

This is an Open Access document downloaded from ORCA, Cardiff University's institutional repository: <https://orca.cardiff.ac.uk/id/eprint/98335/>

This is the author's version of a work that was submitted to / accepted for publication.

Citation for final published version:

Best, Rebecca, Harris, Benjamin, Walsh, Jason and Manfield, Timothy 2020. Paediatric drowning: a standard operating procedure to aid the prehospital management of paediatric cardiac arrest resulting from submersion. *Pediatric Emergency Care* 36 (3) , pp. 143-146. 10.1097/PEC.0000000000001169

Publishers page: <http://dx.doi.org/10.1097/PEC.0000000000001169>

Please note:

Changes made as a result of publishing processes such as copy-editing, formatting and page numbers may not be reflected in this version. For the definitive version of this publication, please refer to the published source. You are advised to consult the publisher's version if you wish to cite this paper.

This version is being made available in accordance with publisher policies. See <http://orca.cf.ac.uk/policies.html> for usage policies. Copyright and moral rights for publications made available in ORCA are retained by the copyright holders.



# Paediatric Drowning: a standard operating procedure to aid the prehospital management of paediatric cardiac arrest resulting from submersion

Rebecca R. Best\*<sup>a</sup>, Benjamin H. L. Harris MBBCh<sup>b,c</sup>, Jason L. Walsh MBBCh<sup>b,d</sup>, Timothy Manfield MBBCh<sup>e</sup>

<sup>a</sup> *Cardiff University School of Medicine, Cardiff, Wales, United Kingdom.*

<sup>b</sup> *Institute of Medicine Education, Cardiff University School of Medicine, Cardiff, Wales, United Kingdom.*

<sup>c</sup> *St Anne's College, University of Oxford, Oxford, England, United Kingdom.*

<sup>d</sup> *Department of Cardiology, St George's Hospital, Tooting, London, United Kingdom.*

<sup>e</sup> *Emergency Medical Retrieval and Transfer Service, Llanelli, Wales, United Kingdom.*

\*corresponding author

## Correspondence Information

Rebecca Best  
171 Malefant Street  
Cathays  
Cardiff  
Wales  
United Kingdom  
CF24 4QG

Telephone number: 07739456402  
Email address: BestRR@cardiff.ac.uk

## Conflicts of Interest and Source of Funding

The authors whose names are listed above certify that they have no affiliations with or involvement in any organisation or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership; employment; consultancies; stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript. No sources of funding were approached or obtained for this project, including the National Institutes for Health, Wellcome Trust and Howard Hughes Medical Institute.

## ABSTRACT

*Objectives:* Drowning is one of the leading causes of death in children. Resuscitating a child following submersion is a high-pressure situation, and standard operating procedures can reduce error. Currently, the Resuscitation Council UK guidance does not include a standard operating procedure on paediatric drowning. The objective of this project was to design a standard operating procedure to improve outcomes of drowned children.

*Methods:* A literature review on the management of paediatric drowning was conducted. Relevant publications were used to develop a standard operating procedure for management of paediatric drowning.

*Results:* A concise standard operating procedure was developed for resuscitation following paediatric submersion. Specific recommendations include: the Heimlich manoeuvre should not be used in this context; however, prolonged resuscitation and therapeutic hypothermia are recommended.

*Conclusions:* This standard operating procedure is a potentially useful adjunct to the Resuscitation Council UK guidance and should be considered for incorporation into its next iteration.

*Keywords:* Paediatrics; Drowning; Standard Operating Procedure; Checklist; Prehospital

## Introduction

Drowning is one of the leading causes of death in children and adolescents worldwide<sup>1</sup>. One of the most important positive prognostic indicators, alongside shorter submersion time and salt versus freshwater submersion, is time from rescue to receiving cardiopulmonary resuscitation<sup>2,3</sup>, making drowning an emergency in which prehospital care is paramount<sup>4</sup>. Standard operating procedures (SOPs) are checklists designed to reduce human error in high pressure and emotionally charged situations, such as when dealing with critically ill children<sup>5</sup>. SOPs have been shown to improve adherence to national guidelines and patient outcomes in a variety of prehospital emergencies<sup>6-8</sup>.

