A PROPOSED DECISION-MAKING GUIDE FOR THE SEARCH, RESCUE AND RESUSCITATION OF SUBMERSION (HEAD UNDER) VICTIMS

Final Report

Professor Mike Tipton & Dr Frank Golden

Department of Sport and Exercise Science, University of Portsmouth, UK

FEBRUARY 2011

ABSTRACT

There is some confusion, and consequent variation in policy, between the agencies responsible for the search, rescue and resuscitation of submersion victims regarding the likelihood of survival following a period of submersion. The aim of this work was to recommend a decision-making guide for such victims. This guidance was arrived at by a review of the relevant literature and specific case studies, and a "consensus" meeting on the topic. The factors found to be important for determining the possibility of prolonged survival underwater were: water temperature; salinity of water; duration of submersion; and age of the victim. Of these, only water temperature and duration are sufficiently clear to form the basis of guidance in this area. It is concluded that if water temperature is warmer than 6°C, survival/resuscitation is extremely unlikely if submerged longer than 30 minutes. If water temperature is 6°C or below, survival/resuscitation is extremely unlikely if submerged longer than 90 minutes.

INTRODUCTON

In the UK and many other countries, immersion-related deaths remain one of the major causes of accidental death and the third most common cause of death in children. Amongst the more difficult decisions required of medics, paramedics and others involved in search and rescue is when to downgrade the search for a submerged individual from "rescue" to "body recovery". This decision involves consideration of the chance of saving a life against the continued risk to those conducting the search; it is made more difficult by knowledge of what seem unbelievable cases of survival with full recovery after many minutes of submersion. For example, whilst the prognostic indicators of a poor outcome following submersion include a period underwater of longer than five minutes[1], the current record for submersion without sequelae is 66 minutes[2]. It is not surprising that this variation engenders a degree of confusion, and consequent variation in policy, in those trying to address the question of how long should a search for a submerged individual continue before successful resuscitation becomes extremely unlikely.

In response to questions from different rescue services, we have endeavoured to propose a decision-making guide for the search, rescue and resuscitation of submerged (head under) victims. To do this we followed a route we have used successfully in the past of reviewing and analysing the relevant literature, meeting with relevant experts and search and rescue agencies and offering proposed guidance for peer review (the contents of this report have been accepted for publication in the journal "Resuscitation").

METHODS

For the purposes of this project we defined submersion as "the complete immersion of an individual, including the airways" and "protracted period of submersion" as submersion for longer than four minutes. In order to formulate the guidance we reviewed current guidelines and practice, as well as the relevant literature, including case studies and media reports. We also held a meeting of relevant agencies and subject-area experts.

a. Review of Current guidelines

We approached members of the International Task Force on the Prevention of Open Water Drowning to ask for details of any guidelines that they were aware of that dealt with the action to be taken during and immediately following a prolonged submersion. We supplemented this with a literature review (University of Portsmouth library, Royal Society of Medicine library, Medline, PubMed, Google Scholar) of relevant international guidelines covering this specific scenario.

b. “Consensus” Meeting

We held a meeting in July 2010 at the University of Portsmouth on the topic of prolonged underwater survival. This was attended by over 50 policy-makers, clinical leads and paramedics from a wide range of organisations involved in the search, rescue and resuscitation of immersion victims. Those attending included: the Ambulance Service; British Cave Rescue; Coastguard SAR flight; Fire Service; Industry; Her Majesty’s Coastguard; Marine Accident Investigation Branch; Mountain rescue; National Health Service; Police Force (specialist operations); Royal Air Force Search & Rescue; Royal Lifesaving Society; Royal Yachting Association; Swift water rescue; members of UKSAR Clinical Group (UK Search and Rescue); members of Joint Royal Colleges Ambulance Liaison Committee (JRCALC); Royal National Lifeboat Institution.

The meeting included presentations on the physiology and pathophysiology of cold water immersion as well as case reports from the RNLI and Fire Service on problematic incidents associated with the rescue and resuscitation of submerged individuals. This was followed by a discussion, chaired by one of the authors, with the specific objective of arriving at a draft guideline for the search, rescue and resuscitation of submerged individuals. The discussion was open-forum, lasted two hours, during which guidance was agreed unanimously. Indeed, based on the minutes of the meeting, some of the organisations attending the meeting have adopted the guidance and it has been well received by the UKSAR medical group. At the meeting, other concerns associated with the rescue of submerged individuals were expressed by some organisations; these were recorded and are presented in brief as a footnote to Figure 2.

