

Severe Hypothermia Management in Mountain Rescue: A Survey Study

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Abstract

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Introduction: Severe hypothermia is a rare but demanding medical emergency. Although mortality is high, if well managed, the neurological outcome of survivors can be excellent. The aim of the study was to assess whether mountain rescue teams (MRTs) are able to meet the guidelines in the management of severe hypothermia, regarding their equipment and procedures.

Methods: Between August and December 2016, an online questionnaire, with 24 questions to be completed using Google Forms, was sent to 123 MRTs in 27 countries.

Results: Twenty-eight MRTs from 10 countries returned the completed questionnaire. Seventy-five percent of MRTs reportedly provide advanced life support (ALS) on-site and 89% are regularly trained in hypothermia management. Thirty-two percent of MRTs transport hypothermic patients in cardiac arrest to the nearest hospital instead of an Extracorporeal Life Support facility; 39% are equipped with mechanical chest compression devices; 36% measure core body temperature on-site and no MRT is equipped with a device to measure serum potassium concentration on-site in avalanche victims.

Conclusions: Most MRTs are regularly trained in the treatment of severe hypothermia and provide ALS. The majority are not equipped to follow standard procedural guidelines for the treatment of severely hypothermic patients, especially with cardiac arrest. However, the low response rate—23% (28/123)—could have induced a bias.

Keywords: emergency medicine; extracorporeal membrane oxygenation; hypothermia; mountain rescue; resuscitation; rewarming

Introduction

THE MANAGEMENT OF PATIENTS in mountain and remote areas is a great challenge in emergency medicine. Patient assessment, decision-making, treatment, and transport have often to be performed in isolated, potentially dangerous terrain, under harsh weather conditions. All necessary rescue

and medical equipment must be carried in the rescuers' backpacks and may be exposed to high levels of humidity and low ambient temperature. Its availability can be limited for some teams due to high cost.

Patients who need rescuing from mountainous areas are often hard to reach for emergency medical service (EMS). This is mainly due to difficult terrain, changeable weather condi-

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tions, and a diminished availability of transport and communication infrastructure. Therefore, mountain rescue teams (MRTs) are often the first and only aid providers at the scene. Thus, survival chances and outcome for the patient mainly depend upon the rescuers' knowledge, skills, and equipment deployed at the scene.

In 2006, Elsensohn et al. conducted a survey on the medical equipment of mountain rescue services. Based on this survey, an official recommendation of the International Commission for Mountain Emergency Medicine (ICAR MEDCOM) outlining the minimum medical equipment requirement for mountain rescue was published in 2011 (Elsensohn et al., 2011).

Severe accidental hypothermia with a core temperature (T_c) below 28°C is a very demanding medical emergency, especially in the out-of-hospital treatment phase. Predominantly, the risk of sudden cardiac arrest during removal and transport, necessitating prolonged resuscitation of the patient, has been emphasized in the literature (Wanscher et al. 2012; Hilmo et al., 2014; Debaty et al., 2015). However, remarkably even after long-lasting low-flow or no-flow situations, hypothermia can result in excellent neurological outcome with the absence of any sequelae (Kosiński et al., 2016). In the main, outcomes in this patient group vary widely and invariably depend on accurate diagnosis, correct field management, and appropriate transport of the patient to the most suitable medical facility (Paal and Brown, 2014; Paal et al., 2016; Van Tilburg et al., 2017). Lack of equipment and skills, or improper transport decisions, can worsen survival chances and outcome.

The European Resuscitation Council and the American Heart Association have previously issued resuscitation guidelines that are easy to apply in an urban setting (Vanden Hoek et al., 2010; Truhlar et al., 2015). However, in mountain and remote emergency scenarios, it can be difficult to adhere to these guidelines, which sometimes must be modified, delayed, or even ignored due to lack of equipment or medical staff.

Aim of the study

The aim of the study is to assess the adherence of mountain rescue personnel to current management guidelines pertaining to hypothermic patients, in mountain rescue scenarios. The secondary aim is to assess whether the MRTs are trained adequately and properly equipped to manage severely hypothermic patients effectively, especially those in cardiac arrest.

