Monroe Livingston Region Program Agency

Division of Prehospital Medicine, University of Rochester
Mailing Address: 601 Elmwood Avenue, Box 655, Rochester, NY 14642
Physical Address: 120 Corporate Woods, Suite 100, Rochester, NY 14623
Phone: (585) 463-2900 Fax: (585) 463-2966 E-Mail: mlrems@urmc.rochester.edu

To: All ALS Providers and Agencies

From: Jeremy T. Cushman, MD, MS, EMT-P
Regional Medical Director

Date: October 22, 2010

Re: Advisory 10-16: New Return of Spontaneous Circulation Protocols 3.2 and 4.2

The use of therapeutic hypothermia in patients with return of spontaneous circulation in adult patients has been associated with an improvement in neurologic outcome. To reflect this therapy option, two new Return of Spontaneous Circulation (ROSC) Protocols replace the previous "Post Conversion of VF/VT" in the adult and pediatric patient and are in effect immediately. **All ALS providers are expected to review and be familiar with the attached protocols, as well as review the attachment describing the role of therapeutic hypothermia in adult patients with ROSC.** At this time, therapeutic hypothermia is NOT a treatment option for pediatric patients.

These two protocols have also been updated to optimize the care of the patient with ROSC and include:

1. Administering an antiarrythmic if conversion results from defibrillation.
2. Performing a complete neurologic exam to include GCS and pupillary response.
3. Obtaining a 12-lead EKG and determining blood glucose (if not done already).
4. Maintaining a Mean Arterial Pressure of at least 65 mmHg.
5. Beginning to cool the adult patient with the goal of improved neurologic function.

All ALS Agencies/Providers are expected to begin therapeutic hypothermia for ROSC patients by placing ice packs to the groin, axilla, and neck if they meet the inclusion and exclusion criteria for therapeutic hypothermia included in the protocol and routing to a facility capable of maintaining therapeutic hypothermia. Agencies that wish to carry 4°C Normal Saline may do so provided they meet all of the following criteria[1]:

- The Agency has purchased a 6-liter Igloo Maxcold cooler (Igloo Products Corp., Katy TX) or reasonable commercial equivalent.
- The Agency has purchased Polar Pack (Tegrant Corp. ThermoSafe Brands, Arlington Heights, IL) reusable foam ice packs or reasonable commercial equivalent.
- The Agency has refrigeration and freezer units available which will allow them to maintain replacement cold ice packs and saline.
- The Agency has a policy in place to assure that the saline and ice packs are changed daily when the ambient temperature of the storage compartment of the vehicle is less than 80°F and twice a day if the temperature is higher.

ALS Agencies are responsible for assuring compliance with this Advisory by January 1, 2011, and all ALS agencies are expected to review all cardiac arrests to assure compliance with the ROSC protocol and the administration of therapeutic hypothermia.

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[1] These materials are referenced in: Kampmeyer M, C Callaway. Method of cold saline storage for prehospital induced hypothermia. Prehospital Emergency Care. 2009;13:81-84. Agencies may obtain this manuscript by contacting the Regional Program Agency.

3.2 RETURN OF SPONTANEOUS CIRCULATION

CRITERIA

The following is for a patient with Return of Spontaneous Circulation (ROSC) as evidenced by a palpable pulse following CPR, electrical, or drug therapy for a patient previously pulseless.

- Post-conversion treatment of VF or VT should only be started if the patient has regained a pulse of adequate rate (>60). If not, refer to other cardiac protocols as appropriate.
- All antiarrhythmics are contraindicated if a ventricular escape rhythm is present.

1. Routine medical care.

EMT STOP
EMT-I STOP

2. If conversion results from defibrillation without any drug therapy:

   Amiodarone (Cordarone) 150 mg diluted in a minimum of 50mL of NS given IV/IO over 10 minutes.

3. If Amiodarone was the drug resulting in conversion from VF/VT, no additional antiarrhythmic is required. If the length of transport post ROSC exceeds 20 minutes from the end of the Amiodarone infusion, repeat Amiodarone once at 150 mg diluted in a minimum of 50 mL of NS given IV/IO over 10 minutes.

