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A CRITICAL REVIEW OF PUBLISHED RESEARCH RELATING TO AN AREA OF MY NURSING PRACTICE

QUESTION:

Is suitable survival training and equipment being provided to Royal Australian Air Force Rotary Wing Aeromedical Evacuation personnel?

KEY WORDS:

Helicopter, Egress, Hypothermia.

SECURITY NOTICE:

INTRODUCTION:

Due to the often-extreme flight parameters that military Rotary Wing Aeromedical Evacuation (RWAME) crews and their casualties are exposed to, RWAME in the military environment takes on a vastly more hazardous nature than that which is generally accepted within the peacetime civilian environment.

Reasons include the requirement for military AME / SAR to be able to turn out within 15 minutes, 24 hours a day in any weather, the extreme nature of the regional topography and sometimes limited local knowledge of the area of operations (AO). Include weather extremes such as low cloud base and perhaps non-existent communications with other aircraft and air traffic control (if available), and you have hazardous flight tasking.

Other factors include the risk of airframe malfunction or crew error, especially when utilizing night vision goggles, (which leave the operator with greatly diminished depth and colour perception). Crew also accept that a secondary SAR mission to recover the primary team in the event of a forced landing.may be many hours away due to airframe availability, flight distance or communications failures at the flight tracking level. This could have tragic consequences for both the RWAME crew and casualty (s), especially should an over water ditching occur.

THE PROBLEM DEFINED:

As at the time of this writing, initial RWAME training for Australian Defence Force (ADF) medical personnel is provided by the RAAFs' Operational Health Support And Training Flight (OHS & TF) based at RAAF Richmond NSW, with rotary wing assets provided by the Army at Oakey NSW.

Education and practical training in the field of Survival Training is not provided as part of the syllabus of this five day course, which for RAAF personnel is undertaken following the extensive 6 week fixed wing AME course, how ever this is by no means adhered to. Effectively, this creates a situation where many RWAME qualified personnel are currently being employed on AME / SAR duties with little or no understanding of the basic principles of survival following an aircraft accident, and no training in the use of survival equipment and techniques available within the ADF system to aircrew.

This presents potentially dire consequences to AME crew and any casualty who may be involved in an aircraft incident, especially over water.

For this literature review, I chose to focus on the relationship between Helicopter Underwater Escape Training (HUET) and the time required to exit an inverted helo.

My aim was to identify a requirement for compulsory HUET training and recertification, and issue of a Helicopter Emergency Egress Device (HEED) to all AME personnel, regardless of crew position, when operating over water. My intent was to identify that by providing an increased breath hold time within the airframe, an increase in crew and ultimately, patient survivability in the all too realistic scenario of ditching may be achieved.

My concern that lead to choosing this topic was that AME personnel were operating in situations where the individual was ill equipped and trained to cope with a forced landing over water, which in turn would impact negatively on the chances of survival of both themselves and their casualty. I was convinced that the time taken for an unassisted member of crew to exit the sinking airframe was generally longer than the average Maximum Breath Hold Time (BHT_{MAX}) of the aircrew, and certainly the patient. This is compounded by variables within the ditching scenario, i.e.:

a. Was a controlled let down into water or an uncontrolled impact experienced?

b. Did the crew have time to prepare the patient and cabin for the impact?

c. Is there any relatives or observers on the flight, who may have no experience of how to behave in such a situation?

d. Did the ditching take place at night, with the compounding effect of spatial disorientation due to lack of lighting?

e. Was the temperature of the water such that it would initiate a ‘Cold Water Shock’ syndrome in all the crew and casualty, thus dramatically lowering BHT_{MAX} to its lowest point, making escape for the crew, and casualty greatly more difficult from the cabin area?

An average survivor in water with a temperature of 21.0 – 15.0 degrees C has a life expectancy of around 12 hours only, if not fitted with an exposure suite [1]. (Moderately lower to the mean water temperature in the AO encountered around East Timor.)

