ARC SAC SCIENTIFIC REVIEW
In-water Resuscitation

Questions to be addressed:

During the rescue of a drowning victim, does the application of in-water resuscitation improve the chance of survival with good neurologic outcome?

Introduction/Overview:

During the process of drowning, the most significant physiologic insult and, therefore, primary cause of morbidity and mortality is systemic hypoxemia. It stands to reason that the earlier an intervention can be applied to reverse this insult, the greater the chances would be for survival with minimal morbidity for the drowning patient. This scientific review will focus on the evidence available describing the technical feasibility and clinical utility of in-water resuscitation in the rescue and treatment of drowning patients.

Search Strategy and Literature Search Performed

Key Words Used

1. (drowning[Title]) AND (resuscitation[title])
2. (in-water[Title]) AND (resuscitation[title])
3. (aquatic[Title]) AND (resuscitation[title])
4. (water[Title]) AND (CPR[title])

Inclusion Criteria (time period, type of articles and journals, language, methodology)

1. Past 40 years (since 1979)
2. English language
3. Full-article available

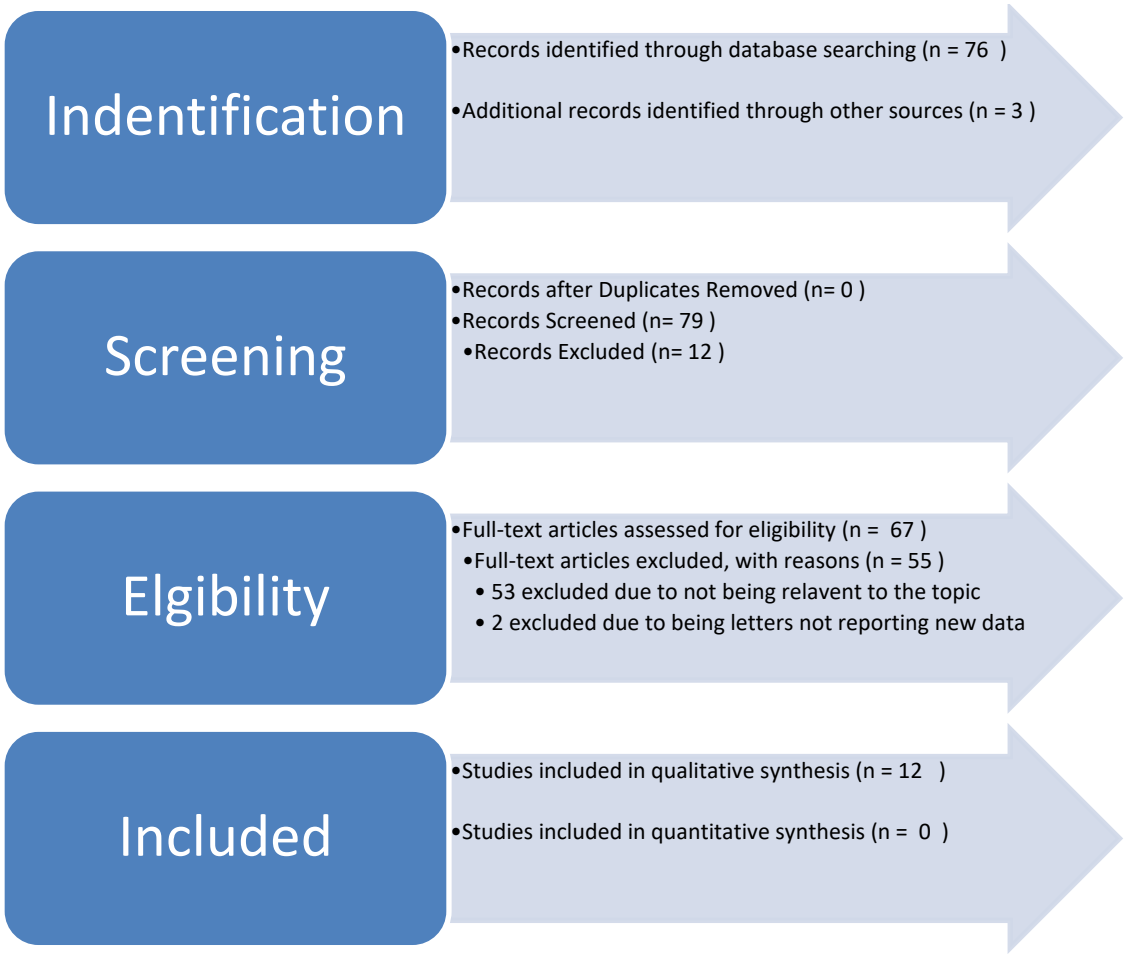
Exclusion Criteria (only human studies, foreign language, etc…)

