Assessment of the LifeVac, an Anti-Choking Device, on a Human Cadaver with Complete Airway Obstruction

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Abstract

Purpose
This study is to determine if LifeVac, a novel anti choking device, is effective in dislodging a food bolus obstruction in the airway of a simulated choking victim.

Method
A human cadaver was used for the study. A simulated bolus, ranging in size from 2-3 centimeters, was placed in the oral pharynx of the cadaver to obstruct the upper airway. Fifty attempts were made to lift the bolus using the LifeVac to clear the completely obstructed airway.

Results
The simulated boli were removed on the first pull, 49/50 trials. Two pulls were required to remove the simulated bolus on one trial.

Conclusion
The LifeVac demonstrated the ability to successfully clear an obstructed upper airway. It is the clinical judgment of this researcher that the LifeVac is a safe, non-invasive and effective method to be used in cases of choking.

Introduction

This study was conducted to determine whether the LifeVac is able to remove a food bolus from an obstructed airway when the potential for choking as a medical emergency exists. The intention of this study was to assess the efficacy of this new invention to confirm recommendation to patients, their caregivers and medical personnel.

The LifeVac is a non-powered, single patient, portable suction apparatus (anti-choking device) developed for resuscitating a choking victim when standard current choking protocol has been followed without success. The LifeVac is designed with a patented valve to prevent air from exiting through the mask. This patented designed valve prevents air from pushing food or objects downward. This creates a one-way suction to remove the lodged food or object. The negative pressure generated by the force of the suction is 3 times greater than the highest recorded choke pressure. The mean peak airway pressure with abdominal thrusts is 26.4 ± 19.8 cmH20 and with chest compressions, 40.8 ± 16.4 cmH20, respectively (P =0.005, 95% confidence interval for the mean difference 5.3-23.4 cmH20.) [1] The LifeVac generates over 300 millimeters of mercury (mm Hg) of suction.

Each year, approximately 3,000–4,000 Americans die from choking, or pulmonary aspiration. [2] Acute foreign body airway obstruction is an important public health threat. In 2012, there were 4,700 deaths due to this problem. [3] Deaths attributed to mechanical suffocation and asphyxiation by foreign materials in the respiratory tract number 4,700 annually. The category, "aspiration of food" includes not only asphyxiation by solid food, but also the presence in the respiratory tract of regurgitated food. [4]

Both children and the elderly are at a higher risk for choking. At least one child dies from choking on food every five days in the U.S., and more than 10,000 children are taken to a hospital emergency room each year for food-choking injuries. [5] Semisolid foods are the cause of a large number of asphyxiations, especially among the elderly. [6]

The Centers for Disease Control and Prevention's Injury Statistics Query and Reporting System (WISQARS), a web-based, online database, revealed that in 2013, Unintentional Suffocation was the third leading cause of unintentional injury deaths in children 1-4 years old, the fifth leading cause in children 5-9 years old, the eighth leading cause in children 10-14 years old, the ninth leading cause in adults 45-54 years old, the seventh leading cause in adults 55- 64 years old and the fifth leading cause of unintentional injury deaths in adults 65 and older (Graph 1).

