Original Research

Minimising delays in commencing therapeutic hypothermia after out-of-hospital cardiac arrest: the importance of a multi-disciplinary team approach

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Abstract

Therapeutic hypothermia (TH) is now a well established therapy in resuscitation guidelines. We retrospectively analysed our first 18 months' data for all patients who underwent TH for out-of-hospital cardiac arrest (OHCA), measuring delays incurred during each patient episode, safety, and ICU outcomes. Sixteen patients received TH for OHCA. A mean delay of 248mins occurred following hospital admission to commencing therapy. Seven patients survived to hospital discharge with a 6 month Glasgow Outcome Score of 4-5 in 100%. A questionnaire evaluating 30 first responders' familiarity and knowledge of TH demonstrated poor awareness and knowledge, with most viewing it with low priority. TH is a safe and easy to achieve therapy, however in practice there are significant delays in commencing treatment.

Keywords

Therapeutic hypothermia (TH), out-of-hospital cardiac arrest (OHCA)

Introduction

Sudden out-of-hospital cardiac arrest (OHCA) remains a significant cause of mortality and morbidity in the UK and overall carries a poor prognosis, with fewer than 10% making a full recovery because of global hypoxic brain injury.[1] In 2006, the Ambulance Service Association reported 57,345 sudden cardiac arrests in the UK, representing a year on year increase in incidence.[2] The impact for intensive care units is also significant, with unconscious, mechanically ventilated survivors of cardiac arrest accounting for 1 in 17 of all ITU admissions.[3] Of those admitted to ITU only 30% will survive to discharge, with up to two thirds of deaths attributed primarily to a neurological cause.[4,5] As a result, significant efforts are being made to identify specific therapies that will improve the outcome for the proportion of patients that survive their initial cardiac event.

In 2002, the use of therapeutic hypothermia (TH) following ventricular fibrillation (VF) cardiac arrest, demonstrated statistically significant improvements in neurological outcome following out of hospital cardiac arrest.[6,7] It has subsequently been incorporated into resuscitation guidelines both in Europe and North America.[8] Despite this, significant problems remain both in terms of local delivery and awareness among physicians.

Our institution initiated a TH protocol in 2007. We retrospectively audited our first 18 months of data to determine the characteristics of those patients undergoing treatment with TH at our institution, characterise the problems and delays incurred during each patient episode and evaluate the survival and neurological outcomes of those admitted to ICU and undergoing TH. We also explored attitudes and knowledge of the use of TH amongst a sample of 'first responders' to cardiac arrest calls in our hospital and its impact on TH uptake, using a questionnaire survey.

Methods

All patients undergoing TH since the introduction of our protocol were identified using the ICU database (WARDWATCHER® 1 March 2007 to 30 June 2008) and all case notes were retrospectively analysed. Each patient episode was characterised in terms of 5 key time delays from the point of cardiac arrest until achieving target temperature for TH:

1. Cardiac arrest (CA) to arrival of a paramedic
2. CA to return of spontaneous circulation (ROSC)
3. CA to arrival at the Emergency Department (ED)
4. CA to initiation of TH
5. CA to reaching target temperature

TH Protocol

Our therapeutic hypothermia protocol was formulated to reflect closely the methods used in the randomised controlled trials published in 2002 (see Table 1).

Therapeutic hypothermia was initiated using 1 litre of intravenous 4°C 0.9% saline and external cooling techniques (ice packs and ice-water soaked sheets) which were used throughout the TH process.

