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In-water resuscitation—is it worthwhile?☆

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Abstract

Objectives: Until now, there is no solid information indicating the best option of rescuing a non-breathing drowning victim in the water. Our objectives were to compare the outcomes of performing immediate in-water resuscitation (IWR) or delaying resuscitation until the victim is brought shore. *Material and methods:* A retrospective data analysis was conducted of non-breathing drowning victims rescued by lifeguards in the coastal area of Rio de Janeiro, Brazil. Patients were coded as IWR and no-IWR (NIWR) cases based on the lifeguard's decision whether to perform IWR. Death and development of severe neurological damage (SND) were considered poor outcome. *Results:* Forty-six patients were studied. Their median age was 17 (9–31) years. Nineteen (41.3%) patients received IWR and 27 (58.7%) did not. The mortality rate was lower for IWR cases (15.8% versus 85.2%, $P < 0.001$). However, among surviving IWR cases, 6 (31.6%) developed SND. In multivariate analysis, higher age [odds ratio (OR) = 1.12 (95% confidence interval (CI) = 1.01–1.2400), $P = 0.038$] was associated with death, while IWR [OR = 0.05 (95% CI = 0.01–0.50), $P = 0.011$] was protective. When death or the development of SND was set as the dependent variable, longer cardiopulmonary arrest (CPA) duration was the unique variable selected (OR = 1.77 (95% CI = 1.13–2.79), $P = 0.013$]. Every patient with CPA duration higher than 14 min had poor outcome. *Conclusions:* Delaying resuscitation efforts were associated with a worse outcome for non-breathing drowning victims. In the cases studied, IWR was associated with improvement of the likelihood of survival. An algorithm was developed for its indications and to avoid unnecessary risks to both victim and rescuer.

Keywords: Out-of-hospital CPR; Mouth-to-mouth resuscitation; Outcome; Respiratory arrest; Drowning; Cardiopulmonary resuscitation (CPR)

1. Introduction

Whenever an apparently non-breathing victim is found in the water, the rescuer is confronted with a difficult choice. Should the rescuer attempt resuscitation procedures in the water or first take the time to bring the victim to shore, and then attempt resuscitation? The hypoxia caused by water aspiration from immersion or submersion results in respiratory arrest [1–4]. When respiratory arrest is not corrected, it is followed by cardiac arrest within a variable, but short interval, influenced by water temperature [1,3–8], victim's physical condition [1,3,8], previous hypoxia [1,3,4,7,8], emotional state [3,8], and associated diseases [1,3,4].

In a drowning [9], hypoxic injury continues after the drowning event if the victim does not resume spontaneous breathing. Thus it follows that the sooner effective resuscitation is initiated, the less hypoxic injury will be incurred, resulting in improved outcome. Generally, resuscitation efforts have been shown to result in a lower death rate if respiratory arrest is corrected prior to cardiac arrest onset (0–44% versus 33–93%) [1,3,4]. In the water, cardiac compression is ineffective and pulse checks are unreliable [1,2]. Attempt to ventilate a non-breathing drowning victim in deep water using a rescue board (a surfboard designed for water rescue) was first demonstrated in Australia, by Surf Life Saving New Zealand in 1975 [2]. This procedure was denominated in-water resuscitation (IWR). In 1978, during a World Lifesaving-Medical Conference held in California, there was expert consensus that artificial ventilation with the aid of a

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flotation device should be employed whenever a delay in removing a non-breathing victim from the water could be anticipated [2]. No successful IWR had been reported until 1981 [2]. Although several lifesaving organizations worldwide have been teaching IWR, this recommendation has, so far, been supported by weak scientific evidence [1,2].

It can be hypothesized that if a rescuer who recovers a non-breathing drowning victim offshore immediately initiates in-water resuscitation by providing ventilation, survivability and outcome for the victim would improve. The objective of the present study was to assess the value of attempting IWR versus delaying resuscitation maneuvers until the drowning victim is rescued to the shore or pool deck. With these data in perspective, we sought to identify variables associated with a poor outcome to refine indications for performing IWR.

