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# Treatment of Foreign Body Obstruction of the Upper Airway

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*The treatment of foreign body obstruction of the upper airway has been the subject of considerable attention and controversy. Current recommendations from the National Academy of Sciences, the American Red Cross and the American Heart Association include the use of back blows, abdominal thrusts (Heimlich maneuver) or chest thrusts (or both) and finger probes, until definitive therapy by trained medical and paramedical personnel becomes available. Nevertheless, a number of authorities on this subject have claimed that these approaches are dangerous, and that abdominal thrusts should be the first and only first-aid technique used in this situation.*

*There are only limited data on which to make recommendations regarding this issue. Clinical evidence is scanty and of a highly anecdotal and unscientific nature. The data that are available suggest that a combination of maneuvers is in fact preferable to any single maneuver. Experimental physiologic data on both humans and animals tend to support this concept and suggest that back blows, which generate high initial pressures, may dislodge objects from the larynx enough to allow subsequent thrust maneuvers, which generate more sustained increases in intrathoracic pressure, to move the object out of the larynx. At this time, in the absence of definitive data, it seems reasonable to teach as many lay citizens as possible to recognize upper airway obstruction due to foreign body and to perform any and all of these techniques (preferably in combination), as well as external cardiopulmonary resuscitation (CPR) where appropriate, on choking victims.*

MUCH ATTENTION has been focused on the treatment of foreign body obstruction of the upper airway. The lay public has long been interested in the problem, to a great extent because of highly publicized comments by Dr. Henry Heimlich that established medical authorities have ignored appropriate treatments and misled the public. Dr. Heimlich,[1] who first proposed the Heimlich maneuver, or "abdominal thrust," in 1974, has made several other eminently quotable statements that have also generated widespread comment. Among these is the claim that back blows, listed by the American Heart Association and the American

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Red Cross as the first treatment modality in upper airway obstruction, are "death blows," and the statement that the various national policy-making committees for these major organizations have engaged in "Watergate cover-ups" to avoid adequate recognition of the Heimlich maneuver.

Interest in this controversy has not been confined to the lay community. Numerous medical groups have sponsored debates regarding the treatment of upper airway obstruction, and official positions have been solicited from a variety of medical organizations. In light of the intense and often strident debate concerning this problem, it is well worth our while to review in detail all the available evidence on this subject.

## History

Dr. R. K. Haugen[2] first coined the term "cafe coronary" in 1963 to describe sudden death following aspiration of pieces of meat into the trachea. Haugen noted large pieces of food materials obstructing the airway and generally lodged at the level of the larynx during autopsies of a number of sudden-death victims. Early suggestions regarding emergency treatment of upper airway obstruction ranged from finger-probe maneuvers and use of mechanical devices to manually remove the object from the airway, to slaps on the back, as well as external cardiopulmonary resuscitation (CPR).[2-4] In 1974 Dr. Heimlich described the "Heimlich maneuver," in which the rescuer "rapidly and strongly presses into the victim's abdomen, forcing the diaphragm upward, compressing the lungs, and expelling the obstructing bolus."[5,6] Early recommendations of the American Red Cross and National Academy of Sciences did not include the Heimlich maneuver, or abdominal thrust, among suggested management techniques.[3] In 1976, however, the American Red Cross changed its policy to include the abdominal thrust.[7] They continued to recommend that four rapid back blows be done initially, followed by four abdominal thrusts, with repetition of these sequences as long as the victim remains conscious. They also recommended that, in the presence of unconsciousness, finger probes be attempted. Finally, they recommended the institution of mouth-to-mouth ventilation and CPR in the event of cardiac arrest. Dr. Heimlich has challenged this set of recommendations, asserting that back blows are injurious and deleterious, and that only the Heimlich maneuver should be used.[8,9] He has also asserted that the failure of the American Red Cross to change its recommendations so as to concur with his own represents an attempt by those committee members responsible for the recommendations to "cover up" their earlier refusal to include the Heimlich maneuver and their continued insistence on the back blow.[10]

There are only a limited amount of scientific data available on the subject of the treatment of upper airway obstruction. This article will review the limited clinical and experimental data available, and determine what conclusions can be safely drawn. We will evaluate the substance of Dr. Heimlich's claim that only the Heimlich maneuver should be used. We will also attempt to formulate what recommendations should be made to the general public for the emergency treatment of upper airway obstruction.