Methods

This study was based upon volitional MRT self-report, in response to a questionnaire-based online survey (Google Form). In total, the survey consisted of 24 questions—3 of them about training, 7 referring to equipment, 7 on organization, and 7 specific to patient management. Only three open questions were included, but for seven questions multiple answers were possible. The questionnaire was added in the Supplementary Data (Supplementary Data are available online at www.liebertpub.com/ham). This questionnaire was sent to 123 MRTs, from 27 different countries, all selected because they were considered to work in geographical locations where severe hypothermia is most likely to be encountered in patient groups. To identify the correct contact details for eligible MRTs, the contact database of the International Commission for Alpine Rescue (ICAR), available for public use at (www.alpine-rescue.org), was consulted. In addition, up-to-date contact information for responsi-

ble team members (team leaders or medical officers) was found through a Google Internet search, utilizing the keywords “mountain rescue” in English, French, German, Italian, and Spanish (through Google Internet search engine). Helicopter Emergency Medical Service and other Emergency Medical System teams were not taken into consideration. Altogether, 123 MRTs from 27 countries (in Europe, North and South America, Australia, New Zealand, and South Africa) were requested to complete the questionnaire, which was placed on the Google platform. Approval by an Ethical Review Board was not required for this study, as no individual patient information was collected and all contact data and MRT responses were treated confidentially.

Owing to the relatively small sample size presented in this study, the statistical analysis has been limited to descriptive statistics. Categorical variables are presented as number of MRTs and percentages.

Results

Responses to the survey were collected from August to December 2016, through an online platform (Google Form). In total, 28 of 123 invited MRTs (23%) returned the completed questionnaires. These teams originate from 10 countries (number of teams in brackets): Australia (2), Austria (1), Bosnia and Herzegovina (1), France (1), Italy (4), Norway (1), Poland (8), Switzerland (4), United Kingdom (4), and United States (2).

Twenty-seven out of 28 (96%) MRTs report an incidence of severe hypothermia in 5 cases per year or less in their practice, and 1 team declared 5–10 cases per year.

Ten (36%) MRTs use esophageal, epitympanic (thermistor based) or rectal thermometers and are, therefore, able to read core body temperature (T_c) on-site. Nine (32%) can assess body temperature using infrared-based epitympanic thermometer. Nine (32%) MRTs are not equipped with any thermometer and estimate T_c using clinical signs (the Swiss Staging) (Durrer, 1991).

The methods of T_c assessment are shown in Table 1.

Twenty-one (75%) MRTs are staffed with advanced life support (ALS) trained doctors, nurses, or paramedics. Twenty-two (79%) MRTs are equipped with an electrocardiograph (ECG) monitor and/or automated external defibrillator (AED). Twenty-two (79%) MRTs are reportedly equipped with endotracheal tube, laryngeal mask, or laryngeal tube, the remaining six (21%) MRTs have no equipment for securing patient's airway. Four (14%) MRTs are able to measure end-tidal CO_2 (ET CO_2). Twenty (71%) MRTs are able to measure serum glucose, but none of the MRT respondents confirm that they can measure serum potassium at the scene. Mechanical chest compression devices (MCCDs) are available in 39% of MRTs.

Transport of the patient to an Extracorporeal Life Support (ECLS) facility within 60 minutes is possible for 79% of

TABLE 1. METHODS OF TEMPERATURE ASSESSMENT USED BY MOUNTAIN RESCUE TEAMS, $N=28$

Temperature assessment	MRTs, n (%)
Ear infrared thermometer	9 (32)
Esophageal probe	6 (21)
Epitympanic thermistor probe	5 (18)
Rectal probe	2 (7)
No thermometer at all	9 (32)

MRT, mountain rescue team.