4. If Lidocaine (Xylocaine) was the drug resulting in conversion from VF/VT:

   Repeat Lidocaine at 0.75 mg/kg IV/IO every 10 minutes up to a total cumulative dose of 3 mg/kg.

5. If more than the above listed doses are needed because of length of transport time, contact Medical Control.

6. Following ROSC, the patient should be reassessed and a complete neurologic exam, including GCS, pupillary response, and core temperature (if available) is performed.

7. Determine blood glucose and perform 12-lead EKG.

EMT-CC STOP

8. Maintain MAP >65 mmHg

   Dopamine 5 mcg/kg/min to maximum 10 mcg/kg/min IV/IO titrated to maintain MAP > 65 mmHg using a rate-limiting device. Use Y-site secondary tubing for dopamine running into free-flowing normal saline primary tubing. Do not use a primary line for dopamine to prevent extravasation.

9. Determine inclusion and exclusion criteria for therapeutic hypothermia:

   Inclusion: GCS ≤ 8

   Exclusion: Pregnancy, arrest as a result of trauma, suspected sepsis, drug intoxication, continued seizure activity, major surgery within 14 days, or temperature < 34°C (if known)

   If patient meets inclusion and exclusion criteria:

   Establish second, large bore, vascular access site and infuse 4°C normal saline to a total of 30 mL/kg or 2 L max (if available)

   Apply ice packs to axilla, groin, and neck; change every 10-15 minutes

Protocol continued on next page

10. Do not delay transport to initiate therapeutic hypothermia. Transport to a facility capable of maintaining therapeutic hypothermia (Rochester General, Unity and URMC-Strong), and contact Medical Control while enroute if hypothermia begun. If recurrent cardiac arrest, transfer to closest Emergency Department.

11. Prevent shivering

    Midazolam (Versed) 2.5 mg IV/IO once if Systolic BP > 100 mmHg
    (Additional doses per Medical Control, must contact Medical Control after use)

    RSI Providers may contact Medical Control for authorization of Vecuronium 0.1 mg/kg to max of 10mg if shivering or ventilatory problems. Paralytic agents are NOT indicated unless sedation can safely be administed AND the patient has an advanced airway.

4.2 RETURN OF SPONTANEOUS CIRCULATION

CRITERIA

The following is for a patient with Return of Spontaneous Circulation (ROSC) as evidenced by a palpable pulse following CPR, electrical, or drug therapy for a patient previously pulseless.

- Post-conversion treatment of VF or VT should only be started if the patient has regained a pulse of adequate rate (>60). If not, refer to other cardiac protocols as appropriate.
- All antiarrhythmics are contraindicated if a ventricular escape rhythm is present.

1. Routine medical care.

EMT STOP
EMT-I STOP

2. If conversion results from defibrillation without any drug therapy:

   Amiodarone (Cordarone) 5 mg/kg diluted in a 1:3 ratio of NS and given IV/IO over 20 minutes (Max 150 mg).

3. If Amiodarone was the drug resulting in conversion from VF/VT, no additional antiarrhythmic is required. If the length of transport post ROSC exceeds 20 minutes from the end of the initial Amiodarone infusion, repeat Amiodarone once at 5 mg/kg diluted in a 1:3 ratio of NS given IV/IO over 20 minutes (Max 150 mg).

4. If Lidocaine (Xylocaine) was the drug resulting in conversion from VF/VT:

   Repeat Lidocaine at 0.75 mg/kg IV/IO every 10 minutes up to a total cumulative dose of 3 mg/kg.