Graph 1

10 Leading Causes of Injury Deaths by Age Group Highlighting Unintentional Injury Deaths, United States – 2013

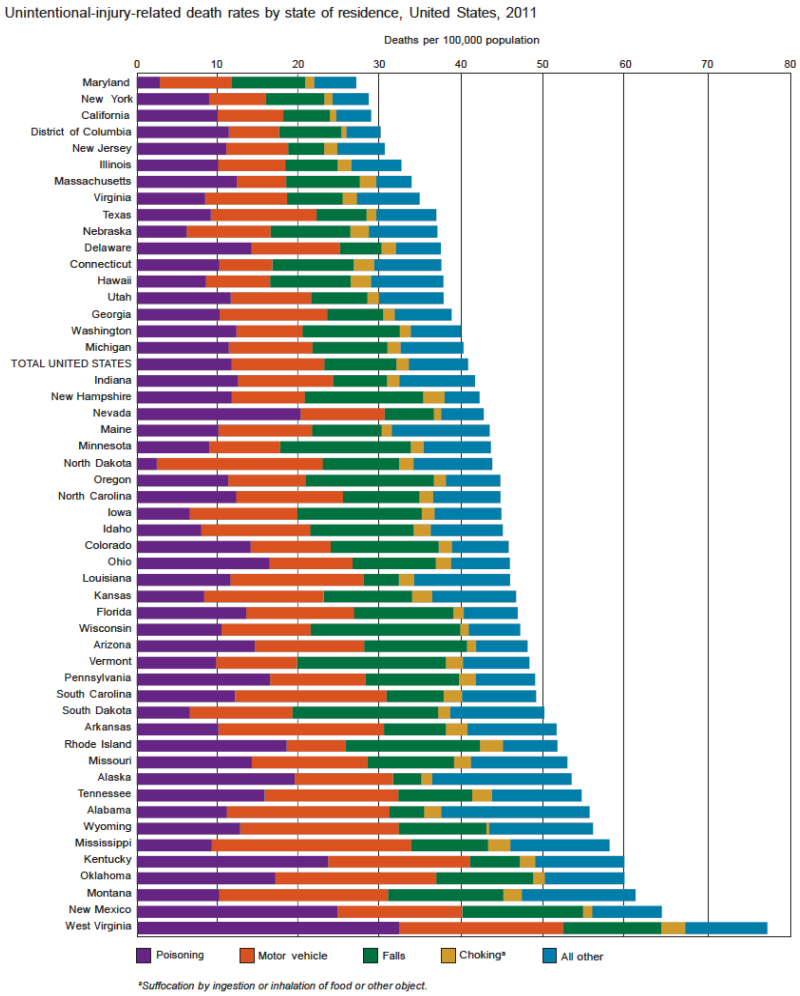
	Age Groups										
Rank	<1	1-4	5-9	10-14	15-24	25-34	35-44	45-54	55-64	65+	Total
1	Unintentional Suffocation 979	Unintentional Drowning 393	Unintentional MV Traffic 342	Unintentional MV Traffic 414	Unintentional MV Traffic 6,510	Unintentional Poisoning 8,251	Unintentional Poisoning 8,374	Unintentional Poisoning 10,651	Unintentional Poisoning 6,388	Unintentional Fall 25,464	Unintentional Poisoning 38,851
2	Homicide Unspecified 139	Unintentional MV Traffic 327	Unintentional Drowning 116	Suicide Suffocation 231	Homicide Firearm 3,704	Unintentional MV Traffic 5,776	Unintentional MV Traffic 4,448	Unintentional MV Traffic 5,082	Unintentional MV Traffic 4,502	Unintentional MV Traffic 6,333	Unintentional MV Traffic 33,804
3	Homicide Other Spec., classifiable 74	Unintentional Suffocation 161	Unintentional Fire/Burn 87	Suicide Firearm 137	Unintentional Poisoning 3,293	Homicide Firearm 3,372	Suicide Firearm 2,948	Suicide Firearm 4,057	Suicide Firearm 3,809	Suicide Firearm 5,113	Unintentional Fall 30,208
4	Unintentional MV Traffic 66	Homicide Unspecified 153	Homicide Firearm 48	Homicide Firearm 94	Suicide Firearm 2,210	Suicide Firearm 2,897	Suicide Suffocation 1,868	Suicide Suffocation 2,007	Unintentional Fall 2,283	Unintentional Unspecified 4,316	Suicide Firearm 21,175
5	Undetermined Suffocation 43	Unintentional Fire/Burn 129	Unintentional Suffocation 44	Unintentional Drowning 93	Suicide Suffocation 1,839	Suicide Suffocation 2,154	Homicide Firearm 1,843	Suicide Poisoning 1,867	Suicide Poisoning 1,528	Unintentional Suffocation 3,616	Homicide Firearm 11,208
6	Undetermined Unspecified 28	Unintentional Pedestrian, Other 90	Unintentional Other Land Transport 29	Unintentional Other Land Transport 49	Unintentional Drowning 501	Suicide Poisoning 716	Suicide Poisoning 1,193	Unintentional Fall 1,266	Suicide Suffocation 1,182	Unintentional Poisoning 1,824	Suicide Suffocation 10,062
7	Unintentional Drowning 23	Homicide Other Spec., classifiable 71	Unintentional Natural/ Environment 22	Unintentional Fire/Burn 48	Suicide Poisoning 418	Undetermined Poisoning 565	Undetermined Poisoning 633	Homicide Firearm 1,158	Unintentional Suffocation 723	Adverse Effects 1,755	Suicide Poisoning 6,637
8	Homicide Suffocation 22	Unintentional Natural/ Environment 42	Unintentional Pedestrian, Other 18	Unintentional Suffocation 37	Homicide Cut/Pierce 331	Unintentional Drowning 424	Unintentional Fall 522	Undetermined Poisoning 801	Homicide Firearm 573	Unintentional Fire/Burn 1,103	Unintentional Suffocation 6,601
9	Unintentional Natural/ Environment 19	Homicide Firearm 39	Homicide, Other Specified, NEC* 15	Unintentional Firearm 24	Undetermined Poisoning 219	Homicide Cut/Pierce 409	Unintentional Drowning 367	Unintentional Suffocation 478	Unintentional Fire/Burn 564	Suicide Poisoning 905	Unintentional Unspecified 5,407
10	Unintentional Fire/Burn 17	Unintentional Struck by or Against 33	Unintentional Firearm 15	Unintentional Poisoning 21	Unintentional Fall 205	Unintentional Fall 305	Homicide Cut/Pierce 267	Unintentional Drowning 404	Undetermined Poisoning 547	Suicide Suffocation 770	Unintentional Drowning 3,391