2. Material and methods

2.1. Setting

The coastal area of Rio de Janeiro is 90 km in length and falls under the authority of the Rio de Janeiro Rescue Service. Data collection was restricted to 55 km of coastline. In the studied area, beach attendance is sometimes estimated at 1.4 million persons during a single day. Seawater is warm throughout the year with an average temperature of 20 °C (68 °F) that encourages year-round beach use.

2.2. Lifeguard and medical assistance

Lifeguards are responsible for the initial evaluation and immediate resuscitation measures, including basic cardiopulmonary resuscitation (CPR). When a rescue involves resuscitation, lifeguards immediately contact a Drowning Resuscitation Center (DRC). The DRC is a pre-hospital facility located at three strategically sites on the Rio de Janeiro beaches to render specialized medical assistance to drowning victims. A medical team (a physician and a paramedic) is dispatched to the scene from the DRC via an advanced life support ambulance or helicopter. A medical examination is conducted at the accident scene and, whenever feasible, medical equipment is carried to the victim to save precious time. Advanced resuscitation procedures are usually accomplished onshore near the accident site. Life support measures follow American Heart Association and International Liaison Committee on Resuscitation protocols for drowning resuscitation [10,11]. During transportation to the DRC, medical examination and treatment are continuously reassessed and modified as necessary. The decision to cease CPR maneuvers is made exclusively by the medical team, and only after the victim has been brought to a core temperature of at least 35 °C with a systole on the ECG monitor. Patients remain at the DRC until clinical stabilization is achieved allowing for their release to home, referral to a hospital or until being considered dead. Detailed reports are completed by the lifeguard and the DRC medical staff.

2.3. IWR procedures

Lifeguards have been taught to perform IWR since 1993 and are annually trained in possible indications and procedures. Since IWR is not supported by a high level of medical evidence, they are encouraged to provide IWR, but there are no specific guidelines. Lifeguards are given the prerogative of deciding whether to attempt IWR. This decision takes into account weather (including water) conditions and the victim's distance from shore, as well as the lifeguard's fitness, experience and self-confidence that IWR can help the victim. After confirmation of unconsciousness and non-breathing, the lifeguard choosing to employ IWR usually attempts it immediately. However, even trained lifeguards cannot always accomplish this difficult technique effectively, especially in deep water.

IWR is performed by providing ventilation (into the water) during the rescue. Cardiac compressions while in the water are inefficient, difficult to perform and may delay the rescue process [1,2]. Therefore, they are not recommended. The technique for this procedure varies for different water depths (Fig. 1). The rescuer should have high suspicion for a back or neck injury, especially in shallow water. If spontaneous breathing is restored, the victim should be kept under strictly observation during the rescue, since within the first 5–10 min the victim could cease breathing again [1].

2.4. Selection of participants, data collection, and processing

From January 1995 to December 2000, all patients referred to a DRC with a diagnosis of drowning requiring medical assistance were retrospectively analyzed by reviewing lifeguard and DRC reports. In addition, the charts of those patients transferred to a hospital were also reviewed. From all cases assisted in a DRC, those reported to have been found unconscious (no-movement) and non-breathing were selected. Patients were excluded when there was no resuscitation attempt in or out of the water by the lifeguard based on submersion duration longer than 1 h or obvious physical evidence of death (rigor mortis, putrefaction or dependent lividity). The following data were collected: gender; age; type of water (salt or fresh); number of lifeguards involved in the rescue; depth of water at the rescue site [deep (rescuer cannot stand up) or shallow (rescuer can stand up)]; use and type of lifesaving equipment; in-water evaluation report (conscious or unconscious, checking for spontaneous breathing and carotid pulse); patient position on sloping beaches for first attendance [head lower than trunk (HD) or head and trunk at the same level (HT)]; any further resuscitation procedure needed onshore; presence of vomiting; estimated cardiopulmonary arrest (CPA) duration (elapsed time since submersion to the start of artificial ventilation); CPR dura-

