SHORT PAPERS

For the 2006 joint conference, three scholarships were offered to non-commissioned officers and ratings of the ADF and ADF reserves supporting individual attendance. To be eligible for the scholarship, applicants had to submit an essay on a topic of military medicine and health. The two papers that follow are two of those essays.

The Association intends to undertake a similar process of offering scholarships for attendance at the 2007 AMMA Conference.

The Role That Therapeutic Hypothermia plays in the Recovery of Hypoxic Patients in the Australian Defence Force

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Oh. They've encased him in Carbonite. He should be quite well protected. If he survived the freezing process, that is.

C-3PO, "Star Wars: Episode V-The Empire Strikes Back" (1980)

INTRODUCTION:

There currently exists a great deal of small scale, independent research and anecdotal evidence that suggests Therapeutic Hypothermia (TH) is useful in the recovery of hypoxic patients. A collective overview of all relevant information is imperative if one is to make an accurate appraisal of the efficacy of TH in the Australian Defence Force (ADF).

Aim:

This essay seeks to define the use of TH in hypoxic patients, review current research, review current protocols and equipment, and make recommendations in regards to the application of TH in the ADF.

WHAT IS THERAPEUTIC HYPOTHERMIA?

TH is the cooling of a patients body core temp to between 32°C and 34°C in order to slow the patients' metabolic rate and improve their possible recovery outcome.

The use of TH was first described in the 1930s, but ceased without formal clinical trials. Interest and research in TH has been gaining momentum since the early 1990s. This revival in interest is due to promise shown in animal trials and preliminary clinical studies. These preliminary studies suggest that patient mortality can be decreased and overall patient outcome increased.

To date, canine, swine, and rat studies have been conducted to assess the efficacy of the use of TH in patients suffering traumatic cardiac arrest and the subsequent overall outcome. Though cooling induction methods, protocols and rules governing rewarming, duration, and patient selection have been many and varied, there is some promise shown which is evidenced by Bernard and Buist (2003) who assert that: "Animal data suggests that the rapid induction of hypothermia may have a role in maintaining the viability of patients with major trauma who are exsanguinating before definitive surgery".

Based on this preliminary animal research and clinical human trials, some medical equipment companies have developed equipment designed for lowering a patient's body core temperature. Whilst the equipment is designed with the four mechanisms of heat loss in mind (Radiation, Conduction, Convention and Evaporation), their designs are many and varied.

Table 1. *Suggested methods of body core cooling:*

- Peripheral cooling fans.
- Air circulating cooling blankets
- Ice packs
- Water circulating cooling blankets
- Immersion
- Cooling caps
- Water and alcohol spray
- Sponge baths
- Exposure of skin
- Core cooling intravascular catheters
- infusion of ice cold fluids
- Extracorporeal circulation
- Anti pyretic agents

WHAT RESEARCH HAS BEEN COMPLETED?

Much of the research is centred on the use of TH in out-of –hospital cardiac arrest and the long term neurological outcome. This and other research has historically been with a very specific focus: "Firstly, uncertainty remains about the effectiveness of this therapy in patients with out-of-hospital cardiac arrest due to causes other than ventricular fibrillation." Therapeutic Hypothermia after cardiac arrest – Bernard, 2004. This makes much of the available material less than useful due to the lack of its academic application in pre-hospital theorems and in the infinitely broad definition

of hypoxia. To date, the most reliable research centred on patients suffering anoxic brain injury or traumatic cardiac arrest is sourced from animal studies.

Table 2. *Suggested positive outcomes from TH*

- Improved long-term neurological outcome post cardiac arrest (specifically ventricular arrhythmias
- Post hypoxic injury following cardio-pulmonary resuscitation
- Anoxic brain injuries

Research suggests that TH may be useful for out-of hospital cardiac arrest and the associated long term neurological recovery, and for post hypoxic injury following cardio-pulmonary resuscitation (CPR). With current research in mind, Nolan and Morley (2003) suggest "hypothermia is a two edged sword: although significant benefits can be achieved, there are many potential side-effects that, if left untreated can diminish or even negate the benefits".

The relevance of the many and varied TH studies and trials are problematic due to the inconsistency of therapeutic algorithms implemented in study and test groups. It is also apparent that techniques for body core cooling are varied and protocols for re-warming a patient are contradictory and wide-ranging depending on the study evaluated.