*Not elsewhere classifiable

Data Source: National Center for Health Statistics (NCHS), National Vital Statistics System.
Produced by: National Center for Injury Prevention and Control, CDC using WISQARS™.

According to *Injury Facts 2015*, choking was the fourth leading cause of unintentional injury deaths in 2011. [7] (Graph 2).

Graph 2



Materials and Methods

This study was conducted at Fusion Solutions, a cadaver based training center in Nassau County, New York. An unselected, recently diseased cadaver was used. The subject was a 71 year old, Caucasian female, 153 pounds, 65 inches with a Body Mass Index of 25. Patient's history was remarkable for Breast Cancer. The patient was edentulous.
The paramedic, placed a simulated bolus 7 to 10 centimeters into the subject's upper airway. (Figure 1) The obstruction was visually and verbally confirmed prior to use of the LifeVac apparatus. Three simulated boli obstructions made of clay were used: a 2 cm (small), a 2 1/2 cm (medium) and a 3 cm (large). The simulated boli were attached to a string.

The paramedic placed the adult mask on the subject following operating guidelines to remove the lodged bolus (Figure 2). The paramedic and SLP observed and recorded the success rate. It should be noted that on the one trial that required 2 pulls, the SLP instructed the paramedic to ensure a tighter seal, achieving increased suction, prior to pulling up the device. See Figure 4 to view the lifted bolus from airway. Figure 3 displays the first trial in which the Lifevac not only cleared the obstruction, it also brought up the contents of the subject's stomach.

Figure 1
Paramedic placed large simulated bolus (3 cm) 7-10 centimeters past tongue base into upper airway of subject.

Figure 2
Paramedic placed the LifeVac on subject using guideline protocol by achieving proper seal, pushing in and pulling up the Lifevac.

Figure 3
On the first trial, the LifeVac removed both the simulated food bolus and food bolus content of subject's stomach. Paramedic suctioned oral cavity and upper airway of stomach to continue with study.

Figure 4
Picture of large simulated bolus (3 cm) lifted from the airway of the subject.

