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Cost-Effectiveness of Therapeutic Hypothermia After Cardiac Arrest

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***Background*—**Therapeutic hypothermia can improve survival and neurological outcomes in cardiac arrest survivors, but its cost-effectiveness is uncertain. We sought to evaluate the cost-effectiveness of treating comatose cardiac arrest survivors with therapeutic hypothermia.

***Methods and Results*—**A decision model was developed to capture costs and outcomes for patients with witnessed out-of-hospital ventricular fibrillation arrest who received conventional care or therapeutic hypothermia. The Hypothermia After Cardiac Arrest (HACA) trial inclusion criteria were assumed. Model inputs were determined from published data, cooling device companies, and consultation with resuscitation experts. Sensitivity analyses and Monte Carlo simulations were performed to identify influential variables and uncertainty in cost-effectiveness estimates. The main outcome measures were quality-adjusted survival after cardiac arrest, cost of hypothermia implementation, cost of posthospital discharge care, and incremental cost-effectiveness ratios. In our model, postarrest patients receiving therapeutic hypothermia gained an average of 0.66 quality-adjusted life years compared with conventional care, at an incremental cost of $31 254. This yielded an incremental cost-effectiveness ratio of $47 168 per quality-adjusted life year. Sensitivity analyses demonstrated that poor neurological outcome postcooling and costs associated with posthypothermia care (in-hospital and long term) were the most influential variables in the model. Even at extreme estimates for costs, the cost-effectiveness of hypothermia remained less than $100 000 per quality-adjusted life year. In 91% of 10 000 Monte Carlo simulations, the incremental cost-effectiveness ratio was less than $100 000 per quality-adjusted life year.

***Conclusions*—**In cardiac arrest survivors who meet HACA criteria, therapeutic hypothermia with a cooling blanket improves clinical outcomes with cost-effectiveness that is comparable to many economically acceptable health care interventions in the United States. **(*Circ Cardiovasc Qual Outcomes*. 2009;2:421-428.)**

Key Words: cost-benefit analysis ■ heart arrest ■ cardiopulmonary resuscitation ■ resuscitation

Out-of-hospital cardiac arrest (OHCA) affects approximately 300 000 people in the United States annually, and survival is generally less than 10%.[1–3] Treatment options for arrest survivors have traditionally been limited to supportive care. In 2002, two landmark articles by Bernard et al and the Hypothermia After Cardiac Arrest (HACA) study group reported that therapeutic hypothermia improves survival and neurological outcomes in comatose resuscitated patients after OHCA.[4,5] A subsequent meta-analysis demonstrated that an average of 6 (95% confidence interval 4 to 13) patients with OHCA needed to be treated with hypothermia for 1 additional patient to be discharged with good neurological outcome.[6] In 2005 the American Heart Association recommended that comatose cardiac arrest survivors receive induced hypothermia after ventricular fibrillation (VF) OHCA.[7]

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Despite these recommendations, use of therapeutic hypothermia remains limited.[8,9] Recent estimates suggest that approximately 2300 (range 300 to 9500) additional comatose patients with cardiac arrest annually would achieve good neurological outcome if hypothermia was fully implemented in US hospitals.[10] Diffusion of new treatments is often slow,[11] but 2 concerns may have limited adoption in this context. Because hypothermia is costly and OHCA has generally poor outcomes regardless of treatment, it is unclear that the benefits of therapeutic hypothermia justify its costs. Furthermore, the use of hypothermia may increase the number of patients who survive with poor neurological outcomes who would otherwise have died, thus prolonging the lives of patients at a very low subsequent quality of life, and at very high cost.

Therefore, the goals of this study were to evaluate the cost-effectiveness of postarrest therapeutic hypothermia in patients with witnessed VF, OHCA, compared with conventional care in these patients across a range of estimates for postresuscitation neurological outcomes.