1. Foreign language
2. Only abstract available
3. Letters not presenting new data
4. Content not relevant to the review topic

Databases Searched and Additional Methods Used (references of articles, texts, contact with authors, etc...)

A keyword search using PubMed was performed using the above-mentioned keywords

ARC SAC SCIENTIFIC REVIEW
In-water Resuscitation



ARC SAC SCIENTIFIC REVIEW
In-water Resuscitation

Scientific Foundation:

The concept of resuscitating a patient while still in the water gained little attention in peer-reviewed literature until the 1980s. In 1980, March and Matthews reported their findings of a manikin-based feasibility study describing the use of chest compressions and ventilations provided by a SCUBA regulator while in the water.[1,2] This study was followed by multiple letters and editorials highlighting the weaknesses of the study methods and probable lack of applicability to real-life resuscitations.[3,4] Since then, no high-quality study has been found in the literature describing the use of chest compressions in the water and the technique in currently not recommended. The use of ventilations in the water, however, has gained acceptance over the decades and does have some data to support its use. For the remainder of this review, the term in-water resuscitation (IWR) will be used to describe the technique of providing rescue ventilations while in the water. IWR specific to open water lifesaving was first discussed in detail in peer-reviewed literature in a 1988 study by Manolios and Mackie. In their study on fatal and non-fatal drownings on Australian beaches, the authors of this paper noted that this technique has been used in New Zealand, especially with the use of a rescue board, since the 1970s. Out of the 262 cases described in this study, 14 involved the lifeguard providing IWR with the assistance of a board, buoy, or fins. No high-quality analysis could be made on these cases other than the fact that 6 of the 14 patients survived, but the authors were led to conclude that IWR "…appears not only feasible but highly successful." [5]

Since this early work, only one other study has described human outcome data on the effects of IWR during open-water rescues. This study was based in Brazil and analyzed 5 years of ocean lifeguard data. From this data, 46 patients who were found unconscious and apneic in the water were included, of which 19 received IWR. After analysis it was found that those patients who received IWR had significantly lower pre-hospital and hospital mortality when compared to those who did not. Although small and despite its inherent design weaknesses, it remains the only study in peer reviewed literature to specifically evaluate IWR from a patient outcome perspective.[6] Following this, all of the IWR-specific studies since have utilized simulated rescue scenarios with manikins. Pooled together, these studies have found the following:[7-10]

1. IWR is feasible, by mouth-to-mouth, bag-mask, and laryngeal tube ventilation
2. IWR increases the time and perceived difficulty of a rescue
3. IWR increases the amount of measured water aspiration on the part of the patient
4. Lifeguards perform IWR more effectively and efficiently than lay-persons

The most important point highlighted by all of these studies is that IWR is feasible, but difficult. Studies have been performed to show objectively that performing a rescue is physically and metabolically taxing to a rescuer.[11,12] This may be easily exacerbated by adding in IWR if the rescuer is not properly trained or physically fit to efficiently perform the rescue. What has also been found is that this physical and metabolic demand, as well as rescue time, is decreased by using rescue equipment such as buoys, fins, and boards. This finding supports the use of this

equipment to lessons the physical demands of IWR and create a safer working environment for the rescuer.

In general, the data surrounding the use of IWR during open water rescues is lacking. The primary study driving opinion is the 2004 Brazilian study which was based on a small number of patients and retrospective analysis. Despite this, the International Life Saving Federation's current Medical Position Statement supports the use of IWR for properly trained professional lifeguards; these are in-line with the 2015 European Resuscitation Council guidelines for resuscitation.[13,14] This is primarily due to the understanding that the earlier the physiologic insults of drowning can be reversed, the greater the chances are for survival with good neurologic outcome for the patient. While both of these documents differentiate between rescues performed in shallow and deep water, this is based purely on expert opinion and consensus without data; the conclusions in this review will, therefore, not include this differentiation. Although most studies have primarily been manikin and simulation-based, they have been beneficial in the fact that they demonstrate that IWR is feasible and performed better with proper training and equipment. They have also demonstrated that while water rescues are inherently physically demanding, the use of rescue equipment may decrease those demands.

