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BRIEF REPORT

A Chemical Heat Pack–Based Method For Consistent Heating of Intravenous Fluids

Matthieu P. DeClerck, MD; Grant S. Lipman, MD; Dennis A. Grahn, PhD; Vinh Cao, BS; Mark Wieland, BS; Tom Troxel, BS; H. Craig Heller, PhD

From the Division of Emergency Medicine, Department of Surgery, Stanford University School of Medicine (Drs DeClerck and Lipman); and the Department of Biology, Stanford University (Drs Grahn and Heller, and Messrs Cao, Wieland, and Troxel), Stanford, CA.

Background.—Transfusion of cold intravenous fluids (IVF) can exacerbate hypothermia. Civilian and military guidelines recommend heated IVF for hypothermic patients; however, there is currently no ideal IVF heating system for use in resource-limited settings.

Objective.—Development of a system that uses flameless ration heaters (FRH) and an insulated sleeve for the consistent delivery of IVF at physiologically appropriate temperatures (40°–42°C) over the range of ambient conditions typical of the prehospital and wilderness environments.

Methods.—The temperatures of 0.9% normal saline (NS) 1-L bags were measured under 3 ambient conditions: 3°C, 10°C, and 20°C. The IVF was placed in an insulated pouch along with a predetermined number of activated FRH (5 FRH for 3°C, 4 FRH for 10°C, and 3 FRH for 20°C) for 10 minutes before removing the FRHs. The insulated IVF bag was drained through 280 cm of intravenous tubing at a flow rate of 77 mL/min. Raw temperature data for internal and delivery temperatures were collected and analyzed.

Results.—The temperature of the IVF throughout the delivery of 1 L of NS under the 3 ambient conditions was as follows (mean ± SD): at 3°C ambient, 47° ± 2.1°C internal and 42.6°C ± 1.4°C at delivery; at 10°C ambient, 52.3° ± 2.7°C and 45.2° ± 1.6°C; and at 20°C ambient, 45.5° ± 1°C and 39.7° ± 0.7°C.

Conclusions.—The IVF heating system described here reliably delivered physiologically appropriate temperature intravenous fluids in 2 of the 3 ambient treatment conditions. With the appropriate number of FRH for the ambient conditions, this system enables the delivery of warmed IVF to provide active warming, which may be clinically beneficial in the prevention and treatment of hypothermia.

Key words: hypothermia, improvisation, resuscitation, intravenous fluids, treatment, prevention

Introduction

Accidental hypothermia, an involuntary drop in core body temperature to less than 35°C (95°F), is a potentially lethal condition common in prehospital medical situations. Hypothermia adversely affects patient outcomes. There is a 7% mortality associated with core temperatures between 35°C and 32.2°C on emergency room admission and a 23% mortality associated with core temperatures less than 32.2°C.[1] Individuals with core temperatures below 35°C on admission have an 8 times greater risk of mortality compared with normothermic individuals.[2] Hypothermia in trauma victims is common, and severe hypothermia is associated with poorer clinical outcomes as well as higher mortality.[3] Delivery of room temperature or cold intravenous fluids (IVF) can reduce the core body temperature by 0.3°C or more, potentially exacerbating the hypothermic condition.[3]

It is recommended that circulatory support in moderate and severe hypothermia be maintained with boluses of IVF warmed to 40°C to 42°C to prevent further core cooling.[4] Although delivery of warm IVF as an isolated clinical intervention cannot reverse severe hypothermia, in situations with limited resources the infusion of warmed IVF may be the only available means for internal rewarming of a hypothermic victim despite its limitations.[2] In prehospital settings, IVF are usually maintained at ambient temperature before use.[5] Current IVF heating systems using battery packs are available but their weight to energy ratio and limited battery life

Corresponding author: Matthieu P. DeClerck, MD, 743 S. Mentor Avenue, Pasadena, CA 91106 (e-mail: mpdeclerck@gmail.com).

render them inefficient for most field applications.[2] Flameless ration heaters (FRHs) from meals ready-to-eat (MREs) have been studied as potentially useful heat sources for warming IVF in the field.[5,6] However, current models lack standardization that can consistently deliver warmed IVF. The aim of this study was to establish a method for heating IVF to recommended temperatures over a range of ambient conditions using an insulated pouch and commercially available FRHs.

