



Commentary and Concepts

Creating a drowning chain of survival[☆]

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ABSTRACT

All nations would benefit from a simple, clear Drowning Chain of Survival. In high income nations this tool will refine prevention and the call for action. In low and middle income nations this tool is a guide for policy making, resource allocation and priority setting in drowning prevention. A best evidence approach was utilized to create a universal *Drowning Chain of Survival*. Education on how to prevent drowning and to how react when a drowning incident occurs has not always been guided by good levels of evidence, or high levels of specialized training in drowning process recognition and management. The *Drowning Chain of Survival* refers to a series of steps that when enacted, attempts to reduce mortality associated with drowning and attempted aquatic rescue. The term “chain of survival” has provided a useful metaphor for the elements of the emergency cardiac care system for sudden cardiac arrest, however interventions and patient management in drowning involves principles and actions that are specific to these situations. The result is a unique and universal *Drowning Chain of Survival* comprised of five links guiding the important life-saving steps for lay and professional rescuers. This may significantly improve chances of prevention, survival and recovery from drowning. The steps of the chain are: Prevent drowning, Recognize distress, Provide flotation, Remove from water, and Provide care as needed.

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1. Introduction

The term “Chain of Survival” has provided a useful metaphor for the elements of the emergency cardiac care system for sudden cardiac arrest, however interventions in drowning involves principles and actions that are specific to these situations. A unique and universal *Drowning Chain of Survival* can guide the important life-saving steps for lay and professionals rescuers. This may

significantly improve chances of prevention, survival and recovery for people in potential danger in water.

Prevention is the most important contributor to reduce drowning mortality and morbidity. In low and medium income countries (LMIC) where more than 90% of the global drowning occurs, guidance to accelerate culturally appropriate prevention, rescue and resuscitation strategies are most urgently needed.¹ High income countries (HIC) have seen dramatic reductions in drowning mortality as a result of reduced risks and effective strategic interventions. Further mortality reduction can be facilitated with the introduction of effective approaches to prevention, rescue and resuscitation in LMIC settings.²

When preventative measures fail, responders need to be able to perform the necessary steps to interrupt the drowning process. The first challenge is to recognize someone in distress and the need to activate rescue and emergency medical services (EMS) appropriately when possible. It is critical that rescuers take precautions not to become another victim by engaging in dangerous behaviors.³

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Early rescue may prevent the initial and subsequent water aspiration, respiratory distress and medical complications.

The entire drowning process, from submersion/immersion to cardiac arrest usually occurs in seconds to a few minutes.⁴ If the person is rescued alive, the clinical picture is determined predominantly by the amount of water that has been aspirated. In some cases, even an early and effective rescue will not prevent the medical consequences and in these cases basic and advanced life support interventions may be required.⁵

An effective educational strategy on drowning can assist both LMIC and HIC responders to recall important preventative measures as well as critical response steps. One such strategy has involved promoting icons in the form of a *Drowning Chain of Survival*.^{6,7}

The purpose of this concept is to describe the development of a new and universal *Drowning Chain of Survival* for the prevention and effective response to drowning incidents based on conceptual, practical, and educational value.

1.1. Reviewing concepts and models

In 2013, a group of experts reviewed the need to update the existing *Drowning Chain of Survival* by examining all elements of current and similar models. The four major elements of the European Resuscitation Council (ERC) and five major elements of the American Heart Association (AHA) chains of survival were evaluated from an applicability to drowning perspective.⁸

The first⁶ *Drowning Chain of Survival* developed in 2002 resulted from a realization that drowning prevention and first aid education had several unique characteristics not captured in the emergency cardiovascular care (ECC) chains of survival. Basic and advanced life support in the aquatic environment requires specific skills and knowledge that were not taught in regular first aid and cardiopulmonary resuscitation (CPR) education.⁹ The result was an original *Drowning Chain* composed of icons that formed 6 links.⁶

