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Original Research

## Transportation of Temperature-sensitive Medications in an Air Medical Setting

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### A B S T R A C T

**Introduction:** This article describes an effective system for the transportation of temperature-sensitive medications within acceptable temperature ranges in the air medical setting.

**Method:** A temperature audit using data logging thermometers of drug bags used to transport temperature-sensitive medications revealed that temperature excursions above the accepted maximums (8°C) occurred frequently. An experimental methodology was developed using a commercially available shipping container that was subject to a rapid conditioning regimen. Through a series of experimental trials, it was determined that with the devised conditioning regimen the system would maintain a consistent 2°C to 8°C. This system was implemented, and data were collected over a series of air medical missions (5) over a 90-day period.

**Results:** The average mission duration was 10 hours with temperature-sensitive medications spending an average of 15.3 hours out of the pharmacy fridge. Temperature data showed temperature-sensitive medications remained within the 2°C to 8°C range for the duration of all missions in which the shipping container was prepared appropriately.

**Conclusion:** This proof of concept study showed a system that can maintain acceptable storage conditions for temperature-sensitive medications.

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Product information from pharmaceutical manufacturers generally stipulates refrigerated ( $\geq 2^{\circ}\text{C}$  and  $\leq 8^{\circ}\text{C}$ ) or room temperature ( $\leq 25^{\circ}\text{C}$  or  $\leq 30^{\circ}\text{C}$ ) storage conditions are required to guarantee medication stability. When an operation has a system of pharmaceutical handling, storage, and monitoring procedures to maintain these temperature ranges, this is called a “cold chain.” Cold chain systems exist because a potential consequence of temperature excursions in a cold chain is the degradation of pharmaceuticals and the associated unpredictability of the clinical effect when administered to a patient. Mass spectrometry has been used to quantify pharmaceutical degradation of medications exposed to experimental thermal cycling replicating environmental temperatures in an ambulance<sup>1</sup> and real-world prehospital emergency medical service temperatures.<sup>2</sup>

In the air medical transport setting, space, weight, and safety constraints dictate that methods used to transport pharmaceuticals must be lightweight, compact, and robust. A number of authors

have described the difficulty of maintaining temperature-controlled conditions in ground and air transport settings.<sup>3–5</sup> These authors universally conclude that temperature-sensitive medications are exposed to temperatures outside (typically above) the allowable thermal ranges frequently and for prolonged durations. One publication describes a system using an insulated pouch and an ice pack to transport temperature-sensitive medications.<sup>6</sup> The outcome of this proof of concept study was that the described system could not maintain acceptable medication storage temperatures  $\geq 2^{\circ}\text{C}$  and  $\leq 8^{\circ}\text{C}$  for the mission duration. There are no other examples of attempts to validate systems used to transport temperature-sensitive medications in the emergency medical service or air medical setting.

A practical solution for the transportation of temperature-sensitive medications is short dating. Short dating is the process of amending the expiry date to reflect the projected shelf life at room temperature. Whilst being a practical and economic option for temperature-sensitive medications with a low per unit cost, when the per unit cost is high, short dating is not acceptable. This operation uses several medications that have a high per unit cost.

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**Table 1**  
High per Unit Cost Medications

	Australian Price per Vial (US Dollars)	Number of Vials Carried	Required Storage Temperature
Curosurf surfactant (Poractant Alfa). Chiesi Farmaceutici S.p.A (Via Palermo, Italy)	\$303	7	2°C–8°C
Prostin VR (Alprostadil). Pfizer Australia Pty Ltd. (West Ryde, Australia)	\$289	1	2°C–8°C
Polyvalent Snake Antivenom concentrate for infusion. Sequirus Pty Ltd, (Parkville, Australia)	\$1373	1	2°C–8°C

## Methods

### Setting

This trial was conducted within the Top End Medical Retrieval Service. This service is provided by a not-for-profit contractor (CareFlight) via fixed and rotary wing platforms to conduct air medical transportation of patients from remote areas of the 700,000 km<sup>2</sup> top half of the Northern Territory (the “Top End”), Australia, to the regional center of Darwin. The climate of the Top End is characterized by humid, tropical conditions with typical daytime highs of 30°C to 34°C (86°F–93.2°F) and nighttime lows of 18°C to 28°C (64.4°F–82.4°F). The remote communities of the Top End are very isolated with a low population density, extremely limited health care services, and a high burden of disease and traumatic injury.

### Mission Duration

The average duration of all missions at this base is 4 hours from the point of tasking to the completion. Typically, temperature-sensitive medications are carried on missions to unwell neonates, which because of the requirement for complex stabilization and intervention at referring sites, have an average mission duration of 10 hours.

### Current Practice

A medication bag containing fridge temperature and room temperature stable medications is taken on all missions and is kept in the fridge when not in use. When necessary, additional high-cost temperature-sensitive medications (see Table 1) are placed inside this medication bag for specific patient groups.

### Temperature Testing

A previous unpublished internal CareFlight audit using Tempmate S1 (imec Messtechnik GmbH, Hilbronn, Germany) data loggers of medication bags (5) over a 100-day period, showed that on average the internal temperature exceeded 8°C for 738 hours per bag (every time the bags were removed from the fridge for >2 hours).

The current study was conducted over a 90-day period. Medications were stored in Packit (PackIt, LLC, Westlake Village, CA) brand pouches in a 5°C temperature-controlled pharmacy fridge. A Hobo MX100 (Onset Computer Corporation, Bourne, MA) data logger colocated with the medications was used to log the temperature at 3-minute intervals for the duration of the study. On tasking, the medication pouch was placed in a reusable passively insulated shipping container (Pelican BioThermal Credo Promed Series 4 2L, Pelican BioThermal, Plymouth MN).

