Managing accidental hypothermia: a UK-wide survey of prehospital and search and rescue providers

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ABSTRACT

Aim The management of hypothermic casualties is a challenge faced by all prehospital and search and rescue (SAR) teams. It is not known how the practice of these diverse teams compare. The aim of this study was to review prehospital hypothermia management across a wide range of SAR providers in the UK.

Methods A survey of ground ambulances (GAs), air ambulances (AAs), mountain rescue teams (MRTs, including Ministry of Defence), lowland rescue teams (LRTs), cave rescue teams (CRTs), and lifeboats and lifeguard organisations (LLOs) across the UK was conducted between May and November 2017. In total, 189 teams were contacted. Questions investigated packaging methods, temperature measurement and protocols for managing hypothermic casualties.

Results Response rate was 59%, comprising 112 teams from a wide range of organisations. Heavyweight (>3 kg) casualty bags were used by all CRTs, 81% of MRTs, 29% of LRTs, 18% of AAs and 8% of LLOs. Specially designed lightweight (<0.5 kg) blankets or wraps were used by 93% of LRTs, 85% of LLOs, 82% of GAs, 71% of AAs and 50% of MRTs. Bubble wrap was used mainly by AAs, with 35% of AAs reporting its use. Overall, 94% of packaging methods incorporated both insulating and vapour-tight layers. Active warming by heated pads or blankets was used by 65% of AAs, 60% of CRTs, 54% of MRTs, 29% of LRTs and 9% of GAs, with no LLO use. Temperature measurement was reported by all AAs and GAs, 93% of LRTs, 80% of CRTs, 75% of MRTs and 31% of LLOs. The favoured anatomical site for temperature measurement was tympanic. Protocols for packaging hypothermic casualties were reported by 73% of services.

Conclusions This survey describes current practice in prehospital hypothermia management, comparing the various methods used by different teams, and provides a basis to direct further education and research.

Key messages

What is already known on this subject

► Hypothermia contributes significantly to morbidity and mortality; assessment and management of hypothermic casualties is a priority during rescue. Previous surveys of mountain rescue in North America and emergency providers in Norway and Sweden have shown lack of consensus with regards to managing accidental hypothermia.

What this study adds

► We invited 189 UK search and rescue teams to complete a questionnaire on their hypothermia practices. Among the 59% of organisations responding, there was substantial variation in packaging, warming and assessment of casualties. Further education and research is warranted in these areas.

INTRODUCTION

Hypothermia increases morbidity and mortality in trauma,[1] as well as being a reversible cause of cardiac arrest. Search and rescue (SAR) providers across the UK cover 2 million square miles of varied terrain,[2] including mountains, lowland areas, underground caves and mines, inland bodies of water, coastal terrain and offshore. In each of these environments, an injured or stranded casualty is at risk of hypothermia. SAR provision in the UK is made up and supported by separate government departments, emergency services, the armed forces and voluntary organisations: each brings their own approach to managing hypothermia, and it is not yet known how the practice of these diverse teams compare.

Previous surveys of mountain rescue teams,[3 4] and both Norwegian and Swedish SAR helicopters and their associated emergency services,[5 6] have shown a lack of consensus in the management of prehospital hypothermia. International consensus statements have been published,[7–10] but there appears to be poor implementation of guidance, and some areas of continued contention, that lead to significant disparity in clinical practice. Priority areas of clinical management for hypothermic patients include packaging casualties to minimise further heat loss, the use of active warming and measurement of core temperature prehospitally. It was these areas of clinical practice that were investigated in this survey.

The aim of this study was to identify current practice in the prehospital management of hypothermia across all SAR organisations operating in the UK.

METHOD

Subjects were identified from the members of the UK Government's UKSAR Operator's Group[2] and are further detailed in the online supplementary table. This group comprises organisations representing air ambulances, ground ambulances, mountain rescue, lowland rescue, cave rescue, Ministry of Defence, lifeboats, surf lifesavers and lifeguards, and government organisations. Local teams within these umbrella organisations were contacted by email between May and November 2017. Contact details were obtained through organisations' websites and