Although the Resuscitation Council UK guidelines provide guidance on managing paediatric submersion, a standard operating procedure has not been produced. In an attempt to improve outcomes of drowning in children, an SOP for prehospital use has been created based on Resuscitation Council UK guidance and critical appraisal of available evidence.

## Methods

The basic outline of the SOP was created using the Resuscitation Council UK guidelines for prehospital resuscitation<sup>9</sup> and paediatric advanced life support<sup>10</sup>, both of which are accredited by the National Institute for Health and Care Excellence (NICE). A literature review of publications related to paediatric drowning was conducted. Relevant literature included commentaries, recommendations, guidelines, case reports, systematic reviews, literature reviews and books. The databases searched included: PubMed, Google Scholar, MEDLINE and Cochrane Library. The search terms used included a combination of “paediatric” or “child” / “drowning” or “submersion” / “prehospital” / “resuscitation” / “basic life support” or “advanced life support” / “cardiac arrest”. Ethical approval was not required for this project.

Each of the suggestions made in publications outside of the Resuscitation Council UK guidelines then triggered a further literature search and critical analysis. The types of literature and databases searched were the same as the preliminary literature review. The search terms used included those already stated as well as “intubation” / “Heimlich manoeuvre” / “therapeutic hypotension” or “induced hypotension” / “parents” or “guardians” or “family” / “prolonged resuscitation”. The additional components focussed on, and later implemented into the SOP comprised:

- Recommendations for intubation
- Use of the Heimlich manoeuvre
- Cardiopulmonary resuscitation – ABC (Airway, Breathing, Chest compressions) versus CAB approach (Chest compressions, Airway, Breathing)
- Resuscitation time
- Therapeutic hypothermia and rewarming
- Parents and carers at the scene

## Results

The resulting SOP (Figure 1) should be used in the specific situation where a patient aged between one and eighteen years has been retrieved from a body of water following submersion and is not responding to verbal or tactile stimuli at the time of arrival on the scene. It should be used by a team of four qualified medical professionals. Each of the four team members should be allocated a specific role before the resuscitation attempt:

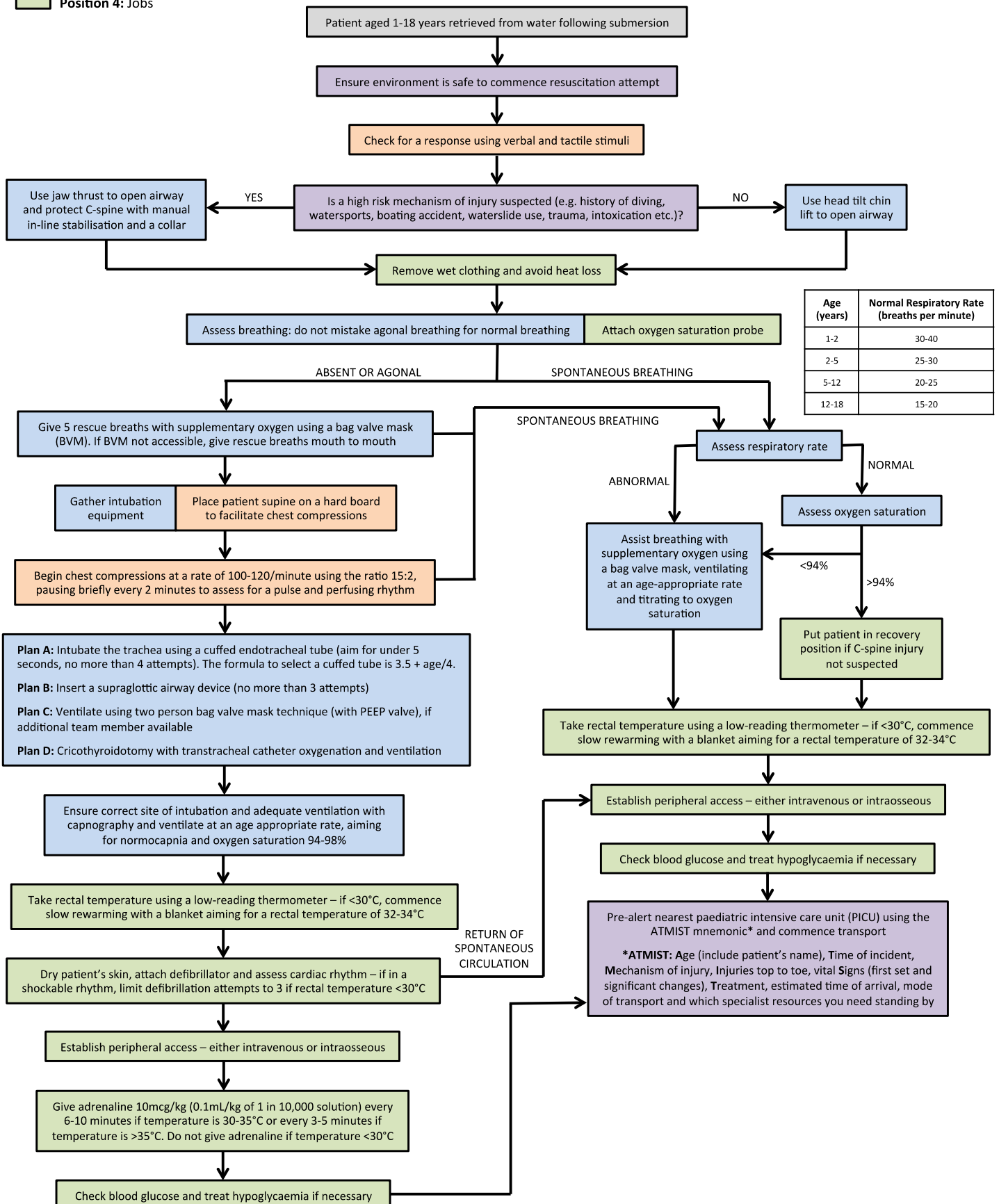
- **Position 1: Team Leader.** This individual is responsible for overseeing the resuscitation attempt from beginning to end using the SOP to guide other members of the team. The team leader should not get physically involved with the resuscitation attempt in any way, unless absolutely necessary.
- **Position 2: Airway.** This individual should be competent at paediatric intubation. They are responsible for intubating and ventilating the patient throughout the resuscitation attempt whilst monitoring capnography and oxygen saturation.
- **Position 3: Cardiopulmonary Resuscitation.** This individual is responsible for the delivery of continuous chest compressions and defibrillator use.
- **Position 4: Jobs.** This individual is responsible for protecting the cervical spine, establishing peripheral access and administering drugs as well as any other jobs deemed necessary by the team leader throughout the resuscitation attempt.

Whilst position 3 and position 4 are described as separate roles, the team members assigned to these positions should swap roles every few minutes to ensure that good quality chest compressions are continuous. Chest compressions should only cease once the patient regains a rhythm compatible with life, at which point progression through the rest of the SOP should continue.