It has been shown that TH can adversely affect drug metabolism and pharmacokinetics (K. Polderman, 2004). In support of this finding, Nolan, Morley and Vanden Hoek (2003) state that the use of anti-spasmodic and neuromuscular blockers are desirable in the maintenance of TH due to the effect of decreasing "shivering" and therefore oxygen consumption. None of the reviewed literature made any reference to, or suggestion of a researched protocol in regarding the appropriate use of drugs in a patient undergoing TH. In ACC protocol manual (MISCPUB 157), (1999) it states: "Be aware of the effects of cardio-active drugs, as metabolism will be reduced in the hypothermic patient". This is also supported in the following quote: "Do not administer medications. They are poorly metabolized in hypothermia, due to the hypometabolic state. Administration may cause medications to persist in the body, resulting in toxic drug levels upon patient rewarming". Paramedic Emergency Care, 3rd edition – Bledsoe, Porter, Shade. (1994).

TH has been associated with an increase in the incidence of pneumonia. This is evidenced by findings from the Alderson, Gadkary and Signorini study (2004):"We found 14 trials with 1094 participants… Hypothermia treatment was associated with a statistically significant increase in odds of pneumonia". In addition to this, post TH pneumonia rates in clinical human trials has been quoted as being as high as 45% by Bernard and Buist (2003). These and other researched, negative effects or TH are illustrated in Table 3.

Table 3. *Suggested negative effects of Therapeutic Hypothermia*

- Impaired coagulation cascade
- Electrolyte disorders (loss of K, Mg, P, and Ca)
- Hypothermia induced diuresis and therefore hypovolaemia
- Changes in drug effects and metabolism
- Insulin resistance
- Airway infections
- Wound infections
- Myocardial ischaemia
- Intracerebral haemorrhage

In all reviewed texts, there is, as yet, no suggested or implemented protocol for the use of TH in paediatrics, pregnant women, or geriatrics. Comprehensive protocols regarding TH are required for military application due to the vast increase of peace keeping operations where regular and close contact with all members of a society are commonplace.

13. Recent, concurrent peer review of TH has also illustrated the need for further research. This is evidenced by Alderson, Gadkary and Signorini (2004) as follows: Conclusions: "There is no evidence that hypothermia is beneficial in the treatment of head injury. The earlier, encouraging, trial results have not been repeated in larger trials… The effect of hypothermia on death or severe disability is unclear."

HOW IS THERAPEUTIC HYPOTHERMIA USED NOW?

TH is being trialled in many health agencies across the world. Trials include conditions ranging from anoxic brain injury due to out of hospital cardiac arrest to newborn infant ischaemic encephalopathy.

In Australia, TH is being implemented predominately in ICU wards on a small scale with what appears to be, from anecdotal evidence, a good result. TH is also being implemented in a pre-hospital setting in some regional ambulance services (Victorian rural ambulance service). This application of TH is still in trial stage of assessment and research findings are pending, however anecdotal evidence suggests that TH is having a positive impact in this stage of patient care.

Currently, research into TH and its application is small scale and varied. In many other fields of specific medical interest, research results and burdens are shared, for example the human genome project. Information gathering and skill development in regards to TH could be expedited by the formation of an international governing body to help in the tasking of research.

WHAT ARE AUSTRALIAN DEFENCE FORCE CONSIDERATIONS?

The ADF is comprised of the Royal Australian Navy (RAN), Australian Regular Army (ARA) and the Royal Australian Air Force (RAAF). As one can appreciate, the individual services have differing roles and therefore requirements. Examples of military specific requirements are identified in Table 4b.

Some considerations for each service may differ. For example, the ARA may require the equipment to be light and man portable where as this may not be so high on the priority list of the RAN. After an agreed protocol and equipment has been developed, individual personnel from their respective services would have to conduct formal feasibility studies with focus on equipment development and simple, easily taught protocols.

This investigation may result in one service being able to implement and use whereas another may find that TH is unworkable. It would be prudent to ensure that all three services medical personnel are trained in equipment and protocols for TH without regard to individual service TH policy as the three services are working closer together in

Australia's Tri-Service Defence environment. An example may be that a RAN sailor may be evacuated by RAN personnel to an ARA Medical Officer via helicopter from a ship to a level three health facility (definitions of medical support levels are identified in table 4a), and then by a RAAF Patient transfer flight by RAAF Aviation Medics back to a level 4 health facility in a short period of time. Given that studies show TH needs to be maintained, confusion could arise during patient handover from inadequacies in training and therefore a reduction in patient care.

A workable solution for this foreseeable training deficit would be to extend the Rotary Wing Aeromedical Evacuation Course (RWAME). This is a tri-service course and would allow for information and skills transfer between the three services. The nature of the tasks involved in RWAME implies that personnel may arrive early on a casualty scene and be able to transport the necessary equipment with relative ease. This approach is consistent with the recommendations made in all of the reviewed literature that indicated the early implementation of TH is advantageous for the patient.