TABLE 1.—*Mortality Data—1973 to 1975**

| Year | Heart Disease | All Accidents | Automobile Accidents | Suffocation From Ingested Objects |
|---|---|---|---|---|
| 1973 | 757,075 | 115,821 | 55,511 | 3,013 |
| 1974 | 738,171 | 104,622 | 46,402 | 2,991 |
| 1975 | 716,215 | 103,030 | 45,853 | 3,106 |

*From Accident Facts.[12]

## Etiology—Epidemiology

Deaths from upper airway obstruction caused by food are reported approximately 3,000 times per year in the United States.[6,11,12] Even this number may represent a significant underestimation, since many sudden deaths resulting from

TABLE 2.—*Principal Types of Accidental Deaths, 1973 to 1977**

| Year | Ingestion of Food, Object | Motor Vehicle | Falls | Drowning | Fires, Burns | Firearms | Poison (solid, liquid) | Poison by Gas |
|---|---|---|---|---|---|---|---|---|
| 1973 | 3,013 | 55,511 | 16,506 | 8,725 | 6,503 | 2,618 | 3,683 | 1,652 |
| 1974 | 2,513 | 46,402 | 16,339 | 7,876 | 6,236 | 2,513 | 4,016 | 1,518 |
| 1975 | 3,106 | 45,853 | 14,896 | 8,000 | 6,071 | 2,380 | 4,694 | 1,577 |
| 1976 | 2,059 | 47,038 | 14,136 | 6,827 | 6,333 | 2,059 | 4,161 | 1,569 |
| 1977 | 3,000 | 49,500 | 14,000 | 7,100 | 6,600 | 2,000 | 3,900 | 1,600 |

Source: National Center for Health Statistics and National Safety Council.

*From Accident Facts—1978 Ed. National Safety Council, Chicago, 1978.

TABLE 3.—*Deaths From Suffocation/Ingested Objects—1975/1976**

| *Age Range (years)* | *No. of Deaths* | *Death Rate (per 100,000)* |
|---|---|---|
| 0- 4 .... | 504 | 2.9 |
| 5-14 .... | 77 | 0.2 |
| 15-24 .... | 223 | 0.4 |
| 25-34 .... | 218 | 0.8 |
| 35-44 .... | 241 | 1.2 |
| 45-54 .... | 369 | 1.6 |
| 55-64 .... | 429 | 2.4 |
| 65-74 .... | 451 | 3.0 |
| 75-Up ... | 594 | 5.7 |
| All ages .. | 3,106 | 1.4 |

*Reproduced from Report on Emergency Airway Management, 1976, with the permission of the National Academy of Sciences, Washington, DC.

upper airway obstruction may not be identified, but rather may be mistakenly ascribed to cardiac disease or other causes. While the recognized total is far smaller than the toll taken by several major causes of death (see Table 1), it is generally equivalent to that of many other important causes of accidental death, including death caused by fires, firearms and poisoning (see Table 2).

Victims tend to be either very young or very old, as shown in Table 3. These figures represent the number of people who die from total obstruction of the airway, generally at the level of the larynx. They do not include the large number of children who aspirate foreign bodies—such as coins, marbles and peanuts—past the larynx, down the trachea and into a mainstem bronchus. Such foreign body aspirations lead to significant pulmonary complications, and can be fatal in some cases. However, pulmonary aspiration of foreign bodies represents a different entity from upper airway obstruction secondary to foreign bodies that are caught at the level of the vocal cords. Those instances in small children of laryngeal obstruction caused by objects such as peanuts or coins are considered in this discussion.

There are several risk factors involved in the precipitation of upper airway obstruction.[2,13] Inebriation significantly enhances the likelihood of such an event. This becomes even more probable statistically when the victim is not only inebriated but has poor eating habits and uses dentures. Most reported cases of upper airway obstruction occur in public restaurants, where victims suddenly collapse following an attempt to swallow large and poorly chewed pieces of meat. A universal choke sign, introduced by Dr. Heimlich in 1974,[5] has been introduced to the public so that a victim will be able to communicate to any onlookers that he is in fact choking.

## Physiology

A number of factors influence the prognosis of the victim of food choking. One of these is the site of obstruction of the foreign object.[14] Objects that lodge at the level of the larynx, either at or just above the vocal cords, will allow a reasonable chance of adequate resuscitation. Objects that are lodged just below the vocal cords, or on the under side, are much more difficult to move via any of the techniques described. For these patients, removal with medical instruments, under direct vision, is probably the only reasonable alternative. Unfortunately, very few such victims would survive the time of transport to a medical facility.

