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Development of In-Water Intervention (IWI) in a Lifeguard Protocol With Analysis of Rescue History

John Hunsucker and Scott Davison

This paper discusses the development and effectiveness of a protocol for lifeguards in enclosed aquatic facilities with special emphasis on scanning, rapid rescue, and applying a resuscitation procedure in the water immediately after contacting a drowning victim. We call this set of procedures In-The-Water-Intervention (IWI). Testing showed abdominal thrusts (ATs) adapted for the protocol were the most effective IWI procedure that could reliably be performed in deep water by 16–18-year-old lifeguards. Data analysis was done on a waterpark attendance of 63,800,000 with 56,000 rescues and 32 respiratory failures including four deaths. This paper concludes that this lifeguard protocol is effective for the environment described in this study. The lifeguard protocol's fatality rate (0.0063 per 100K) is 1.09% of the year 2000 CDC fatality rate for all U.S pools. Only IWI was required to restore spontaneous respiration in 14 (43.75%) of the 32 cases involving loss of spontaneous respiration. In an additional 2 (6.25%) of the 32 cases involving loss of spontaneous respiration, ATs delivered out of the water were all that was required to restore spontaneous respiration.

The individual lifeguard experience has been the basis of many of the procedures found in lifeguarding, but those procedures were generally developed using current practice and experience rather than commonly accepted scientific or engineering principles. The World Congress on Drowning (WCD, 2002) in Amsterdam stated that "Rescue organizations . . . must be encouraged to evaluate the self-rescue and rescue techniques in their training programs in accordance with current scientific data on the effectiveness and efficiency" (WCD, 2002).

The objective of this paper is to describe a procedure that was used to develop the In-Water-Intervention (IWI) component of a systematized lifeguard protocol that can be used by 16–18-year-old lifeguards and then to assess the effectiveness of the protocol using data from rescue history. In-water intervention (IWI) can be defined as applying a resuscitation procedure in the water immediately after contacting a drowning victim. This lifeguard protocol was designed primarily for aquatic facilities such as waterparks, where a successful protocol will either prevent an involuntary submersion or make the incident a short duration (minute or less) submersion. IWI provides lifeguards a tool to help restore spontaneous respiration in

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short-duration submersions before degradation of the respiratory system mandates the use of more advanced life support techniques. This benefits both the Emergency Medical System (EMS) and the hospital Emergency Department (ED) with respect to patient care, because the rapid return of spontaneous respiration for a patient in respiratory arrest would alleviate the need for intubation and cardiopulmonary resuscitation (CPR).

This paper is not a treatment study because the rescue data are, with a few exceptions, limited to short-duration submersions in a guarded, enclosed aquatic facility with a limited number of victims suffering respiratory arrest. This paper also is limited in the time span addressed. The rescue history only has data on what occurred for the time between a drowning victim being identified and Emergency Medical Services (EMS) taking over patient care.

This protocol was developed for an environment where drownings are usually recognized within 30 s and the lifeguard can make contact with the victim within another 20 s or less. It is beyond the scope of this paper to address the question of whether the procedures described should be used outside of an environment where the typical 16–18-year-old lifeguard has few options to aid a drowning victim resume spontaneous respiration as soon as possible. While components of the lifeguard protocol, such as scanning and victim recognition (Hunsucker & Davison, 2008), have a more general application, the full lifeguard protocol was evaluated in this paper only for enclosed aquatic facilities.

Method

The procedure used to develop the in-water-intervention component of the lifeguard protocol depends on the answers to three questions:

Can it be done?

Will it be done?

Is it effective?

Every part of a lifeguard protocol has to answer those three questions in the affirmative. Any action, even if it has a sound theoretical basis, has a much smaller chance of being effective if the lifeguard is reluctant or unable to perform it. This has a profound effect on the reliability of the protocol (Davison & Hunsucker, 2009).

