FIELD-INDUCED THERAPEUTIC HYPOTHERMIA FOR NEUROPROTECTION AFTER OUT-OF-HOSPITAL CARDIAC ARREST: A SYSTEMATIC REVIEW OF THE LITERATURE

José G. Cabanas, MD,*†‡ Jane H. Brice, MD, MPH,§ Valerie J. De Maio, MD, MSC,*†‡ Brent Myers, MD, MPH,*‡ and Paul R. Hinchey, MD, MBA‡†

*WakeMed Health & Hospitals, Raleigh, North Carolina, †Clinical Research Unit, WakeMed Emergency Services Institute, Raleigh, North Carolina, ‡Wake County Emergency Medical Services, Raleigh, North Carolina, and §Department of Emergency Medicine, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina

Reprint Address: José G. Cabanas, MD, Emergency Services Institute, Clinical Research Unit, WakeMed Health & Hospitals, 3000 New Bern Avenue, Raleigh, NC 27514

Abstract—Background: Emergency Medical Services (EMS) has started to embrace the early use of therapeutic hypothermia as standard treatment to improve neurological recovery in out-of-hospital cardiac arrest (OHCA) survivors. Objective: We conducted a systematic review to provide an overall description of the current literature on the use of therapeutic hypothermia in OHCA and to identify possible gaps in the literature. Methods: Comprehensive searches of MEDLINE, PubMed, CINAHL, and ISI Web of Science from 1950 to March 2009, and EMBASE from 1988 to March 2009 were performed. Bibliographies of selected articles were hand searched. Two reviewers independently selected studies on the basis of three inclusion criteria. Two additional independent reviewers assessed selected studies for quality. Results: Of more than 800 screened citations, a total of 11 published studies were included in the systematic review. Three studies were conducted in the United States, three in Finland, and one each in Australia, France, Germany, Austria, and Norway. Four of the studies were pilot clinical trials that provided prehospital mild therapeutic hypothermia during active cardiopulmonary resuscitation. The remaining seven studies performed cooling after return of spontaneous circulation. Significant differences in research methodology and outcome measures were noted. Eight studies scored poor for quality. Conclusions: The use of mild therapeutic hypothermia is gaining acceptance within the EMS community. It seems that hypothermia can be efficiently induced in the prehospital environment. There is a need for more research in this area to understand the effectiveness and timing of early therapeutic hypothermia in the prehospital environment. © 2011 Elsevier Inc.

Keywords—prehospital; hypothermia; cooling; cardiac arrest

INTRODUCTION

Sudden cardiac death is a major public health issue in the United States and around the world. It is estimated that there are approximately 295,000 out-of-hospital cardiac arrest (OHCA) patients evaluated by Emergency Medical Services (EMS) every year in the United States (1). Despite numerous advances in modern out-of-hospital technology and resuscitation techniques, the outcome for cardiac arrest patients is still poor and varies among cities and regions (2). It has been suggested that for those patients with return of spontaneous circulation (ROSC), patient mortality remains high due to secondary brain
injury (3). For all adult patients having a cardiac arrest in the out-of-hospital setting, with any first recorded rhythm, a median of only 7.9% survive to hospital discharge (1). Many patients never regain consciousness and die as a result of anoxic brain injury rather than of their initial cardiac insult (4).

OHCA is a time-sensitive illness that demands definitive interventions in specific time intervals to impact final outcomes. The three-phase model of cardiac arrest described by Weisfeldt and Becker provides a framework for understanding the cardiovascular interventions during cardiopulmonary resuscitation (CPR) (5). In stage one, the electrical phase, which extends from the time of cardiac arrest to approximately 4 min after the arrest, the key intervention is defibrillation. During stage two, the circulatory phase, which extends from 4 to approximately 10 min, the key intervention is chest compressions. Finally, the third stage, considered the metabolic phase, extends past the 10-min mark, where irreversible injuries occur (5). Investigators have suggested that it is in this last phase of cardiac arrest that therapeutic hypothermia may have its greatest impact on improving neurologic outcomes (6).