5. If more than the above listed doses are needed because of length of transport time, contact Medical Control.

6. Following ROSC, the patient should be reassessed and a 12 lead ECG should be performed.

7. Perform complete neurologic exam, including GCS and pupillary response.

EMT-CC STOP

8. Determine blood glucose and perform 12-lead EKG.

9. Maintain MAP >65 mmHg

   Dopamine 5 mcg/kg/min to maximum 10 mcg/kg/min IV/IO titrated to maintain MAP > 65 mmHg using a rate-limiting device. Use Y-site secondary tubing for dopamine running into free-flowing normal saline primary tubing. Do not use a primary line for dopamine to prevent extravasation.

Therapeutic Hypothermia for the MLREMS Provider

JT Cushman, MD, MS, EMT-P
MLREMS Medical Director

Introduction

Historical outcomes of comatose cardiac arrest survivors are abysmal. Cardiac arrest causes the release of toxic compounds directly linked to brain injury. Therapeutic Hypothermia (TH) is a controlled lowering of the body temperature which is believed to reduce the release of toxic compounds, thus reducing brain injury.

Importantly, Return of Spontaneous Circulation (ROSC) comes first! Excellent, high-quality CPR with minimal interruptions, early defibrillation, and controlled ventilations all contribute to higher likelihood of ROSC. ROSC from cardiac arrest is won at the scene, not in the ambulance or at the hospital. Our goal is to maximize opportunities for ROSC at the scene, then transport (when safe to do so, of course).

The benefits of Therapeutic Hypothermia are only useful if we've had ROSC.

Brain Injury and Therapeutic Hypothermia

In cardiac arrest, primary brain injury is directly related to the duration and severity of ischemia. Secondary brain injury occurs during reperfusion, when the production of lactate and oxygen free radicals begin to cause cellular dysfunction. As brain cells are disrupted due to increased permeability of the lipid cell membrane and the Na^+/K^+ pump becomes less effective, the cells themselves release toxic compounds. This cascade of events causes brain cells to become over-stimulated and/or break open (lyse), and an abnormal release of neurotransmitters result also causing hyperthermia to occur.

Therapeutic Hypothermia (TH) is felt to benefit patients with ROSC in a number of ways. TH decreases brain metabolism by retarding the initial rate of ATP depletion by the cell; reduces the amount of neurotransmitter release; and alters intracellular messenger activity. TH may further prevent cell damage by limiting the breakdown of the blood-brain barrier; reducing the inflammatory response; reducing intracellular calcium; and may even alter gene expression and protein synthesis. For every 1°C decrease in temperature there is a 6-7% decrease in metabolism.

The Evidence

The first study involving TH was performed in 1959! In the last decade a number of studies investigating the role of TH in ROSC have been performed. An Australian study found that 49% of patients with ROSC who received TH "returned to a normal life" when compared to 25% who did not receive TH. Similarly, a European study found 55% of patients with ROSC who received TH "returned to a normal life" when compared to 39% who did not receive TH. In 2005, the International Liaison Committee on Resuscitation supported the use of TH for post-ROSC patients. Subsequent studies using both hospital and prehospital data have been similarly supportive. Although a definitive study demonstrating that the prehospital administration of TH improves patient outcome has not been done to date, importantly, there has yet to be a published study indicating that initiating TH results in patient harm or worse outcomes. Unfortunately it was not until just recently that the New York State Department of Health finally allowed EMS providers to provide TH to patients with ROSC.

The Protocol

TH should be initiated using both chemical cold packs and (if available) 4°C Normal Saline. Importantly, TH is not the ONLY treatment that should be initiated after ROSC. Providers must work to prevent cardiac arrest recurrence and prevent ongoing injury by controlling arrhythmia's, providing appropriate airway management and ventilation rates, assure an adequate blood pressure, confirm a normal glucose, and identify the presence of a STEMI. These items are specifically included in the new "Return of Spontaneous Circulation" protocols to remind the provider of their importance and guide the management of the patient with ROSC. Any airway, dysrhythmia, or other medical condition should be managed according to the Standards of Care.

