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# LifeVac Simulation Study

A novel apparatus for the resuscitation of a choking victim

## **Background**

Patients with oropharyngeal dysphasia are at increased risk for choking which can be a leading cause of death in this population. Currently there are no methods to remove an inhaled object if the traditional Heimlich maneuver fails. We have developed an apparatus which is simple to use in order to remove an object lodged in the trachea if the Heimlich maneuver fails.

## **Methods**

The Laerdel choking simulator system was used in order to simulate a choking victim. The Laerdel ALS Megacode Kelly, Megacode kid, and were all evaluated. Items most frequently leading to choking deaths include grapes, hot dogs, popcorn, and toy cars and these items were therefore tested. The item was pushed into the airway in order to create an obstruction. The LifeVac unit was then used per standard protocol and the frequency of dislodging the object was recorded.

## **Results**

Using ALS Megacode Kelly with a grape inserted into the airway the LifeVac successfully moved the object 15 out of 19 tries (79%). It was successful in dislodging a hot dog in line with the airway 16 out of 16 tries or 100%. When the hot dog was perpendicular 4/5 or 80% were successful. Popcorn was removed in 8 of 8 tries or 100%, and 5 out of 5 toy cars in line with the airway or 100% were removed. Using the Laerdel Megacode kid with SIM pad 12 out of 12 grapes were removed (100%), 10 of 10 hot dogs were removed as well. 5 cars however did not move. Using the Laerdel airway trainer 14 hot dogs were all removed successful.

## **Conclusion**

LifeVac is a promising apparatus that is simple to use and appears to be an effective method in successfully dislodging an object lodged in the airway of a choking victim. Further pilot studies in humans are warranted in the hopes of saving lives when the Heimlich maneuver fails.

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## **Vacuum generated by LifeVac apparatus in a closed system versus pressures generated by chest compressions and Heimlich maneuver in cadavers with complete airway obstruction**

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### **Abstract**

In a previous study conducted in Norway in 1999, Langhelle et. al. [1], airway pressure generated by the Heimlich maneuver, and by chest compression were measured in 12 recently dead cadavers. In order to compare the recently developed Lifevac apparatus' effectiveness to chest compressions and the Heimlich, the following test was performed. The LifeVac apparatus was connected to a vacuum test device, and 5 test pulls were performed. Vacuum measurements were made and recorded. This was repeated using 12 different LifeVac units in order to arrive at an average value for vacuum. The mean peak vacuum generated by LifeVac was 232.2 cmH<sub>2</sub>O. The published mean peak airway pressure measured for chest compressions was 40.8 +/- 16.4 cm H<sub>2</sub>O, and for abdominal thrusts were 26.4 +/- 19.8 cmH<sub>2</sub>O. The Lifevac unit can generate more force on an airway obstruction by pulling from above the obstruction, than either chest compressions or abdominal thrusts generate from below. Therefore the LifeVac unit has the potential of being more effective at removing a foreign object from the airway of a choking victim.

### **Introduction**

In the study performed by Langhelle [1], it was demonstrated that chest compressions are potentially more effective at removing a foreign body from an airway than the Heimlich maneuver, generating significantly more airway pressure to force the foreign body out. With the introduction of the new LifeVac apparatus, we now have the potential to improve upon the performance of both the Heimlich and chest compression for this purpose. While the Heimlich and chest compression generate the airway pressure by compressing and forcing the air out of the subjects lungs and thereby pushing the foreign object from below, the LifeVac takes the opposite approach. It is placed over the subject's nose and mouth, and when operated it generates a vacuum in the airway, effectively sucking the foreign object out from above. We therefore performed a test of the LifeVac unit to determine the magnitude of the vacuum generated, and to compare these values to the pressures generated by chest compression in the Langhelle [1] study.



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## **Materials and methods**

The purpose of this study was to obtain results from the LifeVac apparatus which could be compared directly to those reported in the Norwegian study. In that study 12 recently dead cadavers were used as test subjects. All of these subjects had a tracheal tube still in place from intubation. The cuff was inflated to create an airtight seal between the airway and the tube. The tracheal tube was connected to a sensor to measure airway pressure, and the proximal end of the sensor was plugged to simulate a complete airway obstruction. In essence a closed system was created where a fixed volume of air was compressed by either the Heimlich maneuver or chest compressions.