Long term neurological outcomes were evaluated using the Glasgow Outcome Score (GOS) at 6 months following discharge from the ICU (see Table 2). A 'good' neurological outcome was defined as those patients achieving discharge from hospital, with

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Inclusion Criteria	Exclusion Criteria
A presenting arrest rhythm of VF/VT	A tympanic temp <30°C on admission
Unconscious post cardiac arrest	Coma before cardiac arrest
Able to maintain BP > 90mmhg	Severe cardiogenic shock
18 years old	Persistent hypoxia P02 < 8Kpa despite mechanical ventilation
A 5-15 min interval from CA to CPR	
An interval <60min to the ROSC	Patient with a DNR
	Severe systemic infection

Protocol Guidelines

Target temperature range 32 - 34° to be achieved within 4 hours
Target temperature to be maintained for 24 hours
Sedation with remifentanil +/- propofol
All patients to be paralysed if persistent shivering unresponsive to remifentanil sedation. Low threshold for continuing phenytoin if querying seizure activity.
Administer 5g $MgSO_4$ to aim serum Mg^{2+} 1 – 1.5 mmol/l

Table 1. Therapeutic Hypothermia protocol, Medway Maritime Hospital.

GOS	Functional Class	Description
5	Full Recovery	Can resume normal daily activities
4	Moderate disability	Disabled but independent
3	Severe disability	Conscious but disabled – patient is dependent on others for ADLs
2	Persistent vegetative state	Patient exhibiting no obvious cortical function
1	Death	

Table 2. The Glasgow Outcome Score for neurological disability.

a Glasgow Outcome Score of 4 or 5, six months following discharge.

Questionnaire survey

Thirty healthcare professionals were selected at random. All were 'first responders' to cardiac arrest calls in our hospital. Ten each from the specialties of Anaesthetics/ITU, Acute Medicine and Accident and Emergency Medicine were selected. These were generally at Specialist Registrar and Senior House Officer level, but included senior nursing staff in the Emergency Department (ED) sample who would be involved in the initial resuscitation of cardiac arrest patients.

Results

Patient Characteristics

Sixteen patients underwent therapeutic hypothermia for OHCA, all of which were admitted following VF arrest and fulfilled our TH criteria. All patients admitted following a ROSC from VF arrest who met the criteria were included. Nine patients were male and 7 female, with a mean age 61 (range of 23–87). Therapeutic hypothermia was initiated by ED staff for only one patient, while in the majority of patients (14/16) cooling was initiated in ICU. One patient received pre-hospital TH by the paramedic team.

Analysis of Delays Incurred During Cooling

The mean delay from CA to the arrival of paramedics was 10.9 minutes (range = 4-25 minutes). The mean delay to a ROSC was 26.7 minutes post-CA (range = 7-41 minutes) and the mean delay to arrival in ED after CA was 57.5 minutes (range = 29 minutes – 1 hour and 45 minutes). The mean delay to initiate TH was 5 hours and 5 minutes following cardiac arrest (range = 1hr,50min - 10hrs,59mins) with a mean in-hospital delay of 4 hours and 8 minutes. The mean delay to reach target temperature from CA was 9hrs, 14 minutes (range = 2hrs,29mins - 15hrs,40mins) (See Figure 1).

Once cooling had been initiated, the mean time to reach target temperature was 4 hours and 3 mins (STANDARD = 4 hours). Differences in time taken to reach target temperature between summer and winter are summarised in Table 3.

	Mean delay to reaching target temp (<34°C)
Winter (Sept – Feb)	577 mins
Summer (March – August)	447 mins
Difference	130 mins

Table 3. Variation in time delays according to season.

The mean period over which cooling took place was 21 hours and 21 minutes (STANDARD = 24 hours). For those patients where data was available (n=14), maintaining hypothermia within the target range of 32 - 34°C was successful in 12/14 patients (Mean range of temp 32.2 – 33.5°C). In one patient we were unable to maintain a steady temperature due to wide fluctuations of neurogenic aetiology, and one patient was deliberately warmed to 34-34.5°C because of refractory bradycardia.