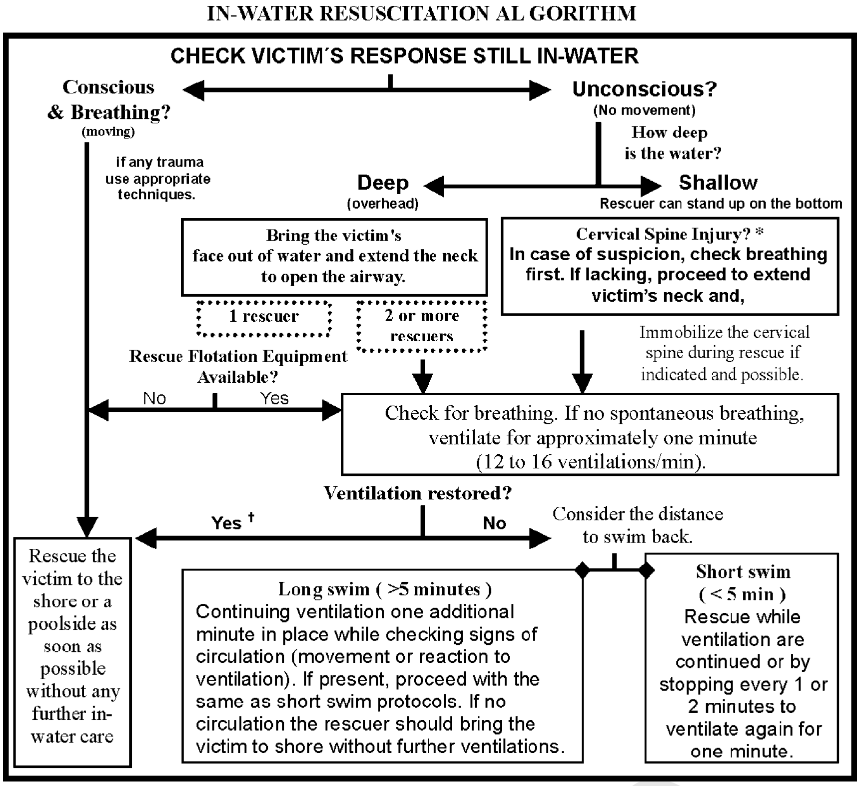

Fig. 1. Recommendations for in-water resuscitation—if breathing is not restored after 1 min of ventilation in shallow water, proceed with short swim procedure. (*) In-water cervical immobilization is indicated in a victim who is highly suspected of trauma, or is in trouble in shallow water for unknown reasons. In unconscious victims the time spent on immobilizing the cervical spine could lead to a cardiopulmonary deterioration and even death. Routine cervical spine immobilization of all water rescues, without reference to whether a traumatic injury was sustained, is not recommended [19]. (†) If ventilation is restored proceed rescuing without any further care other then a quick stop to monitor breathing and restart mouth-to-mouth if necessary.

tion (elapsed time since the start of CPR maneuvers to the restoration of heartbeats or the decision to cease the resuscitation) and ambulance response time. Patients were also excluded in the case of missing essential data. They were coded as IWR and no-IWR (NIWR) cases based on the lifeguard's decision whether to perform this procedure.

2.5. Outcome measures

Mortality (from the scene to the hospital discharge) and neurological function on 30-day (whether in-hospital or not) were the outcomes of interest. Death and severe residual neurological damage (SND) were considered poor outcome. SND was defined as the development of cerebral death (isoelectric trace on electroencephalogram with no other cause associated), persistent vegetative state (no relationship with the environment, coma vigil), and severe neurological sequels (need of assistance for basic and daily activities). Survival without neurological sequels was considered good outcome.

2.6. Statistical analysis and data presentation

Data were analyzed using statistical software SPSS for Windows, version 10.0 (SPSS Inc., Chicago, IL). Continuous variables were reported as medians (interquartile range) and compared by the Mann–Whitney *U*-test. Categorical variables were reported as absolute numbers (frequency percentages) and analyzed by Fisher's exact test or Chi-square test (with Yates correction where applicable). The main outcomes were set as binary. Multivariate logistic regression analyses were used to assess the independent association between the dependent variables and those variables selected in the univariate analyses (P-value < 0.1). The potential associations were summarized by calculating odds ratios (OR) and corresponding 95% confidence intervals (CI). A receiver operating characteristic (ROC) curve was constructed to determine the discriminative power [assessed by area under ROC curve (AUROC)] [12] and a cutoff point for continuous variables found to be related to a specific outcome. A two-tailed P-value < 0.05 was considered statistically significant.