The 2012 “*Drowning Response*” adopted by the American Red Cross (ARC) was reviewed.¹⁰ The ARC Drowning Response chain did not include prevention; instead it addressed the key evidence-based effective drowning prevention strategies by developing a specific Circle of Prevention.¹⁰

The “*Call to Action*” system used by Surf Life Saving New Zealand was also reviewed. It includes a “provide flotation” link as a priority intervention, emphasizes the importance of rescuer safety, and omits links that duplicate information already contained in the ECC Chain of Survival.^{8,11}

A Delphi-like process among experts was performed by email previously to the workshop at the World Conference on Drowning Prevention in 2013 (WCDP-2013) where conceptual, practical, and educational values were examined supported by medical, pedagogical and lifeguarding science. A facilitated discussion identified ways to evaluate whether the proposed model would meet the needs of all layers of prevention and response, as well complying with International Organization for Standardization (ISO) requirements. In closing the session at the WCDP-2013 a final summary including all the relevant ideas, identifying key areas of agreement and unresolved issues were presented. After the workshop, input from the participants continued to be collated and refined.

2. Result

A new concept of a *Universal Drowning Chain of Survival* containing 5 links (Fig. 1) is described.

2.1. “PREVENT DROWNING – be safe in and around the water”¹²

It has been estimated that most drownings are preventable.¹² The ability to avoid a drowning contrasts with the high rates of poor outcomes following these type of incidents. Drowning requires multiple layers of protection. To be effective, drowning prevention must be used by individuals near, on or around the water, and those who supervise or care for others in water settings.

2.1.1. Major advice actions

- Stay within arm’s reach of children when in or near the water
- Swim in water-safe areas where there lifeguards
- Fence pools, spas and other aquatic with 4-sided or any fencing
- Always wear a lifejacket when using watercraft (eg. Boat, kayak etc.)
- Learn how to swim and water-safety survival skills.

2.2. “RECOGNIZE DISTRESS – call for help”

The first challenge is to recognize a person in distress in the water and know how to act safely, and to activate the lifeguard, rescue and emergency medical services (EMS) if possible and available. *Frank Pia* contradicted the prevailing notions that most victims struggle at the water’s surface, call or wave for help, and actively attack rescuers. He showed that a person struggling and about to drown cannot usually call for help.⁴

In 1995, Langendorfer and Bruya identified key developmental components of aquatic readiness and water competency and a *Drowning Risk Assessment* was created.¹³ Identified recognizable elements of a person at high risk of drowning include: Near vertical body position, ineffective downward arm movements, ineffective pedaling or kicking leg actions, and little or no forward progress in water.¹⁴ Sending someone to call for help upon recognizing a person in water distress is a key element in the drowning response chain. Delays in activating EMS/rescue services increases the risk of fatal drowning.³

2.2.1. Major advice actions

1. Recognize early drowning victim’s distress signs. Victims may not wave or call for help
2. Tell someone to call for help while staying on-scene to provide assistance
3. Watch where the victim is in the water, or ask a bystander to keep constant watch.

2.3. “PROVIDE FLOTATION – to prevent submersion”

After recognizing a victim is in distress and asking someone to call for help, the next priority is to interrupt the drowning process by providing flotation to the victim. Providing flotation is a strategy not widely employed despite buying valuable time for emergency services to arrive, or for those on-scenes to plan rescue efforts. Most rescuers tend to focus on the *strategic goal* of getting the victim out of the water even if there is a high threat to life/rescuer safety.¹⁵ Devices such as ring-buoys (life-buoys) are purpose-designed to provide flotation. However, they are not always available at the scene of a drowning incident. Therefore, improvised buoyancy aids such as empty plastic bottles/containers, body-boards, surfboards, driftwood, ice-chests, etc. should be used. It is critical that lay persons take precautions not to become another victim by engaging in inappropriate/dangerous behaviors.³ Given the number of bystanders who drown while attempting to rescue others, reaching out with, throwing, or dropping the buoyancy aid without entering the water is the safest course of action.¹⁶



Fig. 1. Pictogram of the new Drowning Chain of Survival.