Complications

Complications were minimal and consisted of shivering, seizures due to hypoxic brain injury, hypotension and

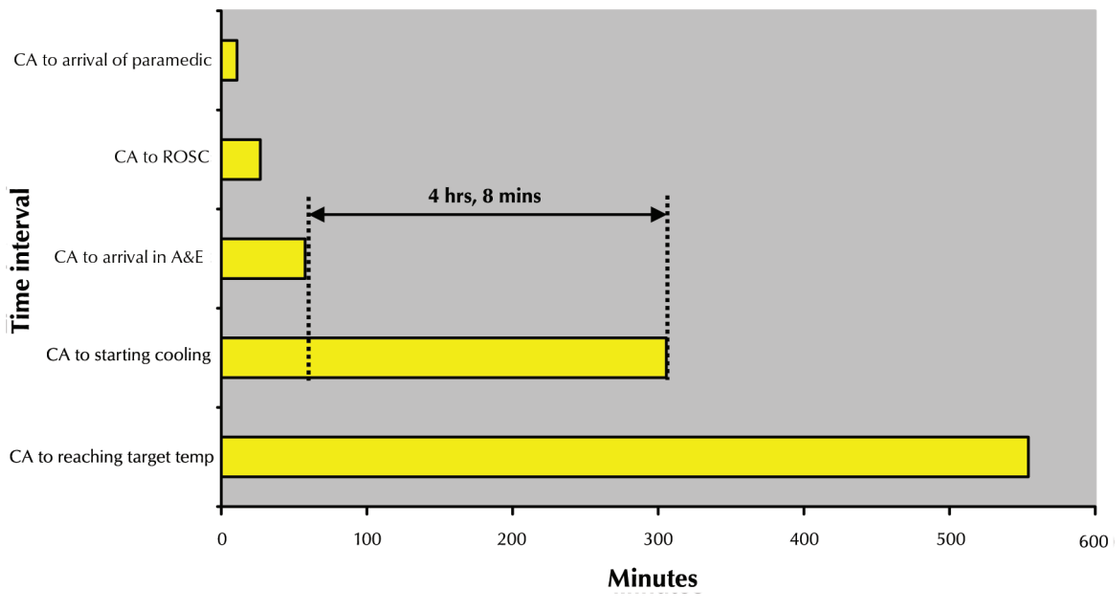

Figure 1. The mean time delays accrued for all patients

Factor	Deaths	Survivors	P value
Mean age ± SEM (years)	63.89 ± 6.17 (n=9)	58.14 ± 7.38 (n=7)	0.56
Mean Time to ROSC ± SEM (mins)	29.5 ± 3.78	23 ± 4.57	0.29
Past History of IHD (%)	66 (n=6)	14 (n=1)	0.06

Table 4. Other factors influencing outcome from OHCA.

bradycardia in three patients respectively. One patient developed seizures from hypoxic brain injury and thus TH was terminated early. In no case was a complication of cooling directly attributed to adverse outcome.

Outcomes

Seven patients survived to discharge (44%). All of the survivors achieved a GOS of 4 (n = 1) or 5 (n = 6) at 6 months follow-up, and therefore all patients who survived achieved a 'good' neurological outcome. The patients who died were more likely to have a past medical history of ischaemic heart disease compared with survivors although this did not quite reach statistical significance (see Table 4).

Questionnaire survey

A summary of responses from first responders to cardiac arrests to a variety of questions regarding TH is outlined in Table 5. Questions were designed to identity familiarity, knowledge and perceptions of the use of TH for OHCA.

Discussion

The results thus far from clinical trials provide strong evidence for the role of TH in improving neurological outcome following cardiac arrest. However enthusiasm for its use and uptake in the UK has been variable.[9] Local rather than national protocols also produce variation in the way TH is applied to patients across the country. Our review further highlights a variety of other problems both in terms of the delays incurred especially following hospital admission and in the awareness and knowledge of TH among healthcare professionals.

Our data are consistent with other published studies confirming that TH is safe to use and associated with few complications that impact on clinical outcome.[10] Our experience also demonstrates that TH is achievable with minimal, inexpensive equipment and hence at low cost:benefit ratio in comparison to other intensive care treatments. We achieved effective induction of hypothermia and subsequent temperature control using only superficial techniques. Whilst this approach can be labour intensive for the nursing staff involved, the advantage is that it can be instituted relatively easily within the hospital.