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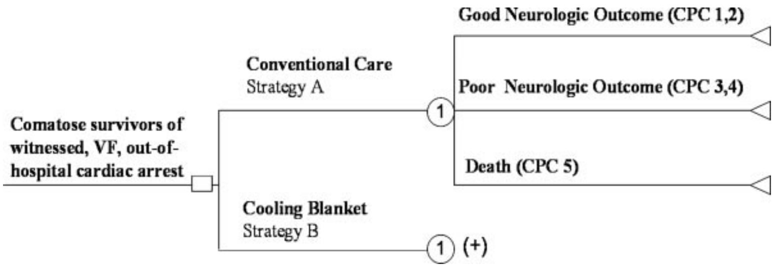

Figure 1. Decision model for management of comatose postarrest patients: conventional care versus hypothermia. This decision model follows a hypothetical cohort of patients who survived cardiac arrest but remained comatose after the event. The square node at the left of the model indicates the treatment options, conventional care compared with hypothermia using a cooling blanket. The circles represent chance nodes, and the accompanying plus sign indicates that the subtree has the same outcome as strategy A. Six months after hospital discharge patients were considered to be in 1 of 3 states: good neurological recovery, poor neurological recovery, or dead.

WHAT IS KNOWN

- Therapeutic hypothermia is the only treatment that has been identified as improving survival and neurological outcomes in patients who remain comatose after out-of-hospital ventricular fibrillation arrest.
- Evaluating the economic implications of implementing cooling is important because hypothermia therapy represents an additional cost for patients with historically very poor survival rates.

WHAT THE STUDY ADDS

- We developed a decision model to assess the cost-effectiveness of providing hypothermia with a cooling blanket and demonstrated that the incremental cost-effectiveness ratio of therapeutic hypothermia was $47 168 per quality-adjusted life year compared with conventional care.
- Even if only one patient per hospital per year was eligible for therapeutic hypothermia, and considerable postresuscitation care costs were accrued by survivors (eg, implantable cardioverter-defibrillator implementation, neurorehabilitation), the cost-effectiveness of therapeutic hypothermia would remain less than $100 000 per quality-adjusted life year.
- These findings are particularly important for clinicians, hospital administrators, and other decision makers responsible for making informed choices about health care resource utilization.

Methods

Decision Model

We created a decision model to follow a hypothetical cohort of comatose patients with return of spontaneous circulation (ROSC) after a witnessed VF OHCA (Figure 1). We also assumed that the patients in our model met the other inclusion criteria from the HACA trial (presumed cardiac etiology of the arrest, age 18 to 75, short time from collapse to resuscitation, and <60 minutes from collapse to ROSC). Exclusion criteria from this trial were also assumed to apply to our cohort (admission temperature <30°C, comatose prearrest secondary to central nervous system depressing drugs, pregnancy, terminal illness preceding arrest, cardiac arrest after the arrival of emergency medical personnel, a known preexisting coagulopathy, or any of the following after ROSC and before study randomization: response to verbal commands, mean arterial pressure less than 60 mm Hg for more than 30 minutes, arterial oxygen saturation less than 85% for more than 15 minutes).[4] Patients entered the model postarrest and were followed until 6 months after hospital discharge. Neurological function at 6 months was based on the postdischarge best achieved outcome within 6 months as reported in the HACA trial.

Our model was designed to capture costs and outcomes associated with postarrest care without hypothermia (conventional care, strategy A) compared with postarrest care with hypothermia (strategy B). Subsequent in-hospital and postdischarge long-term nursing facility/rehabilitation care were also modeled. We used hypothermia induced with a cooling blanket as the reference intervention because this cooling method can be easily implemented and survey data suggests it is among the most frequently used techniques in US hospitals.[8] Furthermore, this cooling technique was used in the largest randomized controlled trial (RCT) of postarrest hypothermia to date, and this trial provided outcomes data for patients 6 months after discharge.[4]

Our model was constructed from a societal perspective. Additionally, rather than use Markov modeling to calculate the net present (ie, discounted) value of downstream costs/outcomes among cardiac arrest survivors, we based our estimates on the results of Markov models previously reported in the literature.

Outcomes

The effectiveness of conventional care and hypothermia was based on published data.[4] Six months postarrest, patients were considered to be in one of three states: alive with favorable neurological outcome (Cerebral Performance Category [CPC] 1 [good neurological recovery], or CPC 2 [moderate disability]), alive with poor neurological outcome, CPC 3 or 4 (severe disability or vegetative), or dead (CPC5). These CPC definitions are consistent with definitions used in previous studies.[12,13] Based on the best CPC disposition at 6 months, costs were assigned over the average life expectancy of a cardiac arrest survivor (Table 1).

Quality of life of cardiac arrest survivors was determined from published data and used to estimate outcomes in terms of quality-adjusted life years (QALYs).[14–17,19] Outcomes for patients with poor neurological recovery included the possibility that this state may be considered worse than death, yielding negative QALYs.