The shipping container (Fig. 1) has a freezable removable internal liner that was stored in a –18°C domestic freezer when not in use. The manufacturer states that with appropriate conditioning of the liner and packing of the shipping container, this device will maintain the cold chain temperature (2°C–8°C) for up to 48 hours.

The process for conditioning and packing the thermal shipping container is as follows:

1. The shipping container freezable inner liner is removed from the freezer and filled with cold tap water (local cold tap water is 26°

C–28°C); the lid is replaced and left for 3 minutes (rapid conditioning)

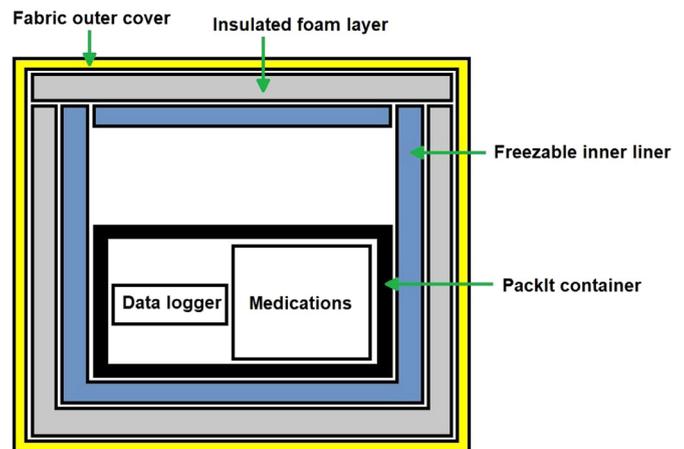
2. The water is emptied out, and the inside/outside of the liner is dried with a towel
3. The liner is placed in the shipping container
4. The temperature-sensitive medication pouch is placed inside
5. The box is sealed per the manufacturer’s recommendation

## Results

Excluding task 4, the system was able to maintain 2°C to 8°C temperatures. The lowest recorded temperature was 2.91°C, and the highest was 7.25°C. Task 4 had a low temperature of –0.82°C. See Table 2.

## Discussion

The transportation of temperature-sensitive medications while maintaining stipulated temperature conditions is a well-described issue in the air medical and EMS literature. The described system was able to maintain 2°C to 8°C cold chain conditions in 4 of 5 episodes (Fig. 2) throughout air medical transport missions. The task 4 temperature excursion data (Table 2) show that when packing and preparation procedures are not followed correctly, temperature excursions

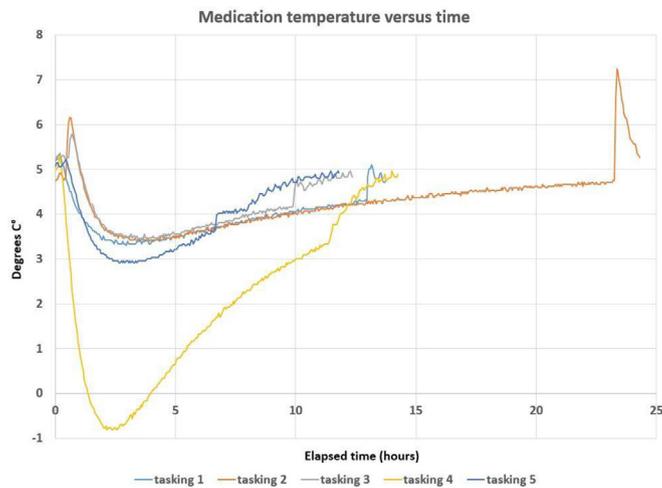


**Figure 1.** A depiction of the shipping container with medications and data logger inside.

**Table 2**  
The Mission Durations and Logged Temperatures

	Duration Outside the Pharmacy Fridge	Low Temperature	High Temperature	Average Temperature
Task 1	13.75 hours	3.39°C	5.36°C	3.91°C
Task 2	24.3 hours*	3.4°C	7.25°C	4.28°C
Task 3	12.35 hours	3.43°C	5.79°C	4.12°C
Task 4	14.25 hours	–0.82°C	5.32°C	2.27°C
Task 5	11.75 hours	2.91°C	5.23°C	3.93°C

\* The actual duration of this mission was 8 hours.



**Figure 2.** The medication temperature within the shipping container over the duration of the time outside the pharmacy fridge.

below or above acceptable ranges can occur. Follow-up with the task 4 flight crew revealed that the rapid conditioning step was omitted, and the affected medications were removed from use. The task 2 (Table 2) flight crew did not return the temperature-sensitive medication pouch to the pharmacy fridge at the completion of the task. This omission was not identified until 24 hours had elapsed, and no temperature excursion occurred. The data presented in this article highlight the benefit of using data logging thermometers, which enable an operation to monitor drug temperatures and intervene

when necessary to remove affected medication stock from circulation if a temperature excursion occurs.

## Conclusion

The prehospital setting is a challenging environment in which it is not always possible to replicate the level of care and clinical systems available in the hospital. This article presents a novel solution to the problem of the storage and transportation of temperature-sensitive medications in the prehospital setting. The use of the described system would enable an air medical provider to avoid unnecessary medication disposal and the associated cost. Significantly, a robust system should give prehospital practitioners some degree of confidence that the medications that they are administering are not heat affected and should work as expected. Although useful as a proof of concept, this trial was ended after 90 days, and a larger data series would provide further validation to support implementation of the described system in the prehospital clinical setting.

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