The Lifeguard Protocol

This lifeguard protocol was developed in the mid to late 1990s for the waterpark lifeguard. The protocol described in this paper has six major parts: (a) scanning; (b) victim identification; (c) getting to, moving, and extracting the victim from the water; (d) In-Water Intervention (IWI); (e) Out-Of-Water Intervention (OWI); and (f) aggressive management (National Aquatic Safety Company Staff, NASCO, 2008; see Figure 1). The protocol emphasizes scanning and early victim identification.

The rescue data used in this paper come from rescue reports that were sent to the lifeguard's certification agency (NASCO Website, 2009) between 1999 and 2009. The facilities where these rescues occurred are waterparks located in North America, primarily in the United States. Information was extracted from those

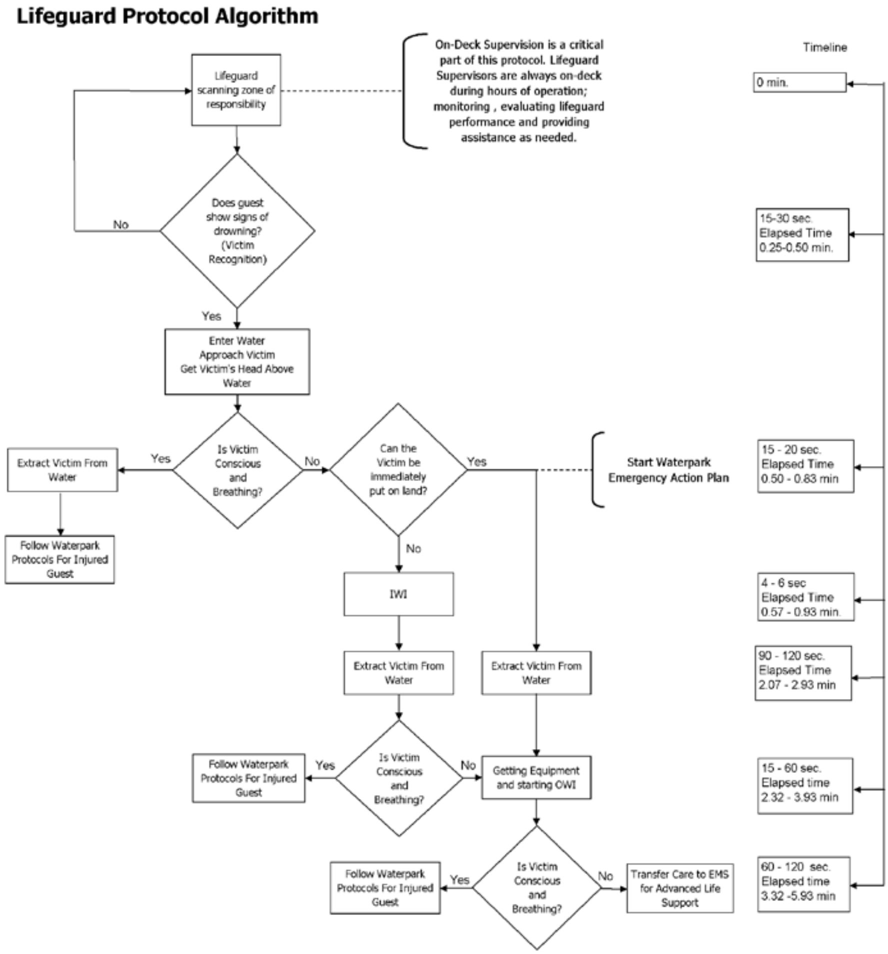

Figure 1 — Lifeguard protocol algorithm. This rescue protocol was designed for use by lifeguards in enclosed aquatic facilities such as swimming pools and waterparks but not for beaches, lakes, or rivers. The time intervals and cumulative times were the results of tests done in the aquatic facilities in the study.

reports and input into worksheets modified from the "Utstein Style for Drowning" (Idris et al., 2003) to standardize the data. The lifeguard certification agency only had access to the victim and scene information and whether Basic Life Support (BLS) techniques were used. The only additional information available was whether the rescue involved a fatality and if the facility saw EMS doing AR, CPR, or defibrillating the victim. It would be up to the EMS service and hospital to provide the Emergency Department Evaluation and Treatment, Hospital Course, and Disposition data.