**Figure 1:** Standard operating procedure for paediatric drowning.

## Standard Operating Procedure: Paediatric Drowning

- Position 1:** Team Leader – use algorithm to guide other team members
- Position 2:** Airway (must be experienced in paediatric intubation)
- Position 3:** Cardiopulmonary Resuscitation
- Position 4:** Jobs



## Discussion: the rationale for checklist components

### *Airway*

The airway recommendations used in this SOP are based on intubation guidelines from the Difficult Airway Society (DAS), a subgroup of the Association of Anaesthetists of Great Britain and Ireland (AAGBI). The paediatric difficult airway guidelines<sup>11</sup> are designed for use during routine induction of anaesthesia in children. However, the same principles can be applied in a prehospital setting assuming the presence of all necessary equipment and a team member trained in paediatric intubation. The only potential alteration to the DAS guidelines is progression straight to cricothyroidotomy after three failed insertions of a supraglottic airway device, if a fifth team member is not available in the prehospital setting to assist with two person bag valve mask ventilation.

The Resuscitation Council recommends the use of cuffed endotracheal tubes in the intubation of children with poor lung compliance, high airway resistance or facial burns<sup>10</sup>. The lung injury resulting from submersion results in decreased lung compliance<sup>12</sup> and therefore the use of an appropriately sized cuffed endotracheal tube is appropriate in the resuscitation of these patients.

Both intubation and cricothyroidotomy are invasive and potentially harmful procedures that should only be performed by experienced operators who have completed appropriate training and have access to the correct equipment. It should also be noted that transtracheal ventilation is intended only for temporary use until a definitive airway can be established, as this technique primarily supports oxygenation without effectively managing carbon dioxide exchange<sup>13</sup>.

### *Heimlich manoeuvre*

The Heimlich manoeuvre was first described in 1975 to aid removal of foreign bodies from the airway, including fluid in the case of submersion victims<sup>4</sup>. Studies of this technique and an improved understanding of the physiology of the lungs, have led to the conclusion that the Heimlich manoeuvre is not beneficial in the case of drowned patients<sup>4,14</sup>. This is due to insufficient evidence supporting Heimlich's hypothesis that fluid aspiration causes brain damage and death<sup>14</sup>, as well as the Heimlich manoeuvre potentially increasing time to intubation<sup>4</sup> and the possibility of gastric aspiration caused by the manoeuvre<sup>15</sup>. Use of the Heimlich manoeuvre is therefore not recommended in this SOP.

### *Cardiopulmonary resuscitation*

The first recommended step in the management of an adult patient with cardiac arrest unrelated to drowning is delivery of chest compressions, according to the Resuscitation Council UK guidelines<sup>16</sup>. However, as the most likely cause of arrest in both children and submersion victims is respiratory rather than cardiac, the Resuscitation Council recommend delivery of five rescue breaths prior to commencement of chest compression in these individuals<sup>9,10</sup>.

### *Resuscitation time*

Cardiopulmonary resuscitation should not be commenced where there is massive cranial and cerebral disruption, decomposition or rigor mortis, as these situations are unequivocally associated with death<sup>9</sup>. Other than in these scenarios, aggressive resuscitation of a patient following submersion should always be undertaken assuming that the rescue attempt and subsequent resuscitation does not pose a risk to others. This is because it is very difficult to predict prognosis from initial presentation, with many of the most unexpected physiological recoveries occurring in the young<sup>17</sup>. This SOP therefore encourages the use of cardiopulmonary resuscitation until either return of spontaneous circulation or arrival at the Emergency Department, at which point further efforts such as extracorporeal membrane oxygenation may be considered.

### *Therapeutic hypothermia*

The International Liaison Committee on Resuscitation (ILCOR) issued a statement in 2002 recommending the cooling of unconscious adult patients to 32-34°C following out-of-hospital cardiac arrest<sup>18</sup> after studies showed mild induced hypothermia increases the chance of survival and of a favourable neurological outcome<sup>19,20</sup>. Whilst most of the available literature on the subject focuses on inducing hypothermia in hospital, a large systematic review explored the practicality and efficacy of prehospital cooling after cardiac arrest, concluding that cooling both with ice packs and cold intravenous fluids improves outcomes<sup>21</sup>.