Methods

DEVICE

The device consisted of a closed-cell foam insulating pouch to contain a 1-L IVF bag and up to 5 FRHs. The pouch was fabricated of 8-mm-thick cloth-finished neoprene. A 50 × 40 × 1.2 cm (approximately 19″ × 16″ × 0.5″ length × width × thickness) piece of neoprene was cut and folded into a 30 × 15 × 5 cm (approximately 12″ × 6″ × 2″) rectangle with overlapping sides (Figure 2). Pieces of hook and loop fabrics (Velcro) were attached to the sides of the perimeters of the neoprene to enable closing the structure (Figure 3). The flaps that formed the base and top of the enclosure were pierced to enable attachment of the intravenous (IV) tubing assemblage to the IVF (base). A hook to hang the

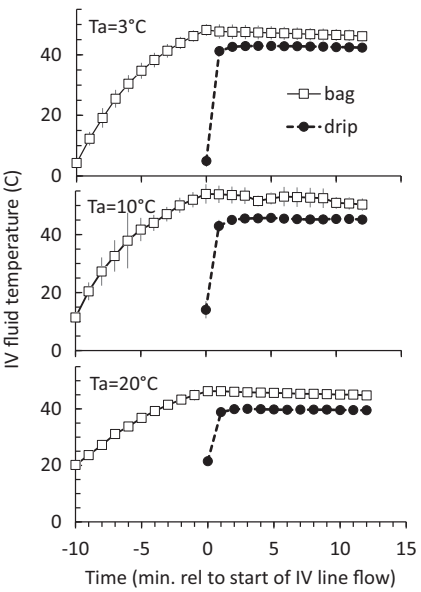

Figure 1. Intravenous (IV) fluid (mean ± SD) vs time at 3 ambient temperatures (Ta). Time is marked relative to the start of the draining of the IV fluid storage. Flameless ration heaters (FRHs) were placed in an insulated pouch along with the 1-L IV fluid bag 10 minutes before the start of the drip. The FRHs were removed at time 0. Five FRHs were used in the top panel, 4 FRHs in the middle panel, and 3 FRHs used in the bottom panel.

Figure 2. Neoprene insulating pouch in open configuration containing 1 L of intravenous fluid and flameless ration heaters.

assembly from a drip stand was attached (top). The neoprene material was laid flat for loading with a 1-L IVF bag and FRH, and once activated, the insulating pouch was closed using the hook and loop fabric.

We measured IVF temperatures at 2 sites, inside the storage bag and at the point of delivery at the distal end of the IV tubing, using thermocouple probes (Mon-a-Therm 503-0028, Mallinckrodt Medical, Inc, St. Louis, MO) that had been stripped of their outermost coats of insulation. The tip of the thermocouple probes were threaded through 16G syringe needles (PrecisionGlide 16G1, Becton, Dickinson and Company, Franklin Lakes, NJ) so that the tips of the thermocouples reached but did not extend past the beveled end of the needle. The probes were then epoxied in place. The temperature of the IVF in the storage bag was measured by inserting a 16G needle encasing a thermocouple probe directly through the rubberized fill port of the IVF bag. The temperature of the IVF at the delivery site was measured by inserting a 16G needle encasing a thermocouple probe through the most remote access port in the IV tubing so that the tip of the thermocouple probe was positioned in the IVF stream. The thermocouple probes were connected to a laptop-based thermocouple transducer/data collection system (GEC Instruments, Gainesville, FL) that recorded temperature data at 1-second intervals. At the conclusion of each trial, the temperature data were downloaded to a central spreadsheet (Microsoft Office Excel for Windows 2003, Microsoft, Inc, Redmond, WA) for analysis.

GENERAL METHODS

The experimental trials were conducted in a 2.4 × 3.3 × 2.4 m (width × length × height) temperature-controlled chamber designed to maintain ambient temperature