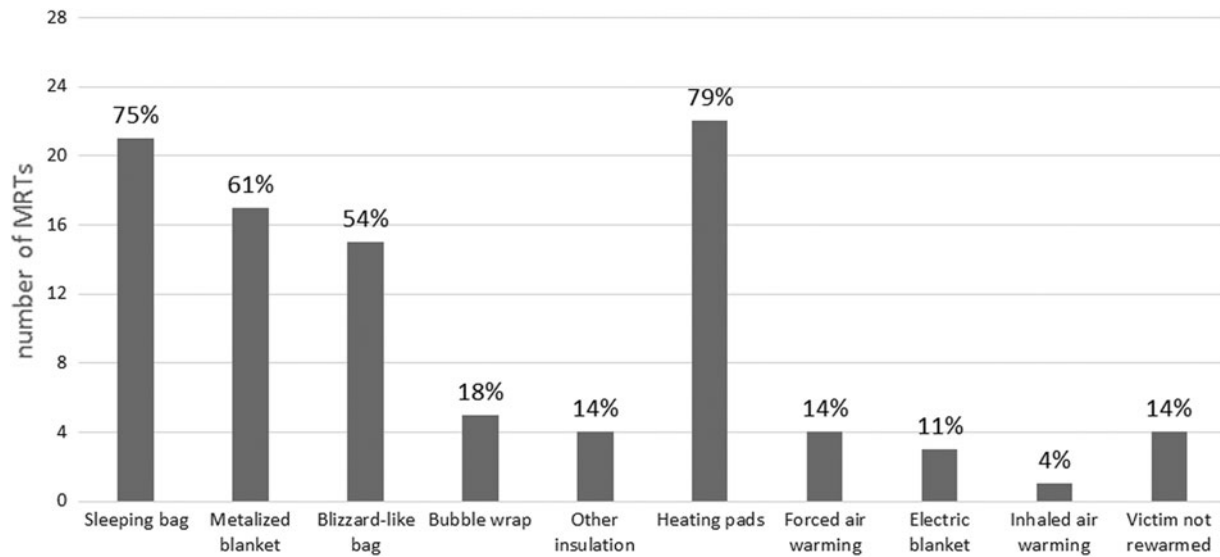


FIG. 1. Equipment of MRTs for the insulation and rewarming of hypothermic patients. MRT, mountain rescue team.

MRTs by helicopter and for 43% by ambulance. Eighteen (64%) MRTs transport severely hypothermic patients in cardiac arrest to a hospital with ECLS and the remaining nine (32%) MRTs to the closest hospital (one MRT omitted a response to this question). As the extracorporeal rewarming is the method of choice in hypothermic cardiac arrest, these nine MRTs were furtherly investigated. Five of them confirmed that a hospital with ECLS is reachable within 1 hour, five provide ALS, and five are equipped with low-reading thermometers. Although eight of these nine MRTs are regularly trained in hypothermia management, seven report no standardized procedures, and seven are not equipped with MCCD.

Overall, standardized procedures for transport and treatment of severely hypothermic patients are established in 15 of 28 (54%) MRTs. Twelve (43%) MRTs provide notification to the ECLS teams of their identified target hospital once rescue action commences; four (14%) do not alert the target hospital. Remaining respondents reportedly provide notification after a patient is located.

Twenty-five (89%) of MRTs are regularly trained in the management of hypothermic patients, plus 27 (96%) MRTs are interested in continuing education in hypothermia.

Equipment necessary for the insulation, rewarming, monitoring, and airway management of severely hypothermic patients with cardiac arrest is shown in Figures 1 and 2.