Children are more likely to become hypothermic after submersion than adults due to increased surface area-to-volume and head-to-body ratios<sup>22</sup>. Whilst there is limited literature on prehospital therapeutic hypothermia in children following drowning, the benefits demonstrated in adults may apply to children. The Resuscitation Council UK guidelines on paediatric resuscitation also recommend maintaining a core temperature of 32-34°C following return of spontaneous circulation for 24 hours following cardiac arrest<sup>10</sup>. This SOP therefore advocates the maintenance of mild hypothermia following return of spontaneous circulation in the drowned child, only initiating gentle rewarming if the rectal temperature is less than 30°C (0.25–0.5°C h<sup>-1</sup>).

### *Parents and carers*

Family presence during cardiopulmonary resuscitation is not always practical for emergency practitioners, particularly when the patient is a child. However, presence during resuscitation in the emergency department has been shown to be psychologically beneficial for family members, particularly if the attempt is unsuccessful, as it decreases post-traumatic stress<sup>23</sup> and facilitates the grieving process<sup>24</sup>. There is very little literature exploring this concept in the prehospital setting, although it has been suggested that parental accompaniment in paediatric trauma requiring helicopter retrieval is probably beneficial for both the patient and the family<sup>25</sup>.

The appropriateness of family presence during prehospital resuscitation following submersion has been left out of the SOP, as this will depend heavily on the situation. Whilst presence is beneficial for the parent, in the prehospital setting physical access to the patient may be compromised and this should take precedent over family involvement. The presence of family members should therefore be left to the discretion of the resuscitation team leader.

### **Conclusion**

Standard operating procedures are known to improve patient outcomes, particularly in high intensity situations, such as paediatric cardiac arrest where human error is likely to be increased<sup>5</sup>. This SOP is based upon a comprehensive literature review and current guidance and may improve the management of paediatric drowning when correctly followed.

A main limitation is the relative paucity of specific literature and research on prehospital management of paediatric drowning. Therefore this SOP, although based on current evidence and guidance, is supported by a relatively small evidence base. This checklist should therefore be used as a guideline only and discretion is advised when applying it to unique scenarios. In addition, this SOP needs validation in the clinical setting. As the field evolves, this SOP may need updating as more evidence becomes available in emerging areas, such as the use of extra corporeal life support<sup>26</sup>.

### **Conflict of interest statement**

The authors declare that they have no conflict of interest.

### **Funding source(s)**

None.

### **Assistance**

None.

### **Acknowledgements**

None.