Recommendations and Strength (using table below):

Standards: None

Guidelines: None

Options:

1. In-water resuscitation (IWR) can be considered in cases where a rescuer has proper training in the technique and is comfortable performing it without causing an unsafe environment for rescuer or patient.
2. Though IWR can be performed without the aid of additional equipment, floating and propelling equipment should be considered.

<u>Knowledge Gaps and Future Research:</u>

- Knowledge gaps
  - True outcome effect still unknown due to single human-focused study
  - No data on rescuer harm caused by attempting IWR
- Future research
  - Further analysis of large lifeguard databases which include IWR as an intervention
  - Focused study on different techniques

Implications for ARC Programs:

The current American Red Cross Lifeguarding course instructs "…if you cannot immediately remove the victim or if doing so will delay care, then perform in-water ventilations." The evidence reported in this review likely will not change this statement. Consideration should be given to adding verbiage to better describe what it means to not be able to "…immediately remove the victim…" For example, if a victim is 50 meters from the closest edge/shore and a complete rescue may take a few minutes, although the patient is being removed "immediately" and without delay, there may be a physiologic benefit to providing initial breaths upon patient contact. As highlighted in this review, the data to supporting this is lacking and primarily based on the fundamentals of drowning physiology.

Attach Any Lists, Tables of List of Recommendations Created As Part of This Review

None

ARC SAC SCIENTIFIC REVIEW
In-water Resuscitation

Summary of Key Articles/Literature Found and Level of Evidence/Bibliography:

Author(s)	Full Citation	Summary of Article (provide a brief summary of what the article adds to this review including which question(s) it supports, refutes or is neutral)	Methodology	Bias Assessment	Indirectness/ Imprecision/ Inconsistency	Key results and magnitude of results	Support, Neutral or Oppose Question	Level of Evidence (Using table below)	Quality of study (excellent, good, fair or poor) and why
March NF, Matthews RC	March NF, Matthews RC. Feasibility study of CPR in the water. *Undersea Biomed Res*. 1980;7(2):141-8.	Manikin-based study with simulated SCUBA drowning. Subjects trained in providing compressions from behind and using SCUBA regulator for breaths. Displayed feasibility of providing compressions and breaths in this manner.	Observational	None		Compressions from behind and breaths delivered with regulator are both feasible given the patient has no SCUBA gear on. The physiologic goals of CPR at the time, however, would not be acceptable today	Neutral	2a	Fair
March NF, Matthews RC	March NF, Matthews RC. New techniques in external cardiac compressions. Aquatic cardiopulmonary resuscitation. *JAMA*. 1980;244(11):1229-32.	Manikin-based study with simulated SCUBA drowning. Subjects trained in providing compressions from behind and using SCUBA regulator for breaths. Displayed feasibility of providing compressions and breaths in this manner. Note: this study is the same as above but was published with a different manuscript in a different journal	Observational	None		Compressions from behind and breaths delivered with regulator are both feasible given the patient has no SCUBA gear on. The physiologic goals of CPR at the time, however, would not be acceptable today	Neutral	2a	Fair