Table 1 Questionnaire sent to study participants

Question	Answer format
Name of your service (eg, Devon Air Ambulance)	Free text
Role of person filling in form	Free text
Which materials/rescue bags does your service use when packaging potentially cold/hypothermic casualties?	Checkboxes: ► Ambulance-style blankets ► Bubble wrap ► Space blanket/reflective sheet ► Specifically designed rescue bag (please give details of make/manufacturer under 'other') ► Other (free text)
Does your service use any active warming methods? If so, which methods/manufacturers are used?	Free text
Does your service manage wet casualties differently to dry casualties?	Free text
Does your service measure the temperature of casualties? If so, which method(s)?	Checkboxes: ► Tympanic/ear ► Rectal ► Oesophageal ► Skin ► Other (free text)
Does your service have any protocols or standard operating procedures for packaging potentially cold/hypothermic casualties?	Multiple choice: ► Yes ► No ► Don't know

from known colleagues. After 3–6 weeks, the form was re-sent if a response had not been received. No further reminders were sent after this. The online survey was sent from the researcher's rnli.org.uk email address, and both email and survey contained a covering letter making the authors and aims of the project clear. The survey had first been piloted on medically trained individuals working on air ambulances and lifeboats.

The title of the questionnaire was 'Prehospital Hypothermia Survey'. The questions in the survey are presented in table 1 and were designed to investigate key areas of contention, or where recent published studies may be changing practice. To minimise the likelihood of confusion, the casualty in question was described as 'potentially cold/hypothermic'.

RESULTS

The overall response rate was 59%, ranging 41%–77% when broken down to different rescuing environments. This represents 112 responses from a wide range of teams contributing to SAR across the UK, with almost all responses provided by team leaders, medically qualified providers in the service or designated medical officers. The breakdown of respondents can be found in the online supplementary table.

Materials used to package hypothermic casualties and the use of active warming are shown in table 2.

Simple ambulance-style blankets, usually made from cotton or synthetic fibres, were widely used and incorporated into a third of packaging methods overall. Bubble wrap was used by 35% of air ambulances, but less commonly in other services.

Specially designed rescue bags or blankets were also widely used. A description or named manufacturer of the bag or blanket was provided in 87% of responses and showed a wide range of products in use. In table 2, these have been subdivided into lightweight, tightly packed blankets (less than 0.5 kg, usually vacuum packed, such as Blizzard blankets or bags (Blizzard Protection Systems, Gwynedd, UK), Mediwrap blankets (Mediwrap, Essex, UK), space blankets or thin survival bags) and heavyweight casualty bags (heavy-duty bags, usually more than 3 kg, such as Aiguille Mountain Rescue Casualty Bag (Aiguille, Cumbria, UK), Wiggy's Victims Casualty Hypothermia Bag (Wiggy's, Grand Junction, Colorado, USA), Flectalon Rescue Stretcher Blanket (Flectalon, now the Ascent Group, Pontypridd, UK), Snowsled Polar bags (now part of Aiguille), Aerohawk Thermal Blanket System (unknown manufacturer), Rocksnake Mountain Bag (Rocksnake, Kirchhof, Austria) or a description matching these designs). Heavyweight casualty bags were used in 81% and 100% of mountain and cave rescue teams, respectively, but only 29% of lowland rescue teams who instead favour lightweight blankets or wraps. Often these systems were combined. A vapour-tight layer, reducing evaporative heat loss, was incorporated into 94% of packaging methods across services.

Two cave rescue teams reported the use of neoprene bags for flooded underground rescues. Similarly, neoprene hoods were used on many lifeboats.

The use of active warming was variable. Chemically or electrically heated pads were used on 65% of air ambulances, 60% of cave rescue, 54% of mountain rescue and 29% of lowland rescue. Active rewarming was not reported to be used on lifeboats and only reported on one ground ambulance. The use of hot drinks was reported but not included in the results as its role purely as an active warming agent is disputed.[11] Rescuer body warmth was also not included for the same reasoning.[12] Warming of intravenous fluids was reported in 41% of air ambulances and also by one of the mountain rescue teams.

When managing wet casualties, 47% of providers reported removing wet clothes where practical. There were also eight mountain and lowland rescue teams reporting the additional use of vapour-tight barriers if not already used, to reduce evaporative heat loss. However, many responders considered almost all casualties in their environment to be wet and therefore would not manage them differently.

Temperature measurement was found to be performed prehospitally in 100% of ground and air ambulances, 75%, 80% and 93% of mountain, cave and lowland rescue teams, and 31% of lifeboat/lifeguard organisations. Tympanic membrane measurement was the most common method. Oesophageal measurement was reported in 53% of air ambulances.

Seventy-three per cent of providers reported having standard operating procedures for packaging hypothermic casualties.

DISCUSSION

To our knowledge, this is the first UK-wide survey of prehospital hypothermia management practice.