The following characteristics of the rescue and the aquatic facility environment need to be examined to define the scope of this paper.

1. The lifeguarding took place in an enclosed aquatic attraction, not a natural waterfront. These attractions included shallow water (where a lifeguard can easily stand up) and deep water (where a lifeguard can't easily stand up), often with moving water.
2. Trained lifeguards were on-scene with on-deck supervision available. The lifeguards were usually employed seasonally—100 days or less a year.
3. A large number of swimmers were present with many aquatic facilities having hundreds of thousands of guests in a season (Waterparks.com, 2009) and a large number of rescues, of which only a tiny percentage involved respiratory failure.
4. The drowning victims were often identified within thirty seconds; the lifeguard then made contact with the victim and got their head above water within twenty seconds.
5. The victim was usually uninjured with no underlying medical reasons for the loss of spontaneous respiration.

Protocol Development

Step 1: Define the Environment and Goal. The goal of this lifeguard protocol is to reduce the loss of life due to drowning. One current definition for drowning is ". . . a process resulting in primary respiratory impairment from submersion/immersion in a liquid medium" (Idris et al., 2003). Lifeguards are taught to interrupt drowning as early as possible by starting a rescue. A rescue is an event that requires action by the guard to mitigate an immersion incident.

Step 2: Examine the Theoretical or Scientific Basis for the Protocol. Extensive literature searches showed that relatively little scientific research on aquatic rescue techniques had been published (PubMed, 2009). The literature did support the view that the faster spontaneous respiration can be reestablished, the better the chance for a good outcome and recovery (Szpilman & Soares, 2004). One possible factor for that improved outcome was that in short duration submersion, the victim had not yet begun to breathe liquid or experience cardiac arrest. One description of the drowning process stated, ". . . Breath holding is usually followed by an involuntary period of laryngospasm secondary to the presence of liquid in the oropharynx or larynx. . . . If the victim is not ventilated soon enough . . . circulatory arrest will ensue" (Layon & Modell, 2009).

Step 3: Establish What Actions Are Possible (i.e., Can It Be done?). This is done using experiments and testing. Tests were conducted in guarded aquatic facilities (see Figure 1). The breakdown of these test results showed the following:

1. Victim identification — 15–30 s
2. From chair to having the victim's head above water — 15–20 s
3. From head above the water to extrication and positioned for CPR — 90–120 s
4. Equipment in place — 15–60 s

If Emergency Medical Services were at the facility, they would usually have been called during extrication and typically responded within one to two minutes, though this may be much longer if they were coming from offsite. According to one study, "Among patients with OHCA (Out of Hospital Cardiac Arrest) due to drowning, only one independent predictor of survival was defined, i.e., time from calling for an ambulance until the arrival of the rescue team, with a much higher survival among patients with a shorter ambulance response time" (Claesson, Svensson, Silfverstolpe, & Herlitz, 2008).

The time line (see Figure 1) showed that the time to the first intervention could be significantly reduced (from between 2–4 min to less than 1 min) if an effective IWI could be done when the lifeguard first made contact with the victim. One of the reasons for this is that extricating a victim safely to the deck of an aquatic facility can be complicated, even if they are very close to the deck. If the victim is very large, the deck is high above the water level, the water is deep, or shallow water is far away, extrication may involve 4–6 lifeguards and will take minutes (NASCO Staff, 2008).

At the time this lifeguard protocol was being developed, there were several procedures being used for restoring spontaneous respiration: cardio-pulmonary resuscitation (CPR), artificial respiration with expired breath or bag-valve-mask (AR), and abdominal thrusts (AT). Each protocol was evaluated for its advantages and disadvantages.