Manolios N, Mackie I.	Manolios N, Mackie I. Drowning and near-drowning on Australian beaches patrolled by life-savers: a 10-year study, 1973-1983. *Med J Aust*. 1988;148(4):165-7.	Summarization of rescue report forms for Australian surf lifesaving clubs over a 10-year period. From these reports, the authors describe 14 cases in which IWR was performed with the use of fins, a buoy, or a paddleboard. Of these, 6 patients survived, but further descriptive data was not available.	Retrospective observational	None		IWR was feasible and resulted in survival after severe drowning.	Support	2b	Poor
Szpilman D, Soares M	Szpilman D, Soares M. In-water resuscitation--is it worthwhile? *Resuscitation*. 2004;63(1):25-31.	Retrospective analysis of open-water rescues performed by professional lifeguards in Brazil. Primarily focused on determining the survival effect of IWR on patients found in the water unconscious and apneic. Supports the use of IWR in terms of survival benefit.	Retrospective observational	None		IWR improved survival in patients found unconscious and apneic. Low number of patients.	Support	2b	Fair
Perkins GD	Perkins GD. In-water resuscitation: a pilot evaluation. *Resuscitation*. 2005;65(3):321-4.	Manikin-based study in which trained lifeguards performed IWR without floatation assistance. Primarily measured rescue duration and breath volume delivered. Determined that IWR was feasible, delivered adequate volumes, and did not significantly delay rescue to land.	Prospective observational	None		IWR was feasible without floatation aid in a controlled environment. IWR provided adequate breath volume and did not delay rescue to land. Low number of subjects	Support	2a	Fair
Winkler BE, Eff AM, Eff S, Ehrmann	Winkler BE, Eff AM, Eff S,	Manikin-based study in which 19 lifeguards performed simulated	Non-blinded randomized cross-over trial	None		IWR was feasible but difficult. When looking at providing	Support	1b	Fair

U, Koch A, Kähler W, Muth CM.	Ehrmann U, Koch A, Kähler W, Muth CM. Efficacy of ventilation and ventilation adjuncts during in-water-resuscitation--a randomized cross-over trial. *Resuscitation*. 2013;84(8): 1137-42.	rescues in the water. They were randomly assigned to each perform a rescue using each of the following: no breaths, mouth-to-mouth, bag-mask, and laryngeal tube. Primarily measured ventilation parameters as well as subjective difficulty and manikin aspiration volumes. Determined that IWR was physically demanding and that providing no breaths was easiest and fastest. Using mouth-to-mouth and bag-mask were feasible but resulted in larger aspirations. When providing breaths, laryngeal tube resulted in good ventilatory parameters and minimal aspiration.				breaths, laryngeal mask provided best ventilatory parameters and protected best against aspiration.			
Winkler BE, Eff AM, Ehrmann U, Eff S, Koch A, Kaehler W, Georgieff M, Muth CM	Winkler BE, Eff AM, Ehrmann U, Eff S, Koch A, Kaehler W, Georgieff M, Muth CM. Effectiveness and safety of in-water resuscitation performed by lifeguards	Manikin-based study in which lifeguards and lay-persons performed simulated water rescues both with and without IWR. Primarily measured rescue duration, physical effort, number of submersions, and aspirated volume in the manikins. Supported the feasibility of IWR and determined that trained lifeguards performed better in all regards. IWR increased rescue time.	Non-blinded randomized cross-over trial	None		IWR was feasible, but only when performed by trained lifeguards. It increased rescue duration as well as submersions and volume aspirated	Support	1b	Fair

	and laypersons: a crossover manikin study. *Prehosp Emerg Care*. 2013;17(3): 409-15.								
Lungwitz YP, Nussbaum BL, Paulat K, Muth CM, Kranke P, Winkler BE	Lungwitz YP, Nussbaum BL, Paulat K, Muth CM, Kranke P, Winkler BE. A novel rescue-tube device for in-water resuscitation. *Aerosp Med Hum Perform*. 2015;86(4): 379-85.	Manikin-based study in which trained lifeguards performed simulated water rescues. A novel rescue tube with built in oxylator was utilized in certain scenarios. Each rescuer performed one of each randomly assigned ventilation strategy: no ventilation, mouth-to-mouth, oxylator-to-mask, and oxylator-to-laryngeal tube. IWR was feasible with all methods, although it prolonged rescue time and aspiration volume. The no ventilation and oxylator-to-tube methods were rated easiest and the mouth-to-mouth resulted in the largest aspiration volumes. This study supports the feasibility of IWR, including the use of supplemental devices and oxygen, although these techniques all increased rescue difficulty, time, and aspiration.	Non-blinded randomized cross-over trial	None		IWR, including the use of supplemental devices and oxygen, is feasible but adds to rescue difficulty, duration, and aspiration volume	Support	1b	Fair
Truhlář A, Deakin CD,	Truhlář A, Deakin CD,	Guidelines for the care of cardiac arrest patients	Guidelines Statement	None		Supports the use of IWR by	Support	5	Fair