From our data, advancing age as a variable did not appear to be related to an adverse outcome. Indeed there is no upper age limit in our exclusion criteria. However the original two randomised controlled trials recruited younger patients, with a median age of 59 years old (and an upper age limit of 75) in the European study,[6] and a median age of 66.8 years old in the Australian study.[7] Therefore the evidence from trials pertains mainly to those under the age of 75 years old, and local policy may dictate an upper age limit of 75 years old based upon this. Overall 44% of patients admitted to the ICU survived to discharge, all of whom had a good neurological outcome,

Sample of results to questions put to 'first responders'	
FAMILIARITY	
1. Number of first responders who had been involved in treating a patient with TH	10/30 ED: 2/10 A/ITU: 7/10 Med: 1/10
2. Number of first responders aware of the presence of the hospital protocol	16/30 ED: 2/10 A/ITU: 9/10 Med: 5/10
KNOWLEDGE BASED	
1. Number of first responders who could correctly identify which rhythm (i.e. VF) for which TH was indicated.	11/30 ED: 2/10 A/ITU: 6/10 Med: 3/10
2. Number of first responders who correctly identified the benefits of TH (improvement of neurological function and mortality)	13/30 ED: 3/10 A/ITU: 6/10 Med: 4/10
3. Number of first responders who could list 2 or more complications of TH	11/30 ED: 2/10 A/ITU: 4/10 Med: 5/10
4. Number who could identify 3 or more exclusion criteria from a list of 10 statements.	8/30 ED: 2/10 A/ITU: 3/10 Med: 3/10
PERCEPTIONS	
Responses to the following questions;	
1. Ideally where should cooling take place after ROSC after cardiac arrest?	
a. In the ambulance	2
b. In ITU	13
c. At the Scene of arrest	10
d. On admission to ED	5

Table 5. Summary of questionnaire results.
(ED = Emergency Dept first responders, A/ITU = Anaesthetic and ITU staff first responders, Med = Medical team first responders)

and these figures are consistent with other published outcome data.

One of the most interesting findings from our review relate to the significant delays to starting therapy following admission. Significant delays were incurred in the initiation of TH following admission to hospital. The mean delay after admission of 4 hours and 8 minutes is clearly incompatible with the urgent practice that resuscitation guidelines demand. This in fact represented the longest mean time delay of the entire patient episode. However this may well reflect the situation in many district general hospitals due to service demands and limited bed states, and so may not be unique to this hospital or this particular sample.

The delays encountered did not seem to be related to the learning curve after introduction of the protocol, but rather persisted throughout the study period. Interestingly, delays were more likely to occur during the winter months (Sept-Feb) as compared to summer months (Mar-Aug), which may reflect service demands and availability of ITU beds.

As a response to try to minimise these delays to TH in the future, we have introduced a protocolised algorithm in poster format in the A&E department, which emphasises the immediate involvement of the ITU team if the patient meets the criteria for TH treatment.

The questionnaire survey amongst first responders at our hospital demonstrated considerable lack of awareness and knowledge about the use and indications of TH. We believe these delays are exacerbated by a lack of awareness and prioritisation among medical staff combined with service constraints. Indeed questions related to its priority and perceived importance also revealed that many believe it is a therapy that it is of low priority in the resuscitation process, and something that can wait until the patient is safely in ITU. Staff from the ITU/Anaesthetic sample tended to score higher compared to both Acute Medicine and A&E staff. As the latter groups are often the first to manage cardiac arrest resuscitation, it is all the more important that ITU staff work closely with the first attending team in order to achieve early TH.

Conclusions

It has been suggested that TH should begin as early as possible following cardiac arrest which would appear to be a logical argument, as its presumed mode of action limits the deleterious effects of cerebral hypoxaemia during the 'no-flow' phase of cardiac arrest and then throughout the reperfusion phase once ROSC has been achieved.

It may well be that the nature of the delays we incurred are more universal and a more nationally co-ordinated approach may be required. The introduction of the concept of a '*door to cooling time*', akin to the 'door to needle time', may help invigorate attitudes to TH, in the same way that a target time frame has helped in the management of acute myocardial infarction. The possibility of pre-hospital TH or even intra-arrest TH needs to be explored further as well. Preliminary trials of pre-hospital cooling are on-going and we await with interest the results from these studies.[11]

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