TH may be initiated if the patient's GCS following ROSC is ≤ 8 AND the patient does not have any exclusion criteria. These exclusion criteria include:

- Pregnancy
- Cardiac arrest as a result of trauma
- Suspected sepsis
- Suspected drug intoxication
- Seizure activity
- Major surgery within 14 days (if known)
- Temperature < 34°C (if known)

These exclusion criteria are primarily related to the knowledge that hypothermia can cause prolonged bleeding and that there is no apparent benefit, and possible risk, to cooling a patient below 34°C.

Surface cooling can be started by any agency and should include the placement of chemical ice packs in the axilla, groin, and around the neck. All clothing should be removed that would interfere with cooling the patient, and the chemical ice pack should be changed every 10-15 minutes. If available, bags of regular ice can be used instead of chemical ice packs, but a towel should be applied over the skin to prevent direct contact of ice on the skin and possible injury.

For those agencies wishing to carry chilled saline, a previous study[i] is the basis for the following storage and exchange requirements expected of the agency in order to maintain the Normal Saline at approximately 4°C (32°F - 40°F):

- The Agency has purchased a 6-liter Igloo Maxcold cooler (Igloo Products Corp., Katy TX) or reasonable commercial equivalent.
- The Agency has purchased Polar Pack (Tegrant Corp. ThermoSafe Brands, Arlington Heights, IL) reusable foam ice packs or reasonable commercial equivalent.
- The Agency has refrigeration and freezer units available which will allow them to maintain replacement cold ice packs and saline.
- The Agency has a policy in place to assure that the saline and ice packs are changed daily when the ambient temperature of the storage compartment of the vehicle is less than 80°F and twice a day if the temperature is higher.

If administering chilled saline, a second vascular access site must be obtained. A large bore IV (External Jugular or proximal arm) is desirable, or an IO if IV is not obtainable. No more than one intraosseous line should be placed, however. Rapidly administer chilled (4°C) saline to a total of 30 mL/kg or 2 liters maximum. No medications should be given through the IV line running chilled saline.

Patients in whom TH has been started must be transported to a facility capable of maintaining TH. That includes as of October 2010, Rochester General, Unity, and URMC-Strong Memorial Hospital. Should a patient with ROSC and TH also have evidence of a STEMI, then the patient should be taken to a STEMI receiving center which as of October 2010 includes Rochester General, Unity, or URMC-Strong Memorial

Hospital. If the ROSC patient receiving TH degrades to recurrent cardiac arrest, the patient should be redirected to the closest hospital.

Shivering may occur in a patient receiving TH and this is counterproductive to the goals of TH. Should shivering occur, administer Midazolam 2.5 mg IV/IO if systolic BP >100 mmHg. RSI providers may contact medical control for authorization of Vecuronium.

Although temperature monitoring of patients with ROSC receiving TH is not required, those agencies that have the capability and wish to monitor patient's temperature may do so according to Regional Policy 9.20. Should the patient's temperature drop below 34°C, the chilled normal saline should be stopped. Do not rewarm the patient.

Pediatric patients should receive the same care as adult patients, with adjustments made for weight-based medication dosing.

Next Steps

It is uncommon for the prehospital provider to obtain the target temperature during transport, however the intent is to start TH as early as possible. The receiving hospital will maintain the patient's temperature at 32-34°C for 24 hours before gradually rewarming them. One cannot prognosticate a good outcome early, as ultimate outcomes cannot be evaluated for at least the 48 hours.

All cases of cardiac arrest should be reviewed by the agency, and ideally their Medical Director, to evaluate for protocol compliance. Agencies are encouraged to maintain a registry of their cardiac arrest patients to identify their rates of ROSC and neurologic outcomes.

Importantly, the first goal of cardiac arrest management is to obtain ROSC, as no therapeutic hypothermia program is successful without good initial care and attention paid to high quality CPR and appropriate ventilation.

With any questions regarding the implementation of this protocol or the use of therapeutic hypothermia, please do not hesitate to contact the Regional EMS Medical Director.

[i] Kampmeyer M, C Callaway. Method of cold saline storage for prehospital induced hypothermia. Prehospital Emergency Care. 2009;13:81-84. Agencies may obtain this manuscript by contacting the Regional Program Agency.