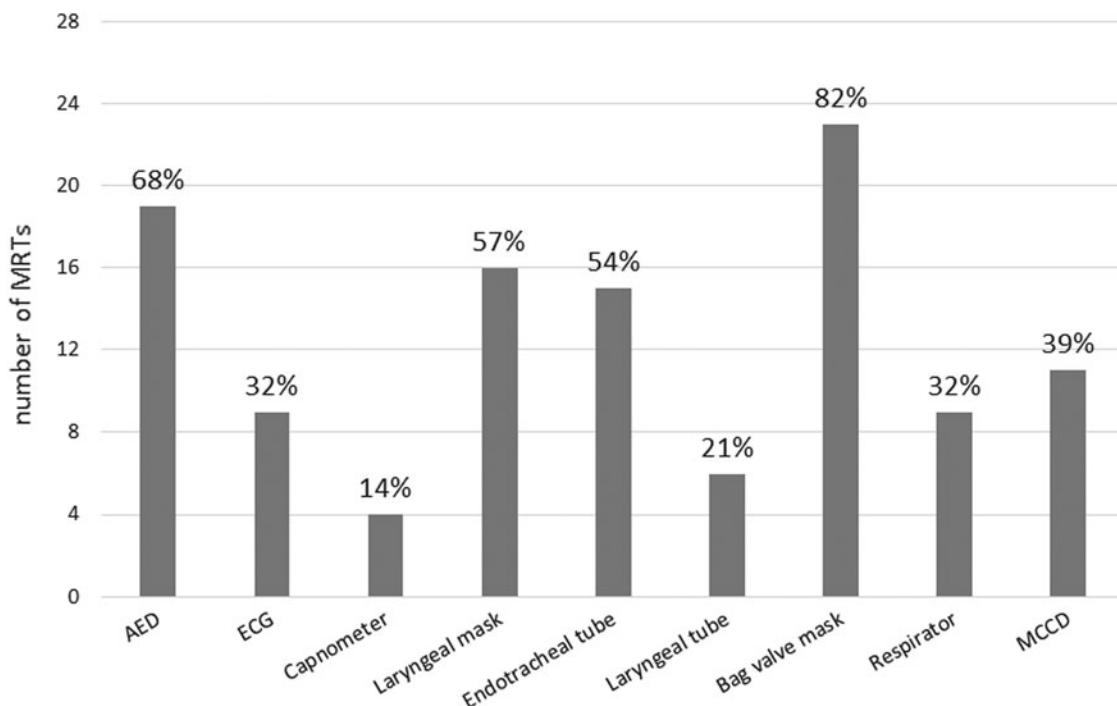


FIG. 2. Equipment of MRTs for cardiopulmonary resuscitation. AED, automated external defibrillator; ECG, electrocardiograph; MCCD, mechanical chest compression device.

Eight (29%) of MRTs are equipped with warming systems for intravenous fluids (flow-warmers, thermo-bags, insulated iv tubing). Four (14%) MRTs have administered intravenous fluids without warming, whereas 16 (57%) MRTs do not administer fluids at all.

Discussion

This study shows that within the MRT respondents surveyed, the current adherence and practical implementation of internationally recognized hypothermia management guidelines are low. The guidelines previously published by European Resuscitation Council, American Heart Association, ICAR MEDCOM, and the Wilderness Medical Society recommend the following: T_c measurement, airway management, use of mechanical chest compression for prolonged cardiopulmonary resuscitation, and direct transport to an ECLS facility for hypothermic patients in cardiac arrest or circulatory instability with T_c <28°C. These guidelines also indicate the use of serum potassium concentration as a criterion for continuation or termination of resuscitation efforts, especially in avalanche victims (Zafren et al., 2014; Truhlar et al., 2015; Paal et al., 2016).

Core temperature is an additional widely accepted criterion to withhold defibrillation after initial three shocks (T_c <30°C), to allow for interruption in chest compressions in some cases (<28°C), plus determine the target hospital for active external or extracorporeal rewarming (Gordon et al., 2015; Truhlar et al., 2015). Missing or incorrect temperature assessment can lead to an inadequate prolongation of low-flow or no-flow time, which purportedly effects brain metabolic requirements, subsequently worsening the survival rate, as well as neurological outcome in survivors. However, only one-third of the MRT respondents surveyed reported the access to a suitable esophageal, thermistor-based epitympanic, or rectal thermometer to assess T_c. Seventy-nine percent of the MRTs estimate the severity of hypothermia on clinical signs with questionable reliability (Deslarzes et al., 2016). Despite the known inaccuracy of this method, 9/28 MRTs use only the Swiss Staging system. Lack of low-reading thermometers among rescue services is a problem that has been previously described in the literature (Karlsen et al., 2013). In 2012, Pasquier et al. described a homemade thermometer suitable for field measurements. More recently, the digital equivalent was launched, a smartphone-based thermometer developed in Poland, which can be connected to standard esophageal or epitympanic temperature probes. An affordable breakthrough, this technology is complete with software enabled to send notifications automatically to EMS dispatcher as well as to ECLS center (Darocha et al., 2016b).

The limited availability of these thermometers may be due to low incidence of severe hypothermia, reported in the survey. However, it should be highlighted that death from accidental hypothermia is potentially avoidable if rescue operatives follow the guidelines and patients in cardiac arrest are rewarmed with ECLS. In this context, the accurate measurement of T_c is essential (Pasquier et al., 2012; Strapazon et al., 2014).

