. Twenty-three different HEMS technical crew members with an average of 9 y of experience were involved in the 141 missions. Fifty-six missions were initially identified as performed in challenging or complex terrain after an analysis of the mission reports. Seven of these were downgraded to simple terrain by the involved HEMS technical crew members, as the reported terrain description did not reflect the actual on-site risk severity. This resulted in an accurate classification of 92 (65%) missions in simple terrain, 38 (27%) in challenging terrain, and 11 (8%) in complex terrain. The missions in challenging and complex terrain required additional safety measures on-site (Table 2). The most common safety measure needed was the ability to operate in a mountain

or alpine environment (26%), followed by water or swift-water (4%), avalanche (4%), and snow-covered glacier and ice (1%). Four adverse events were reported (3%): 2 minor rotations, 1 with a triangle harness and 1 with a stretcher, and 2 contacts with objects, both with a triangle harness. All these events were in simple terrain with the use of a 30-m rope. There were no accidents reported during the study period.

Sixteen static rope missions (11%) were reported as physically demanding by the individual HEMS technical crew members. The most frequent reason recorded was that the HEMS technical crew member was alone at the target site, either with a victim/patient needing repositioning for a safe evacuation or a patient/fatality that had to be placed in a stretcher.

Most static rope missions were carried out over land (96%). Only 5 static rope missions were reported over

Table 2. Terrain classifications and safety measures during 141 helicopter emergency medical services static rope missions in Western Norway 2015–2019

<i>Terrain classifications and safety measures</i>	<i>n (%)</i>	<i>Total</i>
Simple ^a		92
Mountain/Alpine terrain with a steepness <30°	90 (64)	
ATES 1	2 (1)	
Challenging ^b		38
Solo movement in mountain/alpine terrain equivalent UIAA 3–4 or a steepness >30°	26 (18)	
Solo movement on snow-covered glacier and ice with a steepness >30°	2 (1)	
Solo movement in terrain equivalent ATES 2	5 (4)	
Rescue swimming in open water with waves <1 m	4 (3)	
Swift-water rescue equivalent IRGS 1–3	1 (1)	
Complex ^c		11
Solo movement in mountain/alpine terrain equivalent >UIAA 4 or a steepness >40° and		
Use of the helicopter static rope as a fall protection	5 (4)	
Attachment to an anchor	6 (4)	

ATES, avalanche terrain exposure scale²¹; UIAA, Union Internationale des Associations d’Alpinisme¹⁹; IRGS, international river grading scale.²²

^aRisk severity low and safe to operate unaided on-site.

^bRisk severity medium and active use of soft defenses was required as additional on-site safety measure.

^cRisk severity high and active use of both soft and hard defenses was required as additional on-site safety measures.

water or swift-water, and one of these was completed with the secondary static rope over water procedure in swift-water. Four “ihopp” (3%) were registered, but 2 were cancelled before patient contact. The most frequently used evacuation method was triangle harness (62%), followed by stretcher evacuation (32%). A pickup sling was used in 5 (4%) missions, and the victim’s own harness was used in 3 (2%) evacuations. In 81% of all missions, a rope length of 30 m was used. The second most regularly used rope length was 20 m (11%), and 10-m rope was used in 5 missions (4%), all in static rope over water procedures. A rope length of 40 m was used in 4 (3%) missions, and 50 m was used in 2 (1%) missions. The longest rope length, 60 m, was not reported as used in the study period.

Two missions used a double attachment procedure; this is a standardized method where at least 1 attachment point is active at all times, ensuring that the rescuer and patient are secured through all phases of the operation. In 4 missions, the HEMS technical crew member established an anchor at the target site independently. All were in complex terrain, and 1 of the anchors was used in combination with the double attachment procedure. Two anchors involved the use of slings around trees, 1 used slings around rocks, and 1 involved the use of a snow anchor. Five missions reported active use of the helicopter static rope as a fall protection due to a high-risk severity when operating on-site (Table 2).

A total of 117 patients, 12 victims, and 12 fatalities were registered. Thirty-six (41%) of the patients in simple terrain were treated on-site before evacuation. In challenging terrain, 12 (57%) of the patients received medical treatment on-site. Only 4 patients were located in complex terrain, 2 of whom received medical treatment before evacuation. Of those who required medical interventions on-site by the HEMS technical crew member, pain management (58%) was the most frequently administered treatment, most commonly intravenous (33%) and intranasal (25%). The second most common intervention was spinal immobilization (46%), followed by splinting (23%) and fracture realignment (12%).

Discussion

In this retrospective observational study of static rope missions in Western Norway, we found that 35% of the static rope missions were carried out in challenging or complex terrain requiring additional safety measures due to an increased risk severity on-site. Most static rope missions were over land, and the most common medical intervention provided was pain management. No serious incidents were reported in the study period.

Regular safety measures needed seem to be the expertise to assess different operational environments and to be a generalist in mountaineering and rescue swimming (Table 2). These findings have some similarities with results from previous studies. A study from northern Norway classified terrain into simple, demanding, or alpine terrain and focused on whether belaying was required.¹⁸ This study found that 25% of the rescue missions were carried out in demanding terrain and 6% in alpine terrain. However, it did not mention details regarding safety measures or the physical terrain characteristics.¹⁸ A study from the Alpine region of central Europe analyzed terrain difficulties and showed that in 31% of all rescue operations, personal advanced climbing skills were necessary.¹⁷ The consensus recommendations from the International Commission for Mountain Emergency Medicine, regarding HEMS in mountain rescue, also suggests that rescuers should have a high level of experience in mountaineering and rescue techniques.¹¹ Our findings, especially regarding mountaineering, correlate well with the results from these previous studies, but more data are necessary to postulate detailed requirements in a Norwegian context. Related to the Norwegian national standard, which states that the rescuer should be able to operate in all environments and provide rescue while maintaining the safety of both the patient and the crew,¹² our findings support that the standard has safety relevance when conducting static rope missions.