c. Review of the literature

Our information sources were: University of Portsmouth library, Royal Society of Medicine library, Cochrane Library, Medline, PubMed, Google Scholar, Internet-based press-cuttings and other media or news websites. We used the following search terms: underwater survival; drowning; near-drowning; prolonged immersion; cold water immersion/submersion. This resulted in the identification of many hundreds of papers, the vast majority of which did not deal with prolonged submersion (more than four minutes) or have a good outcome (near normal/normal neurological and other functionality). In reviewing the literature the International Liaison Committee on Resuscitation (ILCOR) advisory statements[3] on evidence evaluation were followed as far as was practicable given the nature of the topic: we were not interested in assessing a new medical intervention, simply the outcome of a submersion incident. Relevant case studies, if published, were reviewed and any studies referenced in these papers were obtained and also reviewed. We were left with the papers reported in Table 1.

We were also interested in the age of the casualty, salinity of water and deep body temperature as close as possible to the period of submersion. Whilst more information was available in most of the papers reviewed, for example on treatment regimes; in order to achieve the objective of the present work, as well as for clarity and brevity, the information presented has been confined to the nature of the incident and the outcome. Most of those writing case studies of prolonged survival underwater are primarily interested in treatment, and often do not have exact details of submersion time, water type and so on. Thus, not all of the papers reviewed contained all of the information we were looking for. Therefore, in some cases the data presented are incomplete; this is because this information was not always provided in the original reference. This represents a limitation of the present study; a further limitation is the fact that we have no way of knowing how many cases we have failed to identify.

In general, we assess the case studies (level of evidence P4 "Case series"[3]) reviewed and presented (all but two of the cases) as being of "good" quality. These are identified in Table 1 by reference. The two media-reported cases (BBC and UK Daily Telegraph) had not been peer-reviewed and are regarded as of "fair" quality or, more appropriately for this study, reliability. Again, these cases are identified in Table 1.

RESULTS

a. Review of Current guidelines

We concluded that few formal guidelines exist in this area. From those that we contacted we learned that in the United States (C. Brewster, US Lifesaving Association), the standard practice for search and rescue of victims who have been submerged under water of a temperature "normally used for swimming", is to continue an emergency search for one hour. During this period if the victim is recovered, resuscitation procedures are normally attempted. After one hour the emergency portion of the search is typically terminated, although efforts to find the body of the victim may be continued. In Brazil (Dr D. Szpilman) it has been a recommendation since 1992 that "rescue and resuscitation" changes to "body recovery" after one hour. Szpilman[4] reports that the Rio de Janeiro Drowning Resuscitation Centre protocol for drowning resuscitations includes that CPR should always be started when time of submersion is less than one hour and when there is no obvious physical evidence of death. Of 114 resuscitations undertaken in the Centre between 1998-2002, 18 victims were resuscitated with a submersion time of more than ten minutes; of these, two were without sequelae, five survived with severe neurological sequelae and 11 died within 24 hours. In the UK, the guidelines of the Joint Royal Colleges Ambulance Liaison Committee (JRCALC, Clinical Notice 16/09) on "The Drowning, Immersion or Submersion Incident" (24th August 2009) state that on-scene resuscitation may be withheld or stopped by the senior clinician present if the patient is confirmed as having been submerged for more than 90 minutes. This is an extension of section 3.3 of the Resuscitation and Recognition of Life Extinct Policy.

b. Review of the literature

The result of our search for, and review of, relevant case studies is presented in Table 1. The cases requiring special consideration in terms of producing an evidence-base for any guidance are presented in italics. Of the 43 individual cases, all gave the age of the casualty. It could be confirmed that submersion occurred and there was an estimation of submersion time in 40 cases. 17 cases stated whether the submersion was in fresh, brackish or salt water (although geographical location allowed the conclusion that nearly all of the cases were in fresh water), indeed, only one case was reported to have occurred in salt water. Of the 43 individual cases, 29 (67%) involved children 12 years old or younger. In 37 cases deep body temperature was measured shortly after the incident or on admission to hospital; this temperature was 30°C or below in 30 cases.

Table 1. Summary of papers reviewed that report recovery following a prolonged period of accidental submersion. Extreme cases in italics and marked *.