Cold Water Shock is the term used for the physiological responses of the human body to a sudden immersion in cold water, and includes tachycardia, hypertension, an inspiratory ‘gasp’ response and uncontrollable hyperventilation [2]. These responses severely limit BHT_{MAX} with out the use of an external air supply. There is a direct correlation between cold-water immersion and O^2 consumption rates, to the detriment of the exposed survivor with oxygen consumption increasing in relation to the decrease in water temperature [3].

My search for relevant literature on the topic of helicopter ditching survivability was restricted due to my undertaking this review whilst deployed to East Timor with the United Nations Peace Keeping Force. I was unable to visit any library to undertake searches on their database myself.

I had access to the Internet and also the assistance of the School of Aviation Medicine (AvMed), based at RAAF Edinburgh, South Australia. AvMed identified three original research articles to me that formed the basis of my reviews. These articles came from research papers, published in The Journal of Aviation, Space and Environmental Medicine (JASEM), with a retrospective database search of 10 years for all searches.

The **Key Words** that I used for the article search were Helicopter, Egress and Hypothermia.

I chose these terms as they provided a correlation, between a decrease in BHT_{MAX} and water temperature following a helicopter ditching.
The following search engines were used: Medline, Meta Crawler, Alta Vista, Yahoo and Infotrieve. I was disappointed with the results that I received from most of these search engines, especially in the amount of medical research items that they returned.

I did not feel that I would benefit from altering my key words used in the search, more so that the search engines I was using, (apart from Medline and Infotrieve) were more mainstream than I could use. I suspect their databases did not have access into the type of information I required, however I did identify useful information from HUET providers, survival companies and information from the United States Army and Coast Guard.

While I did find six articles of potential relevance on Medline, there were no abstracts to prove their usefulness. I ran a search of the University of South Australia (UniSA) library

database via their external student portal, but this was fruitless using the key words. Perhaps this was due to the area of nursing practice that I was researching (Aviation Nursing) being too specialised for the university library-nursing database. Perhaps the dearth of research papers that I retrieved proves that there has been little recent published research into helicopter egress.
Finally, I tried to access the CINAHL database via the UniSA library external student portal, but was unable to navigate my way through the site, even after discussion with my Course Co-ordinator, Mr. Tom Laws. (I suggest that this was a fault on my behalf due to a lack of familiarity with the UniSA web sites, which I will address.)

THE PAPERS:

I chose to review the first three of four published papers identified from JASEM, comprising the following titles:

a. Tipton MJ, Balmi PJ, Brahman E, Maddern TA. 'A Simple Emergency Underwater Breathing Aid for Helicopter Escape'. Journal of Aviation, Space and Environmental Medicine, March 1995, 206 – 209.

b. Tipton MJ, Franks CM, Sage BA, Redman PJ. 'An Examination of Two Emergency Breathing Aids for Use During Helicopter Underwater Escapes'. Journal of Aviation, Space and Environmental Medicine., October 1997, 907 – 914.

c. Brooks CJ, Muir HC, Gibbs PNG. 'The Basis for the Development of a Fuselage Evacuation Time for a Ditched Helicopter'. Journal of Aviation, Space and Environmental Medicine, Vol. 72 No 6 June 2001 553 – 561.

d. Chung SS, D'Eon NJ, Brooks CJ, 'Breath holding Ability of Offshore Workers Inadequate to Ensure Escape From Ditched Helicopters", Journal of Aviation, Space and Environmental Medicine, Vol. 72 No 10 Oct 2001 912 – 918. (Abstract only) Medportal.com via the 'Infotrieve' Search engine.

THE WEB DOCUMENTS:

I found many items of general interest, and differing levels of *source* and *focus* on the Internet. These included advertising with short explanations on why someone involved in aviation should partake of the services being offered, a brief on the importance of correct survival equipment / clothing from a pilot who experienced a controlled ditching, to Standard Operating Procedures for organisations including the United States Army, and US Coast Guard flying squadrons.

I briefly read all items of interest, noting relevance and the key words, as well as source before printing out those that were of the most pertinence and within my ten year document age criteria.

