Transportation of blood in a helicopter emergency medical service: The importance of specialised equipment

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Background. Administration of blood in the pre-hospital environment is becoming more feasible, particularly in helicopter emergency medical services (HEMS) during primary response and critical care transfers of major trauma patients. The main challenge in this environment is maintaining a suitable thermal environment for blood transport during missions that may last several hours.

Objective. To investigate whether a simple and cost-effective method of storage in a typical HEMS operation would provide an adequate thermal environment for blood.

Methods. A commercially available cooler box and ice packs were used to simulate a blood transport environment during HEMS missions over three summer and three winter months. In-box temperature was monitored using an electronic thermometer and data logger.

Results. Temperature data were recorded during 146 missions with a mean duration of 02:01:35 (95% confidence interval 01:46:25 - 02:16:46). A total of 344 temperature observations were done in the summer months and 384 in the winter months. All mean temperatures recorded in the cooler box were within the required 1 - 6°C range; however, of the total temperature observations recorded, 30% (102/344) during summer were >6°C while 8% (32/384) during winter were >6°C and 15% (59/384) were <1°C. The maximum temperature recorded overall was 13°C and the minimum was −3°C.

Conclusion. Low-cost, non-specialised materials used in a HEMS operation were not adequate for the safe transport of blood.

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Although the value of blood in improving outcomes after resuscitation from haemorrhagic shock is well known, this form of treatment has not been widely used in the pre-hospital environment. Recently, some studies have begun to reveal the feasibility of blood administration in the field under select circumstances, one of them being helicopter emergency medical services (HEMS) operations – both primary responses and inter-facility critical care transfers involving patients with major trauma.[1-4]

One of the significant challenges of transporting and administering blood in a HEMS environment relates to preserving the required blood storage temperature during missions that may last several hours. Helicopters represent an austere environment for both patient care and storage of temperature-sensitive drugs and fluids with little space, severe limitations on access to external power sources and exposure to thermal variations caused by environmental, diurnal and seasonal changes. Being able to safely transport blood in such an environment could lead to its pre-hospital use becoming more widespread, with benefits for a significant population of patients in South Africa (SA). The aim of this study was to investigate whether a simple and cost-effective method of storage in a typical HEMS operation would provide an adequate thermal environment for blood, reliably maintaining the required temperature range of 1 - 6°C.[5]

Methods

A commercially available cooler box (Lifestyle rigid 15L cooler box, Westpack Lifestyle, SA) was chosen to simulate the kind of low-cost container that we proposed might be used for blood storage in this environment. The chosen container did not have any electrical cooling functionality. Manipulation of the container's internal temperature was facilitated by the addition of one or more commercial cooler bag ice packs, each consisting of a plastic container filled with ice.

Temperatures were measured over two 3-month periods during 2013 - 2014: December - February and June - August. During these times the box was kept in a refrigerator at the HEMS base. The refrigerator temperature was set to remain in the range of 1 - 6°C. This was monitored using an electronic refrigerator thermometer that was checked at shift handover every day.

Some temperatures recorded in the box in early January exceeded the upper limit of 6°C. A decision was made to add another ice pack and the insulation was improved.

For each mission the HEMS crew would remove the box from the refrigerator and place it in the helicopter for the flight.

Temperature conditions in the box were measured using two electronic temperature and humidity data loggers (Model 42270 temperature/humidity data logger, Extech Instruments, USA). Two devices were used in order to provide redundancy in the event that one of them failed. The devices were set to measure and log temperatures every 30 minutes. These temperature data were downloaded every 48 - 72 hours by attaching the data loggers to a notebook computer via a cable and software interface. During the data collection period no device failures were encountered, and therefore data from the same single data logger were used. Raw temperature data and logging times were exported to an electronic spreadsheet application.

Mission times were obtained from the HEMS dispatch centre and used to extract the relevant temperature data for all flights in each 3-month period. These data were descriptively analysed.