Age of victim	Detail	Water/Air temperature	Reference
7 month old female	1991, UK. Immersed in cold bath for estimated **60 min**. Tc* 23°C on admission. Complete recovery no neurological complications	Cold bath, fresh water*	16
16 month old male	6th Feb 1973, found face down in swimming pool, Lowest Tc in pool 28°C (estimated); time submerged **20 min (estimated)**, complete recovery	Air temperature 0.6°C at 6am	17
21 month old male	Denver, US. **25 min** submersion, cardiac arrest for 30 min post-rescue, two days for neurological recovery, complete recovery	Ditch of "freezing water"	The Daily Telegraph, 11th Sept 2010
2 year old male	**25 min** submersion. Tc 32.5°C after 4 hours, complete recovery	5-7°C water	18
2 year old male	**20 min** submersion, freshwater, CPR 1 hour at scene. Tre* 26.7°C on admission, complete recovery		19
2 year old female	10th Feb 2009, London. **20 min** at the bottom of a pool, Complete recovery	Cold fresh water	Murphy (2009) BBC Website
25 month old male	**10 min** submersion, complete recovery	Swimming pool, fresh water, 4°C	20
*25 month old female**	*30 min submersion. Tc on admission 28°C. Full recovery*	*6°C water*	*21*

2.5 year old male	July 6th 1330h, found bottom of swimming pool, **5 min** submersion, mild head trauma**.** Tre <35°C on admission, complete recovery		22
*2.5 year old female**	*Salt Lake City. At least **66 min** submersion. Tre 19°C, complete recovery*	*5°C water*	*2*
3 year old female	July 2002. **20 min** of submersion. Tre 27.2°C in emergency room	Flooded river 15°C	23
3 year 10 month old male	December, found floating face-down in a backyard pool. Estimated time of submersion **12-15 min**. Tre 23°C on admission, fair to good outcome	Fresh water	24
3 year old male	**20 min** submersion. Tre 27°C on admission, survived, speech a little slow one year later, fair to good outcome		25
4 year old female	**20 min** submersion. Tc 29°C, full recovery	Ice-water	Newsweek (1984) in Orlowski[1]
4 year old female	**20 min** submersion. Tc 27.2 on admission. Full recovery.	15°C water	21
4 year old female	Mid-October. Found face-down in a pool. Estimated time of submersion was **15 minutes**. Tc 22°C on admission. One year later almost complete recovery (minor tremor of the left hand)		26
4.75yr average	Review of 55 near-drowning in children (mean age 4.75yt); 32 (58%) survived intact; 5 survived but with profound CNS damage; 18 died.	All in 'cold' water	7
5 year old male	Feb 6th 1974, Norway. **40 min** submersion. Tre on admission 24°C , complete recovery.	Ice-cold fresh water, partially frozen river	27
5 year old male	March 3rd. Submerged for approx **30 min.** Tre 27°C on admission, complete recovery	River 0-1°C fresh water; air temperature -7°C	28
5 year old male	Trondheim, March 6th 1962. **22 min immersion with a period of submersion.** Tre on admission 24°C. Almost complete recovery (loss of peripheral vision, finer finger movements clumsy)	Partially frozen river (fresh water)	29
5 year old male	Drowning victim; submersed **40 min** No signs of life on rescue, complete recovery	Very cold water	30
6 year old male	**15-20 min** submersion, Tc 21°C, complete recovery	2-3°C water	31
6 year old male	**25 min** submersion, Tc 31.8°C, complete recovery	4°C water	32
6 year old male	**15-20 min** submersion, Tc 21°C, complete recovery	2-3°C water	33
6 year old male	February 1993 Nr. Innsbruck, Austria. Fell in water, drifted away rescued 65 minutes later. Fire-fighter drowned during rescue. Tre 16.4°C when rescued. **No comment on whether the airway was submerged.** Almost complete recovery at 5 months (apart from acral polyneuropathy of all extremities)	Fresh water 2.5°C, Ta -4°C.	34
6 year old girl	Motor vehicle accident (drove off bridge) January 1987. Estimated submersion time before rescue **30 min.** T_c 25°C on admission near complete recovery	Ice-cold fresh water	35
7year old male	Face down in ice water **15 min**.On arrival in Hospital 25 min later T_c 27°C. Six months to full neurological recovery	Very cold water.	36
8 year old male	**10 min** submersion, Tre 30°C on admission, survived, some retardation one year later		25
11 year old male (age also give as 7 in the paper)	Fell through ice Red River, N. Dakota & submerged for **46 min** . T_{re} 24°C on admission, discharged from hospital 6 weeks later complete recovery	Iced water	37
12 year old boy	Motor vehicle accident (drove off bridge) January 1987. Estimated submersion time before rescue **30-60 min.** T_c 22°C on admission near complete recovery	Ice-cold fresh water	35
18 year old male	**38 min** submersion, good outcome	Ice-water	Scientific American in Orlowski[1]