The Web based documents are comprised of the following:

a. US Army, 'Standard Operating Procedures for Overwater Operations', Appendix E, http://www.adtdl.army.mil/cgi-bin/atdl.dll/fm1-564/AE.HTM

b. Air and Surface Transport Nurses Association, Standards For Critical Care and Specialty Ground Transport, 'Cold Injuries', Google Search Engine, http://www.astna.org/hypothermia-ce/hypothermia-ce.html

c. Department of the Army Field Manual, US Army Survival Manual, 'Exposure', Aug 96,Yahoo Search Engine, http://www.aircav.com/survival/asurtoc.html

d. Hawley J, Equipped to Survive, 'Ditching Experience' Sept 1997, http://www.equiped.com/1997ditch.htm

e. Star Safety, 'Water Survival', http://starsafety.com/courses/water.htm

f. Newman R, Equipped to Survive, 'Ditching Bibliography', http://www.eqiped.com/ditchbib.htm

The item located at 'sub para f' was of interest, as it contains over 90 documents relevant to my search criteria, albeit with a refinement of the key words to be used. The documents and papers range in date of publishing from 1990 to 1964. This would explain the minimal research papers that I had found within my 10 year search criteria, and also highlights a probable lack of published papers related to work in this area from the mid 90^{s} back to 1990. It also failed to recognise the research done since 1995 so may be in need of updating.

The above items from the Web complimented the formal papers that I had located. They all reinforce my original supposition, that specific training for overwater helicopter operations must be given and regularly practiced, as well as highlight the negative effect that cold water immersion has on the survivor once the aircraft has come to a stop. While these documents are not formal research papers, I am satisfied that the authors and companies are all very well versed in aircraft operations and survival training, equipment, and have relevant understanding of the physiological effects of cold water immersion on the survivor.

CRITIQUING THE DOCUMENTS:

In his paper titled 'A Simple Emergency Underwater Breathing Aid For Helicopter Escape' dated March 1995, Tipton et al measured subjects resting and exercise BHT_{MAX} while simulating ditching stressors, by rotating the test rig 180 degrees, as would generally occur in a helicopter. They highlighted the 'average' times returned, with some subjects returning a greatly reduced BHT_{MAX}, down to six seconds. This clearly indicated there was not enough time to leave a cramped, distorted airframe, especially with other stressors included.

Tipton et al made the following conclusions.

a. The BHT_{MAX} of his research subjects comprising eight male subjects with no relevant previous diving or HUET experience was insufficient to clear the airframe without the use of an Emergency Underwater Breathing Apparatus (EUBA).

b. There is a direct correlation between water temperature and BHT_{MAX}, as demonstrated by the results of his immersing subjects in water with a temp of 25 deg C and 10 deg C, with a corresponding mean BHT_{MAX} of 30 seconds and 17.2 seconds respectively.

c. With the use of a simple EUBA, the BHT_{MAX} of the research subjects was increased to up to 60 seconds in cold water, without introducing any additional dangers from use of the equipment.

After reviewing this paper, I cannot fault the conduct of the research within the confines that Tipton et al proposed. Indeed, by limiting the diving and HUET experience that his subjects had, and including real world fitness levels, he seems to have a true representation of his target group, gaining relevant findings. They also identified their next research proposition, to simulate a more realistic helicopter ditching, with more thorough measurement of the physiological and behavioral responses of the research subjects.

The second original paper was again by Tipton MJ et al, and was titled,

'An Examination of Two Emergency Breathing Aids for Use During Helicopter Underwater Escapes', dated October 1997.

Within this paper, the researchers went on to expand on their previous paper on BHT_{MAX} and Helo egress, by improving the reality of the test rig used. They utilised a ' Shallow Water Egress Trainer', complete with helicopter window mock-ups and seating, capable of inversion. To simulate escape along the cabin of the aircraft, they had the subjects haul

them selves along a horizontal ladder at 1.25 meters below the surface. This added another dimension to the stress and O^2 utilasiation experienced by the subjects.
Water temps were 15 and 5 Deg C and aimed directly at Helo operations in colder climates, specifically the North Sea oil industry. Research funding was provided in part by Shell and ESSO Petroleum.