The degree of obstruction also plays a critical role in prognosis.[14,15] Partial obstruction allows the passage of some air, and a partially obstructing object is easier to remove. Complete obstruction rapidly produces severe hypoxia, concomitant with much higher pressure requirements for removing the obstructing object. Finally, the size of the object is of course an important factor, as larger objects are more difficult to remove and tend to produce more complete obstruction.[15]

Normal coughing produces large increases in intrathoracic pressure, upper airway flow and tidal volume.[14] The maneuvers we will be discussing, especially back blows, abdominal thrusts and chest trusts, can be thought of as artificial cough techniques intended to generate similar increases in pressure, flow and volume. Dr. Heimlich states that clearance of an obstructing object from the larynx is directly related to the peak flow achieved by his technique.[10] Other investigators claim that the direct pressure to which the object is subjected is responsible for movement of the object,[14] while still others consider the kinetic energy applied to the object to be the determining factor.[16] The question of which factors are important in budging a wedged object is an important one, as the various artificial cough techniques produce widely divergent effects in terms of pressure, flow and volume.

Movement of an object where there is no resistance present is proportional to the amount of force (pressure over a given area) delivered to it. This is likewise related to the total pressure delivered to the object over a period of time, and correlates with the amount and rate of air flow

in the vicinity of the object. In the presence of resistance, however, an object can be moved only if the sudden force generated overcomes the static resistance of the object. Instantaneous increases in pressure proportional to the sudden force delivered are critical if there is any amount of resistance. A wedged object subjected to high pressures over a short period may move a short distance, but then no further if the applied force is removed. On the other hand, small increases in pressure (and thus force) sustained over a long period of time will move a frictionless object a great distance (along with the air around it), but will fail to budge a wedged object if instantaneous force never exceeds the static resistance. We will soon see the importance of these observations in the treatment of upper airway obstruction.

## Clinical Data

No controlled prospective studies in the treatment of upper airway obstruction have been reported, nor are any likely to be performed. Because of obvious ethical considerations, analysis of efficacy of various therapeutic techniques must rely on isolated reports sent to scientific organizations by isolated individuals. These reports are by nature not only anecdotal but also retrospective, and generally they reflect the experience of lay rescuers. They also reflect an inherent bias, as civilian reports are more likely to document successful cases than unsuccessful ones. This same type of bias may be reflected by a tendency to ascribe success to a particular procedure among several used when the citizen is reporting a case to the expert who has recommended that procedure.

Furthermore, the inherent difficulties with record keeping and inability on the part of the reporters to distinguish between the effect of individual sequential maneuvers as opposed to combined effects of various maneuvers make it very hard to accurately interpret the results. These reporting limitations are present in each of the reported clinical series on which we will comment.

It is worth emphasizing that anecdotal reporting is notoriously difficult to evaluate, particularly when the reports come from isolated nonprofessional people. The landmark *Journal of the American Medical Association (JAMA)* supplement issue in 1974, devoted to the American Heart Association Protocol for CPR, displays on its cover an entire series of techniques anecdotally reported at various times throughout history to be successful in reviving dead persons.[17] Anecdotal assertions as to the efficacy of Laetrile (*l*-mandelonitrile-$\beta$-glucuronic acid) as an antitumor agent, for instance, or of vitamin E for the treatment of a multiplicity of unrelated ailments, have received widespread public attention despite the lack of any scientific evidence. A variety of techniques to resuscitate drowning victims, including rectal fumigation, led to a parade of 2,000 such victims "saved" in England on the first day of the nineteenth century.[18,19] The efficacy of various procedures in the treatment of upper airway obstruction should not be compared to these examples. However, it is important to recognize that anecdotal assertions and sweeping generalizations made on the basis of such anecdotes should be viewed with some degree of caution.

When Heimlich first described his abdominal thrust maneuver in 1974, he called on physicians and members of the lay public to contact him if and when they used, or know of someone else's having used, the Heimlich maneuver. He has subsequently collected a large series of patients from these individual reports sent to him, and has reported results at various times.[5,6,8,9] Dr. Heimlich's reports consistently suggest almost universal efficacy of the Heimlich maneuver, with very limited adverse effects, and these Dr. Heimlich ascribes to misuse of the maneuver rather than to inherently deleterious consequences. Dr. Heimlich has also reported that the authors of a number of these testimonials make the claim that other maneuvers, such as the "back blow," were unsuccessful with patients whose obstruction was subsequently relieved by the abdominal thrust.

A similar experience was reported by Dr. Trevor Hughes, whose series of 428 cases of food choking has been summarized in an abstract of scientific papers for the American Society of Anesthesiologists (and later expanded to 536 cases).[20] Hughes' results are very similar to Heimlich's, but this is perhaps not surprising as over 90 percent of Dr. Hughes' cases were supplied by Dr. Heimlich. None of the cases were gathered by Dr. Hughes himself.