*21 year old female**	*Car accident into 11m deep water,* ***45 min*** *submersion, Tre 26°C on admission, complete recovery after 15 days*	*4°C* ***salt water***	*8*
21 year old male	April 1963. Fell into water striking wharf on the way. Tidal reaches of River Yarra, Melbourne**. At least 17 min** submersion, Tre 3 hours after admission 32°C, complete recovery		38
23 year old female	Charles River, Boston. **25.5 min** submersion trapped in car, Tre 28.8°C on admission, discharged after 15 days, complete recovery apart from some amnesia	Icy fresh river water	39
27 year old quadriplegic male	Charles River, Boston, late Autumn. Drove motorised wheelchair into river. **6 min** submersion, Tre 33.4°C on admission, discharged after 7 days, complete recovery	Icy fresh river water	39
29 year old female	**20 min** submersion, Tc 28°C, full recovery	10°C water	40
*29 year old female**	*January 2000. She found an air pocket and struggled for 40 min before she fell still. It was another 40 min before her friends cut a hole in the ice and dragged her out, Tre 13.7°C on admission, complete recovery*	*Ice water,* ***but possible airway remained in air for some of the time***	*41*
31 year old male	Submerged for **45-60 min**. On admission Tc 23°C. Initial neurological complications but eventual full recovery	1°C, partially frozen fresh water	42
31 year old woman	Alaska 1:00pm. Submerged for at least **30 min**. Eight hours after submersion Tc was 31°C. Full recovery after 3 months.	"Icy fresh water"	15
33 year old male	Submerged for at least **20 min**. Tc 22°C at start of cardiopulmonary bypass. Recovery with some neuropsychological disorders.	Ice water	43
*33 year old black male**	***22 min*** *submersion, complete recovery*	*Water temperature* ***21°C****, air temperature 30°C. Brackish dark canal water*	*4*
41 year old male	April 2nd 2002 at 06:11 am, car found upside down in a canal. At 6:23 divers managed to remove man from car, Tre 22°C on arrival at hospital, complete recovery. **Not know how long car was in canal or if/how long man was submerged**	"Fresh cold water"	44
56 year old male	Submerged for at least **20 min**. Tc 24°C at start of cardiopulmonary bypass. Recovery with some neuropsychological disorders.	Ice water	43
62 year old male	**15 min** submersion, Tre 36°C on admission, outcome: discharged after 27 days minor neurologic abnormalities	2-3°C water	45

NB *"Fresh water" refers to water that is not sea (salt) water. Tc = core (deep body) temperature. Tre = rectal (deep body) temperature.

DISCUSSION

Numerous publications (e.g. Golden et al[5]) have highlighted the importance of a young age, hypothermia and short submersion time on a positive prognostic outcome in drowning cases, for example:

Orlowski[1]: child (but older than 3 years), less than five minutes submersion;

Bierens et al[6]: "young" age and less than ten minutes of submersion;

Biggart & Bohn[7]: hypothermia (Tc<33°C) is one of two factors that determine outcome in near-drowning in children (the other is the presence of a heart beat).

On the basis of the information reviewed, relevant case studies, general reviews and epidemiological studies, the major factors contributing to a successful outcome in an incident involving prolonged submersion are, if the:

- water is very cold;
- duration of submersion is short;
- victim is a child or small adult;
- submersion is into fresh water.

However, and with regard to establishing some guidance in the area, these factors do not all represent *necessary* conditions for a successful outcome. For example, whilst the vast majority of those that survive following prolonged submersion were rescued from fresh water, at least one incident has involved submersion in salt water[8] (Table 1). It is possible that this particular incident was unusual in that the young woman was trapped at a depth of 11m in a car, however the fact that this case exists means it would be unwise to limit extended searches to just fresh water and claim that people cannot survive prolonged submersion in salt water. Not all agree with this approach and the consequent necessity it introduces of conducting extended searches in salt water.

In connection with the above, a number of incidents have involved submersion in a vehicle. In such cases it is not possible to know in advance of rescue if the airway is submerged or in an air pocket within the vehicle. In such a situation rescuers should assume the latter. Such a scenario falls outside of the present guidance.

Whilst the victim is usually a child, adults have also survived prolonged submersion (Table 1), although it appears that it is usually small adults (high surface area to mass ratio). This may be of only academic interest; it will often not be possible to determine the exact age or size of an individual involved in a submersion incident. Given that adults have survived prolonged submersion it would seem prudent not to try to make a distinction between children, adults and/or small adults in any guidance on the rescue of submerged individuals.

With regard to water temperature, we have been unable to identify and substantiate any case in which an individual survived for longer than 30 minutes submerged in water warmer than 6°C. However, a child (2.5 years old) has survived submersion for up to 66 minutes in water at 5°C[2], and others have survived following prolonged submersion in water at 4-5°C (Table 1). Figure 1 shows the relationship between water temperature and submersion time for the cases that provide both of these pieces of information. There are only a few cases of survival reported following prolonged submersion in water at temperatures between 6-22°C, this is likely to be a reflection of the fact that such survival is extremely rare in water warmer than 6°C, rather than indicating that we have missed a large number of incidents in our search of the literature.