Assumptions

Cooling and Rewarming

Postarrest temperature was considered 35 to 36°C. Target temperature was considered 32 to 34°C. Cooling was assumed to start with 2 L of intravenous saline[24,25] and temperature measurement performed with a rectal or bladder thermometer. Hypothermia (induction and maintenance) was assumed to occur for 32 hours followed by active (with the same cooling device) or passive rewarming for 8 hours. Although paralysis may not be necessary for all patients receiving induced hypothermia, we added the average cost of providing neuromuscular blockade (vecuronium, or cistaricurium)

Table 1. Base–Case Variables and Ranges

	Base–Case* (95% CI)	Distribution†	Reference
Probability of survival with good neurologic outcome			4
Conventional care	0.39 (0.32–0.46)	Logistic nl	
Hypothermia (Strategy B)	0.55 (0.48–0.62)	Logistic nl	
Probability of survival with poor neurologic outcome			4
Conventional care	0.06 (0.03–0.11)	Logistic nl	
Hypothermia (Strategy B)	0.04 (0.01–0.11)	Logistic nl	
Probability of death			4
Conventional care	0.55 (0.48–0.62)	Logistic nl	
Hypothermia (Strategy B)	0.41 (0.34–0.48)	Logistic nl	
Utility, good neurologic outcome	0.75 (0.5–0.97)	Logistic nl	14, 15
Utility, poor neurologic outcome	0.39 (−0.23–0.5)	Logistic nl	16, 17
			Extrapolation
Life expectancy			
Good neurologic outcome, y	5.59 (4.79–10)	Log nl	18–20
			Extrapolation
Poor neurologic outcome, y	1 (0.5–1.5)	Log nl	Assumption
Overall time course, cool/rewarm (hrs)	40 (30–50)	Log nl	4, 5, 21
Cooling device, $	6000 (4000–8000)	Log nl	Device co
Cooling blanket/pads, $	80 (100–120)	Log nl	Hosp adm
Supplemental ice bags, $	20 (12–30)	Log nl	Hosp adm
Neuromuscular blockade	130 (45–300)	Log nl	22†
cost/day			Extrapolation
Nurse time for implementation, min	75 (50–108)	Log nl	Nursing mgrs
Staff training (initial+annual), min	60 (50–70)	Log nl	Device co, nursing mgrs
Thermometer (rectal or bladder), $	200 (160–250)	Log nl	Device co
Intravenous fluids and tubing, $	5 (2–10)	Log nl	Hosp adm
Refrigerator for intravenous fluids, $	100 (50–180)	Log nl	Hosp adm
Annual depreciation cooling equip.	0.20 (0.15–0.25)	Uniform	Device co
Hospital level factors			
ED and ICU nurses/hospital	200 (20–250)	Log nl	Nursing mgrs
Hourly nursing salary, $	28 (22–35)	Log nl	23‡
Patients eligible for hypothermia/year	6 (1–50)	Poisson	Assumption

Hosp adm indicates hospital administrators; Device co, device company; Nursing mgrs, nursing managers; equip, equipment; and nl, normal.

*The base–case mean and 95% CI were used for the parameters of the probability distributions.

†For Monte Carlo simulations.

‡Adjusted to 2008 US dollars.

for 24 hours during cooling therapy. The cost of sedation was included in the daily cost of intensive care unit (ICU) care reported for mechanically ventilated patients.[26]

In-Hospital Postarrest Care

To estimate postresuscitation resource use, we included ICU and ward days previously reported for cardiac arrest survivors (Table 2).[27]

In the HACA trial, there were no statistically significant differences in adverse events of postarrest patients receiving hypothermia compared with normothermia.[4] However, in the hypothermia group, there were substantial, but nonstatistically significant, differences in a few important complications (pneumonia, sepsis, pulmonary edema, bleeding), and it is possible that statistical significance would have been attained with a larger sample size and that these complications could increase ICU length of stay. The base case received 2 additional ICU days for patients receiving hypothermia to account for time spent inducing cooling followed by rewarming. We modeled the range of potential additional days in the ICU from −1 to 7 days for the hypothermia group to allow for the possibility that hypothermia could decrease ICU length of stay (LOS)[28] or increase ICU LOS because of more complications, or because patients with better outcome received more procedures.