A breakdown of selected, specific issues faced by each service is as follows:

a. Australian Regular Army: Due to the changing face of warfare over the last 30 years, it could be expected that the burden of extra equipment could hamper the Medic further in an infantry and mounted setting (level one and two health facilities). It could be envisaged that the earliest implementation of TH would be at a level three health facility due to weight and transportability of equipment.

b. Royal Australian Air Force: The RAAF could, possibly utilise TH quite effectively given the transport capability and capacity. It could be envisaged that TH could be utilized and maintained at nearly every level of health facility provided by the RAAF.

c. Royal Australian Navy: TH could be used by the RAN; however a review into specific ships and boats would be required due to storage space and experience of personnel posted to specific ships. It is possible that TH could be implemented and maintained at most levels of health facility provided.

Table 4a. *Levels of Australian Military Medical Support.*

- Level One – immediate first aid
- Level Two – Patient sorting, Limited Resuscitation, Limited patient holding
- Level Three – First Formal Surgery, patient holding, Medical officer available
- Level Four – Specialised surgery, Rehabilitation. Normally highest level of health care in an Area of operations
- Level Five – Highest level of care, research capability, located in Australia

Table 4b. *Military Specific Considerations.*

- Portability
- Weight
- Durability/robustness
- Ease of training and use
- Cost
- Logistic infrastructure required
- Size
- Noise, Thermal, Infra-red, radiation, acoustic signature
- Servicing intervals and requirements
- Helicopter, vehicle transportability and

interoperability
- Other uses
- Setup and pack down times
- Personnel required for use

The efficacy and value of TH in the recovery of hypoxic patients in the ADF is also questioned by one of the fields leading research medical officers, Mr. Stephen Bernard, MD: "There would be very little role for hypothermia in the Defence forces. The staff would be at very low risk for sudden cardiac arrest of cardiac cause. I would imagine that cases of near drowning are also very rare... You may also be interested to know that the US Army is funding research into resuscitation from traumatic cardiac arrest using deep hypothermia, but this is all at an animal stage." - Original Message sent by: Stephen Bernard on 19/08/05 18:11:08, original sent to: Ky Wittich.

WHAT FUTURE DEVELOPMENTS ARE BEING INVESTIGATED?

If the current trend of advancement in the field of TH continues, it is probable that the technology to induce hypothermia will improve greatly. Methods to cool more expeditiously, such as:

a. The development of novel coolant fluids
b. Use of cold IV fluids
c. Cooling catheters will make therapeutic hypothermia more accessible to physicians and hospitals developing cooling protocols.

Ticherman and Samuel (2004) have initiated an interesting and novel approach to alternatives for TH: "The majority of soldiers killed in action in Vietnam without brain trauma had penetrating truncal injuries. They exsanguinated internally within a few minutes. Such casualties are still considered unresuscitable, although many have technically repairable injuries on autopsy. In 1984, Bellamy, a U.S. Army Surgeon and Safar met and pondered recent military casualty data and agreed a novel approach was necessary (i.e., suspended animation)".

The above quote represents an exciting scope for future development. A suggested method for the induction of suspended animation includes the use of TH. Perhaps, TH would be rendered "old hat" if suspended animation could be achieved with few extra procedures?

Conclusion and Recommendations:

Given the contradictory and incomplete research both in the methodology of TH and equipment, TH is not currently a treatment that can be implemented reliably in the ADF at this early stage of development. Much research needs to be done before a feasibility study can be completed. This research would need to focus on the following:

a. How to optimally cool a patient?
b. When to cool a patient?
c. How long to cool a patient?
d. How to re-warm a patient?

It also remains an open question by what mechanism hypothermia improves outcomes after pronounced hypoxia or otherwise. An understanding of the mechanism could, ultimately lead to the development of more effective equipment and protocols in a pre-hospital environment.

Information and skills transfer could be expedited if an international body was formed to delegate and guide research aims so as to eliminate researchers working independently and in relative academic solitude.

Comprehensive protocols will need to be researched and developed. These will be of most use if paediatrics, geriatrics and pregnant women are included as considerations.

Detrimental side effects of TH will also need to be researched more thoroughly. Evidence regarding the incidence of post TH pneumonia is contradictory and as such should be investigated more thoroughly.

Drug metabolism in hypothermic patients is still an unknown and controversial area. Research needs to be conducted in this area as this would have positive benefits for existing hypothermia and hyperthermia protocols.

The ADF lacks the bulk of numbers that other Allied Defence bodies have. Participation or at least active liaison with Allied Defence Agencies would be of great benefit. This liaison could lead more ADF relevant research into TH following traumatic cardiac arrest and hypoxia.

It is foreseeable that TH could be applied in the ADF in the near future. To eliminate confusion between inter-service patient handover, it would be most prudent to conduct TH training during the RWAME course. As this course is tri-service and all ranks can participate; this would enable the widest possible dissemination of skills and information.

Once the methodology, equipment and protocols have been researched and implemented by our civilian counterparts, only then can it be determined if TH will have a role in the recovery in hypoxic patients in the ADF.

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