CPR Advantages. The full CPR protocol is the most comprehensive intervention available of the Basic Life Support skills available to the lifeguard.

CPR Disadvantages. "CPR- Cardiac compressions while in the water are inefficient, difficult to perform and may delay the rescue process … Therefore, they are not recommended." (Szpilman & Soares, 2004)

Artificial Respiration—Advantages. AR is a robust protocol that is effective under a variety of conditions.

Artificial Respiration—Disadvantages. "Although IWR (In-Water Resuscitation – Artificial Respiration done on a rescue board) seems to be very beneficial, it remains difficult, even for a trained rescuer, to recognize an isolated respiratory failure and to perform mouth-to-mouth ventilation in-water, particularly in deep water. . . . Moreover, many lifeguards are reluctant to perform mouth-to-mouth ventilation . . ." (Szpilman & Soares, 2004).

Abdominal Thrusts—Advantages. AT can easily be performed in either deep or shallow water. Several ATs can be given within a few seconds.

Abdominal Thrusts—Disadvantages. Most clinical evidence only addresses ATs effectiveness in clearing an obstructed airway (Additional concerns are addressed in Step 6.).

Step 4: Determining Whether the Lifeguard Will Perform the Task (i.e., Will It Be Done?). In an aquatic facility, the typical lifeguard is 16–18 years old. Before the season starts, lifeguards pass a swimming test and then receive 20–30 hr of training on physical skills and instruction in a variety of topics (NASCO Staff, 2009). Most lifeguards will typically work one or two seasons.

Research has shown that lifeguards, following a trend even among medical practitioners (Horowitz & Matheny, 1997), are reluctant to perform mouth-to-mouth resuscitation even using universal precautions such as masks and gloves. In investigating immersion fatalities at aquatic facilities other than the ones in this paper, only one time in eleven accident investigations was CPR actually performed by the lifeguard. In the other 10 incidents, they relinquished control to someone else, such as a by-stander or other adult or waited until such a person arrived (Davison & Hunsucker, 2004). In our experience, no lifeguard has refused to administer abdominal thrusts (Davison & Hunsucker, 2004).

Lifeguards are always given a certain amount of discretion with regard to the protocol because a waterpark is a very dynamic environment. Proximity to land, crowds, currents and/or wave action, and other varying conditions can make it advisable to go directly to OWI. The lifeguard always has that option.

Step 5: Choose the Best Technique and Adapt It for Your Environment. Because ATs were the only resuscitation technique that could be used effectively in the water, be easily taught, and had a reasonable expectation that they would be performed by the lifeguard, it was decided to implement abdominal thrusts as the IWI. The AT was adapted for use with the rescue tube (a flexible floatation device) when applied in deep water.

Step 6: Monitor Protocol Results and Environment: Make Modifications as Needed (i.e., Is It Effective?). The results of any lifeguard protocol need to be rigorously examined to make sure the lifeguard protocol is effective. Initial returns from the guarded aquatic facilities were very positive. The protocol was succeeding, but very strong concerns about using abdominal thrusts for drowning then appeared in the literature. These concerns were addressed as follows:

1. There is no clinical evidence ATs are effective in resuscitating drowning victims (Layon & Modell, 2009).

   The early rescue history results from short-submersion rescues that used ATs were very positive. The incident reports were very carefully analyzed to be sure that drowning victims who received this protocol were responding favorably. There are several possible factors that may have led to this finding.