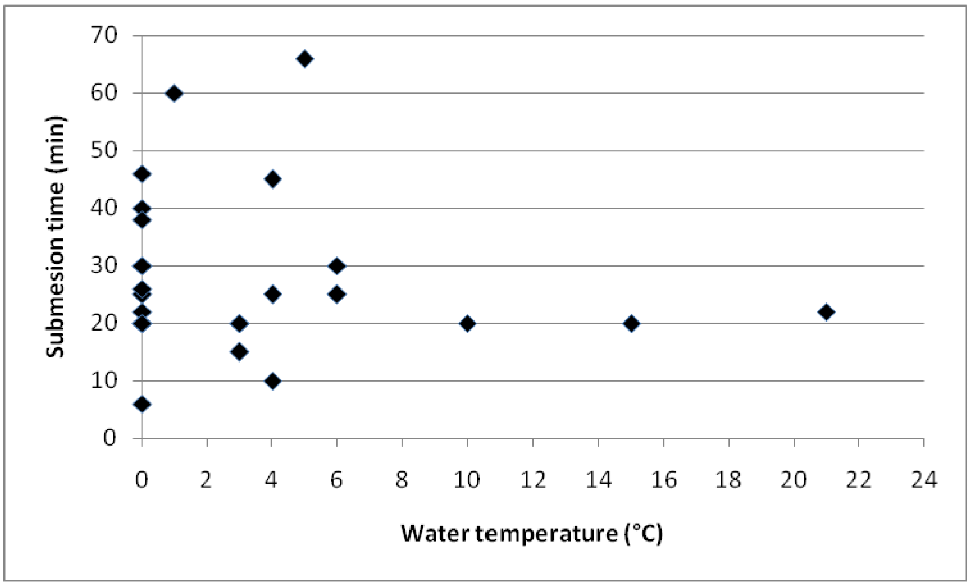

Figure 1. Relationship between water temperature and submerged survival time. Points represent individual cases (some are overlaid) in which the period of immersion was followed by full recovery (*n*=26, Table 1 excluding submersions in vehicles and incidents for which no water temperatures were stated).

Two primary mechanisms have been proposed for survival following prolonged submersion. The mammalian “diving response”[8, 9] is an oxygen conserving triad of apnoea, bradycardia and selective vasoconstriction, which is known to be stronger in children than adults[10]. Alternatively, “selective brain cooling”[5, 11, 12], involves the aspiration of very cold water, cooling of the heart and blood in the carotid artery and thereby the brain. The hypoxic survival time of the brain is then extended by hypothermia; with cerebral activity and therefore oxygen demand falling close to minimal levels at a brain temperature of 22°C[13]. Conn et al[11] have reported 7.5-8.5°C falls in the carotid arterial temperature of dogs after just 2 minutes of submersion – this is about the time respiratory and cardiac function are maintained during drowning in dogs[14]. The neuro-protective effects of hypothermia have long been recognised with three underlying mechanism being suggested as the basis of the protection: decreased metabolism; decreased cerebral oedema; and the inhibition of glutamate release[15].

In theory, selective brain cooling could occur in adults as well as children but, the fact that relatively more children survive, and following longer periods of submersion (Table 1), suggests that a second factor may be operating. It could be that the initial rapid selective brain cooling, due to the pulmonary mechanism mentioned above, allows more time for general body cooling, and this occurs more rapidly in children (and smaller adults) due to their higher surface area to mass ratio.

Of these two mechanisms (Diving response and Selective brain cooling), we believe the latter is more likely, as selective brain cooling rapidly reduces brain temperature before severe hypoxia develops. In contrast, during the initial short-term apnoea of the ‘diving reflex’, significant hypoxia, associated with continued muscle activity, will reduce cerebral hypoxic survival time before the effects of cerebral cooling start to become beneficial.

Incidentally, selective cooling of the brain has implications for those involved in rescue and resuscitation:

- Given that cooling is selective (specific) to the heart and brain, and a low brain temperature is protective during hypoxia, any deep body temperature other than brain temperature is likely to be significantly higher than brain temperature (e.g. rectal temperature) and therefore a poor prognostic indicator following short to medium term submersions.
- Even when the rescued individual is “drowned” and in cardio-respiratory arrest, they may still have a viable and therefore recoverable brain, particularly if bypass is available.

On the basis of all of the evidence presented above, the decision-making guide in Figure 2 is recommended. It is emphasised that Figure 2 is only a guide, and local circumstances and/or clinical signs may dictate an alternative course of action to the incident controller/senior medic at the scene. The guide is likely to be of more use when rescuers are themselves placed at high risk by continuing a search.