The Emergency Cardiac Care Committee of the American Heart Association also collected a series of 225 victims of food choking, treated with various artificial cough techniques.[21] The findings in this series were evaluated by Dr. Joseph Redding in the July 1979 issue of *Critical Care Medicine*.[22] Dr. Redding warns, as do the statisticians of the American Heart Association itself, that it is difficult to interpret the material they

gathered (R. Britten, personal communication). This is because the material was gathered retrospectively, on the basis of individual ancedotal reports, with considerable problems of record keeping. Several data forms were used and many answers were either illegible or ambiguous. Other questions were not answered. Perhaps the most important drawback was that the forms contain no mechanism for rescuers to distinguish between combined effects of various maneuvers and individual effects of sequential maneuvers. Many correspondents marked several measures as having been simultaneously successful, while others marked only one maneuver as successful (ostensibly the last maneuver employed). Of 225 total cases, success was attributed to one method in 116 cases in which only that method was used. In 29 cases, several methods were noted to be successful, while in 75 other cases, several maneuvers were used but only one was marked successful.

Because multiple successes were occasionally reported with individual victims, a total of 256 successes were noted, with 130 failures, on only 225 victims (see Table 4). Attempts were made to analyze the results both when multiple successes were included in the series and when these cases were excluded, so that only success unequivocably related to the single maneuver marked successful would be counted. The final data, with all the reservations that we must ascribe to it, seem to demonstrate that back blows are moderately successful (around 50 percent), while the abdominal thrust and chest thrust are much more successful (70 percent to 85 percent). Interestingly, external CPR had the highest rate of success (86 percent) in a small number of trials (14).

Each of the maneuvers was marked successful in at least several cases where it was the only maneuver employed. Furthermore, each of the maneuvers was marked successful in cases where one or all of the other maneuvers were marked unsuccessful (see Table 5). There were 38 cases where the Heimlich maneuver was considered successful after the back blow had ostensibly failed. On the other hand, there were 14 instances where the back blow was considered life-saving after the Heimlich maneuver had been considered to have failed. A similar pattern was seen for all of the maneuvers in all the various combinations.

Finally, there is some suggestion that in many of the cases it may have been the combination of maneuvers that dislodged the foreign body. This is difficult to ascertain from the limited reporting of each of these events, but in at least several instances rescuers noted their feeling that using a combination of maneuvers simultaneously or sequentially had contributed to success. While it is hard to know from these reports whether in fact it was the combination of maneuvers in these cases that saved the victim, it is equally difficult to know whether techniques marked unsuccessful on some of the other reports did not in fact contribute to the ultimate success of the final maneuver, to which the success was solely attributed.

The latest clinical series has recently been reported by Dr. Edward Patrick.[23] In this report Dr. Patrick published a detailed questionnaire that, if correctly filled out, might help to clarify the sequence of events taking place in each individual rescue attempt. If accurately reported,

TABLE 4.—*Effectiveness of Food-Dislodging Maneuvers**

| *Maneuver* | *Trials* | *Successes* | *Failures* |
|---|---|---|---|
| Back blows (BB) ..... | 109 | 53 (22) | 56 |
| Abdominal thrust (AT) .. | 168 | 132 (74) | 36 |
| Chest thrust (CT) ..... | 25 | 16 ( 9) | 9 |
| Finger probe (FP ..... | 52 | 30 ( 9) | 22 |
| Instrumentation (IN) ... | 18 | 13 ( 2) | 5 |
| Cardiopulmonary resuscitation (CPR) ... | 14 | 12 ( 0) | 2 |

Reported as "successful" when used as one or more maneuvers. Figures in parentheses indicate "successful" application with no other maneuver used.

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TABLE 5.—*Effectiveness of Subsequent Maneuvers After Initial Failures**

| *Initial Failures* | | *Successful Subsequent Maneuvers* |
|---|---|---|
| Back blows (BB) ..... | 56 | AT 38, CT 4, FP 5, IN 4, AT+FP |
| Abdominal thrust (AT) ..... | 36 | BB 14, CT 2, FP 5, IN 6, BB+CPR 2, IN+CPR |
| Chest thrust (CT) ..... | 9 | BB 2, FP 2, IN 3, CPR |
| Finger probe (FP) ..... | 22 | BB 4, AT 7, CT 2, IN 4, BB+CPR |
| Instrumentation (IN) ..... | 5 | FP, BB+CPR |
| Cardiopulmonary resuscitation (CPR) .. | 2 | BB |

Maneuvers or combinations of maneuvers reported as "successful" after reported "failure" with the initial measure applied.