   Abdominal thrusts lift the diaphragm and force enough air from the lungs to create an artificial cough (American Heart Association, AHA, Heimlich Maneuver, 2009). This increases the internal airway pressure (Langhelle, Sunde, Wik, & Steen, 2000) and might help break up the laryngospasm that has been described as part of the drowning process (Layon & Modell, 2009). Some medical evidence exists to support this view (Milstein & Goetzman, 1977). Recent animal experiments have shown that ATs may have the potential of being as effective as AR and CPR in ventilating and circulating blood (Pargett, Geddes, Otlewski, & Rundell, 2008). Research in this area should be carefully monitored for its application to drowning. Intense fear might contribute to respiratory failure due to over activity of the sympathetic limb of the autonomic nervous system (Samuels, 2007). An aware victim who is in respiratory arrest might respond positively to abdominal thrusts when being rescued and resume respirations.

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Obviously a treatment study would be necessary to pinpoint the mechanism that is involved, but that is outside the scope of this paper. It should also be pointed out that the drowning victim the lifeguard encounters during a short-submersion drowning may be very different than what the health professional will see in the hospital from a long-submersion drowning and that the techniques that can be used by a 16-year-old lifeguard in deep water will be very different than those available to health providers with advanced medical equipment, advanced medical training, and a controlled environment.

2. CPR is delayed.

While the concern that CPR is delayed is true, other aspects need to be considered. Testing has shown that the time needed to do five abdominal thrusts in the water is four to six seconds. It was felt that if there was a good possibility that respiration could be restored before further degradation of the respiratory and circulatory systems occurred, the four to six second delay was justified. This issue was addressed by emphasizing that five and only five abdominal thrusts were to be quickly administered and then the victim was to be taken immediately to a place where they could be extricated from the water for additional care. As previously stated, animal studies show that ATs may also aid in providing circulation (Pargett, Geddes, Otlewski, & Rundell, 2008).

3. The victim will vomit.

The concern for vomiting is also true, but again, other aspects need to be considered. Vomiting is a concern when any form of resuscitation is performed. One study showed that 86% of people receiving CPR and 68% receiving AR vomited (ILCOR, 1997). The authors reasoned that if there was a good chance that respiration could be restored before AR or CPR was needed, the possibility of issues arising from vomiting was justified. To address the concerns about vomiting, the lifeguard only applies ATs once they have the victim in a stable, upright posture in the water with the victim's head angling slightly forward and above the water. The lifeguard uses a rescue tube for floatation in deep water. It is noteworthy that none of the rescues examined in this paper reported vomiting as an issue in preventing restoration of respiration.

4. The victim may be injured by abdominal thrusts.

We realize the risk of injury associated with abdominal thrusts, but the possibility of ancillary injuries from any medical procedure does not necessarily reduce the need for that procedure. One study of injuries associated with CPR shows that fractures of the ribs and sternum can be as high as 95% (Lederer, Mair, Rabl, & Baubin, 2004). Reported complications from ATs are rare and usually attributed to performing the procedure incorrectly (Lee, Kim, Shekherdimian, & Ledbetter, 2009). The authors felt that if there was a good chance that respiration could be restored, the risk of injuries associated with ATs was balanced by the benefits. To address the concern about injuries, lifeguards are trained to apply five and only five abdominal thrusts according to established guidelines with the correct pressure, hand placement, and thrust direction. None of the rescues in this paper reported any injuries from using ATs.

This lifeguard protocol started to be used in the mid 1990s, and by 1998 had been modified to address many of the concerns that had appeared in the literature. This paper refers to the mature protocol resulting from 15 years of experience. There are always unresolved issues with any protocol, but one often has to implement a protocol in the manner that experience determines is best. For example, the American Heart Association Emergency Cardiovascular Care Committee used this approach when they commented on their decision to recommend Compression-Only CPR in 2008. "After careful consideration, weighing all the known evidence, and considering the many unanswered questions, The ECC Committee held that the likely advantages in favor of this recommendation outweigh the possible disadvantages" (Sayre et al., 2008).