Soar J, Khalifa GE, Alfonzo A, Bierens JJ, Brattebø G, Brugger H, Dunning J, Hunyadi-Antičević S, Koster RW, Lockey DJ, Lott C, Paal P, Perkins GD, Sandroni C, Thies KC, Zideman DA, Nolan JP	Soar J, Khalifa GE, Alfonzo A, Bierens JJ, Brattebø G, Brugger H, Dunning J, Hunyadi-Antičević S, Koster RW, Lockey DJ, Lott C, Paal P, Perkins GD, Sandroni C, Thies KC, Zideman DA, Nolan JP; Cardiac arrest in special circumstances section Collaborators. European Resuscitation Council guidelines for resuscitation 2015: Section 4. Cardiac arrest in special circumstances. *Resuscitation*. 2015;95:148-201.	from the European Resuscitation Council. Supports the use of IWR by professional lifeguards with the proper training and equipment				professional lifeguards with the proper training and equipment			

Barcala-Furelos R, Szpilman D, Palacios-Aguilar J, Costas-Veiga J, Abelairas-Gomez C, Bores-Cerezal A, López-García S, Rodríguez-Nuñez A	Barcala-Furelos R, Szpilman D, Palacios-Aguilar J, Costas-Veiga J, Abelairas-Gomez C, Bores-Cerezal A, López-García S, Rodríguez-Nuñez A. Assessing the efficacy of rescue equipment in lifeguard resuscitation efforts for drowning. *Am J Emerg Med*. 2016;34(3): 480-5.	Professional lifeguards performed CPR both before and after simulated water rescues. Each lifeguard performed a rescue utilizing each of the following methods: no equipment, fins and buoy, fins only, and rescue board. Quality of CPR, rescue time, physiologic parameters, and subjective effort were all measured. Pertinent to this review, the study determined that the use of floating and propelling equipment decreased the time of rescue and, in the case of a rescue board, significantly decreased subjective effort. This study supports the use of lifeguard equipment to ease the inherent difficulty of IWR.	Non-blinded, randomized, quasiexperimental	None		Water rescues are inherently difficult and physically taxing. The use of floating or propelling equipment, especially a rescue board, improves rescue time and subjective difficulty.	Support	1b	Fair
International Life Saving Federation Medical Committee	International Life Saving Federation. Medical position statement-MPS 08: In-water resuscitation. Updated February	Positions statement for the International Life Saving Federation. Supports the use of IWR by professional lifeguards with the proper training and equipment	Position Statement	None		Supports the use of IWR by professional lifeguards with the proper training and equipment	Support	5	Fair

	11, 2015. Accessed June 5, 2019.								
Abelairas-Gómez C, Barcala-Furelos R, Mecías-Calvo M, Rey-Eiras E, López-García S, Costas-Veiga J, Bores-Cerezal A, Palacios-Aguilar J	Abelairas-Gómez C, Barcala-Furelos R, Mecías-Calvo M, Rey-Eiras E, López-García S, Costas-Veiga J, Bores-Cerezal A, Palacios-Aguilar J. Prehospital emergency medicine at the beach: what is the effect of fins and rescue tubes in lifesaving and cardiopulmonary resuscitation after rescue? *Wilderness Environ Med*. 2017;28(3): 176-184.	Professional lifeguards performed CPR both before and after completing simulated water rescues. Each lifeguard performed both an un-aided rescue and a rescue with fins and a buoy. Pertinent to this review, rescue time and physiologic parameters were measured. The study determined that the use of fins and buoy decreased rescue time. While rescue efforts were found to be physically taxing, there was no significant difference between un-aided and aided rescues.	Non-blinded, randomized, quasiexperimental	None		Water rescues are physically taxing. The use of floating and propelling equipment decreases rescue time but, based on objective physiologic parameters, does not ease physical stress.	Neutral	1b	Fair