2.3.1. Major advice actions

While helping others:

1. Stay out of the water to reduce rescuer risk.
2. Throw something that floats to the victim

To help yourself:

1. If you are in difficulty, do not panic; stay with any flotation you may have
2. Signal for help as soon as and if possible, and float.

2.4. "REMOVE FROM WATER – only if safe to do so"

Removing the victim from the water is essential in order to provide a definitive end to the drowning process. Several strategies for removal can be used: Assist the victim to get out of the water by giving directions, i.e. pointing out to the closest and safest place to get out. Attempt to remove the victim without fully entering the water by utilizing rescue techniques such as, reaching, throwing and wading out with equipment; If all else fails, the lay rescuer may then consider entering the water. The entry of an untrained person into the water to rescue someone is extremely dangerous and is not recommended.^{3,16} In order to mitigate the risk during a rescuer **must** bring a source of flotation as to assist the victim.

2.4.1. Major advice actions

1. Assist the victim on how to self-rescue by giving them directions for getting out of the water
2. Try to remove the victim without entering the water
3. Only if safe to do so, rescue the victim using any flotation available.

2.5. "PROVIDE CARE AS NEEDED – seek medical attention"

Basic life support for drowning patients is unique due to the dangerous environment which may pose some difficulties in providing care before, during or after the rescue process. The need for, and initiation of basic life support may occur while the victim is still in water if the rescuer is trained and can provide in-water resuscitation safely.⁵ If not interrupted, the drowning process leads to apnea followed by cardiac arrest within minutes. Any attempt to immobilize the spine will impede rescue, and more importantly delay resuscitation. Therefore, attempts to immobilize the spine should only be made where there is strong evidence of cervical spine injury.¹⁷ Transporting and positioning drowning victims also requires specialized adaptations.¹⁸

CPR is needed when the heart stops following a period of apnea.⁵ It is imperative that CPR follows the traditional Airway–Breathing–Circulation (ABC) approach in this setting of hypoxic induced cardiac arrest.¹⁹ Initial ventilations may be ineffective in drowning due to the presence of water in the upper

airway.⁵ Airway management is always challenging due to vomiting/regurgitation and the fluid that is commonly present in the upper airway. Also unique to drowning is that the most common rhythm in cardiac arrest following drowning is asystole.

As soon the victim is removed from the water, rescuers must recognize the drowning severity especially if there is a life-threatening situation so immediate care can be provided.²⁰ As the majority of people with mild distress may not actually aspirate water it is important to educate responders when to call the ambulance or seek medical assistance/hospital care.²⁰

2.5.1. Major advice actions

1. If not breathing, start CPR (ventilations and compressions) immediately.²⁰
2. Consider the use of oxygen and an automated external defibrillator as soon as possible if available.
3. If breathing, stay with victim until help arrives.²⁰
4. Seek medical aid/hospital if any symptoms are present, and for all victims who require resuscitation.²⁰

Summary

Education on how to prevent and to how act when a drowning incident occurs has not been guided by high-level evidence. The concept of having a suggested course of action for drowning is not new, but has never had worldwide acceptance, and never been adopted as a standard of care, instruction or communication.

During the process of establishing a new and universal *Drowning Chain of Survival* the authors faced many challenges. The major issues were: the diversity of how drowning is perceived around the world, the heterogeneity of knowledge, existing drowning response models, how best to reconfigure the chain and the evaluation of compliance with international signage standards so "one shoe could fit all". As work on the model progressed, it became evident that the simpler the message the more acceptable and widely used it would be for different scenarios and levels of rescuer-experience.

The resultant new *Drowning Chain of Survival* does not prescribe specific advice but rather gives general guidance to all involved in preventing or taking action in a drowning incident.

Although a consensus on a new *Drowning Chain of Survival* has resulted from this process, the model still needs to be accepted, used, and validity-tested in different aquatic scenarios and with groups of professionals to lay persons, in HIC and LMIC settings, that may be called upon to respond in an aquatic emergency.

Conflict of interest statement

None declared.