Packaging hypothermic casualties for extraction aims to reduce further heat loss that occurs through conduction, convection, evaporation and radiation. Several trials have compared methods,[11 13–18] but the optimal strategy is still unknown. Expert consensus recommends a combination of non-compressible insulation with a windproof/waterproof vapour-tight layer.[7–10] This survey demonstrates considerable variation in casualty bags and blankets used by UK prehospital and SAR services, but published guidance is largely being practised, with a high proportion of services incorporating vapour-tight layers among insulation. This contrasts with relatively poor use of vapour-tight layers in a Swedish survey.[6] Practical considerations such as cost, working environment and portability must also be considered and may explain why teams working in remote locations favour specially designed equipment, while road/air teams can make use of less-specialised bulky equipment such as ambulance-style

Table 2 Overall results table

		Air ambulance and EMRS	Ground ambulance	Mountain rescue	Lowland rescue	Cave rescue	Lifeboats and lifeguards
Response rates (see the online supplementary table for more detail)		17/22 77%	11/16 69%	52/77 68%	14/30 47%	5/12 42%	13/32 41%
Packaging materials and methods	Cotton or wool blankets	9/17 53%	11/11 100%	2/52 4%	8/14 57%	0 0%	7/13 54%
	Bubble wrap	6/17 35%	1/11 9%	1/52 2%	1/14 7%	0 0%	0 0%
	Heavyweight casualty bag	3/17 18%	0 0%	42/52 81%	4/14 29%	5/5 100%	1/13 8%
	Lightweight blanket or wrap	12/17 71%	9/11 82%	26/52 50%	13/14 93%	0 0%	11/13 85%
	Vapour-tight layer	16/17 94%	10/11 91%	48/52 92%	14/14 100%	5/5 100%	12/13 92%
	Reflective layer	16/17 94%	9/11 82%	26/52 50%	13/14 93%	1/5 20%	10/13 77%
Active warming	Electronic or chemical heat pads	11/17 65%	1/11 9%	28/52 54%	4/14 29%	3/5 60%	0 0%
	Warmed intravenous fluids	7/17 41%	0 0%	1/52 2%	0 0%	0 0%	0 0%
Temperature measurement	Yes/no	17/17 100%	11/11 100%	39/52 75%	13/14 93%	4/5 80%	4/13 31%
	Skin	2/17 12%	1/11 9%	13/52 25%	4/14 29%	2/5 40%	3/13 23%
	Tympanic/ear	15/17 88%	10/11 91%	27/52 52%	12/14 86%	0 0%	1/13 8%
	Oesophageal	9/17 53%	1/11 9%	2/52 4%	0 0%	0 0%	0 0%
	Rectal	1/17 6%	1/11 9%	1/52 2%	0 0%	1/5 20%	1/13 8%
	Oral	1/17 6%	0 0%	1/52 2%	1/14 7%	2/5 40%	0 0%
	Not stated	0 0%	1/11 9%	0 0%	0 0%	0 0%	0 0%
Protocols for packaging	Yes	15/17 88%	4/11 36%	42/52 81%	9/14 64%	5/5 100%	7/13 54%
	No	2/17 12%	7/11 64%	8/52 15%	4/14 29%	0 0%	5/13 38%
	Don't know	0 0%	0 0%	2/52 4%	1/14 7%	0 0%	1/13 8%

blankets and bubble wrap. In addition, road and air ambulances, and all-weather lifeboats have the ability, to some extent, to control the environment with shelter and ambient heating. While bubble wrap is limited in its insulating abilities, it does have vapour-tight properties.[13–15] UK practice appears to favour other vapour-tight materials to reduce evaporative heat loss. The use of neoprene casualty rescue bags by cave rescue teams appears to be unique to the wet underground environment, but may offer future use on open inshore lifeboats where casualties are being extracted in wet environments.

Active warming As advised by consensus guidance,[7–10] applying exogenous heat to hypothermic patients should be considered for all cases, particularly in the presence of significant trauma, and this is standard practice in the military. Applying heat in moderate and severe hypothermia is important not to rewarm but to slow the cooling rate of cardiac muscle in order to minimise the risk of arrhythmias and cardiac arrest. Use of large heated pads are supported by current international guidelines on prehospital hypothermia[7–10] and have shown benefits in clinical trials.[19 20] Chemically or electrically heated pads and blankets are being variably used by mountain rescue, cave rescue and air ambulances, and lowland rescue. Some teams report plans to incorporate this practice in the near future. The relatively infrequent adoption of these methods was also shown in previous surveys of other systems[3–6] and suggests further education could be beneficial. However, a likely contributing factor is the cost, size and weight of equipment needed. The potential risk of burns must also be considered, as the skin of hypothermic casualties is especially vulnerable. The heat packs should therefore not be placed immediately on to the skin[8] and extra care taken when used in conjunction with supplemental oxygen.[21]

Warmed intravenous fluids are used by 41% of air ambulance teams. It is important to warm intravenous fluids, especially refrigerated blood, to avoid further cooling of core temperature. This is commonly practised in operating theatres and has been shown to help maintain core temperature. However, as a means to warm a casualty, it is in itself ineffective. Danzl and Huecker calculated in Auerbach's Wilderness Medicine that each litre of fluid at 42° C provides 14 kcal to a 70 kg patient at 28°C, elevating core temperature only 0.33°C.[22] Vast quantities of warm fluid would therefore be needed to raise the core temperature to any substantial degree. It is likely not an intervention useful for other SAR organisations unless fluids are given for other reasons.