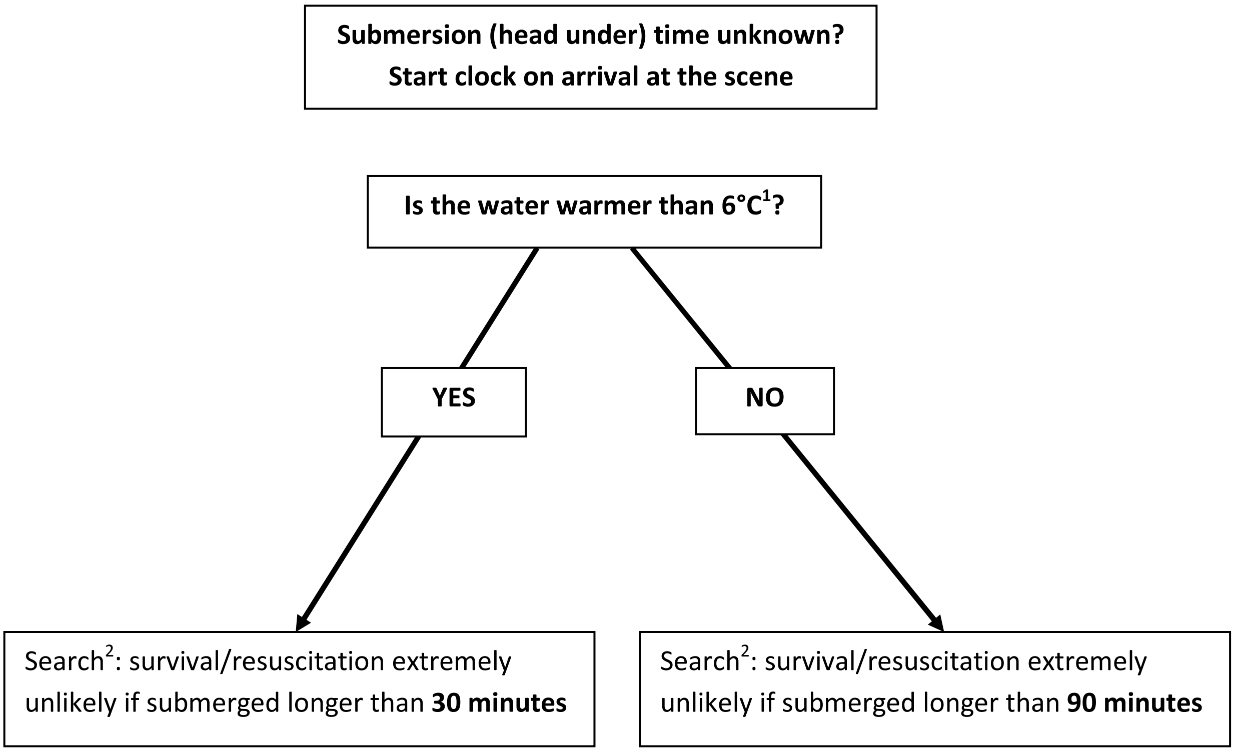

Figure 2. Decision-making guide for immersion incidents involving total (head under) submersion

[1]Water temperature outdoors in and around the UK averages about 10°C over the year but varies between about 0°-25°C, depending on location and the type of the water. UK coastal water can, on occasion, fall below 5°C and mountain streams and pools can be below 5°C for the majority of the year.

[2]Search. Factors to consider when making a risk assessment: the perennial problem facing members of the Emergency Services when confronted with the rescue of a submerged victim is whether the risk to the rescuer outweighs the probability of a successful outcome. The dilemma has increased in recent years with the publication of a number of accounts of a successful resuscitation in a minority of cases (Table 1). Given this information, rescue personnel feel obliged to continue the search for submerged individuals for a period of at least 60 min or longer, regardless of the risk to themselves; failure to do so may be adjudged as being negligent and possibly leave a sense of failure in the rescuer. Likewise, failure to continue with resuscitative efforts in these victims for several hours, regardless of the practical difficulties (and efficacy) involved in the prevailing 'field' conditions, may also be considered negligent or lacking in commitment.