Method of Cold Saline Storage for Prehospital Induced Hypothermia

Mitch Kampmeyer, BS, Clifton Callaway, MD, PhD

ABSTRACT

Objective. Research over the last decade has supported the use of cold intravenous (IV) fluid as a method for initiating therapeutic hypothermia in post–cardiac arrest resuscitation. However, prehospital care programs employing this treatment have encountered various difficulties. Barriers to prehospital induced hypothermia (IH) protocols include the lack of effective or economically reasonable methods to maintain cold saline in the field. Validation of a simple method could allow agencies to equip numerous rigs with cold saline. The aim of this study was to determine whether a standard commercial cooler can maintain two 1-L normal saline solution (NSS) bags below 4°C in three different environments. **Methods.** Environments simulating those of an ambulance compartment were created for the experiment. NSS temperatures were continuously recorded inside a standard commercial cooler under one of three scenarios: ambient room temperature (25°C) without ice packs, ambient room temperature with ice packs, and 50°C ambient temperature with ice packs. Four trials under each condition were performed. **Results.** In a room-temperature environment without ice packs, the NSS warmed to 4°C in a mean interval of 1 hour 21 minutes. Using room temperature with ice packs, the NSS warmed to 4°C in a mean interval of 29 hours 53 minutes. In a constant hot environment of 50°C, the NSS warmed to 4°C in a mean interval of 10 hours 50 minutes. A significant difference was found between the three environments (log-rank = 17.90, df = 2, p = 0.0001). **Conclusions.** Prehospital refrigeration devices are needed for current and future IH protocols. Low-technology methods in the form of a cooler and ice packs can provide cold saline storage for longer than a full 24-hour shift in a room-temperature ambulance. In extremely hot conditions, 4°C NSS can be maintained for nearly 11 hours using this method. This model exhibits an economical, easily deployable cold saline storage unit. **Key words:** induced hypothermia; heart arrest; emergency medical technicians; resuscitation; emergency medicine; cold saline storage

PREHOSPITAL EMERGENCY CARE 2009;13:81–84

Introduction

Induced hypothermia (IH) is an effective neuroprotective modality in cardiac arrest and brain injury care. In 2002, the International Liaison Committee on Resuscitation (ILCOR) recommended the use of mild hypothermia (32–34°C) in the treatment of post–cardiac arrest patients.[1] Supporting this recommendation, a number of studies have demonstrated that rapid cooling can be effectively accomplished in humans with an intravenous infusion of cold fluid.[2–6] As a consequence, current practice includes use of 2–4°C normal saline administration as one method of rapidly attaining mild hypothermia in patients because of the effectiveness of this fluid temperature in previous studies.[4–7] One human trial is now investigating the potential benefit of instituting therapeutic hypothermia in the prehospital environment,[7] while other emergency services have already begun using IH as a standard treatment after cardiac arrest.[8]

Ideally, the resources would be available to install compact refrigeration units in ambulances nationwide. However, the cost of such an enterprise might delay or even prevent hypothermia therapy from ever reaching certain services and communities because of budgetary constraints. Emergency medical services (EMS) systems desiring to institute a hypothermia therapy protocol rapidly and economically may use a low-technology method involving ice packs and commercial coolers. However, a simple, effective process for such delivery of cold fluids has not yet been fully described.

In laboratory conditions designed to mimic various ambulance settings, this study determined the time required for the normal saline solution (NSS) temperature to exceed the target temperature of 4°C using a cooler in three scenarios: room temperature (25°C) without ice packs, room temperature with ice packs, and 50°C with ice packs. The study tested whether saline could be maintained at <4°C for the duration of a typical EMS shift using inexpensive, off-the-shelf equipment.