Wet casualties are particularly prone to heat loss by evaporation. Consensus guidance, supported by recent studies, have suggested that the use of vapour-tight layers to reduce evaporative heat loss may negate the need to remove wet clothing.[23] This could be highly beneficial, as the removal of wet clothing exposes the casualty to a cold environment and risks reducing core temperature further. It is worth noting that studies comparing removal of wet clothes with using a vapour-tight layer have so far used small sample sizes in laboratory conditions and showed limited effect.[23] Further research is therefore warranted in this topic. Ninety-four per cent of services are using vapour-tight layers as standard; 47% of services would still consider removing wet clothes. In the field, there are many factors to consider, and the clinical scenario in question would be likely to influence this decision.

Assessing the severity of hypothermia aids prehospital decision-making, such as determining the urgency of extraction and location of definitive care. Severity of hypothermia can be assessed by core temperature, environmental cues and clinical signs, such as level of consciousness and presence or absence of shivering. While accurate core temperature measurement in the prehospital environment is challenging, it is a practice supported by recent guidance.[7–9] Overall, this survey found a lack of consensus and poor implementation of current guidance for core temperature monitoring, which is consistent with similar surveys.[3–6] Most services reported using thermometers, but also commented that this can be unreliable, and stressed the importance of clinical signs. Skin and oral temperature measurements are used by a quarter of providers, but evidence suggests it will not reflect core temperatures in hypothermia.[24] The disadvantages of rectal measurement, used by five services, include risk of significant lag time behind core temperature and exposing the casualty to the cold environment.[7–9] While oesophageal probes are the more reliable method of recording core temperature,[24] they are invasive and generally require the patient to be unresponsive. It is therefore unsurprising that this method is used mainly on air ambulances. Tympanic membrane thermometers were found to be the most commonly used in this survey. While infrared devices are unreliable in hypothermia,[7–9] epitympanic measurement with a thermister or thermocouple probe does provide reliable results, providing the external auditory meatus can be insulated from the elements, is clear of ear wax and water/ice and providing there is adequate cardiac output.[7–9]

Protocols

Almost three quarters of SAR teams reported having protocols for packaging hypothermic casualties. Guidance for managing hypothermia is becoming more refined, and there is a call for better integration between SAR services and EDs so that optimal definitive care can become more available.[25]

In December 2014, Mountain Rescue England and Wales adopted the Lake District Search and Mountain Rescue Association Hypothermia Protocol for all mountain rescue teams. It is surprising therefore that some teams appeared to be unaware of this guideline and only 54% acknowledged the use of active rewarming, which is described in this protocol. It is clear that although protocols are required to set appropriate standards for clinical practice, more needs to be done to produce and disseminate local and national guidance.

Limitations to this study include the response rate of 59%. A contributing factor to this was the variability in organisational structure of teams and therefore the difficulty in reaching the responsible medical officer or team leader. Telephone contacts and addresses were not attempted, as these were not uniformly available across teams. However, respondents were from a wide range of teams which suggests the responses are generalisable. This study asked broad questions about the management of a cold/hypothermic patient but did not specify whether this referred to the management of mild or severe hypothermia, which may have produced different responses.

In summary, published consensus guidelines and national protocols have provided guidance to prehospital hypothermia management, but there are still key areas where variation exists. Further education and research is needed in the areas of the optimal packaging solution for evacuating casualties; the use of active warming; and reliable, core temperature assessment. Further work on protocols and education may aid the conversion of new research into working practice.