Posthospital Discharge Care

In both the hypothermia and normothermia arms of the HACA study, some of the patients with poor neurological function at discharge were noted at the 6-month evaluation to have a substantial improvement in neurological functioning from CPC 3 or 4 to CPC 1 or 2. To account for this potential late transition to the "final" neurological outcome state, we modeled the possibility of change in outcomes between discharge and 6 months postdischarge. Based on reports of neurological recovery in patients in a persistent vegetative state after

Table 2. In-Hospital and Posthospital Discharge Costs

	Base–Case* (95% CI)	Distribution†	Reference
In-hospital care			
Intensive care unit		Log nl	
Cost/day, $	2200 (2000–2400)		26§
Days, survivors	2.9 (1.4–6.6)		27
Days, nonsurvivors	1.1 (0.4–2.6)		27
Additional ICU days for the hypothermia cohort‡	2 (−1–7)		assumption[28]
Hospital ward		Log nl	
Cost/day, $	820 (650–1020)		26§
Days, survivors	18 (10–36)		27
Days, nonsurvivors	2 (1–4)		27
Postdischarge care			
Rehabilitation		Log nl	
Cost/day, $	1390 (695–2500)		29§
Days	30 (7–90)		Assumption
Long-term care facility		Log nl	
Nursing home, cost/day, $	250 (125–500)		29§
Chronic ventilation care facility, cost/day, $	1520 (760–2730)		29§
Long-term care facility, days	365 (180–545)		Assumption
Lifetime expenditure cost of an ICD, $	123 870 (102 290–148 650		19§
Estimated % of CPC 1 and 2 patients eligible for an ICD	80% (46%–100%)	Logistic nl	30§

nl indicates normal.

*The base–case mean and 95% CI were used for the parameters of the probability distributions.

†For Monte Carlo simulations.

‡Additional ICU days for the hypothermia cohort to account for days spent initiating cooling/rewarming and potential complications from hypothermia implementation.

§Cost adjusted to 2008 US dollars.

nontraumatic brain injury, we assumed that if improvements in neurological function occurred that this change would happen during the first month after discharge.[31,32]

Costs

Our model included cooling equipment costs, cooling device training and retraining costs, and costs associated with nursing time spent implementing and maintaining cooling (Table 1).

Cost estimates of equipment considered standard for acute care hospitals (ie, ice bags, intravenous fluids, thermometers, rewarming devices) were provided by equipment purchasing administrators at 2 large academic institutions. Cost estimates for external cooling machines and cooling blanket/pads were obtained by surveying cooling device companies and the HACA trial authors. Device companies provided estimates of equipment depreciation over time and hospital equipment administrators provided estimates of how often cooling equipment was used for indications other than cardiac arrest (eg, heat stroke, control of neurogenic fever). These estimates were used to determine the frequency of equipment use for cooling arrest patients and the typical depreciation in equipment cost over the equipment lifetime. Discounts were assigned for equipment standard for hospital operation. We distributed the cost of durable equipment over the average number of patients who received hypothermia over 2 years at 2 large US academic hospitals.

We assumed that a hypothermia program would require a hospital to initially train all emergency department (ED) and critical care nurses in appropriate technique with subsequent annual retraining. The average number of ED and critical care nurses per hospital was based on the average number of nurses at 2 academic hospitals. Nurse training time was based on recommendations from device companies and nursing managers.

Time expended by nurses' implementing cooling was estimated by querying ED and critical care nurse managers at 2 hospitals with cooling programs. ICU and ward costs were extrapolated from data on the costs of care for mechanically ventilated patients.[26] Nursing facility and rehabilitation costs for the CPC 3 and 4 group were extrapolated from a previous report of arrest survivors (Table 2).[29] Rehabilitation costs were also assigned to the CPC 1 or 2 group as some of the patients classified as CPC 2 (moderate disability) may require additional therapy. Costs are expressed in 2008 US dollars.

Additional Postarrest Care Costs

Although the exact usage rate of implantable cardioverter-defibrillator (ICD) uptake in postarrest patients with both reversible and irreversible causes is unknown, we modeled 80% ICD penetration in both the hypothermia and conventional care group with CPC 1 and 2. This conservative estimate was intended to account for differences in ICD uptake for secondary prevention attributable to patient eligibility criteria, patient preference, and other factors that may impact device implantation rates.[30,33] The lifetime expenditure cost of an ICD was estimated from previous reports and adjusted to 2008 dollars.[19] Both of these estimates were included in the sensitivity analysis.