Most of the surveyed teams (68%) are equipped with an AED. This is slightly more than in 2006 when only 50% of teams had an AED (Elsensohn et al., 2011). However, one-fifth of the MRTs within this survey are not equipped with any cardiac monitoring equipment (ECG or AED) and, therefore, are not able to assess cardiac rhythm. This is a key issue to highlight, as the management of asystole, ventricular

fibrillation, and pulseless electrical activity is different in an avalanche rescue scenario (Truhlar et al., 2015). For this reason, respondents currently without this equipment are not able to follow the avalanche rescue algorithm, or correctly perform recommended on-site triage procedures in a multiple casualty avalanche accident. An additional item in the established triage algorithm is the on-site measurement of serum potassium concentration. This parameter is one of the key criteria in the decision for termination or continuation of cardiopulmonary resuscitation until ECLS rewarming (Truhlar et al., 2015). The serum potassium level could be determined using portable devices, otherwise measurement has to be delayed until hospital admission. Although such a delay is compliant with current guidelines, serum potassium level measured at hospital rather justifies termination of resuscitation than supports the early triage. In our opinion, this topic should be discussed in the future. In this study, none of the surveyed MRT respondents is equipped with a portable device to measure potassium level at the scene.

ETCO₂ monitoring is one of the recommended methods to confirm preserved spontaneous circulation in severe hypothermia (Zafren et al., 2014). In addition, it should be a standard monitoring for intubated patients. According to ICAR recommendations issued in 2011, a capnometer should be a part of the physician's backpack equipment in MRTs. Our study reveals that capnometry is available only in 14% of surveyed teams. In 80% of the MRTs that provide ALS, ETCO₂ monitoring is not available, similar to the Elsensohn et al.'s (2011) study.

Hypothermic cardiac arrest is an unquestioned indication for ECLS (Truhlar et al., 2015). The survival rate without neurological impairment can be as high as 100% (Wanscher et al., 2012) plus the chances of survival could be higher when extracorporeal membrane oxygenation (ECMO) is used (Ruttman et al., 2007; Morita et al., 2011). However, one-third of the MRTs (9 out of 28) transfer patients in hypothermic cardiac arrest to the nearest hospital instead of the ECLS facility, even though for five of those nine MRTs a hospital with ECLS is reachable within 1 hour. Lack of standardized procedures and chest compression devices is also notable among these nine MRTs.

Early notification of a search or an avalanche rescue operation is recommended by ICAR MEDCOM (Brugger et al., 2013; Paal et al., 2016) and other authors (Brodmann Maeder et al., 2011; Darocha et al., 2015) to allow the ECLS center to prepare staff and equipment for patient admission. However, in this study, it is evident that only 43% of MRTs notify the target hospital at the beginning of the rescue operation. This delay can significantly delay the subsequent in-hospital treatment and may, in the worst case, lead to treatment failure. Another aspect that should be discussed in tandem is the possibility to transfer a mobile ECMO to a regional hospital that is not equipped with ECMO instead of transporting the victim under ongoing cardiopulmonary resuscitation to the center with ECLS. This may shorten the low-flow time (Darocha et al., 2016a).

Regular training in hypothermia management is reportedly performed by majority of the MRTs, as also previously reported (Elsensohn et al., 2009). Within this study, most respondents have also expressed the need for continued education and re-education pertaining to this topic, ideally in an e-learning format in their first language. The main point to address here remains that although rescuers are well trained in hypothermia treatment, and demonstrate aptitude and in-

terest in continued education, they have very few possibilities to fully utilize their knowledge into practical emergency situations due to lack of proper equipment.

The study has two important limitations. First, the response rate was only 23%. The distribution of the individual levels of organization, equipment availability, and educational facility may be variable between different countries, which may have affected the validity of data collected. It is likely that responses come from well-motivated, equipped, and trained MRTs, rather than from less developed MRTs. Second, overall sample selection bias may have affected the results, as Polish MRTs, existing in a common rescue system, are overrepresented compared with other countries' MRTs (8/28).

In conclusion, the proper equipment of MRTs with suitable thermometers and chest compression devices would expectantly have a positive impact on procedural alignment within severe hypothermic management. Equally, the establishment of regional, standardized procedures for the transport of severely hypothermic patients to ECLS facilities seems justified and actionable, considering the potentially excellent neurological outcome of hypothermic patients in cardiac arrest.

Improper allocation of patients in hypothermic cardiac arrest is associated with lack of protocols and MCCDs in 77% surveyed MRTs, although statistical significance was not calculated due to small sample size.

Rescue teams are regularly trained, but the majority of them are not properly equipped to perform treatment of severely hypothermic patients in line with current international guidelines.

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Author Disclosure Statement

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