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SCIENTIFIC REVIEW

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Sub-Diaphragmatic Thrusts and Drowned Persons

**Advisory Council on First Aid, Aquatics, Safety,
and Prevention (ACFASP)
American Red Cross
Scientific Review**

(Triennial Re-Evaluation – June, 2009)

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Peter G. Wernicki, M.D., David Markenson, M.D.**

Questions to Be Addressed

After removing a person in respiratory or cardiac arrest from the water, what is the first step a first responder should carry out?

Introduction/Overview

The International Liaison Committee on Resuscitation (ILCOR) conducts a scientific evidence review and the American Red Cross (ARC) uses this review as one of the sources to provide Guidelines for Emergency Care and Education. These reviews and guidelines apply, but are not limited, to people in respiratory or cardiac arrest.

The 2005 Guidelines for Emergency Care and Education state if a person is in cardiac arrest, the rescuer should begin CPR immediately. If after repositioning the patient's airway, ventilation efforts are not effective, the rescuer should try to clear the airway by using age-appropriate methods for relieving a solid foreign body airway obstruction. The ILCOR evidence evaluation is supported by multiple professional and scientific organizations including the American Academy of Pediatrics, the American College of Cardiology, the American College of Emergency Physicians, and the Institute of Medicine of the National Academy of Sciences.

Despite consensus, which is part of the ILCOR scientific evidence review process, Henry J. Heimlich MD, has advocated that when treating drowned persons, subdiaphragmatic abdominal thrusts should be tried before CPR is given. Dr. Heimlich asserts aspirated water obstructs the patient's airway and significantly hinders ventilation of the lungs. He argues subdiaphragmatic abdominal thrusts will relieve the alleged airway obstruction, remove water from the patient's lungs, and should be continued until no water or fluid flows from the patient's mouth.

Review Process and Literature Search Performed

The titles and abstracts of 128 citations were retrieved using a computerized search of the National Library of Medicine Medline database from 1966 to 2009. MeSH heading combinations of “drowning” or “near-drowning:” with “Heimlich maneuver” were used as search features. The abstracts of all citations were analyzed and those suitable for full review were obtained. Manual search of the reference lists from these articles was also conducted for added relevant citations. This process resulted in the review of 37 citations of which 18 (all class III) were found to discuss the role of the Heimlich maneuver to treat drowned people.

a. Original ACFAS Scientific Review (2000)

Heimlich states that drowned persons aspirate large amounts of water and that the water causes obstruction of the airway.¹ He advocates that the safest and most effective method for removing water from the lungs of a drowned person is the subdiaphragmatic abdominal thrust (Heimlich maneuver). He states that this maneuver should be the first step in the management of these patients and should be repeated until no water or fluid flows from the patient’s mouth. In order to minimize the risk of aspiration (which he believes to be low since the patient is not breathing and will not inhale any vomitus), the head of the patient should be turned to one side and/or on a reverse incline such as a sloping shore so the patient can be placed in a head down position. Heimlich cites several anecdotal case reports, including one involving an aspirated piece of vegetable, to support his drowned person’s protocol opinion.^{2,3}

There is no scientific literature available supporting the concepts that drowned persons aspirate either large volumes of water, or that aspirated water obstructs the airway of these individuals. Modell in a review article reported that 15% of drowned patients have no evidence of any water aspiration.⁴ The remaining 85% do aspirate some water, up to 22 milliliters per kilogram of body weight, although he stresses that in many cases the amount is much less than the 22 ml/kg.⁵ He points out that one would expect electrolyte abnormalities in patients who have aspirated large amounts of water. In actuality, these changes are rarely found, thus suggesting that aspiration of water does not occur. Consequently, Modell recommended immediate airway control and initiation of ventilation and correction of hypoxemia.⁶ Simcock also reported that many drowned patients did not have any signs of aspiration of water, including some who appeared apneic when removed from the water.⁷

Rosen, chairing an expert committee for the Institute of Medicine (IOM), could find no evidence that water aspiration caused airway obstruction or prevented efforts to ventilate patients.⁸ The IOM panel recommended that the current ECC guideline of establishing an airway and ventilation be the priority. Quan, in a study of submerged persons, reported no finding of airway fluid to impair paramedics’ ability to incubate nor any difficulty in ventilating patients once intubated.^{9,10}