3. Results

Out of 29,972 rescues made by lifeguards, 469 (1.6%) cases involved a drowning requiring medical assistance and referral to a DRC. Of these cases, 86 were reported to be found unconscious and non-breathing in the water.

Table 1
Main characteristics related to patient rescue and assistance ($n = 46$)

Variables	NIWR group; $n = 27$ (58.7%)	IWR group; $n = 19$ (41.3%)	P-value
Lifeguards involved in the rescue			NS
One	16 (59.3%)	8 (42.1%)	
More than one	11 (40.7%)	11 (57.9%)	
Deep of water			NS
Deep	17 (63.0%)	12 (63.2%)	
Shallow	10 (37.0%)	7 (36.8%)	
Lifesaving equipment use (yes vs. no)			NS
No	11 (40.7%)	4 (21.1%)	
Yes	16 (59.3%)	15 (78.9%)	
Ignored	0	1	
In-water evaluation (any vs. no evaluation)			<0.001
Breathing	0	14 (73.7%)	
Breathing and circulation	0	5 (26.3%)	
No evaluation	27 (100%)	0	
First position on shore			NS
HD	9 (33.3%)	5 (26.3%)	
HT	18 (66.7%)	14 (73.7%)	
Procedure done on shore or pool deck (any vs. none)			<0.001
CPR	27 (100%)	8 (42.1%)	
Mouth-to-mouth	0	2 (10.5%)	
None	0	9 (47.4%)	
Vomit	9 (33.3%)	5 (26.3%)	NS
Ambulance response time (min)	12 (9–15)	11 (9–12)	NS
Estimated CPA duration (min)[a]	19 (9–30)	7 (5–10)	0.002
Estimated CPR duration (min) ($n = 35$)[b]	28 (18–53)	12 (1–32)	0.001

IWR indicates in-water resuscitation; NIWR, no in-water resuscitation; CPA, cardiopulmonary arrest; CPR, cardiopulmonary resuscitation; NS, non-significant ($P > 0.05$).

[a] Submersion and rescue time without ventilation.

[b] Includes all CPR cases at a dry place and excludes 11 IWR cases (two needed only ventilation onshore and nine needed no other procedure than IWR).

Twenty-eight patients were excluded for missing essential data: estimated CPA time ($n = 14$), outcome measures ($n = 9$), and both ($n = 5$). Twelve patients were excluded because the lifeguard(s) made no resuscitation attempt. Thirty-nine (97.5%) excluded patients died. There were no significant differences between excluded and included patients with respect to gender, age, type of water, and ambulance response time. Therefore, the remaining 46

Table 2
Outcome evaluation for IWR and NIWR cases ($n = 46$)

	NIWR group ($n = 27$)	IWR group ($n = 19$)	P-value
Pre-hospital outcome (death vs. survival)			0.001
Death	17 (63.0%)	1 (5.3%)	
Survival	10 (37.0%)	18 (94.7%)	
Hospitalization	8	16	
Released home	2	2	
Hospital outcomes			0.005
Death	6 (75.0%)	2 (12.5%)	
Survival with severe residual neurological damage	2 (25.0%)	6 (37.5%)	
Survival without sequels	0	8 (50%)	
Final outcome (poor outcome vs. good outcome)			0.001
Poor outcome	25 (92.6%)	9 (47.4%)	
Death	23	3	
Survival with severe residual neurological damage	2	6	
Severe neurological sequels	2	2	
Persistent vegetative state	0	4	
Cerebral death	0	0	
Good outcome (survival without sequels)	2 (7.4%)	10 (52.6%)	

IWR indicates in-water resuscitation; NIWR, no in-water resuscitation.