The use of therapeutic hypothermia has been proposed for some time as a treatment modality to improve neurological outcomes in cardiac arrest patients (7–9). In 2002, the resuscitation community began to consider such therapy in the post-resuscitation care of OHCA survivors after the publication of two randomized clinical trials of mild therapeutic hypothermia (10,11). In 2005 the American Heart Association (AHA) published its guidelines on emergency cardiovascular care, in which the use of mild therapeutic hypothermia (32–34 °C) for 12–24 h in all unconscious adults with ROSC after OHCA due to ventricular fibrillation was classified as a class IIA indication, meaning that the weight of evidence or opinion is in favor of the procedure or treatment (12). Although the optimal timing for induction and target temperature are still under investigation, animal models suggest that therapeutic hypothermia could have a maximum benefit when it is started immediately after ROSC, and other studies suggest that delayed initiation of induction could result in less beneficial outcomes (13,14).

Although the use of such treatment is uncommonly employed in the hospital setting, a number of EMS systems around the world have begun to initiate the use of prehospital therapeutic hypothermia for comatose cardiac arrest survivors (15–17). Studies indicate that many post-ROSC patients in the prehospital setting will already have a temperature close to 35 °C (18). Therefore, prehospital providers may be able to get the patient to target temperature with just one degree of cooling. Nevertheless, the impact of employing this therapy in the prehospital setting is not clear. We therefore conducted a systematic review to provide an overall description of the current literature on the use of prehospital mild therapeutic hypothermia in OHCA and to identify possible gaps in the literature.

**METHODS**

**Inclusion Criteria**

We included all randomized controlled trials, quasi-control trials, pilot, observational, and safety studies of prehospital therapeutic hypothermia. Studies were selected based on three inclusion criteria. First, study participants must have been adult patients (16 years or older) who suffered OHCA regardless of initial rhythm or cause. Second, prehospital therapeutic hypothermia must have been started in the field either during the resuscitation or after return of spontaneous circulation. Third, the main focus of the study should have been cooling in the prehospital setting. We excluded from the systematic review all case reports, editorial letters, position statements, and articles from non-peer-review publications. Published abstracts meeting inclusion criteria were included.

**Search Strategy**

The following electronic databases were searched using logical queries of key terms (Table 1): MEDLINE, CINAHL, and ISI Web of Science (1950 to March 2009) and EMBASE (1988 to March 2009). In addition, bibliographies of other systematic reviews and the selected articles of therapeutic hypothermia were hand searched to find relevant studies that may have been overlooked in the initial database search. Experts in the field were contacted to determine if there were other relevant published articles that were not identified by our search strategy.

**Selection of Articles**

An a priori, non-blinded, two-step process was utilized for article selection. First, one of the authors (JGC) collected all the citations and imported them into commercial bibliographic software (RefWorks 2008, Bethesda, MD). After this, all citations in the bibliographic database were screened to exclude duplicates and non-relevant articles. Later, a clean list of citations was exported and assigned to two reviewers (JGC, PH). Both authors independently screened all abstracts from the database search to see if the study met inclusion criteria. If the abstract did not provide all the necessary information to determine inclusion criteria, the full article was retrieved and read by both reviewers. Any disagreements were resolved through detailed discussion and consensus. At the
end of the selection process, inter-rater agreement was calculated.

Quality of Studies

Two independent reviewers (JHB, BM) assessed selected studies for quality. All selected articles were objectively analyzed using a quality assessment tool. For randomized clinical trials, we used the Jadad criteria (i.e., scale of 0–5, with 5 representing the best score) (19). For observational studies, the Newcastle-Ottawa Quality assessment scale was utilized (20). We contacted a study’s primary authors when there was any missing information in study manuscripts for quality analysis. No studies were excluded on the basis of quality scores.