Weinstein et al point out hypoxemia is the final pathophysiologic result of near drowning.¹¹ As noted in the IOM report, there is no evidence in any study that removing water from the lungs will alter this sequence of events or result in the removal of significant amounts of fluids from the lungs of these patients. In conclusion, no studies have demonstrated that water must be removed immediately

upon rescue of the patient, or that the Heimlich maneuver (abdominal thrust) is an effective and safe method for removing aspirated water from the airway and lungs.

b. ACFAS Reevaluation of Scientific Data (2006)

Safar, Escarraga, and Chang found an improperly opened airway was the most common cause of airway impediment.¹² Rosen, Stoto, & Harley could not find evidence that water aspiration causes an airway obstruction or prevents efforts to ventilate patients.¹³

Numerous other authorities have also recommended that obtaining an airway, ventilating the patient, and correcting hypoxemia are the immediate treatment priorities. The work of Neal, Ornato, Modell, Olshaker, Brass, and Weinstein and Krieger supported immediate airway control, introduction of ventilation, and correction of hypoxemia as the treatment priorities for drowned people.¹⁴⁻¹⁹

Since the Heimlich maneuver cannot remove water from a drowned person's lungs, attempting this procedure prolongs the correction of hypoxemia because it delays the initiation of CPR. Given that the Heimlich protocol for drowned persons is unnecessary, multiple consecutive abdominal thrusts increase the likelihood of visceral or vascular injuries.

The recommendation by Heimlich that the drowned person's head be turned to the side to facilitate drainage of fluid expelled while performing this maneuver has also raised concerns. With suspected spinal injury patients, turning the head to the side increases the potential exacerbation of a cervical injury.

An expert committee for the Institute of Medicine of the National Academy of Sciences recommended the ECC guideline of setting up an airway, immediately beginning ventilations, followed by chest compressions remain the first responders' treatment sequence.

c. ACFASP Re-evaluation of Scientific Data (2009)

The current re-evaluation found no study that demonstrated the Heimlich maneuver can remove fluid from the lungs of drowned persons. Since water in the airways or lungs of drowned patients is not considered a solid object airway obstruction, subdiaphragmatic abdominal thrusts should not be given to drowned person by a first responder.

The sequence of events that occurs following water aspiration into the lungs is a patho- physiologically complex process. The aspiration of water includes laryngospasm, fluid shifts across the pulmonary alveolar membrane, destruction of surfactant, atelectasis, intrapulmonary shunting, and pulmonary edema formation. Any attempt to remove the water from the airway is unnecessary, will delay CPR, hamper the correction of a drowned person's hypoxemia, can induce vomiting, and may cause visceral or vascular injuries to the drowned person.

Several researchers have cited concerns that an abdominal thrust may cause regurgitation. This vomitus could then interfere with efforts to ventilate the patient or may result in aspiration further fostering pulmonary status deterioration. Orłowski noted concerns that the use of the Heimlich maneuver could induce regurgitation.²⁰ Weinstein & Krieger also argued abdominal thrusts may cause vomiting, which

would then interfere with efforts to ventilate the patient, and may result in aspiration of stomach contents.²¹

Two studies have shown that standard chest compressions demonstrated robust efficacy in removing solid objects in a patient's airway. Skulberg, in a single case study, cited an instance where a foreign body in the trachea was removed with a single chest compression after 3-4 Heimlich maneuvers to the epigastrium failed to remove the object.²² This author theorized that since a standard chest compression created greater thoracic pressure it might be an alternative to the Heimlich maneuver.

Langhelle et al. conducted a study of the airway pressure generated by chest compressions and abdominal thrusts in 12 recently dead cadavers with simulated complete airway obstructions.²³ This study found chest compressions created a greater mean airway pressure than sub-diaphragmatic thrusts. Airway pressure from chest compressions were 40.8 <> 16.4 cmH₂O, while abdominal thrust yielded pressures of 26.4 <> 19.8 cmH₂O. These values had a 95% confidence interval with a mean difference of 5.3 -- 23.4 cmH₂O.

One can derive from Skulberg's case report and Langhelle's study that chest compressions for a hypoxic patient generate greater force for removing solid foreign body airway obstructions than sub-diaphragmatic thrusts. Langhelle further theorized if removal of a solid foreign body can be achieved by chest compressions, this will reduce the time without circulation for a patient in cardiac arrest. These patients will be treated identically whether or not there is a foreign body airway obstruction.