Table 3
Univariate analyses for the variables associated with death and death or severe neurological damage

Variables	Death		Death or severe neurological damage	
	Odds ratio (95% CI)	*P*-value	Odds ratio (95% CI)	*P*-value
Age (years)	1.08 (1.02–1.15)	0.013	1.05 (0.98–1.12)	NS
Male sex	1.35 (0.24–7.55)	NS	0.53 (0.05–5.03)	NS
In-water resuscitation	0.03 (0.01–0.17)	<0.001	0.047 (0.01–0.39)	0.001
Lifeguards ($n > 1$)	0.86 (0.27–2.75)	NS	1.40 (0.37–5.29)	NS
Use of lifeguard equipment	0.76 (0.22–2.68)	NS	0.58 (0.13–2.58)	NS
Deep water	1.84 (0.55–6.19)	NS	1.31 (0.34–5.03)	NS
HT position on shore	0.40 (0.10–1.54)	NS	0.15 (0.02–1.27)	0.073
Presence of vomiting	1.59 (0.43–5.80)	NS	2.73 (0.51–14.53)	NS
Salt water	2.36 (0.56–9.87)	NS	2.33 (0.53–10.35)	NS
Estimated CPA duration (min)	1.17 (1.04–1.31)	0.008	1.42 (1.07–1.89)	0.016
Estimated CPR duration (min)	1.07 (1.02–1.13)	0.005	1.13 (1.03–1.23)	0.007

HT indicates head and trunk at the same level; CPA, cardiopulmonary arrest; CPR, cardiopulmonary resuscitation; NS, non-significant ($P > 0.1$).

cases were included in the final analyses. Their median age was 17 (9–31) years and there were 40 (86.9%) males.

IWR was performed in 19 (41.3%) patients (IWR group). In 27 (58.7%) patients (NIWR group), resuscitative efforts were started only upon rescuing the victim to shore. Age and gender were similar for both groups. Median estimated CPA and CPR durations were significantly greater for NIWR cases than for IWR cases. As expected, in-water evaluation was carried out more often in IWR than NIWR cases. Main characteristics related to patient rescue and assistance is shown on Table 1.

At the scene, 18 (39.1%) patients died, 24 (52.2%) were referred to a hospital, and four (8.7%) were released to home. Out of the 24 patients referred to a hospital, eight (33.3%) died. IWR cases were more successfully released to home or transferred to a hospital than NIWR cases. Both pre-hospital and hospital mortality rates were significantly lower for IWR than for NIWR cases. Although overall neurological outcome was also better for IWR cases, six (31.6%) IWR patients developed SND. Detailed outcome evaluation is presented on Table 2.

The results of univariate analyses are depicted on Table 3. Higher age and both estimated CPA and CPR durations were associated with death and IWR was protective. In multivariate analysis, IWR [odds ratio (OR) = 0.05 (95% CI = 0.01–0.50), $P = 0.011$] and higher age [OR = 1.12 (CI 95% = 1.01–1.24), $P = 0.038$] were selected. When death or the development of SND (poor outcome) was set as the dependent variable, higher CPA duration was the unique independent factor [OR = 1.77 (95% CI = 1.13–2.79), $P = 0.013$]. An ROC curve was constructed to determine the ability for CPA duration to discriminate patients with good and poor outcomes. The AUROC was 0.881 ± 0.057 (95% CI = 0.769–0.992) and every patient with a CPA time higher than 14 min died or developed SND.

4. Discussion

This study demonstrates, for the first time, that IWR may result in a significant outcome improvement for severe drowning victims. It further confirms that estimated CPA duration is a crucial parameter to be taken into account when deciding to start any resuscitation efforts either in-water or not. This early intervention in the water can be expected to reduce death and SND rates by saving precious time during the rescue.