They also looked into the benefits of two differing types of EUBA, the Air Packet (AP), essentially a bag, which the survivor exhales into and rebreaths expired air to claim any unspent O^2. The other system was the 'Helicopter Emergency Egress Device' (HEED), a mini SCUBA bottle with a fixed mouthpiece that attaches to the persons survival vest.
They assessed that the HEED system was the more useful and offered an increase of BHTMAX by 60 seconds. It was easier to use, as assessed by clinical observation, quantitative research methods and subjective data reports.
The authors went on to identify that irrelevant of which EUBA was utilised, "In water training, preferably including exposure to cold water will significantly improve the individuals ability to use the device"[4].

One area where the researchers deviated from their previous study was in the use of a young and fit test group. They do not state why, but I suggest that it was due to the extreme cold water that subjects were exposed to. Even with the fit test group, five of the eight test subjects withdrew from the research, three due to intolerance of the water temperatures Vs task required to be undertaken. I suggest that if this artificial group had problems tolerating the exposure and maintaining a usable BHTMAX, then, a decrease in BHTMAX of an untrained group of AME personnel should be expected.

I strongly support the findings and research methodology as conducted by Tipton et al within this paper. It reinforces and builds on their previous research in this area, while highlighting the benefits of the HEED system and identifying its associated training, cost and maintenance requirements [5].

Paper number three comprised original research by Brooks CJ et al and is titled:

'The Basis for Development of a Fuselage Evacuation Time for a Ditched Helicopter', dated June 2001.

Brooks et al explored the relationship between aircraft design used by military and civilian operators, and the BHTMAX required to actually exit a well mocked up test rig, when inverted, in both day and night situations. (Rescue divers in the pool activated low-level pool lighting after 15 seconds so as to provide visual supervision of the test subjects.)

The temperature of the water was at 24 Deg C and all research subjects were either Royal Navy Clearance Divers or HUET instructors. While this may represent an artificial

experience base, I believe that due to the extreme nature of the research being carried out that to use lesser-qualified subjects would have courted disaster.
The test rig was configured to Super Puma specifications with seating for 18, and 18 personnel, three being female, immersed in the test rig each session. While submerged, all had to exit the aircraft via normal escape routes, while exploring their BHT_{MAX}. All subjects had issued to them a HEED in which to resort when required.

Within this highly experienced group of subjects, the minimum number of people using the HEED on each test was four personnel out of 18, with a maximum of 11 subjects in one test [6]. BHT_{MAX} for the last subject to clear the water was between 28 and 90 seconds, depending on conditions (i.e., lighting, orderly conduct of the group and increasing familiarity of the task to be undertaken).

Subjective data from this group highlighted difficulty-getting use to holding breath while inverted. A minimum of two subjects became panicky as they thought the people in front of them had blocked the exits. Some quoted an uncertainty in direction to surface due to the rapidity of the inversion in night conditions.

A total of 132 immersed subject evaluations were undertaken in this series of evaluations. Indeed, more were planned but the commercial test rig hoist could not cope with the weight of the eighteen test subjects and HUET configuration. The design parameters of this research included time taken to exit a submerged helo, maximum amount of test subjects routinely in the cabin, and conditions of egress undertaken, i.e. in normal and low light conditions.

Again, I consider this series of assessments well documented and well planned (except for hoist capabilities), and the informed subjective results from the highly experienced subjects of great value, especially when applied to a regular group of passengers. When related to my own area of interest, the airframe used was of the type that I routinely work in, and the water temperature of 25 Deg c was around that of my current AO.

The finding of Brooks et al further reinforce the previous two papers, in as much as BHT_{MAX} is generally insufficient to allow all passengers and crew to exit a submerged helicopter cabin. This is especially so if several people are involved, in low light situations without HEED provision.

The limitations of this study were that it is impossible to identify every negative occurrence that may impact on the egress time of survivors, as these may include panicking passengers, airframe damage, smoke or fire, colder water conditions, as well as sea state.