Rosen et al. cited case reports of abdominal thrust injuries but found no evidence indicating if these injuries were caused by faulty application of the Heimlich maneuver. Wolf, citing the work of Haynes & Yong and Agia & Hurst noted that correct administration of the Heimlich maneuver can lead to intra-abdominal injuries.^{24,25,26} A concern was noted that the incidence of complications might be greater in unconscious drowned persons than conscious choking persons.

The Heimlich maneuver/abdominal thrusts have shown efficacy in removing documented solid body airway obstructions. However, repeating the maneuver until no water or liquid flows from the person's mouth may increase the possibility of paradoxical visceral or vascular effects.

Severe complications from the use of this technique have been cited in the medical literature. Desai et al reported a case of traumatic dissection and rupture of the abdominal aorta after a forceful Heimlich maneuver.²⁷ In addition to this complication, these authors cite reports of other complications occurring with the use of the Heimlich maneuver. These injuries include retinal detachment, rib fractures, ruptures of abdominal organs.^{28,29} Additional injuries included rupture of the diaphragm, jejunum, liver, esophagus, and stomach.³⁰ Other reported vascular structure injuries consisting of aortic stent graft displacement,³¹ rupture of the aortic valve,³² acute aortic regurgitation,³³ laceration of a mesenteric vessel,³⁴ and acute aortic thrombosis in both aneurismal and non-aneurismal aorta.³⁵⁻³⁹

Summary

There is compelling evidence to support a treatment standard. The first step after removing a drowned person from the water should be to obtain an airway, start rescue breathing and deliver cardiac compressions. The 2005 American Red Cross Guidelines for Emergency Care and Education provide one approach to patients with airway, respiratory and cardiac emergencies without variation for the tech-

techniques applied to the drowned patient. The one exception is the insertion of a step for removing the patient from the water.

Studies have shown that there is no need to clear the airway of aspirated water. Only a modest amount of water is aspirated by the majority of drowned persons and it is rapidly absorbed into the central circulation. Therefore, it does not act as an obstruction in the trachea (Institute of Medicine Report; Rosen, Stoto, & Harley, 1995). It has also been shown that some drowned persons do not aspirate fluid because they develop laryngospasm or experience breath-holding (Modell, 1993). An attempt to remove water from the breathing passages by any means other than suction (e.g., abdominal thrusts or the Heimlich maneuver) are unnecessary and potentially dangerous (Institute of Medicine Report; Rosen Stoto, & Harley, 1995).

The routine use of abdominal thrusts for drowned persons is not recommended. The 2005 guidelines also eliminated the phrase “Heimlich maneuver” and replaced it with the more descriptive term “abdominal thrust.”

Recommendation and Strength

Standards

Manage a drowned person with airway, breathing or circulatory problems the same as any other patient with airway breathing or circulatory problem. The one variation is to remove the patient from the water as part of the care rendered.

Guidelines

Manage drowned child or infant with airway, breathing or circulatory problems the same as any other patient with airway breathing or circulatory problem. The one variation is to remove the patient from the water as part of the care rendered.

Overall Recommendation

Subdiaphragmatic abdominal thrusts are neither effective nor safe methods for attempting water removal from the airway or lungs of drowned persons. No scientific literature supports the idea that aspirated water obstructs these patients’ airways thus hindering ventilations. Since no scientific study has shown water can be removed from drowned person’s airways or lungs through subdiaphragmatic abdominal thrusts, the 2005 COSTR Guidelines remain the CPR treatment standard for drowned people.

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

The following studies (see Table 1) found that obtaining an airway, ventilating the patient, and correcting hypoxemia were immediate treatment priorities for drowned persons. These experts contended performing subdiaphragmatic abdominal thrusts prolonged establishment of an airway, delayed ventilations of a patient’s lungs, might induce regurgitation and aspiration of stomach contents, and could lead to a variety of internal injuries. The only exceptions to these treatment priorities were the articles written by Dr. Heimlich (1979, 1981, 1988).