RESULTS

The initial literature search on all databases yielded a total of 800 citations. A total of 154 were exact duplicates and therefore excluded. We also excluded 326 citations after reviewing the abstracts because they were clearly not relevant to our systematic review. This selection left a total of 320 citations to be evaluated by the reviewers for inclusion criteria. During this process, four studies did not have enough information in the manuscript to determine if they met inclusion criteria. After contacting the primary author, it was determined that none of those studies met selection criteria. Finally, after independently reviewing all 320 citations, reviewers identified a total of 11 manuscripts that met criteria to be included in the systematic review (k = 0.8) (Figure 1).

Description of Studies

A total of eight clinical trials and three case series were included. Three studies were conducted in the United States, three in Finland, one each in Australia, France, Germany, Austria and Norway. Four of the studies were pilot clinical trials that provided prehospital mild therapeutic hypothermia during active cardiopulmonary resuscitation. The remaining seven studies performed the cooling after return of spontaneous circulation. The target temperature for all studies was 33–34 °C. The characteristics of the included studies are summarized in Table 2 (11,18,21–29).

Significant differences in research methodology and outcome measures were noted among the studies. Most differences were related to the technique for temperature monitoring in the field. Some studies used tympanic readings, whereas others utilized esophageal thermometers. Three studies used nasopharyngeal thermometers for temperature readings. Only one study measured temperatures with a rectal probe.

Outcome measures were different among most studies (Table 3) (11,18,21–29). Most trials were pilot projects that evaluated specific methods of cooling in the field. The vast majority of studies looked at temperature changes, volume of saline infused, time to start cooling, and complications related to the process of inducing mild hypothermia. Survival to discharge was reported in six studies. Only one study reported Cerebral Performance Category (CPC) scores at 6 months.

During our review process for quality assessment, eight studies scored poor for quality, whereas only three had a Jadad score equaling three or more, considered by most authors to represent the cutoff point for moderate to high quality. All of the studies with poor scores were non-randomized trials.

DISCUSSION

After a systematic and comprehensive database search for clinical evidence, we identified 11 studies that directly involved induced hypothermia in the field. Most were small trials that evaluated the process of specific cooling techniques in the field. These studies show that prehospital personnel can provide therapeutic hypothermia for OHCA patients in addition to established prehospital interventions that impact survival. However, there are significant
methodological differences in the current available clinical evidence for field induction of therapeutic hypothermia.

The scientific literature is clear that survival from sudden cardiac arrest is dependent on rapid lifesaving interventions such as early defibrillation, early bystander CPR, and effective chest compressions (30). For over a decade, these sequential time-sensitive out-of-hospital interventions have been promoted through the popular AHA “chain of survival” concept (31). During this time, a number of good quality clinical trials focusing on specific components of cardiac arrest resuscitation have revealed improvements in survival rates. It has been suggested that, to further enhance long-term survival, post-resuscitation care may be the missing link in the chain of survival (32). Presently, therapeutic hypothermia is one of the most promising post-resuscitation interventions for OHCA survivors. The AHA recommends the use of therapeutic hypothermia for OHCA survivors as a class IIA intervention and, just recently, EMS has started to embrace its early utilization (33–36).

Prehospital Hypothermia after ROSC

Bernard et al. conducted a 3-year randomized control trial on out-of-hospital ventricular fibrillation patients with ROSC (11). Seventy-seven patients were randomized to one of two groups: hypothermia or standard of care. Hypothermia patients began cooling with applied ice packs in the field, a treatment that was aggressively continued in the emergency department and maintained for 24 h. Of the 43 patients randomized to the hypothermia group, 21 (49%) were discharged with a “good outcome” (i.e., discharged home or to a rehabilitation institution), compared to 9 of 34 patients (26%) in the control group. The odds ratio for a good outcome for therapeutic hypothermia when compared to the control group was 5.25 (95% confidence interval 1.47–18.76). Interestingly, the rate for bystander CPR was higher in the control group (71%). Mean response times were similar in both study groups (8 min). There was no difference in the frequency of adverse events (i.e., incidence of cardiac dysrhythmias, evidence of myocardial damage, and abnormal cell counts) between the two groups (11).