## **Materials and methods - continued**

The pressure exerted by this compressed air was measured by the sensor (see figure 2). In the study performed on the LifeVac apparatus, the unit was connected to a fitting with a sized boss and o-ring seal. This fitting was connected by tubing to a vacuum gauge (Druck DPI 104 by GE). This system simulates a completely obstructed airway, with the LifeVac unit covering a choking victim's nose and mouth. It is a closed system with a fixed volume of air. In this scenario the bellows assembly of the LifeVac is used to generate the pressure, or in this instance, vacuum. The magnitude of the vacuum is measured by the vacuum gauge (see figure 3). Twelve different LifeVac units were tested to account for any manufacturing inconsistencies. Each LifeVac unit was installed on the vacuum test fixture (see Figure 1). Five compress/pull cycles were performed for each, and the values for vacuum were recorded for each cycle. This was repeated for each LifeVac unit. The person performing the test had no medical training whatsoever, and is therefore more representative of the type of person who would be using the LifeVac in an emergency situation in a public place, or a home.

Figure 1.



Figure 1. Vacuum testing fixture used in LifeVac testing.



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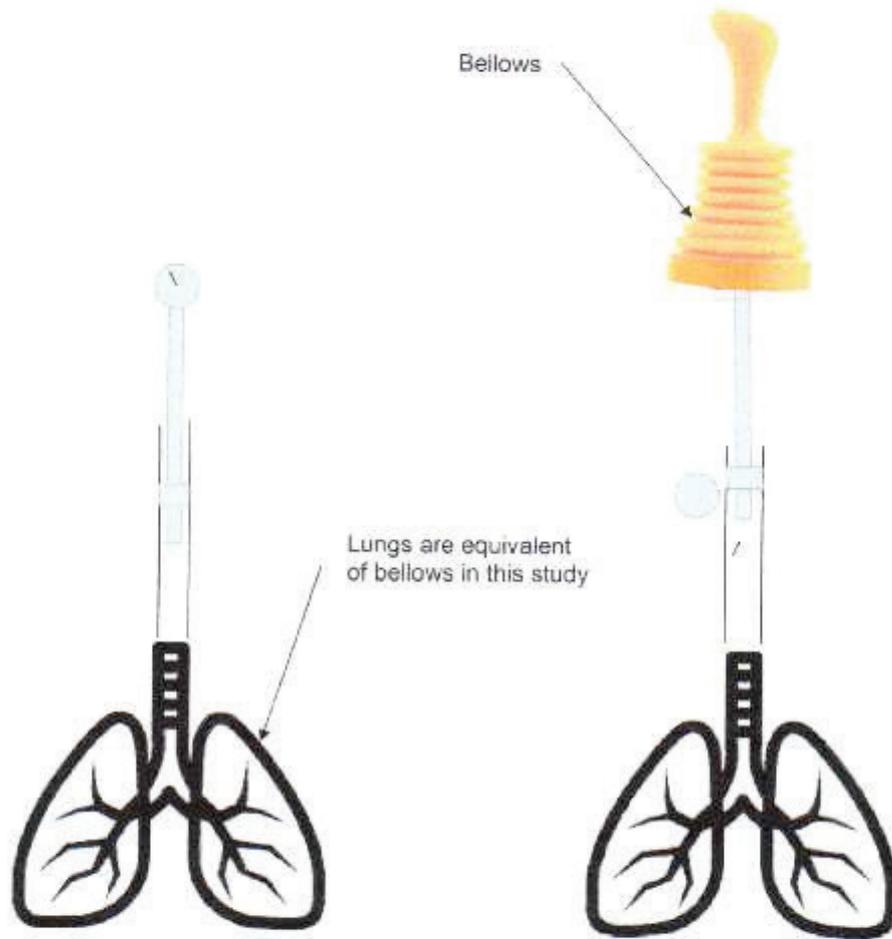


Figure 1. Simplified drawing of test setup for Norwegian study (Langhelle)

Figure 2. Test setup for LifeVac testing.