Patients receiving IWR had lower scene and in-hospital mortality rates than those who did not. They were less likely to require full CPR or any additional resuscitation procedure than IWR. They were also more likely to be successfully transferred to a hospital (if that transfer was necessary). In multivariate analysis, IWR was associated with a significant reduction of the probability of death. Nonetheless, although most patients receiving IWR had good outcomes, about one-third of them developed SND. The small sample size did not allow evaluation of factors related to the development of SND in surviving patients ($n = 8$), so we decided to set death or the development of SND as a new binary dependent variable. A higher estimated CPA duration was selected in the logistic regression and this variable showed a very good accuracy in predicting these poor outcomes. However, of great concern was the cutoff point found, in which every patient with CPA duration greater than only 14 min died or developed SND. In drowning, submersion duration has been reported to figure among the most powerful outcome predictors [1,3,6,13–17]. A study by Quan and coworkers [18] found that the higher the submersion duration, the greater the frequency of death and SND, as follows: 0–5 min, 10%; 5–10 min, 56%; 10–25 min, 88%; >25 min, 100%. The longer it takes from recognition that someone has submerged to the start of IWR or the victim's rescue to shore, the worse the outcome [19]. Besides submersion and CPA times, water temperature is another important factor that should influence the decision to begin IWR. Small children were reported to survive after submersion in icy water for more than 1 h [20]. However, in icy waters in-water rescue attempts are impractical and resuscitation should be started as early as it can be effectively accomplished after rescue. Water temperature was not considered in our study because seawater in the study area is warm throughout the year.

Interestingly, higher age was also independently associated with death and, in fact, patients with a favorable outcome were younger. It is well known that older patients tend to have a reduced functional capacity and a higher number of comorbidities that may worsen the probability of a successful resuscitation [21]. Nonetheless, our patients were too young, mostly children or adolescents, and probably these explanations were not associated with our results.

Although IWR seems to be very beneficial, it remains difficult, even for a trained rescuer, to recognize an isolated respiratory arrest and to perform mouth-to-mouth ventilation in-water, particularly in deep water. Several factors can interfere with this decision, such as: water surface conditions, depth of water, distance to shore, availability of lifesaving equipment, and victim characteristics (obesity, high suspicion of neck or facial trauma). In our study, position of the patient on shore and presence of vomiting that might be expected to influence outcome [1,3], did not. However, we observed trends in the decision whether to attempt IWR when there was more than one rescuer and when lifesaving equipment was available. The small sample size might also have limited these evaluations. Moreover, many lifeguards are reluctant to perform mouth-to-mouth ventilation without a barrier device to minimize the risk of communicable disease. Nevertheless, the use of a barrier device in-water adds a complicating element to an already difficult maneuver. While lifeguards should be provided with this option, they should also be advised of the extremely low chance of contracting a communicable disease via mouth-to-mouth ventilation, especially in water where fluids are continually flushed [22].

Our study has substantial limitations. First, it was based on a retrospective data assessment and, consequently, 28 (32.6%) patients were excluded due to missing data. Since the mortality rate for excluded cases was higher than for included ones, we cannot rule out the possibility that a selection bias caused us to study cases that had been rescued more appropriately. Second, it was not possible to assess some variables related to patient characteristics (body mass, for example), beach conditions, rescue site, as well as factors such as lifeguard experience and self-confidence in the rescue, any of which could potentially affect the decision to offer IWR. Therefore, we cannot exclude a bias has occurred because lifeguards were given the prerogative of deciding whether to attempt IWR or not.

5. Conclusions

In retrospect, increasing attention must be given to the pre-hospital rescue of severe drowning victims because of the potential to save lives in this setting. IWR may be a promising intervention to this finality. Although IWR cases had a lower death rate and were more prone to have a favorable recovery, the possibility of resuscitating a person who subsequently develops persistent SND is worrisome. Higher CPA duration was independently associated with poor outcome, however further research is needed to guide the decision whether to offer resuscitation after 14 min of CPA, especially in warm water. Otherwise, it is reasonable to recommend IWR if the CPA duration is less than 14 min or is unknown. In addition, remaining in hazardous water conditions (e.g. high seas) to perform IWR can endanger rescuers. Given the hazards of IWR, it seems reasonable to consider developing guidelines to avoid unnecessary risks to both victim and rescuer. An algorithm was developed to assist in on-scene decision-making (Fig. 1). This algorithm may also be useful to the design of further prospective randomized studies necessary to clearly define the best option of rescuing a non-breathing drowning victim.

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