Results

Over the combined 6-month study period, 183 missions were flown. In 37 missions data were not recorded because the flight

Table 1. Mean recorded temperatures

Month	Mean temperature (°C)	95% confidence interval
December	5.1	4.5 - 5.8
January	5.9	5.5 - 6.4
February	3.5	3.0 - 3.8
June	2.6	2.3 - 2.9
July	2.8	2.4 - 3.2
August	3.8	3.5 - 4.2

crew either did not take the cooler box on the flight, or did not place the required number of ice packs in the box. This left 146 missions during which temperature data were logged: 72 in the summer months (December - February) and 74 in the winter months (June - August). The mean (95% confidence interval) time for all missions was 02:01:35 (01:46:25 - 02:16:46). Mean recorded temperatures for each month are shown in Table 1. A total of 344 temperature observations were done in the summer months and 384 in the winter months.

Despite all of the mean temperatures being within the 1 - 6°C range identified, several maximum and minimum temperatures fell outside of this range for short periods during both the summer and winter months.

During the summer months, 102 (30%) of 344 individual temperature measurements exceeded 6°C. The maximum recorded temperature was 13°C. Further analysis of upper-range temperature breaches showed that 22 of these lasted for between 30 and 120 minutes, 2 ranged between 180 and 210 minutes, 2 lasted for 300 minutes and 1 lasted for 390 minutes. Over the same period of time, 18 (5%) individual temperature measurements fell below 1°C, with 2 lower-range breaches for a single 30-minute measurement window, 2 for 60 minutes, 3 for 90 minutes and 1 for 120 minutes.

During the winter months, 32 (8%) of 384 individual temperature measurements exceeded 6°C. Eight of these lasted for between 30 and 60 minutes, one lasted 90 minutes and three lasted for between 120 and 150 minutes. Over the same period, 59 (15%) of 384 individual temperature measurements fell below 1°C. Of these, nine lower-range breaches were for a single 30-minute temperature measurement window, while between one and four were for between 120 and 150 minutes. The two longest temperature measurement periods below 1°C were 210 and 390 minutes, and the lowest temperature recorded during this time was −3°C.

There did not appear to be any discernible diurnal pattern to the above- and below-range temperature fluctuations, with some occurring during daytime and others during the night. However, another distinct pattern was observed – that temperature deviations below 1°C occurred within the first few temperature measurements during a flight, and that temperature deviations above 6°C occurred towards the end of a flight, the shortest of which was approximately 60 minutes in duration.

Discussion

This study was aimed at investigating the feasibility of using low-cost materials for the safe storage of blood in the pre-hospital environment during HEMS missions. Although the required blood storage temperature range of 1 - 6°C was maintained most of the time, several periods, ranging between 30 and 390 minutes, were observed where storage temperatures deviated from this range. The majority of these were during summer months and were deviations above the maximum temperature limit.

Temperatures that fell outside of the required range mostly represented the consequences of trying to maintain a stable temperature within a relatively narrow range using a crude method – the inclusion of ice packs in the cooler box and adding an insulating layer. Although a reasonably stable temperature was obtained in most cases, in some situations the temperature drop with the addition of ice packs at the beginning of a flight was too extreme. Conversely, in other situations the thawing of ice packs led to the temperature gradually becoming too warm towards the end of a flight. The rise in temperatures later in a mission during summer months was, to a limited extent, ameliorated by the addition of insulation to the cooler box as explained above. However, breaches of the maximum temperature limit still occurred after this intervention, although less frequently and for shorter periods.

Although there are undoubtedly a number of factors contributing to the observed temperature deviations from the required range, it is not likely that these would be amenable to control in such an environment with use of the materials that were considered in this study. More specialised cooler boxes which have superior insulation have been designed specifically for the storage of blood and other products in pre-hospital conditions.[6] These boxes are designed to be used with gel cooling packs (rather than ice), which are purported to be more effective in maintaining a temperature just above freezing. Although better insulation would logically prevent the drift above 6°C with increased mission times, this feature would not necessarily prevent lower temperature range breaches and might actually cause them to persist for longer.

The specialised equipment referred to above is imported, and therefore significantly more costly than the materials we used. Externally powered cooler boxes may also be more effectively used to maintain temperatures within a narrow range, although size and availability of a power source may be problematic in a helicopter.

Safe storage and transport of blood in a helicopter under climatic conditions found in an SA HEMS system cannot be achieved with simple and low-cost materials. More specialised transport boxes which allow for more accurate temperature control for longer periods of time are required, at an associated higher cost.

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