Table 1 Summary

Author(s)	Full Citation	Summary of Article (provide a brief summary of what the article adds to the literature and review)	Level of Evidence (Using table below)
Heimlich HJ; 1981	Subdiaphragmatic pressure to expel water from the lungs of drowning persons. <i>Ann Emerg Med.</i> 1981; 10:476-	General description and rationale for performing the maneuver	7
Heimlich HJ, Uhley MH; 1979	The Heimlich Maneuver. <i>Clin Symposia.</i> 1979; 31:3-32.	General review of the maneuver primarily for the choking victim; describes a few anecdotal drowning cases treated with Heimlich maneuver.	3b
Heimlich HJ, Patrick EA; 1988	Using the Heimlich maneuver to save near-drowning victims. <i>Postgrad Med.</i> 1988; 84:62-73.	Flooding of the lungs occurs routinely in drowning victims and mouth-to-mouth ventilation is ineffective until the water is removed. The Heimlich maneuver expels aspirated water, vomitus, debris, and other foreign matter. The Heimlich maneuver is a form of artificial respiration. It elevates the diaphragm, increasing intrathoracic pressure and compressing the lungs, and should be performed intermittently until all water is expelled. Further treatment has not been necessary in most instances. If the victim does not recover after water ceases to flow from the mouth, ventilation techniques, cardiopulmonary resuscitation, and other measures as indicated should be used.	3b
Modell JH; 1993	Drowning. <i>N Engl J Med.</i> 1993; 328:253-256.	Responds that the Heimlich maneuver should be reserved for those instances where a patient cannot be ventilated and airway obstruction is suspected.	7
Modell JH; 1986	Near Drowning. <i>Circulation.</i> 1986; 74 (suppl IV):27-28.	The first step in resuscitation of the near-drowning victim is to initiate ventilation and circulation. The Heimlich should only be performed if the patient cannot be ventilated.	7
Simcock AD; 1986	Treatment of near drowning – a review of 130 cases. <i>Anaesthesia.</i> 1986; 41:643-648.	Many patients had no evidence of aspiration.	2b

(continued)

Table 1 (continued)

Author(s)	Full Citation	Summary of Article (provide a brief summary of what the article adds to the literature and review)	Level of Evidence (Using table below)
Rosen P, Stoto M, Harley J; 1995	The use of the Heimlich maneuver in near drowning: Institute of Medicine report. <i>J Emerg Med.</i> 1995; 13:397-405.	No evidence was found documenting massive aspiration causing airway obstruction or the usefulness of the Heimlich maneuver in near drowning. The first step in resuscitation of the drowned person is to initiate ventilation and circulation.	6
Quan L; 1993	Drowning issues in resuscitation. <i>Ann Emerg Med.</i> 1993; 22 (pt 2):366-369.	Recommends against using Heimlich maneuver as the first step in resuscitation of drowned persons.	7
Quan L, Wentz KR, Gore E, et al.; 1993	Drowning issues in resuscitation. <i>Ann Emerg Med.</i> 1993; 22 (pt 2):366-369.	Prehospital care providers had no difficulty ventilating submersion victims.	2b
Weinstein MD, Krieger BP; 1996	Near-drowning: Epidemiology, pathophysiology, and initial treatment. <i>J Emerg Med.</i> 1996; 14:461-467.	No evidence to support Dr. Heimlich's opinion of the efficacy of the maneuver to expel fluid from the lungs of drowned persons.	2b
Olshaker JS; 1992	Near Drowning. <i>Emerg Med Clinics N Amer.</i> 1992; 10:339-350.	The first step in resuscitation of the drowned person is to initiate ventilation and circulation.	5 (Literature review)
Neal JM; 1985	Near-drowning. <i>J Emerg Med.</i> 1985; 3:41-52.	Notes that virtually all experts recommend that the first step in resuscitation of the drowned person is to initiate ventilation and circulation, only Heimlich recommends the use of the maneuver.	5 (Literature review)
Bross MH, Clark JL; 1995	Near-drowning. <i>Amer Fam Phys.</i> 1995; 51:1545-1551.	The first step in resuscitation of the drowned person is to initiate ventilation and circulation. The Heimlich maneuver should be reserved for those cases with documented airway obstruction.	5 (Literature review)
Ornato JP; 1986	Special resuscitation situations: near drowning, traumatic injury, electric shock, and hypothermia. <i>Circulation.</i> 1986; 74 (suppl IV):23-26.	The recommendation was to use the Heimlich for those cases with a documented airway obstruction.	5

(continued)

Table 1 (continued)

