Performance Characteristics of Portable Fluid Warming Technology

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INTRODUCTION

Resuscitation of the critically ill/injured is a vital and complex task in any setting, often compounded by environmental influences in austere environments. The need for equipment to support this function is paramount and the devices used must provide reliable performance meeting clinician expectations for intended use. In the setting of resuscitation, some devices used for infusions are also designed to warm fluids. We evaluated four portable fluid warmers to determine the ability to warm fluids at different flow rates and temperatures and the total time each device could operate on battery power.

METHODS

We evaluated fluid warmers currently employed and/or under procurement consideration using normal saline and chilled packed red blood cells (PRBC); Buddy Liter and Buddy Lite AC, (Belmont Instrument Corp., Billerica, MA), Thermal Angel, (Estill Medical Technologies, Dallas, TX), and M Warmer System, (MEQU, Copenhagen, DK). Using standard IV tubing attached to a room temperature (22-24ºC) 1000 mL bag of 0.9% NaCl solution or 1 unit of iced PRBC, each device was attached to the distal end of the tubing. Fluid temperature was measured via a thermocouple (Compact DAQ, National Instruments, Austin, TX) before entering the device and after flowing through the device at the end of extension tubing, simulating the point at which the fluid would enter a patient. Temperature was measured every second and recorded to a computer for later analysis. Two flow rates were utilized for testing with each device. One hundred twenty-five mL/hr was used to simulate a non-emergent maintenance rate for 1 hour and was controlled with an IV pump. An emergent IV rate was simulated by placing a 1000 mL bag of NaCl or 2 units of iced PRBC in a pressure infusion bag inflated to 300 mm/Hg, allowing the fluids to free flow under pressure through the device. Two of each device was used for the evaluation with two tests accomplished at each flow rate. Battery testing was done at the non-emergent rate and each device was operated until the battery was exhausted as shown by the device indicator and/or a decrease in fluid temperature. A one-way ANOVA test was used to determine statistically significant differences in temperature between the devices at each condition ($p < 0.05$).