The authors concluded that induced hypothermia improves neurological outcome and is not associated with adverse events. The study showed that prehospital providers can start the cooling process once the patient has ROSC. From this study, it is difficult to link improvement in outcomes to the fact that hypothermia was started in the field. However, the study did demonstrate a large improvement in survival to discharge among comatose survivors of OHCA after treatment with therapeutic hypothermia throughout an established system of care.
Table 3. Prehospital Therapeutic Hypothermia Studies: Main Outcomes and Results

<table>
<thead>
<tr>
<th>Included Studies (First Authors)</th>
<th>Main Outcomes of Interest</th>
<th>Results</th>
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<tbody>
<tr>
<td>Callaway, 2001 (18)</td>
<td>Temperature changes</td>
<td>Mean esophageal and nasopharyngeal temperatures were higher in patients with ROSC vs. no-ROSC (esophageal: 35.7 ± 1.2 °C vs. 35.2 ± 0.9 °C; nasopharyngeal: 35.7 ± 1.5 °C vs. 34.6 ± 1.0 °C). Rate of core cooling mean difference between groups was −0.05 °C/min (95% CI for difference, −0.106–0.007). Cranial temperature mean difference also did not differ between hypothermia (−0.06 ± 0.06 °C/min; 95% CI −0.11 to −0.03) vs. normothermia (−0.04 ± 0.07 °C/min; 95% CI −0.08–0.00).</td>
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<tr>
<td>Bernard, 2002 (11)</td>
<td>Survival to discharge</td>
<td>Hypothermia group 21/43 (49%) vs. control group 9/34 (26%).</td>
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<tr>
<td>Virkkunen, 2004 (21)</td>
<td>Temperature changes</td>
<td>Mean temperature decreased significantly, by 0.7 °C/h.</td>
</tr>
<tr>
<td>Kamarainen, 2007 (23)</td>
<td>Temperature changes</td>
<td>Mean decrease in temperature = 1.9 °C during CPR. Mean volume of infused cold fluids = 892 mL (mean time of 28 min); calculated mean rate of temperature decrease during CPR was 4.1 °C/h.</td>
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<tr>
<td>Kim, 2007 (24)</td>
<td>Temperature changes</td>
<td>Mean temperature difference in °C (i.e., hospital minus initial), −1.24 ± 1.09 randomized to field cooling vs. 0.10 ± 0.94 no field cooling (p &lt; 0.0001).</td>
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<tr>
<td>Storm, 2008 (25)</td>
<td>Temperature changes</td>
<td>Median tympanic temperature dropped from 35.5 °C (34.8–36.3) to 34.4 °C (33.6–35.4) (p &lt; 0.001).</td>
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<tr>
<td>Brue, 2008 (26)</td>
<td>Temperature changes</td>
<td>Mean temperature decreased significantly, by −2.1 °C ± 0.29 °C after intravenous cooling during advanced life support interventions to a median temperature of 33.3 °C (32.3–34.3 °C). The median time to reach mild hypothermia (&lt; 34 °C) after ROSC was 16 min (11.5–25.0 min).</td>
</tr>
<tr>
<td>Kamarainen, 2008 (27)</td>
<td>Temperature changes</td>
<td>Mean initial nasopharyngeal temperature 35.17 ± 0.57 °C. Temperature on hospital admission was 33.83 ± 0.77 °C (−1.34 °C, p &lt; 0.001). Mean infused volume of cold fluid was 1571 ± 517 mL.</td>
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<tr>
<td>Uray, 2008 (28)</td>
<td>Temperature changes</td>
<td>Esophageal temperatures decreased from 36.6 °C (36.2–36.6 °C) to 33 °C within 70 min (55–106 min). Absolute increase for survival from baseline to full implementation including field therapeutic hypothermia was 7.3% (95% CI 3.7–10.9%).</td>
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<tr>
<td>Hinchey, 2010 (29)</td>
<td>Survival to hospital discharge</td>
<td>Witnessed V-fib/V-tach survival was 27.0% (95% CI 18.6–40.4%).</td>
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</table>

ROSC = return of spontaneous circulation; CI = confidence interval; CPR = cardiopulmonary resuscitation; V-fib = ventricular fibrillation; V-tach = ventricular tachycardia.