Methods

The study was conducted in a research laboratory. A commercially available beverage cooler was selected that was sufficiently compact for the confined quarters of an ambulance patient compartment. This cooler, a 6-liter Igloo Maxcold cooler (Igloo Products Corp., Katy, TX), was insulated by the manufacturer on all six sides, including the lid. Two of the three scenarios used

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Address correspondence and reprint requests to: Mitch Kampmeyer, BS, University of Pittsburgh, Department of Emergency Medicine, 230 McKee Place, Suite 400, Pittsburgh, PA 15213. e-mail: kampmeyerm@upmc.edu

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Polar Pack (Tegrant Corp. ThermoSafe Brands, Arlington Heights, IL) reusable foam ice packs of the same length and width as the interior of the cooler. The dimensions of the ice pack are 20.63 × 13.75 × 1.88 cm. The sizing of the ice packs was an intentional effort to reduce airspace and airflow within the cooler, thereby reducing potential convective warming of the unit. Finally, two 1-L bags of NSS were used in all of the trials. The ice packs were frozen in a commercial freezer to a starting temperature of −15°C, which is the average temperature of a standard household freezer. A commercial refrigerator was used to cool the NSS bags to a starting temperature of 2°C.

Monitoring of the saline temperature was accomplished using a thermocouple fluid probe (Physitemp, Clifton, NJ) plunged into the rubber stopper of the bottom bag of NSS in the unit. This thermocouple probe was connected to a BAT-12 digital thermometer (Physitemp) and Powerlab unit (ADInstruments, Bella Vista, NSW, Australia) with temperature recordings performed on a computer data-logging program (Chart v5.3, ADInstruments). Temperatures were continuously recorded at a sampling rate of 1/sec for the duration of the trials. Data sampled from the recording for analysis were extracted at a rate of once per 3 minutes.

The study was conducted in the Emergency Responder Human Performance Laboratory at the University of Pittsburgh, Pittsburgh, Pennsylvania. The extreme environment simulations were conducted in a conventional oven using the same monitoring equipment.

Different ambient environments were examined for comparison of warming trends. The first scenario involved placing the two NSS bags into a cooler with no coolant and an ambient temperature maintained at room temperature (22–25°C). The second scenario placed the NSS bags into the cooler with three ice packs in a layered configuration (Fig. 1) and an ambient temperature maintained at room temperature (22–25°C). In the third scenario, the NSS bags were once again layered in the cooler with the three ice packs at an average ambient temperature of 50°C inside a conventional oven. Because of safety concerns and potential for equipment damage at higher temperatures, 50°C was used to mimic an excessively hot ambulance compartment. Once the saline temperatures reached 10°C, the trials were ended. A temperature of 10°C was used as an endpoint to illustrate the continued progression of warming beyond 4°C. Each of the above scenarios was repeated four times.

Data were exported from Chart and analyzed using Microsoft Excel (Microsoft Corp., Redmond, WA) and SPSS v11.0 (SPSS, Inc., Chicago, IL). Times for temperature to exceed 4°C were compared between scenarios using Kaplan-Meier survival curves and the log-rank test. Time to exceed 4°C in each trial was considered to be a single data point for survival analysis.

RESULTS

Temperature curves were produced to graphically represent the change in saline temperature over time for each of the trials (Fig. 2). The first scenario with no ice showed an immediate but gradual increase in saline temperature during all of the trials, with a mean time to reach 4°C of 1 hour 21 minutes. In the second scenario with ice and room ambient temperature, all trials showed a mild decline in temperature followed by a long period of temperature stability before slowly climbing to 4°C. The mean time to reach 4°C in this scenario was 29 hours 52 minutes. Finally, in the third scenario using ice and a 50°C ambient temperature, a shorter period of temperature stability below 4°C was seen before rapidly rising to 10°C. For this final scenario, 10 hours 49 minutes was the mean time to reach 4°C. Because of the small sample sizes, mean, median,