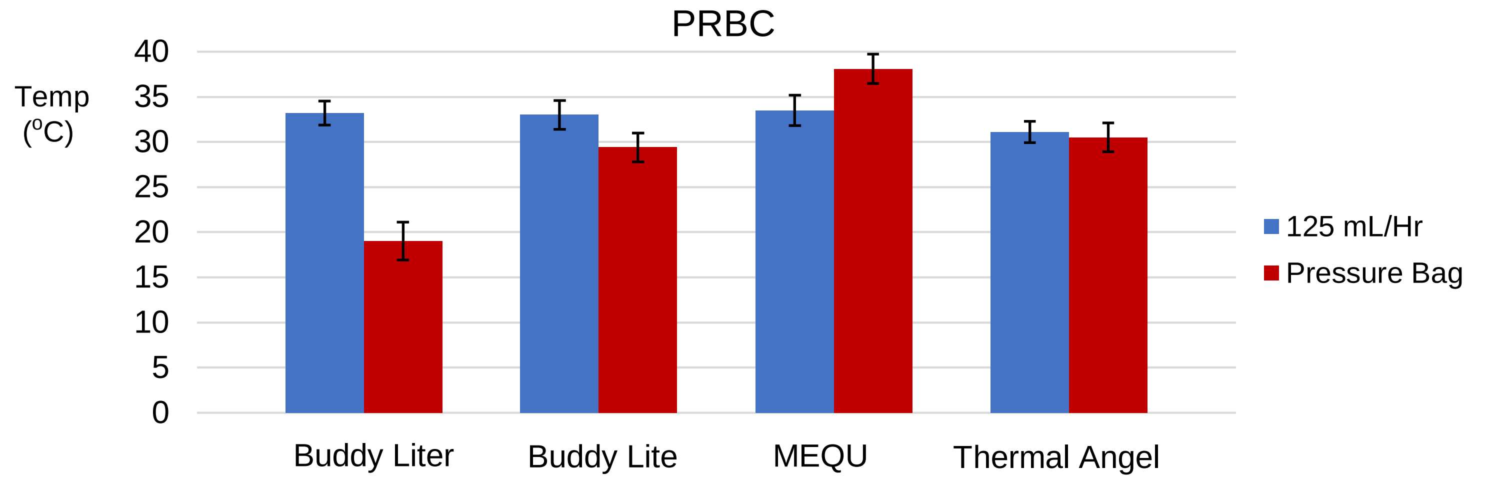

Fig 1. Post warmer Mean (SD) temp on battery power using iced PRBC

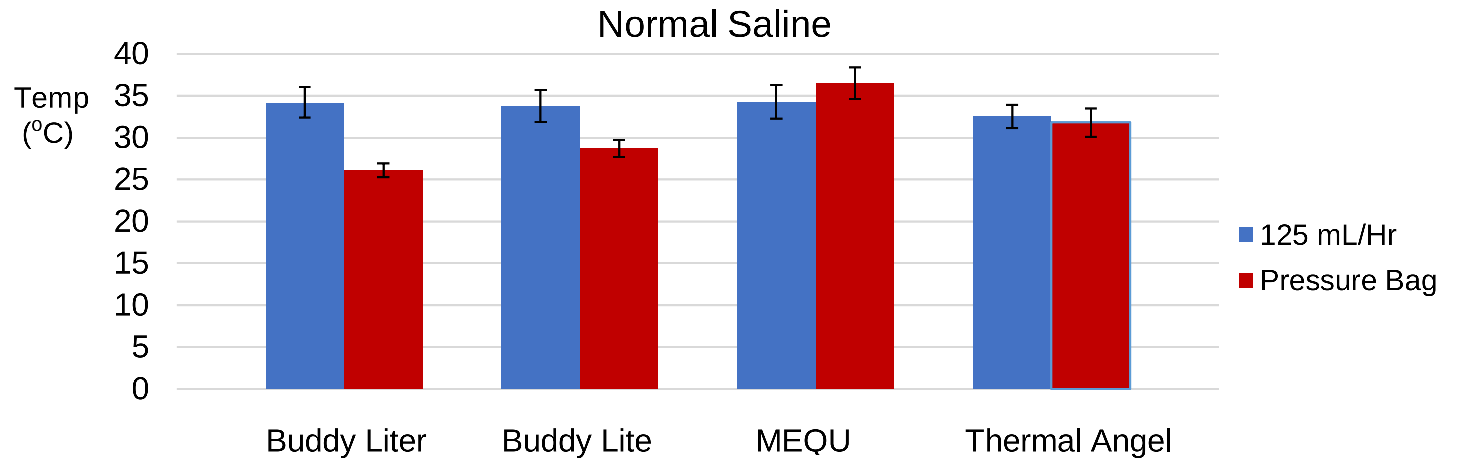

Fig 2. Post warmer mean (SD) temp on battery power using room temperature normal saline

Buddy Lite AC

Buddy Liter

MEQU

Thermal Angel

RESULTS

Mean and peak fluid temperatures and battery life varied between the different devices. Data was averaged over all tests with each device type at each condition. Temperature is reported in ^{o}C and time is reported in minutes. Figures 1 & 2 show the mean (SD) temperatures using iced PRBC and room temperature saline at flow rates of 125/hr and free flowing using a pressure bag. Figure 3 shows the peak temperature produced by each device at all 4 conditions. The battery life in minutes ± SD at the 125 mL/hr flow rate was 634 ± 33.9 with the Buddy Liter, 1208.3 ± 65.1 with the Buddy Lite AC, 890.0 ± 13.8 with the MEQU, and 503.3 ± 6.9 with the Thermal Angel ($p < 0.0001$). Differences in temperature between the devices were statistically significant at all 4 conditions ($p \leq 0.03$). The greatest differences in peak and mean temperature between devices was when using the pressure bag with saline and PRBCs ($p \leq 0.0002$).

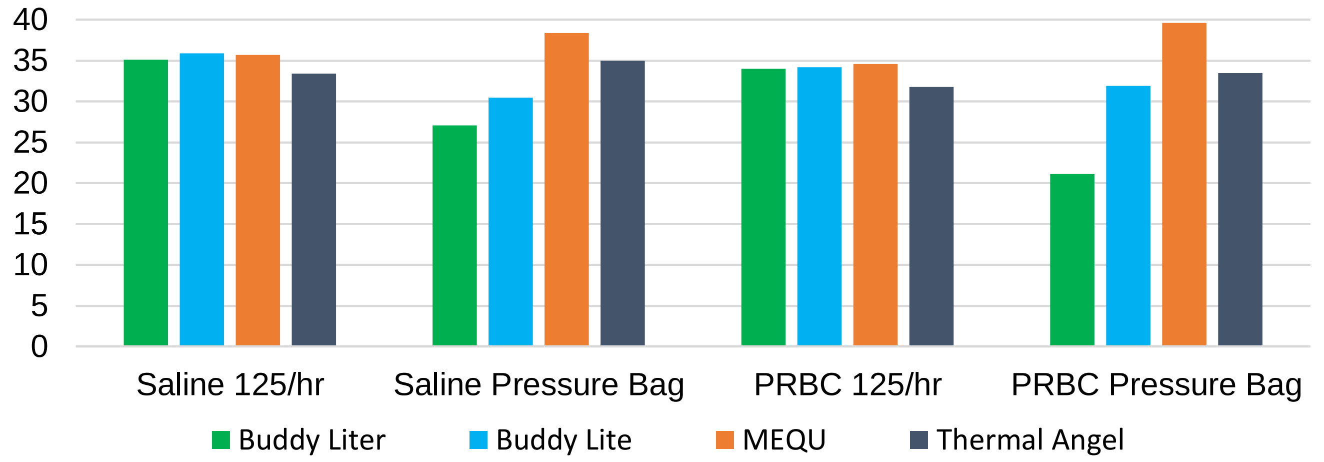

Fig 3. Peak temperature at all 4 conditions

CONCLUSION

In our evaluation, fluid flow rate had an impact on the temperatures attained by the devices. At the non-emergent flow rate, none of the devices were able to warm the saline or PRBCs to normal body temperature (37^{o}C). At the emergent rate, the peak temperature with the MEQU exceeded 37^{o}C with both saline and PRBCs whereas the other warmers did not. The MEQU and Thermal Angel attained higher peak temperatures at the faster flow rate. Understanding the performance characteristics of fluid warming devices and their role in management of resuscitation is vital for the caregiver especially in austere environments.

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