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REFERENCES

1 Ireland S, Endacott R, Cameron P, *et al*. The incidence and significance of accidental hypothermia in major trauma—a prospective observational study. *Resuscitation* 2011;82:300–6.
2 United Kingdom Search and Rescue. Strategic overview of Search and Rescue in the United Kingdom and Northern Ireland. 2017 https://www.gov.uk/government/publications/search-and-rescue-framework-uksar (accessed 28 Jul 2017).
3 Hamilton RS, Paton BC. The diagnosis and treatment of hypothermia by mountain rescue teams: a survey. *Wilderness Environ Med* 1996;7:28–37.
4 Podsiadło P, Darocha T, Kosiński S, *et al*. Severe hypothermia management in mountain rescue: a survey study. *High Alt Med Biol* 2017;18:411–6.
5 Karlsen AM, Thomassen O, Vikenes BH, *et al*. Equipment to prevent, diagnose, and treat hypothermia: a survey of Norwegian pre-hospital services. *Scand J Trauma Resusc Emerg Med* 2013;21:63.
6 Henriksson O, Björnstig U, Saveman BI, *et al*. Protection against cold—a survey of available equipment in Swedish pre-hospital services. *Acta Anaesthesiol Scand* 2017;61:1354–60.
7 Paal P, Gordon L, Strapazzon G, *et al*. Accidental hypothermia—an update. *Scand J Trauma Resusc Emerg Med* 2016;24:111.
8 Zafren K, Giesbrecht GG, Danzl DF, *et al*. Wilderness medical society practice guidelines for the out-of-hospital evaluation and treatment of accidental hypothermia: 2014 update. *Wilderness Environ Med* 2014;25:S66–S85.
9 Zafren K. Out-of-hospital evaluation and treatment of accidental hypothermia. *Emerg Med Clin North Am* 2017;35:261–79.
10 Haverkamp FJC, Giesbrecht GG, Tan E. The prehospital management of hypothermia—an up-to-date overview. *Injury* 2018;49:149–64.
11 Oliver SJ, Brierley JL, Raymond-Barker PC, *et al*. Portable prehospital methods to treat near-hypothermic shivering cold casualties. *Wilderness Environ Med* 2016;27:125–30.
12 Giesbrecht GG, Sessler DI, Mekjavić IB, *et al*. Treatment of mild immersion hypothermia by direct body-to-body contact. *J Appl Physiol* 1994;76:2373–9.
13 Thomassen Ø, Færevik H, Østerås Ø, *et al*. Comparison of three different prehospital wrapping methods for preventing hypothermia—a crossover study in humans. *Scand J Trauma Resusc Emerg Med* 2011;19:41.
14 Jussila K, Rissanen S, Parkkola K, *et al*. Evaluating cold, wind, and moisture protection of different coverings for prehospital maritime transportation—a thermal manikin and human study. *Prehosp Disaster Med* 2014;29:580–8.
15 Zasa M, Flowers N, Zideman D, *et al*. A torso model comparison of temperature preservation devices for use in the prehospital environment. *Emerg Med J* 2016;33:418–22.
16 Grant SJ, Dowsett D, Hutchison C, *et al*. A comparison of mountain rescue casualty bags in a cold, windy environment. *Wilderness Environ Med* 2002;13:36–44.
17 Press C, Duffy C, Williams J, *et al*. Measurements of rates of cooling of a manikin insulated with different mountain rescue casualty bags. *Extrem Physiol Med* 2017;6:1.

18 Henriksson O, Lundgren JP, Kuklane K, *et al*. Protection against cold in prehospital care—thermal insulation properties of blankets and rescue bags in different wind conditions. *Prehosp Disaster Med* 2009;24:408–15.
19 Watts DD, Roche M, Tricarico R, *et al*. The utility of traditional prehospital interventions in maintaining thermostasis. *Prehosp Emerg Care* 1999;3:115–22.
20 Lundgren P, Henriksson O, Naredi P, *et al*. The effect of active warming in prehospital trauma care during road and air ambulance transportation—a clinical randomized trial. *Scand J Trauma Resusc Emerg Med* 2011;19:59.
21 Brooks B, Deakin CD. Relationship between oxygen concentration and temperature in an exothermic warming device. *Emerg Med J* 2017;34:472–4.
22 Danzl D, Huecker M. Accidental hypothermia. In: Auerbach P, Cushing T, Harris N, eds. *Auerbach's wilderness medicine*. 7th edn. Philadelphia, PA: Elsevier, 2017:151–2.
23 Henriksson O, Lundgren PJ, Kuklane K, *et al*. Protection against cold in prehospital care: wet clothing removal or addition of a vapor barrier. *Wilderness Environ Med* 2015;26:11–20.
24 Strapazzon G, Procter E, Paal P, *et al*. Pre-hospital core temperature measurement in accidental and therapeutic hypothermia. *High Alt Med Biol* 2014;15:104–11.
25 Gordon L, Ellerton JA, Paal P, *et al*. Severe accidental hypothermia. *BMJ* 2014;348:g1675.