ARC SAC SCIENTIFIC REVIEW
In-water Resuscitation

Level of Evidence	Definitions (See manuscript for full details)
Level 1a	**Experimental and Population based studies** - population based, randomized prospective studies or meta-analyses of multiple higher evidence studies with substantial effects
Level 1b	**Smaller Experimental and Epidemiological studies** - Large non-population based epidemiological studies or randomized prospective studies with smaller or less significant effects
Level 2a	**Prospective Observational Analytical** - Controlled, non-randomized, cohort studies
Level 2b	**Retrospective/Historical Observational Analytical** - non-randomized, cohort or case-control studies
Level 3a	**Large Descriptive studies** – Cross-section, Ecological, Case series, Case reports
Level 3b	**Small Descriptive studies** – Cross-section, Ecological, Case series, Case reports
Level 4	**Animal studies or mechanical model studies**
Level 5	**Peer-reviewed Articles** - state of the art articles, review articles, organizational statements or guidelines, editorials, or consensus statements
Level 6	**Non-peer reviewed published opinions -** such as textbook statements, official organizational publications, guidelines and policy statements which are not peer reviewed and consensus statements
Level 7	**Rational conjecture** (common sense); common practices accepted before evidence-based guidelines
Level 1-6E	**Extrapolations** from existing data collected for other purposes, theoretical analyses which is on-point with question being asked. Modifier E applied because extrapolated but ranked based on type of study.

Approved by ARC SAC June 2019

References

1. March NF, Matthews RC. Feasibility study of CPR in the water. *Undersea Biomed Res*. 1980;7(2):141-8.
2. March NF, Matthews RC. New techniques in external cardiac compressions. Aquatic cardiopulmonary resuscitation. *JAMA*. 1980;244(11):1229-32.
3. Ghaphery JL. In-water resuscitation. *JAMA*. 1981;245(8):821.
4. Kizer K. Aquatic rescue and in-water CPR. *Ann Emerg Med*. 1982;11(3):166-7.
5. Manolios N, Mackie I. Drowning and near-drowning on Australian beaches patrolled by life-savers: a 10-year study, 1973-1983. *Med J Aust*. 1988;148(4):165-7.
6. Szpilman D, Soares M. In-water resuscitation--is it worthwhile? *Resuscitation*. 2004;63(1):25-31.
7. Perkins GD. In-water resuscitation: a pilot evaluation. *Resuscitation*. 2005;65(3):321-4.
8. Winkler BE, Eff AM, Eff S, Ehrmann U, Koch A, Kähler W, Muth CM. Efficacy of ventilation and ventilation adjuncts during in-water-resuscitation--a randomized cross-over trial. *Resuscitation*. 2013;84(8):1137-42.
9. Winkler BE, Eff AM, Ehrmann U, Eff S, Koch A, Kaehler W, Georgieff M, Muth CM. Effectiveness and safety of in-water resuscitation performed by lifeguards and laypersons: a crossover manikin study. *Prehosp Emerg Care*. 2013;17(3):409-15.
10. Lungwitz YP, Nussbaum BL, Paulat K, Muth CM, Kranke P, Winkler BE. A novel rescue-tube device for in-water resuscitation. *Aerosp Med Hum Perform*. 2015;86(4):379-85.
11. Barcala-Furelos R, Szpilman D, Palacios-Aguilar J, Costas-Veiga J, Abelairas-Gomez C, Bores-Cerezal A, López-García S, Rodríguez-Nuñez A. Assessing the efficacy of rescue equipment in lifeguard resuscitation efforts for drowning. *Am J Emerg Med*. 2016;34(3):480-5.
12. Abelairas-Gómez C, Barcala-Furelos R, Mecías-Calvo M, Rey-Eiras E, López-García S, Costas-Veiga J, Bores-Cerezal A, Palacios-Aguilar J. Prehospital emergency medicine at the beach: what is the effect of fins and rescue tubes in lifesaving and cardiopulmonary resuscitation after rescue? *Wilderness Environ Med*. 2017;28(3):176-184.
13. International Life Saving Federation. Medical position statement-MPS 08: In-water resuscitation. Updated February 11, 2015. Accessed June 5, 2019.
14. Truhlář A, Deakin CD, Soar J, Khalifa GE, Alfonzo A, Bierens JJ, Brattebø G, Brugger H, Dunning J, Hunyadi-Antičević S, Koster RW, Lockey DJ, Lott C, Paal P, Perkins GD, Sandroni C, Thies KC, Zideman DA, Nolan JP; Cardiac arrest in special circumstances section Collaborators. European Resuscitation Council guidelines for resuscitation 2015: Section 4. Cardiac arrest in special circumstances. *Resuscitation*. 2015;95:148-201.