Importantly, Brooks et al suggest that future design of Helos' in relation to evacuation times when submerged must be addressed [7]. They identify that all aircraft have design parameters incorporated for the maximum escape time for the number of passengers they are licenced to carry when on land, but not when in water. They also identify the requirement of commercial and military pressurised aircraft to carry oxygen generators in case of a rapid decompression, why not then helos in cases of ditching?

CONCLUSIONS:

All three of the above papers utilised similar research methodologies, which included:

a. Measurement of BHT_{MAX} on land, and submerged BHT_{MAX} relevant to the water temperatures experienced and;

b. Quantitative research techniques of data recording and processing, as well as subjective data recording from test subjects, including ease of any supplementary air supply device used, and stress levels involved with undertaking the tasks required.

The complexities of the research undertaken seem to have logically built on the research carried out by the preceding authors. All established that the average person would have difficulty exiting a sinking airframe, and concluded that multiple survivors exiting an airframe would almost certainly experience a degree of death by drowning without supplemental air supplies and redesign of emergency exits.

All authors proved the relationship between water temperature and its negative effects on BHT_{MAX}, and highlighted the need for some form of HEED when operating over water. Also, the supplementary Web based documents that I reviewed reinforced the need for HUET experience for all personnel who routinely travel over water in helicopters, and identify the need for a HEED system when doing so.

IMPLICATIONS FOR MY FLIGHTNURSING PRACTICE:

The research papers and Web documents reinforce that there is a HUET requirement for all members of RAAF RWAME prior to becoming qualified. There should also be training and equipping with a HEEDs' system as per Army and Navy helo water operations, and survival training to allow crew to at least experience the minimal stressors involved in water borne helicopter egress with relevant cold water exposure.

The defence logistics system has the capability to equip and maintain the relevant hardware once allocated to the AME team members, as all rotary wing squadrons carry the required HEEDs' as a matter of course within their relevant life support maintenance section.

Revision must be directed to the syllabus of the RWAME course provided by OHS & TF, taking into account the extra training time, personnel and financial requirements needed to provide an introductory HUET and HEEDs training. This need should be impressed on the Training Command hierarchy so that its importance may be understood, and the cause taken up by senior members of the RAAF medical and nursing categories if it is to get beyond discussion.

Provision of the HEEDs' for the casualty should be explored, so as to improve the potential BHT_{MAX} of the casualty as required, and should be integrated in basic RWAME HEED training.

Through training in HUET and provision of HEEDs', the AME team member would be greater equipped to deal with a ditching scenario, both physically and mentally via an increase in BHT_{MAX} and capability. This may allow more time to escape the airframe, and where possible assist the casualty from their stretcher after impact, providing egress from the sinking craft and an alternate air supply to the casualty. In doing so, we will at least be able to enter the next step of the survival scenario, and provide a greater level of safety to the casualty.

Endnotes:

1. Water Temp Vs Survival Times, WWW.aircav.com/survival/asurtoc.html fig 16.7

2. Tipton MJ, The Initial response to Cold Water Immersion, Clin Sci 1989 77 581 – 588

3. Ibid.

4. Tipton MJ, Franks CM, Sage BA, Redman PJ. An Examination of Two Emergency Breathing Aids for use During Helicopter Underwater Escapes. J. Aviat, Space and Environ Med. 1997; 66: 914

5. Tipton MJ, Balmi PJ, Bramhan E, Maddern TA, Elliot DP. A Simple Emergency Underwater Breathing Aid For Helicopter Escape. J. Aviat, Space and Environ Med. 1995; 66: 210

6. Brooks MJ, Muir MA, Gibbs PN. The Basis for the Development of a Fuselage Evacuation Time for a Ditched Helicopter. J. Aviat, Space and Environ Med. 2001; 72: 561

7. Brooks MJ, Muir MA, Gibbs PN. The Basis for the Development of a Fuselage Evacuation Time for a Ditched Helicopter. J. Aviat, Space and Environ Med. 2001; 72: 560

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