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## **Discussion**

In this test we obtained vacuum values using the LifeVac unit which were much higher than airway pressures previously published by Langhelle et. al. [1]. We have demonstrated that the results of this test can be compared directly to the Langhelle study, since both tests took place in a closed, fully blocked, system. In the Langhelle study a cuff was inflated around a tracheal tube, and a sensor with the proximal end blocked off was inserted into the airway. The lungs were essentially the bellows which, when compressed, generated the pressures which were measured. In the LifeVac test, the closed system consists of the LifeVac unit connected to a vacuum gauge with flexible tubing. The LifeVac unit itself contains the bellows which, when compressed then pulled up rapidly, generates a vacuum. In a real world choking situation this vacuum will suck the foreign object from the airway. We can also state that the LifeVac results would be the comparable if the test was performed on cadavers, since the airway would be totally blocked off, and the vacuum is generated by the LifeVac bellows and is independent on the anatomy of the cadaver.

In conclusion, the findings of this test indicate that the LifeVac unit generates much higher pressures than either the Heimlich maneuver or chest compressions without the possibility of broken ribs or other physical damage, and is a more effective way to treat subjects with complete airway obstruction by a foreign body.

## **Results**

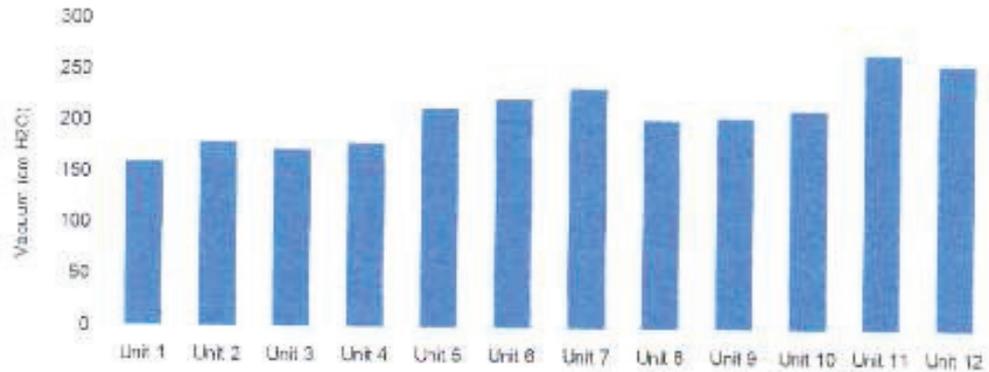
Twelve LifeVac units were tested, and five vacuum readings were taken for each unit. The mean peak vacuum obtained was 233.2 cm H<sub>2</sub>O. This is in comparison to a mean peak airway pressure of 40.8 +/- 16.4 cmH<sub>2</sub>O for chest compression and 26.4 +/- 19.8 cmH<sub>2</sub>O for the Heimlich maneuver. The vacuum values recorded during testing are shown on Chart 1 below. The results from the Langhelle [1] study are reprinted in Chart 2.

### **Chart 1. Mean vacuum values obtained with Lifevac**



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**Chart 1. Mean vacuum values obtained with Lifevac**



**Chart 2. Reprint of results from Norwegian study (Langhelle)**

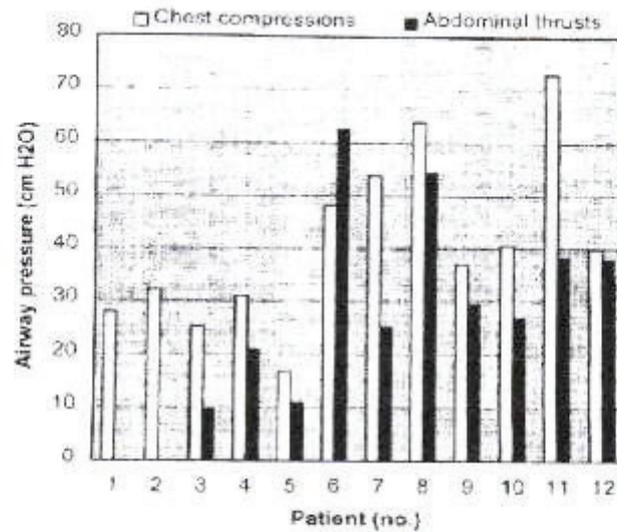


Fig. 1. Airway pressures with chest compressions and abdominal thrusts on twelve recently dead adults with complete airway obstruction. The airway pressure is significantly lower with abdominal thrusts than chest compressions ( $P = 0.005$ ).