Results of Cadaver Test

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Trial #	Simulated Bolus/ Object	Number of pulls to clear airway	Trial #	Simulated Bolus/ Object	Number of pulls to clear airway
1	**2 cm**	1	**26**	2 cm	1
2	**2 cm**	**1**	**27**	2 cm	1
3	**2 cm**	**2**	**28**	2 cm	1
4	**3 cm**	**1**	**29**	2 cm	1
5	**3 cm**	**1**	**30**	2 cm	1
6	**2 cm**	**1**	**31**	2 cm	1
7	**2 cm**	**1**	**32**	2 cm	1
8	**2 cm**	**1**	**33**	2 cm	1
9	**2 cm**	**1**	**34**	2 cm	1
10	**2 cm**	**1**	**35**	2 cm	1
11	**2 cm**	**1**	**36**	2 cm	1
12	**2 1/2 cm**	**1**	**37**	3 cm	1
13	**2 1/2 cm**	**1**	**38**	3 cm	1
14	**2 1/2 cm**	**1**	**39**	3 cm	1
15	**2 1/2 cm**	**1**	**40**	3 cm	1
16	**2 1/2 cm**	**1**	**41**	3 cm	1
17	**2 1/2 cm**	**1**	**42**	3 cm	1
18	**2 1/2 cm**	**1**	**43**	3 cm	1
19	**2 1/2 cm**	**1**	**44**	3 cm	1
20	**2 1/2 cm**	**1**	**45**	3 cm	1
21	**2 1/2 cm**	**1**	**46**	3 cm	1
22	**2 1/2 cm**	**1**	**47**	3 cm	1
23	**2 1/2 cm**	**1**	**48**	3 cm	1
24	**2 cm**	**1**	**49**	3 cm	1
25	**2 cm**	**1**	**50**	3 cm	1

Discussion

This study was designed to examine the effectiveness of the use of the LifeVac on a simulated choking victim. Choking is the blockage or hindrance of respiration by a foreign-body obstruction in the internal airway, including the pharynx, hypopharynx, and trachea. Airway obstruction can be fatal if it leads to serious impairment of oxygenation and ventilation. [8] Choking is signaled by an inability to speak, cough or breathe, and may result in a loss of consciousness and death.

The American Heart Association's recommends that the treatment for a choking person who begins to turn blue or stops breathing varies with the person's age. In adults and children older that one year of age, abdominal thrusts (formerly referred to as the "Heimlich maneuver") should be attempted. Abdominal thrusts is an emergency technique to help clear someone's airway. The procedure is done on someone who is choking and also conscious. [9] This is a thrust that creates an artificial cough. It may be forceful enough to clear the airway. The quick, upward abdominal thrusts force the diaphragm upward very suddenly, making the chest cavity smaller. This has the effect of rapidly compressing the lungs and forcing air out. The rush of air out will force out whatever is causing the person to choke. [10] Hence the standard protocol, the Heimlich Maneuver or abdominal thrusts may be employed only when a person is choking and his or her life is endangered by an airway obstruction.

According to Langhelle et al, standard chest compressions are more effective than the Heimlich manoeuvre for treating complete airway obstruction by a foreign body. [1] Rescuers attempting to resolve a complete airway obstruction in a conscious or unconscious adult should provide abdominal thrusts or chest compressions. [11] Rescuers attempting to resolve a complete foreign body airway obstruction in an unconscious adult should provide CPR and use a finger sweep if a foreign body is seen in the mouth. [3]

A study using the "table maneuver" consisted of 4 cases of elderly patients (70-89 years old) in a long- term care facility, which was conducted over 6 years. The choking person was laid down on the table in prone position with the head facing downwards, with the arms hanging over the table, and then given sharp blows between the scapulas with the heel of the hand. The study concluded that this could be a potentially life-saving technique that could be applied to patients with severe choking caused by foreign-body airway obstruction who fail to respond to the Heimlich maneuver and other conventional treatments. [12] One would need the manpower to lift and place a person on a table as cited. Further, many elderly people, dependent upon their diagnosis and symptoms, may not be a candidate for this potential approach.

