INTRODUCTION

Primary hypothermia accounts for an estimated 700 deaths per year in the United States. The incidence of secondary hypothermia, which typically occurs in the setting of illness, trauma, or intoxication, is unknown and probably exceeds that of primary hypothermia. The mortality rate for patients with primary hypothermia is reported to be 95%, while we have found a mortality rate of 9% for patients with an initial temperature <32°C and a mortality rate of only 1% for patients with an initial temperature between 32.2°C and 33.0°C. Two prospective studies have found that aggressive treatment of hypothermia improves outcomes.

For hypothermic patients receiving care in the Emergency Department or in a prehospital setting with limited access, electrical devices are not always available and fluids are refrigerated in the cold environment. These patients are at risk for hypothermia, and once hypothermia occurs, it is likely to progress to secondary hypothermia. This may be lethal. In the case of patients rescued from a cold environment, heating fluids on scene may be impossible. We conducted an experimental study to evaluate various methods of warming intravenous fluid for a bolus infusion in a cold environment with lightweight equipment typically available to a wilderness rescuer.

MATERIALS AND METHODS

All tests were performed in a 5ºC cold room, and all equipment was stored for at least 24 hours in the cold room prior to testing to ensure equilibration with the ambient temperature. One liter and 500 mL bags of 0.9% sodium chloride intravenous fluid (Hospira, Lake Forest, IL) were infused through a 20G IV tubing (¾ inches internal diameter; Intravenous Tube (Howard Laboratories, Inc, Vining, TN) over 5 minutes. The small size of each bag eliminated the need for warming the entire contents of each bag. The high weight of the equipment would be prohibitive in the wilderness. An infant warm-water bath at a temperature of 30°C was also included in all trials.

Three cold rooms were used to cool the 5ºC water, which almost filled the pot. A 1.8L Kwik-Heat® Instant Hot Pack attached to 500 mL of fluid and a 1.8L Kwik-Heat® Instant Hot Pack attached to a coil of fluid were able to increase the fluid temperature to a level acceptable for infusion. The high initial and final temperatures noted during method 10 (Figure 2) would be unacceptable to administer to a patient because the generally accepted maximum temperature for infused fluids is 42ºC. The safety of the current protocol when used in the field remains to be determined.

RESULTS

We used a 5°C cold room and in fluids in order to simulate a cold environment. Much variation exists in the actual conditions encountered in prehospital settings, which limits the application of these results. Variations in water temperatures, heat pack size, and battery life make these results specific to the conditions we studied. Our results demonstrate that fluid infused at an initial temperature of 36 to 40°C regardless of the starting temperature of the fluid is a practical option in a cold ambient temperature. Further testing of selected methods is needed to determine if it is possible.

We found that bolus infusions were the most important type of fluid administration in a prehospital setting, in settings, maintenance fluids are more appropriate. Non-isotonic infusions are not appropriate in hypothermia and our results are not directly applicable to situations requiring maintenance fluids.

CONCLUSION

Our results suggest two general conclusions about warming intravenous fluids in a remote, cold environment. The first is that fluid must be warmed to a level that allows bolus infusions. The second is that there is little clinical value in warming fluids beyond a therapeutic level. Conversely, infusion protocols that use these methods will need to be modified to prevent delivery of fluids that are too cold or too hot to the patient.

For both the 500 mL and 1 liter fluid volumes, the Kwik-Heat® Instant Hot Packs and Wilderness IV Wamer achieved only small increases in fluid temperature. The approximately 5ºC increase in fluid temperature which occurred when these methods were applied to 500 mL bags of fluid may have some clinical value but falls short of the goal of warming the fluid between 35 and 40ºC. Only two methods, the stove applied to 500 mL bags of fluid and the stove applied to the fluid in the later part of the infusion. Furthermore, during bolus infusions we demonstrate that only minimal cooling of the fluid occurs even in the absence of continuous heat source.

Of the methods we studied, only the MRE heat packs and the stove were able to heat the fluid to a temperature above 30ºC. In comparing the two methods with the most desirable temperature profiles, methods 11 and 12, we found that the stove was able to maintain a consistent fluid temperature regardless of ambient and initial fluid temperatures. Further study of these two methods is warranted to determine whether either approach can provide a consistent application in warmphases in the absence of continuous heat source.

REFERENCES

11.1,12 In method 11, we were able to eliminate these high peak temperatures by heating the fluid either approach can provide a consistent infusion temperature regardless of ambient and initial fluid temperatures.

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