In a more recent study, Hinchey and colleagues conducted a before-and-after multiphase study that evaluated impact on survival after the sequential implementation of 2005 AHA guidelines for cardiac arrest in an urban EMS system (29). Investigators implemented the successive interventions of new CPR, controlled ventilations, and therapeutic hypothermia over a 3-year period from 2004 through 2007. All patients with ROSC in the field were transported to one of two receiving hospitals with percutaneous coronary intervention capability. During the final intervention phase, 87 patients met criteria and were treated with therapeutic hypothermia in the field, utilizing cold intravenous fluids and ice packs, and this therapy was continued in-hospital for 24 h. In this study, there was a gradual improvement in overall survival to discharge over a 3-year period, with the sequential addition of the various interventions, including therapeutic hypothermia. There was an overall four-fold increase in survival between the final phase and the baseline; however, the incremental benefit of hypothermia alone was not determined due to limitations in study design. Despite this, this is the only primary EMS study describing an out-of-hospital structured approach to post-resuscitation care utilizing therapeutic hypothermia.

Prehospital Cooling Methods

As EMS systems continue to implement therapeutic hypothermia protocols, questions remain regarding which cooling mechanisms should be used in the field. Presently, there are three cooling options available to EMS: surface cooling, cold intravenous fluids, or a combination
of both. With a goal of achieving target temperatures early in the post-resuscitation process, several studies have examined surface cooling as an option. Busch and colleagues conducted a before-and-after study on 27 patients that remained comatose after ROSC (22). In the study, authors developed a surface cooling protocol with icepacks that was started in the field and aggressively continued in the hospital. After the implementation of the protocol, authors reported increased survival to hospital discharge compared to historical controls. Interestingly, target temperatures were achieved 89% of the time. The median time to achieve target temperatures was 7.5 h. Callaway et al. attempted to lower brain and core temperatures in OHCA patients through external cranial cooling by utilizing ice bags; but they found this approach was cumbersome and it had minimal effects on temperature changes (18). In Vienna, Uray et al. performed a prospective case series to evaluate the use of a 12-part cooling pad in OHCA survivors (28). Once patients (n = 15) were resuscitated in the field, cooling was started within 12 min of ROSC. Patients were transported to a hospital that was capable of continuing hypothermia for 24 h. Authors reported a median time to target temperature of 70 min (range 55–106) (28). Important weaknesses in the study were the lack of a control group, the small number of patients, and its lack of randomization. Although current evidence is inconsistent, it seems the use of surface cooling alone may not be suitable in the prehospital environment to achieve the goal of reaching target temperatures early.

Adopting a different surface cooling strategy, Storm et al. conducted a clinical trial with 24 patients to evaluate the feasibility of using a cooling cap (25). Patients were enrolled after ROSC regardless of initial rhythm. Of the 24 patients enrolled in the study, 20 were cooled to a target temperature of 34.0 °C. He compared temperature changes with a historical control group that was not cooled in the field. The median temperature in the control group was 35.9 °C at hospital admission. Once in the intensive care unit, it took a median of 6 h to achieve target temperatures in the study group. The hypothermia group observed a temperature drop to a median of 34.4 °C after the cooling cap. Authors argued that starting the cooling in the field would shorten the time to achieve target temperatures. However, the study had several limitations, which include a small number of subjects, lack of randomization, lack of hospital data on the hypothermia group, and the possibility of false tympanic temperature readings due to the cooled cap. Authors did conclude that the prehospital use of hypothermia caps was safe and rapidly available, as well as easy to learn and to use.