Analyses

A decision-analytic model was used to calculate incremental cost-effectiveness. Sensitivity analyses for every variable (estimating costs and QALYs) in the model were performed across a wide range of values (see Tables 1 and 2). Based on the range of the ICER produced by changing each input variable to its minimal and maximal value, we determined the most influential variables in the model (tornado diagram). Two-way sensitivity analyses were then performed on selected plausibly correlated inputs with high impact on cost and effectiveness.

Table 3. Economic Costs and Clinical Outcomes for a Hypothetical Cohort of 100 Patients Assuming Base–Case Model Inputs*

	Conventional Care	Hypothermia
Good neurologic outcome; CPC 1 or 2		
Pts in this category at hospital discharge, n	39	55
Average cost, $	200 182	208 217
Average QALY	4.19	4.19
Poor neurologic outcome; CPC 3 or 4		
Pts in this category at hospital discharge, n	6	4
Average cost, $	328 318	333 844
Average QALY	0.39	0.39
Expired; CPC 5, n		
Pts in this category at hospital discharge, n	55	41
Average cost, $	7722	13 166
Average QALY	0	0
Total cohort, n	100	100
Total cost, $	10 201 716	13 327 117
Incremental cost, $		3 125 401
Total QALY	165.75	232.01
Incremental QALY		66.26
Incremental cost effectiveness		47 168

Pts indicates patients.

*Based on patients randomized to hypothermia or conventional care in the Hypothermia After Cardiac Arrest trial.[4]

All variables in the model were assigned a distribution. Probabilities were assigned logistic normal distributions,[34] cost variables were assigned ln distributions,[35] and cardiac arrest incidence was assigned a poisson distribution.[36] A uniform distribution was assigned to the variable: annual depreciation of cooling equipment, because the distribution is unknown. In addition, 10 000 Monte Carlo simulations were performed to estimate the overall variability in cost and outcomes of each strategy, and we examined the proportion of simulations below the $100 000/QALY threshold. We used the arbitrary cutpoint of $100 000/QALY to be consistent with previous cost effectiveness analyses, although empirical studies suggest that the willingness to pay for US healthcare may very well exceed these estimates.[37]

Tree Age Pro Health Care Module Software 2007 (Tree Age Software) was used for all calculations. The authors had full access to the data and take responsibility for its integrity. All authors have read and agree to the manuscript as written.

Results

Base–Case Analysis

In our model, witnessed VF OHCA patients treated with therapeutic hypothermia gained an average of 0.66 QALYs (95% CI, 0.11 to 1.3) over those receiving conventional care, at an incremental cost of $31 254 (95% CI, −5581 to 77 553) yielding an incremental cost effectiveness ratio of $47 168 (95%CI, −16 673 to191 369) per QALY (Table 3). Overall, hypothermia and rewarming accounted for only 1% of the total cost attributed to patients in the hypothermia cohort of our model, whereas posthypothermia in-hospital care and postdischarge care accounted for 99% of the total cost. Patients who survived but had poor neurological outcome accounted for the majority of the postdischarge care costs (Table 3).

Sensitivity Analysis

A series of 1-way sensitivity analyses of the inputs used to estimate cost and effectiveness of conventional care versus hypothermia demonstrated that the probability of poor neurological outcome after hypothermia and the cost of posthypothermia care (in-hospital [ICU, ICD] and rehabilitation) were the most influential variables in the model (Figure 2). However, even large reasonable changes in the value of these variables did not increase the cost-effectiveness of therapeutic hypothermia to greater than $100 000/QALY.

Two-way sensitivity analyses were also performed to account for the probability of correlation between poor