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References

1. Rahman A, Mashreky SR, Chowdhury SM, et al. Analysis of the childhood fatal drowning situation in Bangladesh, exploring prevention measures in low-income countries. *Inj Prev* 2009;15:75–9.
2. WHO/UNICEF. Child injury prevention; 2008.
3. Venema AM, Groothoff JW, Bierens JJLM. The role of bystanders during rescue and resuscitation of drowning victims. *Resuscitation* 2010;81:434–9.
4. Pia F. Observations on the drowning of non-swimmers. *J Phys Educ* 1974;71, 164–67 and 181. Retrieved from <http://www.pia-enterprises.com/Observations.pdf>
5. Szpilman D, Bierens JJLM, Handley AJ, Orłowski JP. Drowning: current concepts. *N Engl J Med* 2012;366:2102–10.
6. Szpilman D, Morizot-Leite L, Vries W, et al. First aid courses for the aquatic environment; section 6(6.7). Resuscitation. In: Joost Bierens, editor. Hand book on drowning: prevention, rescue and treatment. Springer-Verlag; 2005. p. 342–7.
7. Wilson-Saliba L. Does the teaching of water safety and swimming reduce the incidence of death by drowning? World Water Safety, Matosinhos – Portugal; 2007. p. 244. Book of Abstracts. ISBN:978-989-95519-0-9.
8. Field JM, Hazinski MF, Sayre MR, et al. Part 1: Executive summary: 2010 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation* 2010;122(Suppl. 3):S640–56.
9. Deakin CD. Tailoring bystander CPR – a step too far? *Resuscitation* 2012;83:134–7.
10. Quan L, et al. American Red Cross preventative and response chain of survival for drowning. Scientific Advisory Council – Aquatic Sub Council; 2012.
11. Webber J. Surf lifeguard response to drowning: the SENTINEL system revisited. Paper presented at the lifesaving foundation drowning prevention and rescue conference, September, Ireland; 2012.
12. Moran K, Quan L, Franklin R, Bennett E. Where the evidence and expert opinion meet: a review of open-water: recreational safety messages. *Int J Aquat Res Educ* 2011;5:251–70.
13. Langendorfer SJ. Applying a development perspective to aquatics and swimming. In: Kjendlie PL, Stallman RK, Cabri J, editors. Biomechanics and medicine in swimming XI. Oslo: Norwegian School of Sport Sciences; 2010. p. 20–2.
14. Lanagan-Leitzel LK. Identification of critical events by lifeguards, instructors, and non-lifeguards. *Int J Aquat Res Educ* 2012;6:203–14.
15. Water Safety New Zealand. Drowning statistics 1980–2012 where the victim has been attempting to rescue others [Dataset]; 2013. Retrieved from DrownBase™ database.
16. Turgut A, Turgut B. A study on rescuer drowning and multiple drowning incidents. *J Saf Res* 2012;43:129–32, <http://dx.doi.org/10.1016/j.jsr.001201205>.
17. Soar J, Perkins GD, Abbasc G, et al. European Resuscitation Council Guidelines for Resuscitation 2010. Section 8. Cardiac arrest in special circumstances: electrolyte abnormalities, poisoning, drowning, accidental hypothermia, hyperthermia, asthma, anaphylaxis, cardiac surgery, trauma, pregnancy, electrocution. *Resuscitation* 2010;81:1400–33.
18. Szpilman D, Handley A. Positioning the drowning victim. In: Bierens JJLM, editor. Handbook on drowning: prevention, rescue, and treatment. Berlin: Springer-Verlag; 2006. p. 336–41.
19. Kitamura T, Iwami T, Kawamura T, et al. Conventional and chest-compression-only cardiopulmonary resuscitation by bystanders for children who have out-of-hospital cardiac arrests: a prospective, nationwide, population-based cohort study. *Lancet* 2010;375:1347–54.
20. Szpilman D. Near-drowning and drowning classification: a proposal to stratify mortality based on the analysis of 1831 cases. *Chest* 1997;112:660–5.