Other methods to achieve target temperatures rapidly have been studied. Virkkunen et al. cooled 13 prehospital non-traumatic cardiac arrest patients with 30 mL/kg of iced Ringer’s acetate (21). All cooling was initiated in the prehospital environment in an EMS system using physicians as providers. Patients were cooled without regard for presenting rhythm. Authors were able to decrease temperature from 35.8 ± 0.9 °C at the start of cold fluid infusion to 34.0 ± 1.2 °C on arrival at the hospital (p < 0.0001). The only reported complication was transient hypotension in one patient. Four of the 13 patients survived, all with CPC scores of 1 or 2. However, there was no control group, and not all cardiac arrests were from primary cardiac etiology. Kamarainen et al. conducted a prospective case series and cooled five EMS patients in cardiac arrest by using cold Ringer’s acetate intravenous fluid infused through a peripheral intravenous line (23). Two of the five patients had ROSC, and both of these died within 24 h. They were able to achieve their target temperature of 33.0 °C and reported no major complications. Authors were able to infuse a mean of almost 900 mL of cold saline and decreased temperatures by 1.9 °C during CPR. However, even though the saline infusion was slowed once patients achieved ROSC, 2 patients continued to drop core temperatures to 31 °C and therefore overshot goal temperatures. Later on, the same authors replicated the study in 17 adult prehospital cardiac arrest patients while they were undergoing CPR (27). ROSC was achieved in 13 (76%) patients. Both studies demonstrated that the use of cold fluids during resuscitation successfully decreased nasopharyngeal temperatures without increasing chances of ROSC. However, both studies used a small sample and lacked a control group, so selection bias must be considered.

In Seattle, Kim et al. randomized 125 patients with out-of-hospital ROSC to either cooling with iced saline or standard of care in a single center (24). Temperature changes were monitored by utilizing esophageal thermometers. Patients were enrolled regardless of the presenting rhythm. Of 63 cooled patients, 21 (33%) survived to hospital discharge, as compared to 18 of 62 patients (29%) in the control group. Results showed that patients in ventricular fibrillation were more likely to be discharged alive than those with other presenting rhythms. In 78% of cases, paramedics were able to infuse between 500 and 2000 mL, and investigators reported a 1.2 °C mean decrease in temperature during the first 30 min of therapeutic hypothermia. The author concluded that the use of cold saline in the field is safe, feasible, and effective in lowering core temperatures.

**Prehospital Hypothermia before ROSC**

Animal studies suggest that starting hypothermia before ROSC is feasible and may result in better outcomes (37,38). These trials suggest that cooling earlier may
confer benefits, perhaps even during CPR and before ROSC. In France, Bruel and coworkers conducted a prospective clinical trial with 33 OHCA patients (26). Utilizing pressure bags, authors infused 2 L of chilled 0.9% normal saline in 30 min during advanced life support interventions and before hospital arrival. Remarkably, they were able to achieve target temperatures (< 34 °C) in 16 min. However, one patient did develop pulmonary edema after 1500 mL of fluid. Although the study had a small number of participants and lacked a control group, authors argued that the infusion of 2 L of cold normal saline during advanced life support may be feasible and safe, and that this approach warrants further consideration.

**Post-Resuscitative Care Considerations**

Patient care in the post-resuscitative phase is often complicated. Not only do prehospital providers have to consider the injured, recently resuscitated heart, but they must also address the now oxygen-starved brain. We have made great progress in caring for the resuscitated heart, but until recently have paid little attention to reversing the potential consequences for the brain, which has suffered a period of decreased cerebral perfusion and oxygen deprivation secondary to the cardiac arrest (39). Post-resuscitation science is constantly evolving and new questions are being raised. It is important to understand that therapeutic hypothermia is not a substitute for the well-researched elements of the chain of survival, nor should it be considered the only therapeutic intervention after ROSC. Post-resuscitation care is time sensitive and should follow general established recommendations for the acute management of critically ill patients. Therefore, EMS systems should consider the implementation of hypothermia protocols and other post-resuscitation care measures as part of an overall prehospital resuscitative effort that includes early defibrillation, quality compressions, controlled ventilations, and specific destination policies for post-cardiac arrest patients (40,41). No clinical data suggest that a brief period of hypothermia during the prehospital phase alone will improve outcomes. Therefore, therapeutic hypothermia by EMS is recommended only in those systems that have established in-hospital protocols for continuing this therapy.