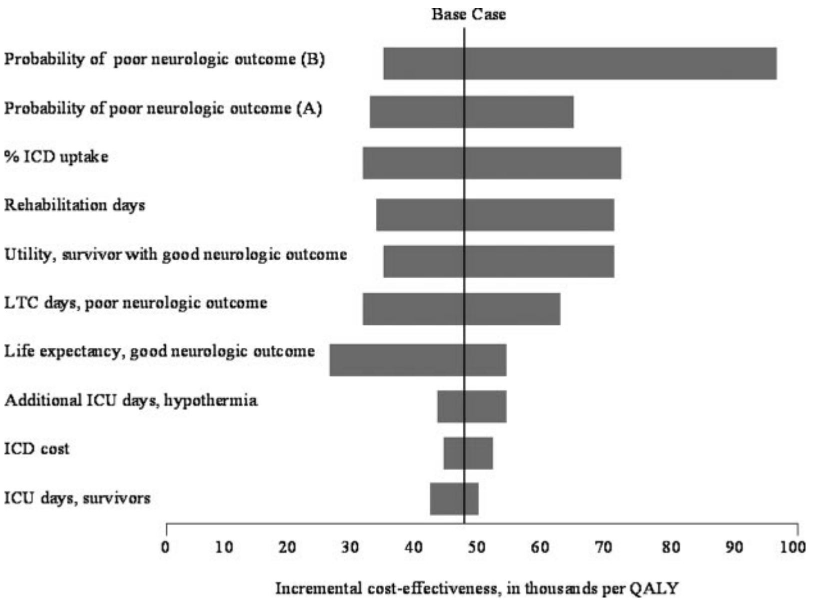

Figure 2. One-way sensitivity analyses of the cost-effectiveness of therapeutic hypothermia. The horizontal bars represent variability in the model estimates. Specifically, each bar represents 1-way sensitivity analyses of influential variables in the model across a range of possible outcomes, with the range of values listed in Tables 1 and 2. Inputs are labeled on the *y*-axis, and the variability of the incremental cost-effectiveness ratios are indicated on the *x*-axis.

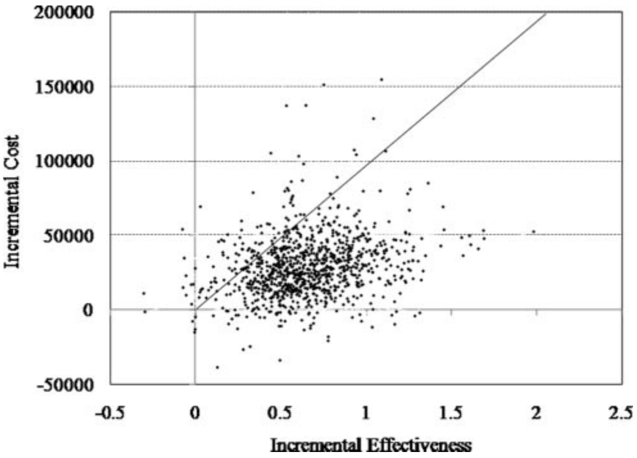

Figure 3. Monte Carlo simulation distribution plot. The figure illustrates the incremental cost effectiveness of hypothermia compared with conventional care. The slope of the scatterplot indicates incremental cost-effectiveness ratios of $100 000/QALY.

neurological outcome in both the hypothermia and conventional care group. If the absolute number of additional individuals with poor neurological outcome in the hypothermia group is 5% greater than those in the conventional care group then the ICER will exceed $100 000/QALY.

Monte Carlo Analyses

Monte Carlo simulation allows for all of the model inputs to be randomly varied at the same time across each parameter's assigned probability distribution. Independent random selections of all input parameters are combined to produce a simulated model output (ie, incremental cost-effectiveness). The random selections are repeated 10 000 times to produce an empirical probability distribution of the cost-effectiveness estimate of the model. This approach allows for a simultaneous evaluation of the effect of uncertainty in all parameters in the model. In our Monte Carlo simulation, the incremental cost-effectiveness ratio for cooling remained less than $100 000/QALY in 91% of 10 000 Monte Carlo simulations. The distribution plot from the Monte Carlo simulation is depicted in Figure 3.

Discussion

Therapeutic hypothermia is the only postresuscitation therapy shown to improve both survival and neurological outcomes after cardiac arrest. We demonstrated that hypothermia with a cooling blanket costs less than $100 000/QALY gained, and this finding was sustained despite extensive variation in model inputs. Specifically, this finding was consistent in 91% of the 10 000 Monte Carlo simulations performed where model parameters were varied at random. Even if a hospital had only 1 patient eligible for hypothermia therapy annually, and considerable postresuscitation care costs were accrued by survivors, the cost-effectiveness of hypothermia would remain less than $100 000/QALY. This level of cost-effectiveness is consistent with many widely accepted health care interventions and is considerably lower than some other estimates of US societal willingness-to-pay for health care.[38]