Most static rope missions were performed with a 30-m rope. This is a practical rope length for most situations and provides a reasonable trade-off in maintaining enough distance between the HEMS technical crew member and the helicopter, allowing access in difficult terrain, and precisely maneuvering the HEMS technical crew member to the scene. From that perspective, it might seem like an efficient solution to stick with this 1 rope length for all missions. When analyzing the rope lengths considering the terrain classifications, 58% of the missions using rope lengths of 10, 20, 40, or 50 m were completed in challenging or complex terrain, compared to 30% of the missions with 30-m rope. This might indicate that more demanding terrain sharpens the need for precision and better visual references for the pilot.

Static rope missions are a very small portion of the HEMS repertoire. Several studies have shown that patients requiring evacuation in remote areas and HEC in Norway suffer from minor injuries.⁶⁻⁸ The Norwegian model, where the rescue specialist, the HEMS technical crew member, is at the “sharp end” of the rope to provide both a safe rescue and adequate medical care for patients therefore seems like a safe and cost-beneficial model. Regular and increasing dispatches to

rescue missions also necessitate that the service has preparedness and training in rescue techniques.¹⁶

In common with our research, several studies have shown pain management to be the most common medical intervention provided during HEC missions.^{7,9,23} In most services, high-dose pain medication is a physician-only intervention. In Norway, however, the HEMS technical crew member can administer analgesics independently, on delegation from the emergency physician. Recently, intranasal administration has also emerged as an alternative that may be a safe route of administration with a similar analgesic effect.²⁴ Most missions requiring medical interventions prior to static rope evacuation were performed in simple terrain. However, several patients in challenging and complex terrain required medical treatment before evacuation. This illustrates that the HEMS technical crew member must be able to operate safely to evacuate the patient and be able to provide medical care even in complex and challenging terrain.

To our knowledge, Norwegian HEMS is the only service to have developed and implemented a static rope method for over water rescue such as the “ihopp” procedure. Although the number of static rope over water missions was small in our data, we know from a recent report to the Norwegian Labour Inspection Authority (April 2020) that HEMS is dispatched to incidents involving water rescue on a regular basis, but in most cases the patient is evacuated to land before the arrival of HEMS. Water rescue can be very time-critical, and to minimize preparation time for the “ihopp” procedure, the method allows for the HEMS technical crew member to be fully prepared for “ihopp” when the helicopter takes off from the HEMS base. No studies have so far investigated the relevance and time effectiveness of this method. Further research regarding HEMS HEC water rescue would be beneficial.

In the static rope missions analyzed in our study, missions in complex terrain were rare: approximately 0.1% of all the HEMS missions. Complex terrain involves a higher risk for both patients and rescuers, and although Norwegian HEMS has methods such as the double attachment procedure that can mitigate some of the risks, we do not know for certain how often missions are completed in either challenging or complex terrain on a national level. There are no known quality indicators specific to the skills required by the HEMS technical crew member in a Norwegian context, but the national standard lists several formal rescue requirements.^{12,25} Even though the NOLAS database has extensive data regarding HEMS missions in general, the method used in this study for validating terrain classifications has detected that the database lacks details regarding difficulties and challenges encountered on-site in rescue missions.

Indexing data as an alternative to free text registering of safety measures and terrain might improve these identified database discrepancies. We hope that the system used in this study to quantify terrain challenges (Table 2) could contribute to a more comprehensive understanding and analysis of rescue missions in the future.

LIMITATIONS

The study has some limitations. First, as it was based on data registered by several HEMS technical crew members over a time span of 5 y, it may be prone to observational bias and reporting bias on behalf of the HEMS technical crew members entering the data. For example, both experience and current training may have influenced the data registered, leading to over- or underreporting. Second, some of the included data are based on the rescue reports written in free text by the HEMS technical crew members; this constitutes a potential important source of analysis bias. To counteract this, all registered data and terrain classifications were validated by the involved HEMS technical crew members using the criteria in Table 2 to ensure accuracy and supply extra information. Third, the number of static rope missions analyzed in this study was small and involved the 3 HEMS bases operating in the area covered by the Western Norway Regional Health Authority. However, a total of 13 HEMS bases operate in Norway, and we do not know for certain whether our findings are representative for other areas of Norway with somewhat different geographic challenges (eg mountain bases). Future studies should, therefore, include prospective data from all 13 HEMS bases in Norway. Fourth, patient sensitive data, like age, gender, or injury, were not included in this study. We therefore cannot exclude the possibility that a patient’s condition influenced the choice of rescue technique. Future studies should therefore also include patient data, to improve our understanding of how this may impact the static rope mission profile.

Conclusions

Over a 5-y period at 3 HEMS bases in Western Norway, 49 (35%) out of 141 static rope missions were completed in challenging or complex terrain, requiring additional safety measures on-site. The most common safety measure needed was the ability to operate in a mountain or alpine environment. Of the patients rescued in challenging or complex terrain, 56% received medical treatment before evacuation. Our findings support the safety relevance of the Norwegian national standard for rescuers.

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