In an endeavour to bring some practical sense to this complex question the following advice is offered. Open water rescue of submerged victims, clearly visible from the surface may, to the unwary, appear to be straightforward, but nevertheless requires an understanding of the risks involved. Rescues involving an underwater search require special skills and training to increase the chance both of success and reduce the threat to the life of the rescuer. Apart from a basic full understanding of the dangers of cold shock (i.e. the requirement for a period of adaptation before moving into deep water) and the impact of progressive impairment of physical activities with time in cold water[47], other factors must be considered before attempting a rescue of submerged victims, these include:

1. Have you received specialised training in cold water /underwater search & rescue?
2. Do you have adequate (or) specialised immersion protective clothing or equipment?
3. Are there adequate supporting personnel/facilities?
4. Are you competent and do you have the necessary support to undertake rescues at night or in water with poor visibility?
5. Are there potentially dangerous currents?
6. What is the distance/time to transport rescued casualty to specialised unit capable of the treatment of apparently dead hypothermic casualties (i.e. unit with capability to provide cardio-pulmonary bypass)?

ACKNOWLEDGEMENTS

Thanks to: Paul Amos, Heather Lunt, Joanne Merritt, Gemma Milligan, Dr John Stephenson, Dr David Szpilman (Brazil), Dr Chris Brewster (US), Mr Norm Farmer (Aus) and Dr Lumb for their help in producing this paper.

REFERENCES

1. Orlowski JP. Drowning, Near-Drowning, and Ice-Water Submersions. Pediatric Clinics of North America 1987; 34(1): 75-92.
2. Bolte RG, Black PG, Bowers RS, Thorne JK, Corneli HM. The use of extracorporeal rewarming in a child submerged for 66 minutes. JAMA. 1988; Jul 15 260(3): 377-9.
3. Morley PT. Evidence evaluation worksheets: The systematic reviews for the evidence evaluation process for the 2010 International Consensus
4. Szpilman D. A care report of 22-minute submersion in warm water without sequelae. In: Handbook on Drowning (Ed: Bierens JJLM), Springer, 2006: 372-4.
5. Golden FStC, Tipton MJ, Scott RC. Immersion, near-drowning and drowning. British Journal of Anaesthesia (Review paper) 1997; 79(2): 214-225.
6. Bierens JJ, van der Velde EA, van Berkel M, van Zanten JJ. Submersion in The Netherlands: prognostic indicators and results of resuscitation. Ann Emerg Med. 1990; Dec 19(12): 1390-5.
7. Biggart MJ, Bohn DJ. Effect of hypothermia and cardiac arrest on outcome of near-drowning accidents in children. J Pediatr. 1990; Aug 117(2 Pt 1): 179-83.
8. Perk L, Borger van de Burg F, Berendsen HH, Wout JW van't. Full recovery after 45 min accidental submersion (letter). Intensive Care Med 2002; 28: 524.
9. Hunt PK. Effect and treatment of the "diving reflex" Can Med Journ 1974; Dec 21 111: 1330-1.
10. Gooden BA. Why some people do not drown. Hypothermia versus the diving response. Med J Aust. 1992; Nov 2 157(9): 629-32.
11. Conn AW, Miyasaka K, Katayama M, Fujita M, Orima H, Barker G, Bohn D. A canine study of cold water drowning in fresh versus salt water. Crit Care Med. 1995; Dec 23(12): 2029-37
12. Golden, FStC. Mechanisms of body cooling in submersed victims. Editorial. Resuscitation 1997; 35: 107-109.
13. Adams RD, Victor M. Hypoxic hypotensive encephalopathy. In: Adams RD, Victor M (Eds) Principles in neurology. New York, McGraw-Hill Book Co 1977: 732-4.
14. Fainer DC, Martin CG, Ivy AC. Resuscitation of dogs from fresh water drowning. J Appl Physiol. 1951; Jan 3(7): 417-26.