Prior cost-effectiveness analyses of cardiac arrest have focused on intraarrest interventions like cardiopulmonary resuscitation (CPR) and defibrillation.[39–42] These studies have evaluated the economic burden and ethical appropriateness of widespread training and resource use for patients with a minimal chance of survival. Widespread layperson resuscitation training has been estimated as costing $202 400/QALY; public access defibrillation has been estimated to have a cost-effectiveness of $44 000/QALY; and full deployment of airline defibrillation programs in all US commercial aircraft has been estimated to cost $94 700/QALY.[40–42] Few studies, however, have specifically assessed the medical and societal cost of caring for patients who survive cardiac arrest. This is important as some survivors will have severe neurological disability and subsequently use costly health care resources. In our analysis, the downstream cost of posthypothermia in-hospital and postdischarge care were among the most important factors in overall cost estimates. The equipment and staff training costs for implementing hypothermia and rewarming, however, were extremely small in comparison to downstream costs.

Neurological recovery after cardiac arrest cannot be predicted accurately among comatose cardiac arrest survivors at the time of admission.[43] Hypothermia could increase overall cost of care for all cardiac arrest survivors by generating additional days in the ICU, even for those patients who ultimately do not survive to hospital discharge. Critical decisions—for example, whether to continue aggressive management, withdraw care, or donate organs—could be delayed in comatose arrest survivors who receive hypothermia from 1 to 2 days postarrest to several days postcooling and rewarming. Although recent data from a study comparing patients receiving hypothermia to historical controls suggests that ICU days may be fewer in patients who receive hypothermia and have good outcomes, ICU length-of-stay among patients who receive hypothermia and have poor outcomes (CPC 3 or 4) remains uncertain.[28]

Postdischarge care was an important component of the total cost attributed to caring for arrest survivors. The majority of this cost reflected long-term nursing facility care accrued by a small minority of patients with significant neurological disability. This cost is important to quantify accurately because any effective therapy for cardiac arrest may also increase the proportion of survivors with poor neurological outcome. In our model, even when we increased the proportion of neurologically impaired survivors in the hypothermia group, we still observed favorable cost-effectiveness estimates for hypothermia. Better estimates are needed of the incidence of poor neurological outcome among survivors of cardiac arrest treated with hypothermia and the subsequent long-term care resource use of this population.

The benefit of cooling may have been underestimated in our model because the reference case was based on inducing hypothermia with a cooling blanket. However, it is not clear that this approach represents the optimal cooling technology. Previous reports have demonstrated that hypothermia can be induced with alternate methods such as external application of ice bags, which are readily available and inexpensive, or an endovascular cooling device, which would be more expensive.[5,44] The incremental cost-effectiveness of any therapy can be markedly altered depending on the costs and benefits of the next best alternative.[45] Little is known, however, about the effectiveness thresholds of different cooling methods, and a large sample size would be needed to determine small but significant differences in survival benefit between methods. Comparative effectiveness studies would be necessary to determine the incremental benefit of alternative means of delivering hypothermia.

Limitations

Our analysis has several limitations regarding approximations of outcomes and cost. First, our estimates of the effectiveness of hypothermia derive from a single RCT with fewer than 400 patients. Patients in this study were also limited to those with an initial arrest rhythm of VF who then met strict study inclusion criteria. Patients with asystole or pulseless electric activity were excluded, although hypothermia may be beneficial in some of these individuals. Sufficient data were not available to make plausible predictions for our model about neurological outcomes and posthypothermia cost estimates in this population. Additional evaluation of use of hypothermia outside of clinical trial settings would provide estimates more likely to reflect real world effectiveness of the therapy.

Our estimates of equipment and staffing costs to implement cooling are also approximations, but these estimates had little influence on our final results. Second, in-hospital and postdischarge resource use for patients receiving hypothermia has not been extensively studied and was not reported in the HACA trial. Several of our estimates were based on extrapolations from studies of conventional treatment of cardiac arrest and extrapolations from stroke literature that may not reflect practice patterns in patients receiving hypothermia. Although the cost of postdischarge care was influential in our final results, our conclusions will largely be sustained unless there are unexpected differences in the costs of caring for survivors who received cooling compared to survivors who did not. Additionally, our estimates for life-expectancy postarrest were conservative and extrapolated from several studies.

Conclusions

We demonstrated that therapeutic hypothermia with a cooling blanket technique in witnessed, VF, OHCA is an acceptable investment of health care dollars and has an incremental cost effectiveness ratio of $47 168/QALY. From a societal perspective, postarrest hypothermia produces benefits that justify its costs.

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