Results

The guarded aquatic facilities reported in this paper had approximately 63,800,000 attendance, 56,000 rescues, and 32 respiratory failure rescues including four fatalities (0.0063 per 100,000 guests) during the reporting period (see Table 1). Two of the fatalities were long immersion drownings (records 19 and 25 in Table 2). In the short-immersion fatalities, one lifeguard did not use IWI (record 3) and the other lifeguard used IWI. The rescue using IWI (record 10) could not establish an open airway and even two paramedics who were on scene at extrication were unable to do so. These results can be compared with the 1983 drowning rate of guarded public pools in Texas of 0.7 fatalities per 100,000 (Hunsucker, 1983) and the CDC drowning data that shows approximately 0.62 fatalities per 100,000 in pool usage (based on all pool drownings, both guarded and unguarded, being 50% of all drowning in the U.S. and the 2000 drowning rate being 1.24 per 100,000; Layon & Modell, 2009). The drowning rate shown in this paper for this protocol was 0.0063 per 100,000 (see Table 1). If the more conservative CDC rate is used, that means that the drowning rate for guarded aquatic facilities where the protocol is in effect is only 1.02% of the drowning rate for all U.S. pools in 2000.

Detailed information about each rescue has been provided in Table 2. The data were indexed (see Table 3 for Indices) for two reasons: The first reason is that information taken in the prehospital environment is often imprecise (e.g., the submersion time). It is more accurate to report a range of values. The second

Table 1 Cumulative Data From Selected Facilities Over Study Period

	Units	Per 100K
Number of guests	63,800,000	
Number of rescues	56,000	87.8000
Number of rescues where there was respiratory failure	32	0.0500
Number of fatalities	4	0.0063

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Table 2 Rescue Data for Rescues Involving Respiratory Failure

1	2	3	4	5	6	7	8	9
Rescue Number	**Gender**	**Age**	**Depth**	**Length of Submersion**	**IWI OWI**	**Type of Intervention**	**Neuro**	**Outcome**
1	F	5	4	3	1	4	3	1
2	M	1	2	1	2	2	1	1
3	M	1	1	1	2	3	3	2
4	F	5	2	1	1	1	1	1
5	F	3	2	1	2	3	1	1
6	M	3	2	1	1	1	0	1
7	M	5	2	1	1	1	1	1
8	M	5	4	1	2	1	1	1
9	M	3	2	1	1	2	1	1
10	M	6	3	1	1	4	3	2
11	M	4	4	1	2	2	0	1
12	M	5	3	1	1	1	1	1
13	M	1	1	2	2	2	1	1
14	U	1	1	1	1	1	1	1
15	F	3	3	1	1	1	1	1
16	M	6	2	1	2	1	1	1
17	F	3	2	1	1	1	1	1
18	M	4	2	1	1	1	1	1
19	M	4	4	4	2	3	3	2
20	F	3	2	1	1	2	1	1
21	M	2	2	1	1	2	0	1
22	M	1	2	1	1	1	1	1
23	F	4	3	1	1	1	1	1
24	F	3	1	1	2	2	1	1
25	F	4	4	4	0	0	3	2
26	M	6	2	1	1	1	1	1
27	M	1	1	1	2	2	1	1
28	M	3	2	1	1	1	1	1
29	F	4	3	1	1	2	1	1
30	M	3	2	1	2	1	1	1
31	F	4	2	1	1	1	1	1
32	F	3	3	1	1	1	1	1

Note. The data in Table 2 has been randomized chronologically for confidentiality. Column 1 is a rescue number. Column 2 shows gender. Column 3 shows age category by index. Column 4 shows the depth category by index. Column 5 shows the length of submersion by index. Column 6 shows whether the first intervention was in the water or out of the water by index. Column 7 shows the highest level of intervention by index. Column 8 shows the Conn Drowning Coma Scale (ABC) by index. Column 9 shows the outcome by index. See Table 3 for index key.

reason is that spreadsheet analysis often is more straightforward. A major result from the rescue data was apparent when columns 5, 6, 7, and 9 all show an index of 1. This meant that spontaneous respiration was restored in short-term submersion drownings by IWI alone in 14 out of 32 (43.75%) rescues. The neurological outcome was Alert in 24 cases out of 32 (75%).