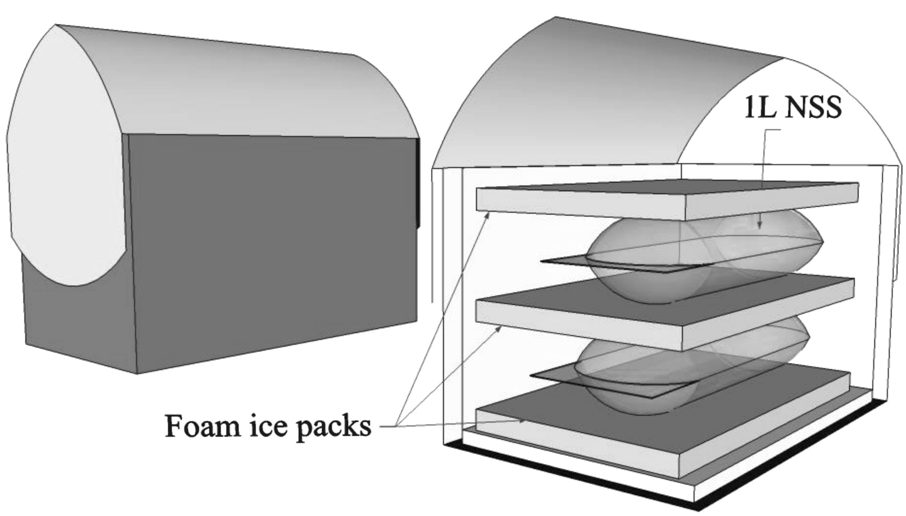

FIGURE 1. The normal saline solution (NSS)/ice pack configuration.

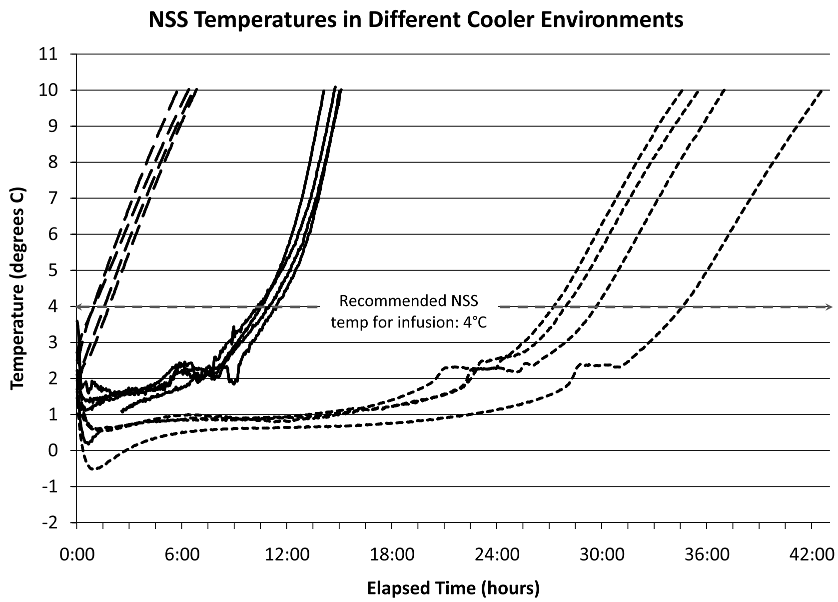

Figure 2. Normal saline solution (NSS) temperature curves.

and range were tabulated (Table 1). The times required for saline to reach 4°C differed significantly between scenarios (log-rank = 17.90, df = 2, p = 0.0001).

Discussion

The results of this study show the ability of inexpensive, off-the-shelf technology to maintain an NSS target temperature near 4°C for an EMS shift up to 24 hours at approximately room temperature. Extreme ambient conditions, as could be met in the compartment of a stationary ambulance in summer, can reach temperatures up to 60°C.[9] Under similar conditions in this study, the cooler method can maintain 4°C NSS temperatures for up to 11 hours.