**LIMITATIONS AND FUTURE RESEARCH**

This systematic review describes the current evidence for the use of therapeutic hypothermia in the prehospital setting. Despite using predefined selection and review methodology, systematic reviews are susceptible to selection and publication bias. Our review includes only published studies and does not take into account any unpublished data nor ongoing clinical trials. In addition, there is the possibility that we may have overlooked studies through the literature search. Methodological heterogeneity among selected studies precluded us from performing a meta-analysis.

There is a clear need for more studies in the prehospital setting. Clinical research in EMS is challenging and demanding due to the nature of the environment. However, EMS needs more objective data to understand its role in the provision of therapeutic hypothermia and post-resuscitation care. One of the limitations of present studies is the marked variation among study settings, population, and EMS configuration services in the delivery of care. Such variations limit the results to the study population and system.

There are several important gaps in the evidence regarding therapeutic hypothermia in the field. Clinical human data that demonstrate how soon hypothermia should be started in the field are lacking. Although patients who present with ventricular fibrillation seem to derive the greatest benefit, it is not clear if there are subsets of patients, with specific cardiac arrest etiologies, that will experience the greatest benefits from therapeutic hypothermia in the field. The number of OHCA patients with rhythms other than ventricular fibrillation is small, which makes the study of these other sub-groups difficult.

It is not clear which valid and accurate methods for temperature monitoring should be used by EMS. Data evaluating differences between rural and urban systems are lacking. Additionally, there are gaps in our understanding of the process of cooling.

Preliminary studies demonstrate that EMS can provide therapeutic hypothermia. The question now relates to the clinical benefit that is or is not conferred by this intervention. Many believe that using a control arm of normothermic patients may by unethical. We may have to rely upon randomizing the timing of hypothermia induction (e.g., during CPR, after ROSC, after hospital arrival) rather than randomization with a normothermic control arm. Methodologically robust randomized-controlled clinical trials are difficult to conduct in the field due to the austere prehospital environment and the large sample sizes required to detect improvements in neurologic function of survivors of cardiac arrest.

**CONCLUSION**

Therapeutic hypothermia is gaining more acceptance as an essential treatment in OHCA survivors who remain comatose. There is strong evidence that in-hospital mild therapeutic hypothermia improves neurological outcomes, particularly for patients who have suffered ventricular fibrillation/pulseless ventricular tachycardia. But, there is a lack of clinical data to guide decision-makers on
what the role of EMS should be in the provision of therapeutic hypothermia for cardiac arrest. It seems that hypothermia can be induced in the prehospital environment efficiently. Some evidence suggests that the infusion of ice-cold intravenous fluid is more efficient than passive cooling. Most studies suggest that starting the cold fluids in the field is feasible and safe, and may impact neurological outcomes. Albeit limited, the current evidence suggests that prehospital initiation of therapeutic hypothermia is safe and potentially feasible; nevertheless, there is a need for more rigorous studies to understand its impact and effectiveness as it pertains to the prehospital environment.

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REFERENCES

ARTICLE SUMMARY

1. Why is this topic important?
   There is evidence that therapeutic hypothermia improves neurological outcomes in cardiac arrest survivors. Emergency Medical Services (EMS) has started to embrace the early utilization of therapeutic hypothermia.

2. What does this study attempt to show?
   This study demonstrates the need for more clinical research in the utilization of therapeutic hypothermia in the prehospital setting. Based on our findings, preliminary studies suggest that EMS can provide therapeutic hypothermia. However, the clinical benefit that is or is not conferred by this intervention in the prehospital environment remains unanswered.

3. What are the key findings?
   Our findings reveal that clinical human data demonstrating how soon hypothermia should be started in the field are lacking. We also show that present studies have a marked variation among study settings, population, and EMS configuration services. Such variations limit the results to the study population.

4. How is patient care impacted?
   EMS medical directors should consider the implementation of hypothermia protocols for out-of-hospital cardiac arrest patients as part of an overall prehospital resuscitative effort that includes early defibrillation, quality compressions, and avoidance of hyperventilation. There are no clinical data suggesting that a brief period of hypothermia during the prehospital phase alone will improve outcome.