## References

1. World Health Organisation. Drowning. 2014. [www.who.int](http://www.who.int) [accessed June 2016].
2. Eich C, Bräuer A, Timmermann A, et al. Outcome of 12 drowned children with attempted resuscitation on cardiopulmonary bypass: an analysis of variables based on the "Utstein Style for Drowning". *Resuscitation* 2007; **75**(1): 42-52.
3. Quan L, Bierens JJLM, Lis R, Rowhani-Rahbar A, Morley P, Perkins GD. Predicting outcome of drowning at the scene: A systematic review and meta-analyses. *Resuscitation* 2016; **104**: 63-75.
4. Quan L. Drowning issues in resuscitation. *Annals of Emergency Medicine* 1993; **22**(2): 366-9.
5. Hales BM, Pronovost PJ. The checklist—a tool for error management and performance improvement. *Journal of Critical Care* 2006; **21**(3): 231-5.
6. Kortgen A, Niederprüm P, Bauer M. Implementation of an evidence-based "standard operating procedure" and outcome in septic shock\*. *Critical Care Medicine* 2006; **34**(4): 943-9.
7. Wurmb TE, Frühwald P, Knuepfer J, et al. Application of standard operating procedures accelerates the process of trauma care in patients with multiple injuries. *European Journal of Emergency Medicine* 2008; **15**(6): 311-7.
8. Cuschieri J, Johnson JL, Sperry J, et al. Benchmarking outcomes in the critically injured trauma patient and the effect of implementing standard operating procedures. *Annals of Surgery* 2012; **255**(5): 993.
9. Deakin C, Brown S, Jewkes F, et al. Prehospital resuscitation. 2014. [www.resus.org.uk](http://www.resus.org.uk) [accessed 20th June 2016].
10. Maconochie I, Bingham B, Skellett S. Paediatric advanced life support. 2015. [www.resus.org.uk](http://www.resus.org.uk) [accessed 20th June 2016].
11. Difficult Airway Society. Unanticipated difficult tracheal intubation - during routine induction of anaesthesia in a child aged 1 to 8 years. 2015. [www.das.uk.com](http://www.das.uk.com) [accessed 28th June 2016].
12. Mtaweh H, Kochanek PM, Carcillo JA, Bell MJ, Fink EL. Patterns of multiorgan dysfunction after pediatric drowning. *Resuscitation* 2015; **90**: 91-6.
13. Mallari CA, Ross EE, Vieux Jr EE. Emergency Airway: Cricothyroidotomy. *Interventional Critical Care*: Springer; 2016: p. 59-65.
14. Rosen P, Stoto M, Harley J. The use of the Heimlich maneuver in near drowning: Institute of Medicine report. *The Journal of Emergency Medicine* 1995; **13**(3): 397-405.
15. Orłowski JP. Vomiting as a complication of the Heimlich maneuver. *JAMA* 1987; **258**(4): 512-3.
16. Perkins G, Colquhoun M, Deakin C, Handley A, Smith C, Smyth M. Adult basic life support and automated external defibrillation. 2015. [www.resus.org.uk](http://www.resus.org.uk) [accessed 15th December 2016].
17. Cushing TA, Hawkins SC, Sempsrott J, Schoene RB. Submersion Injuries and Drowning. In: *Wilderness Medicine*. Sixth ed. Philadelphia: Elsevier; 2012: p. 1494–513.
18. Nolan JP, Morley PT, Hoek TLV, et al. Therapeutic hypothermia after cardiac arrest: an advisory statement by the advanced life support task force of the International Liaison Committee on Resuscitation. *Circulation* 2003; **108**(1): 118-21.
19. Hypothermia After Cardiac Arrest Study Group. Mild therapeutic hypothermia to improve the neurologic outcome after cardiac arrest. *New England Journal of Medicine* 2002; **2002**(346): 549-56.
20. Bernard SA, Gray TW, Buist MD, et al. Treatment of comatose survivors of out-of-hospital cardiac arrest with induced hypothermia. *New England Journal of Medicine* 2002; **346**(8): 557-63.
21. Cabanas JG, Brice JH, De Maio VJ, Myers B, Hinchey PR. Field-induced therapeutic hypothermia for neuroprotection after out-of-hospital cardiac arrest: a systematic review of the literature. *The Journal of Emergency Medicine* 2011; **40**(4): 400-9.
22. Meyer R, Theodorou A, Berg R. Paediatric considerations in drowning. *Drowning*: Springer; 2014: 641-9.
23. Robinson SM, Mackenzie-Ross S, Hewson GLC, Egleston CV, Prevost AT. Psychological effect of witnessed resuscitation on bereaved relatives. *The Lancet* 1998; **352**(9128): 614-7.
24. Tinsley C, Hill JB, Shah J, et al. Experience of families during cardiopulmonary resuscitation in a pediatric intensive care unit. *Pediatrics* 2008; **122**(4): e799-e804.
25. Cowley A, Durge N. The impact of parental accompaniment in paediatric trauma: a helicopter emergency medical service (HEMS) perspective. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine* 2014; **22**(1): 1.
26. Lamhaut L, Jouffroy R, Soldan M, et al. Safety and feasibility of prehospital extra corporeal life support implementation by non-surgeons for out-of-hospital refractory cardiac arrest. *Resuscitation* 2013; **84**(11): 1525-9.