On more than one occasion, transport and maintenance of cold NSS have been identified as impediments to the institution of prehospital hypothermia therapy. Suffoletto et al. reported from a 2007 survey that only 6.2% of EMS physicians were affiliated with EMS agencies implementing prehospital hypothermia therapy, reflecting low prehospital involvement in IH. The same survey found that 60.0% of EMS physicians view the lack of refrigeration equipment as a barrier to beginning a cooling protocol.[10] Additionally, one EMS system that was utilizing a cooling protocol had encountered transporting saline as one of their only difficulties. Because of the prohibitive cost of outfitting all rigs in the service, this system provided refrigerators only to supervisor vehicles, thereby limiting the availability of the cooling agent to providers.[8]

Table 1. Summary Data from Cooler Trials (Time in Hours: Minutes to Reach 4°C)

Condition	Mean	Median	Range: Minimum	Range: Maximum
No ice packs	1:21	1:18	0:57	1:51
Ice packs, 25°C ambient temperature	29:52	28:50	27:15	34:36
Ice packs, 50°C ambient temperature	10:49	10:47	10:21	11:24

Currently, prehospital uses for IH are directed at cardiac arrest care, but it is possible that IH will be expanded to the treatment of additional injuries and conditions. Spinal injury care, for example, is a recent highly publicized area of focus for IH. Stroke care teams are also investigating feasibility and effectiveness of IH in their treatment regimens.[11]

While the use of a low-technology method such as a cooler may require an investment of labor in the maintenance, it is a cost-effective and immediately employable solution for implementing IH in EMS. Infusions of cold fluids at 30 mL/kg (approximately 2 L for a 70-kg adult) after return of spontaneous circulation (ROSC) have been shown in previous studies to be feasible and effective.[4–7] Because of the availability of NSS in prehospital medicine, this would be the fluid of choice.

Incorporating this method of cold saline storage into an agency's structure would require minimal change in day-to-day operations. After the purchase of \$15–\$25 retail coolers and \$1–\$2 ice packs to outfit the agency (ice packs sized to cooler dimensions are recommended), a minor alteration to start-of-shift responsibilities is all that remains. At the beginning of a 24-hour shift, equipment checks would include the rotation of ice packs from a base freezer to the crew's cooler and NSS bags from a base refrigerator to the cooler. Standard refrigerator temperatures are on average 2–4°C, can be adjusted to meet this range, and can be monitored with a thermometer.

If an agency location experiences a climate of high ambient temperatures, more frequent rotations, twice per 24-hour shift, may be recommended. Care should be taken to avoid placing the cooler in a location of obvious high temperatures in the ambulance. Also, care should be taken if using this unit for blood products. As seen in the graph (Fig. 2), the temperature of the saline can drop to or below 0°C because of the <0°C temperatures of the ice packs. While freezing and thawing of saline is not problematic, the initial dip in temperature could be very detrimental for fragile fluids such as blood products.

LIMITATIONS AND FUTURE STUDIES

Only one of the two NSS bags could be monitored throughout the length of the trials. The bottom bag of the system was consistently used as the monitored bag, but the top bag temperatures were not recorded. Upon termination of trials, the top bags in the system were noted to be warmer than the bottom bags. As an example, in one trial the top bag was recorded to be 5.0°C, while the bottom bag was recorded to be 1.4°C at a single time point after 24 hours in a room-temperature ambient environment. Use of the bottom bag of the system first is suggested.

Of note, patient safety is not a concern with administering a bolus of saline that is not 4°C because it is typical to administer saline at temperatures up to 37°C. If the top bag is slightly warmer than 4°C, the patient's core body temperature will still decrease, and that is the intent of the cold solution. However, future studies may need to examine this limitation of the top bag of the unit.

CONCLUSION

This laboratory study confirmed that simple, inexpensive methods can effectively maintain two 1-L NSS bags near 4°C under normal conditions for more than 24 hours. Under more extreme constant 50°C ambient temperatures, these coolers maintained the target NSS temperature for nearly 11 hours. Regarding the cooler units, it is important to note the small size for practicality, limited air flow within the unit, and simple configuration of the ice packs and NSS. This study will allow EMS systems who are unable to undertake the financial burden of in-ambulance refrigeration for prehospital hypothermia protocols to consider this more simple, off-the-shelf solution in order to rapidly implement prehospital cooling protocols. These data also provide reference for storage of other cold solutions.

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