Table 4 shows the highest level of intervention that was used. It shows that abdominal thrusts were all that was required in over half of the incidents (17 out of 32). In three of these cases, IWI was not performed and the thrusts were done on the deck as the obstructed airway portion of the CPR protocol (AHA, 2005).

Discussion

The findings from the rescue history data and early testing of the protocol alternatives need to be applied to the three questions to do an evaluation.

Could It Be Done?

Extensive experiments and tests during the development cycle showed that the full lifeguard protocol, including the abdominal thrusts used in the IWI portion of the lifeguard protocol, can be quickly done by the typical lifeguard. Alternative procedures were examined and found to have major problems when being performed in deep water.

Would the Protocol Be Followed?

The protocol was followed approximately 56,000 times up to the point where the lifeguard made contact with the victim and found them conscious and breathing. The protocol where the victim was not breathing was followed 30 times. The protocol was not followed in the two long-term submersions because the lifeguard did not see the victim.

Was the Protocol Effective?

The fatality rate for the facilities using this protocol was only 1.02% of all U.S. pools in 2000. In addition, the percentage of rescues where the victim resumed spontaneous respiration was 87.5% with 28 out of the 32 rescues and the percentage of rescues where the neurological rating was Alert was 75% with 24 out of 32 rescues. This showed that the lifeguard protocol with IWI was very effective. Again, it must be emphasized that effectiveness values were for the entire lifeguard protocol as used in an enclosed aquatic facility with lifeguards who were trained in a protocol that emphasized scanning and early victim identification, not for abdominal thrusts alone.

Conclusions

The results of this paper lead the authors to two major conclusions. First, the protocol was effective in reducing the loss of life due to drowning. The fatality rate for this protocol was only 1.02% of the fatality rate for all U.S. pools in 2000. Second, IWI

Table 3 Index Key for Rescue Data

Table 2 Column	3	4	4	5	6	7	8	9
Index	**Age (yrs)**	**Depth (m)**	**Depth (ft)**	**Length of Submersion (min)**	**IWI OWI**	**Type of Intervention**	**Neuro**	**Outcome**
0	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
1	1, 2, 3	(0, 0.91)	(0, 3)	(0, 1)	IWI	Abdominal Thrusts	Alert	Alive
2	4, 5	(0.91, 1.52)	(3, 5)	(1, 3)	OWI	AR/Mouth/Mask/BVM	Blunted	Deceased
3	6–12	(1.52, 2.13)	(5, 7)	(3,5)		Chest Compressions	Comatose	
4	13–18	(2.13, -)	(7, -)	(5, -)		AED		
5	19–40							
6	40–60							

Note. Directions for use: Look at the information on a rescue number line in Table 2 and use the index key to translate. For example: Rescue number 29 was an adolescent female found in 5–7 feet of water and contacted by the lifeguard within 1 min of submersion. Her first intervention was IWI, but she also needed AR. She survived the drowning and was alert at the end of the rescue.

Table 4 Highest Level of Intervention For Rescues Involving Respiratory Failure

Intervention	Count	Percent
Unknown	1	3.13%
Abdominal thrusts	16	50.00%
AR/mouth/mask/BVM	10	31.25%
Chest compressions	3	9.38%
AED	2	6.25%

made a contribution to the lifeguard protocol. Of the 32 rescues where respiratory failure occurred, 14 (43.75%) responded positively to IWI alone by regaining spontaneous respiration, and 28 (87.5%) responded positively to a combination of IWI and OWI by regaining spontaneous respiration. There were no reports of injuries from ATs, resuscitation complications arising from vomiting, or delays that would have affected the implementation of CPR. Again, the authors caution the reader that these results were for enclosed aquatic facilities with a highly trained group of lifeguards using a protocol that emphasized scanning and early victim identification.

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