15. Huckabee HCG, Craig PL, Williams JM. Near drowning in frigid water: A case study of a 31-year old woman. J of the International Neurophysiological Society 1996;2: 256-260.
16. Kemp AM & Sibert JR. Outcome in children who nearly drown: a British Isles survey. BMJ 1991; 302; 331 - 339.
17. Dominguez de Villota E, Barat G, Peral O, Juffe A, Fernandez de Miguel JM, Avello F. Recovery from profound hypothermia with cardiac arrest after immersion. Brit Med Journ 1973; 17 Nov: 394-395.
18. Imbach P, Kabus K, Tonz O. Successful treatment of a severe drowning accident after 20 minutes submersion. Schweiz med Wschr 1975; 105: 1605-1611.
19. Modell JH, Idris AH, Pineda JA, Siverstein JH. Survival after prolonged survival in freshwater in Florida. Chest 2004; 125(5): 1948-51.
20. Stotz M, Ummenhofer W. A case report of an extreme situation. In: Handbook on Drowning (Ed: Bierens JJLM), Springer, 2006: 372-4.
21. Eich C, Brauer A, Timmermann A, Schwarz S, Russo S, Neubert K, Graf B, Aleksic I. Outcome of 12 drowned children with attempted resuscitation on cardiopulmonary bypass: An analysis of variables based on the "Ustein Style for Drowning". Resuscitation 2007; 75: 42-52.
22. Montes JE, Conn AW. Near-drowning: an unusual case. Canadian Journal of Anesthesia 1980; 27(2): 172-174.
23. Eich C, Brauer A, Kettler D. Recovery of a hypothermic drowned child after resuscitation with cardiopulmonary bypass followed by prolonged extracorporeal membrane oxygenation. Resuscitation 2005; 67: 145-8.
24. Nugent SK, Rogers MC. Resuscitation and intensive care monitoring following immersion hypothermia. J Trauma 1980; Sep 20(9): 814-5.
25. Ohlsson K, Beckman M. Drowning: Reflections based on two cases. Acta Chir Scand 1964; 128: 327-339.
26. WollenekG, Honarwar N, Golej J, Marx M. Cold water submersion and cardiac arrest in treatment of severe hypothermia with cardiopulmonary bypass. Resuscitation 2002; 52: 255-263.
27. Siebke H, Rod T, Breivik H. Survival after 40 minutes submersion without cerebral sequelae. Lancet 1975; June 7 1: 1275-7.
28. Hunt PK. Effect and treatment of the diving reflex. Can Med Assoc J 1974; 111(12): 1330-1331.
29. Kvittengen TD, Naess A. Recovery from drowning in fresh water. Br Med J 1963; 1: 1315-1317.
30. Mair et al. Prognostic markers in patients in accidental hypothermia and cardiovascular arrest. Resuscitation 1994; 27: 47 – 54.

31. Klarskov P, Amter F. Hypothermia following submersion corrected by peritoneal dialysis. Ugeskr Laeg 1976; 138: 1937-1940.
32. Theilade D. The danger of fatal misjudgement in hypothermia after immersion. Anaesthesia 1977; 32: 889-892.
33. Jessen K, Hagelsten JO. Peritoneal dialysis in the treatment of profound accidental hypothermia. Aviat Space Environ Med 1978; 49(2): 426-429.
34. Antretter H, Dapunt OE, Mueller LC. Survival after prolonged hypothermia. New Eng J Med 1994; 330(3): 219.
35. Letsou et al. In (1992) Cardiopulmonary Bypass an effective treatment of hypothermic arrest due to drowning or exposure? Arch Surg 127; 525 – 528.
36. Young RS, Zalneraitis EL, Dooling EC. Neurological outcome in cold water drowning. JAMA, 12 244(11): 1233-5.
37. Norberg WJ, et al. Successful resuscitation of a cold water submersion victim with the use of cardiopulmonary bypass. Critical Care Medicine 1993; 20(9); 1355 – 1357.
38. King RB, Webster SW. A case of recovery from drowning and prolonged anoxia. Med J Aust 1964; 1: 919-920.
39. Sekar TS, MacDonnell KF, Namsirikul P, Herman RS. Survival after prolonged submersion in cold water without neurologic sequelae. Report of two cases. Arch Intern Med 1980; Jun 140(6): 775-9.
40. Genoni L, Domenigheti G. Beinahe-Ertrinken beim Erwachsenen: gunstiger Verlauf nach 20-minutiger Submersionszeit. Schweiz med Wschr 1982; 112: 867-870.
41. Gilbert M, Busund R, Skagseth A, Nilsen PA, Solbø JP. Resuscitation from accidental hypothermia of 13.7 degrees C with circulatory arrest. Lancet. 2000; Jan 29 355(9201): 375-6.
42. Waters et al. Portable Cardiopulmonary Bypass: Resuscitation from Prolonged Ice-Water Submersion and Asystole. Ann Thorac Surg 1994; 57: 1018 – 1019.
43. Samuelson H, Nekludov M, Levander M. Neuropsychological outcome following near-drowning in ice-water: two adult cases. J. Int Neuropsychol Soc 2008; 14(4): 656-659.
44. Scheffer G-J (2006) A case report of a successful resuscitation from accidental hypothermia of 22°C and submersion with cardiac arrest. In: Handbook on Drowning (Ed: Bierens JJLM), Springer 2006: 372-4.
45. Chochinov AH, Baydock BM, Bristow GK & Gesbrecht GG. Recovery of a 62-year-old man from prolonged cold water submersion. Ann Emerg Med 1998; 31: 127-31.
46. Tipton MJ, David G, Eglin CM, Golden FStC. Basic life support on small boats at sea. Resuscitation 2007; 75(2): 332-337.

47. Golden FStC, Tipton MJ. Essentials of sea survival. Human Kinetics, 2002.