Author(s)	Full Citation	Summary of Article (provide a brief summary of what the article adds to the literature and review)	Level of Evidence (Using table below)
Safar P, Escarraga LA, Chang F; 1959	Upper airway obstruction in the unconscious patient. <i>J Appl Physiol.</i> 14: 760-764, 1959.	Airways were obstructed in 80 anesthetized, spontaneously breathing patients patients, both in the supine and prone positions. When the neck is flexed and the mandible is not held forward the tongue is pushed against the posterior pharyngeal wall. The frequency and degree of obstruction was similar in the prone and supine positions, with comparable positions of the head, neck and mandible	1b
Langhelle A, Sunde K, Wik L, Steen PA; 2000.	Airway pressure with chest compressions versus Heimlich maneuver in recently dead adults with complete airway obstruction <i>Resuscitation.</i> 2000 Apr; 44(2):105-8	In a randomized crossover design standard chest compressions and Heimlich maneuvers were performed on 12 cadavers with simulated complete airway obstruction. The mean peak airway pressure was significantly higher with chest compressions compared to abdominal thrusts	4
Orlowski JP; 1987	Vomiting as a complication of the Heimlich maneuver. <i>JAMA</i> 1987; 258:512-513.	Vomiting after the Heimlich maneuver can cause serious complications. The first step in resuscitation of the drowned person is to initiate ventilation and circulation. The Heimlich maneuver should be reserved for those cases with documented airway obstruction.	3b
American Red Cross; 2005	<i>2005 Guidelines for Emergency Care and Education: Unconscious person</i>	If chest does not rise after two rescue breaths, re-tilt head and administer two more rescue breaths. If chest still does not rise give chest compressions and look inside person's mouth. If object is seen remove from person's mouth. If no object is seen give two rescue breaths. If chest does not rise, give 30 chest compressions	6
American Red Cross; 2005	<i>2005 Guidelines for Emergency Care and Education: Conscious person</i>	Confirm person is choking, obtain consent, and give 5 back blows. If the person is still choking give 5 abdominal thrusts. If the person is still choking administer 5 back blows.	6

(continued)

Table 1 (continued)

Author(s)	Full Citation	Summary of Article (provide a brief summary of what the article adds to the literature and review)	Level of Evidence (Using table below)
Skulberg A; 1992	Chest compression-an alternative to the Heimlich maneuver. <i>Resuscitation</i> . 1992; 24:91.	A single case study of a foreign body in the trachea, removed by chest compression.	3b
Wolf DA; 2001	Heimlich trauma: a violent maneuver. <i>Am J Forensic Med Pathology</i> . 2001. 24 (1) 65 – 67.	The Heimlich maneuver is a life-saving technique for dislodging foreign material from the respiratory tract. This report illustrates intraabdominal injuries, including a large mesenteric laceration, mesenteric contusions, and intraperitoneal hemorrhage, that occurred in a recipient of a vigorously applied Heimlich maneuver. The potential for confusing such injuries with homicidally inflicted injuries is emphasized.	3b
Desai SC., Chute DJ, Bharati C, Desai MD, Koloski ER; 2008	Traumatic dissection and rupture of the abdominal aorta as a complication of the Heimlich maneuver. <i>J Vasc Surg</i> . 2008; 48:1325-7	Although the Heimlich maneuver is considered the best intervention for relieving acute upper airway obstruction, several complications have been reported in the literature. These complications can occur as a result of an increase in abdominal pressure leading to a variety of well documented visceral injuries, including the great vessels. Acute abdominal aortic thrombosis after the Heimlich maneuver is a rare but recognized event; however to date no case of traumatic dissection and rupture of the abdominal aorta has been described. We report the first known case, to our knowledge, of a traumatic dissection and rupture of the abdominal aorta after a forcefully applied Heimlich maneuver	3b

(continued)

Table 1 (continued)

Level of Evidence	Definitions
Level 1a	Population-based studies, randomized prospective studies or meta-analysis of multiple studies with substantial effects
Level 1b	Large non-population-based epidemiological studies or randomized prospective studies with smaller or less significant effects
Level 2a	Perspective, controlled, non-randomized, cohort or case controlled studies
Level 2b	Historic, non-randomized, cohort or case-controlled studies
Level 3a	Large observational studies
Level 3b	Smaller observational studies
Level 4	Animal studies or a mechanical model studies
Level 5	Peer-reviewed, state of 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 practice is accepted before evidence-based guidelines
Level 1-6E	Extrapolations from existing data collected for other purposes, theoretical analyses which are on point with question being asked. Modifier E applied because extrapolating but rank base on type of study

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