So what if the Heimlich maneuver is unsuccessful? Choking is a medical emergency that warrants prompt, precise action by anyone available. Time is of the essence in this emergent situation. An emergency medical team can be called to save a choking victim's life. An emergency tracheostomy or cricothyrotomy may be necessary to prevent

suffocation. When all attempts to rescue a choking victim fail and emergency medical help is unavailable, there is a treatment of last resort: a cricothyrotomy, which is easier and quicker to perform than a tracheotomy. [13] *J .K. Dillon et al* discussed these emergency surgical airway practices in his article; however this would require a medically trained professional, who may not be present during the time of an actual emergency. In many cases, it may be too late. [13]

Conclusions

Many Speech Language Pathologists evaluate and treat patients with dysphagia in a subacute, home or office setting. Swallowing treatment predominantly consists of teaching compensatory strategies, feeding approaches, aspiration precautions and providing an appropriate diet to ensure a safe swallow sequence. SLPs provide patient and caregiver training to prevent aspiration. When asked by patients, caregivers and RNs what to do if the patient is choking, "The Heimlich Maneuver and call 911" is the standard response. Patients diagnosed with neurological disorders may be wheelchair bound or bed bound which is of concern to caregivers in case of an emergent, choking event.

This study proved that the LifeVac is able to clear a completely obstructed upper airway. Given the potentially life-or-death nature of the situation, it is judged that the LifeVac should be utilized as it is a safe, simple and effective method to save a choking victim. The LifeVac is observed to be non invasive and therefore can be used on anyone and by a layperson. Follow up results of the use of this anti choking device is needed so that LifeVac may be included as part of the guidelines for the basic life support management of choking.

References

1. Airway pressure with chest compressions versus Heimlich manoeuvre in recently dead adults with complete airway obstruction. A. Langhelle, K. Sunde, L. Wik, P.A. Steen. Resuscitation, Vol. 44, Issue 2, p105–108. 2000. Published online: August 17 2004

2. A Breathtaking Experience. Harvard Health Publications, Harvard Medical School, September 1, 2005.

3. American Red Cross Scientific Review. Dr. Richard Bradley M.D., Disaster Medicine, Emergency Medical Care, Emergency Medicine University of Texas Health Science February 2015.

4. The Injury Fact Book Second Edition. Susan P. Baker Professor of Health Policy and Management Johns Hopkins University School of Hygiene and Public Health, Brian O'Neill President Johns Hopkins University School of

Hygiene and Public Health, Marvin J. Ginsburg, Marvin J. Guohua Li, President Johns Hopkins Injury Prevention Center 1992.

5. New York State Department of Health, Healthy New York Web Page, Revised March 2015.

6. Foreign body asphyxia: a preventable cause of death in the elderly. Berzlanovich AM, Fazeny-Dörner B, Waldhoer T, Fasching P, Keil W. American Journal of Preventive Medicine. 2005 Jan;28(1):65-9.

7. Injury Facts (book). Choking Prevention and Safety Tips. The National Safety Council. Web Page. Updated 9/14/2015.

8. Policy Statement: Prevention of Choking Among Children. Committee on Injury, Violence, and Poison Prevention. Pediatrics 2010; 125:3 601-607.

9. Abdominal Thrusts, Jacob L. Heller, MD, MHA, Emergency Medicine, Virginia Mason Medical Center, Seattle, WA. University of Maryland Medical Center. Web Page Last reviewed on 4/12/2015

10. The American Heart Association, Medical Author: John P. Cunha, DO, FACOEP , Medical Editor: Melissa Conrad Stöppler, MD, Chief Medical Editor

11. Existing Research Is Inadequate for the Development of Guidelines for the Basic Life Support Management of Airway Obstruction in Adults: Results of a Systematic Review. Richard Bradley; American Red Cross Scientific Advisory Council 2012 ;126: Abstract 86 The American Heart Association.

12. The Table Maneuver: A Procedure Used with Success in Four Cases of Unconscious Choking Older Subjects. Hubert Blain, MD, PhD, Mireille Bonnafous, RN, Nicolas Grovalet, MD, Olivier Jonquet, MD, PhD, Michel David, MD. American Journal of Medicine, December 2010.

13. What Comes After the Heimlich Maneuver, Jane E. Brody, The New York Times, September 14, 2015.

14. The emergent surgical airway: cricothyrotomy vs tracheotomy. J.K. Dillon, B. Christensen, T. Fairbanks, G. Jurkovich, K.S. Moe. International Journal of Oral and Maxillofacial Surgery, Vol. 42, Issue 2, p204–208. Published online December 20 2012