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meticulous answering of the questionnaire should help to alleviate some of the confusion created in other clinical series. Nevertheless, it might still be difficult to ascertain whether sequential maneuvers have potentiating effects. In the same paper Dr. Patrick also reports his findings on 1,164 patients whose treatment outcome was evaluated. He then divides these 1,164 cases into two groups: Group I consists of 972 patients treated with the Heimlich maneuver alone or before other maneuvers; Group II is comprised of 192 patients who received back blows initially. Dr. Patrick presents a statistically significant increase in negative outcomes when the second group is compared with the first, and argues that current recommendations that the back blow be used first are dangerous.

There are a number of problems with Dr. Patrick's report. In the first place, less than 10 percent of the patients reported in this very large series actually filled out Dr. Patrick's questionnaire (personal communication). It is not clear how the data were gathered on the remaining 90 percent of the patients in the series. For this reason, there is a reasonable question as to the accuracy of the majority of these anecdotal reports.

In the second place, over 900 of the patients in the series represent testimonials gathered by and delivered to Dr. Patrick by Dr. Heimlich.

Third, negative outcome is defined in terms of the victim collapsing, becoming unconscious or dying. Onset of unconsciousness, or "collapsing," is more likely related to the degree of antecedent hypoxia at the time any given maneuver was introduced, rather than to the effect of that maneuver. Perhaps a more appropriate way to evaluate outcome would be to look at death or neurologic impairment following the event. This of course would be more difficult, but clearly very important. Dr. Patrick makes no attempt to evaluate neurologic outcome, and does not report incidences of death following back blows as compared to abdominal thrusts.

Finally, it is somewhat difficult to evaluate Dr. Patrick's choice of these two specific groups. If the more successful group consisted of patients who received the Heimlich maneuver *first* or alone, at least some members of this group must have had other maneuvers following the Heimlich maneuver, ostensibly because the Heimlich maneuver was unsuccessful by itself in removing the obstruction. It would be hard to use such cases to try to prove that these other maneuvers should not be used in the treatment of airway obstruction. It is not clear from Dr. Patrick's report what percentage of patients in this first group had the Heimlich maneuver alone, as compared to the Heimlich maneuver followed by other maneuvers. Evidently Dr. Patrick's data have been computerized, so it may be possible to retrieve numbers on a much larger and more detailed set of subgroups, including those who received only the Heimlich maneuver, or only back blows, and those who received several maneuvers in various combinations. Such information might be more helpful, but would still require careful evaluation because of the method of data collection.

## Physiologic Data

There are to date four reports of experimental studies regarding the treatment of airway obstruction. In 1975 Dr. Heimlich measured the pressures generated, volume of air expelled and peak flow rates with the Heimlich maneuver in ten conscious human volunteers.[6] He also tested the Heimlich maneuver on four beagles who had been intubated with an endotracheal tube, the lumen of which had been plugged by a rubber stopper. After inflating the tubes' cuffs, Dr. Heimlich found that "the endotracheal tube (bolus) popped out of the trachea" in over 20 attempts, with no failures reported. Abdominal thrust during early expiration moved an average of 0.94 liter of air (0.35 liter was expelled when the maneuver was applied at end expiration) and peak flow rates of 205 liters per minute (74.9 liters per minute at end expiration) were measured.

In 1977 Dr. Charles Guildner and colleagues[24] reported a comparison of abdominal thrust and chest thrust in normal anesthetized human volunteers. They initially also attempted to measure the effects of back blows, but abandoned this because back blows were "so ineffective in creating air flow or increased pressure in the chest." Dr. Guildner and associates report significantly higher peak pressures, peak flows and vital capacities with the use of the chest thrust as compared with the abdominal thrust, in both the sitting and supine positions. They thus recommend the chest thrust as the procedure of choice, although inexplicably conclude the article by proposing a treatment regimen wherein back blows would be used before any thrust procedure.

Dr. Archer Gordon has completed the most extensive series of experiments on anesthetized apneic humans designed to evaluate artificial cough techniques.[14,25] He found first of all that none of

these procedures could generate comparable pressures, flows or volumes to that of normal cough. He also found that the effects of normal coughing are enhanced by increased precough volume in the lung, and noted that increased lung volume in turn increases the effectiveness of any of the artificial cough procedures.

Dr. Gordon also found that back blows produced substantially higher pressures and generated these pressures over a much shorter time than either chest thrust or abdominal thrust (see Figure 1). Chest thrust was found to be somewhere in between the other two. Chest thrust and abdominal thrust both produced higher volumes of air moved than the back blow, and the same was true for peak flows. Interestingly, external CPR produced results similar in all respects to those of chest thrusts and abdominal thrusts. None of these maneuvers approached the normal cough in effectiveness. Dr. Gordon speculates on the basis of

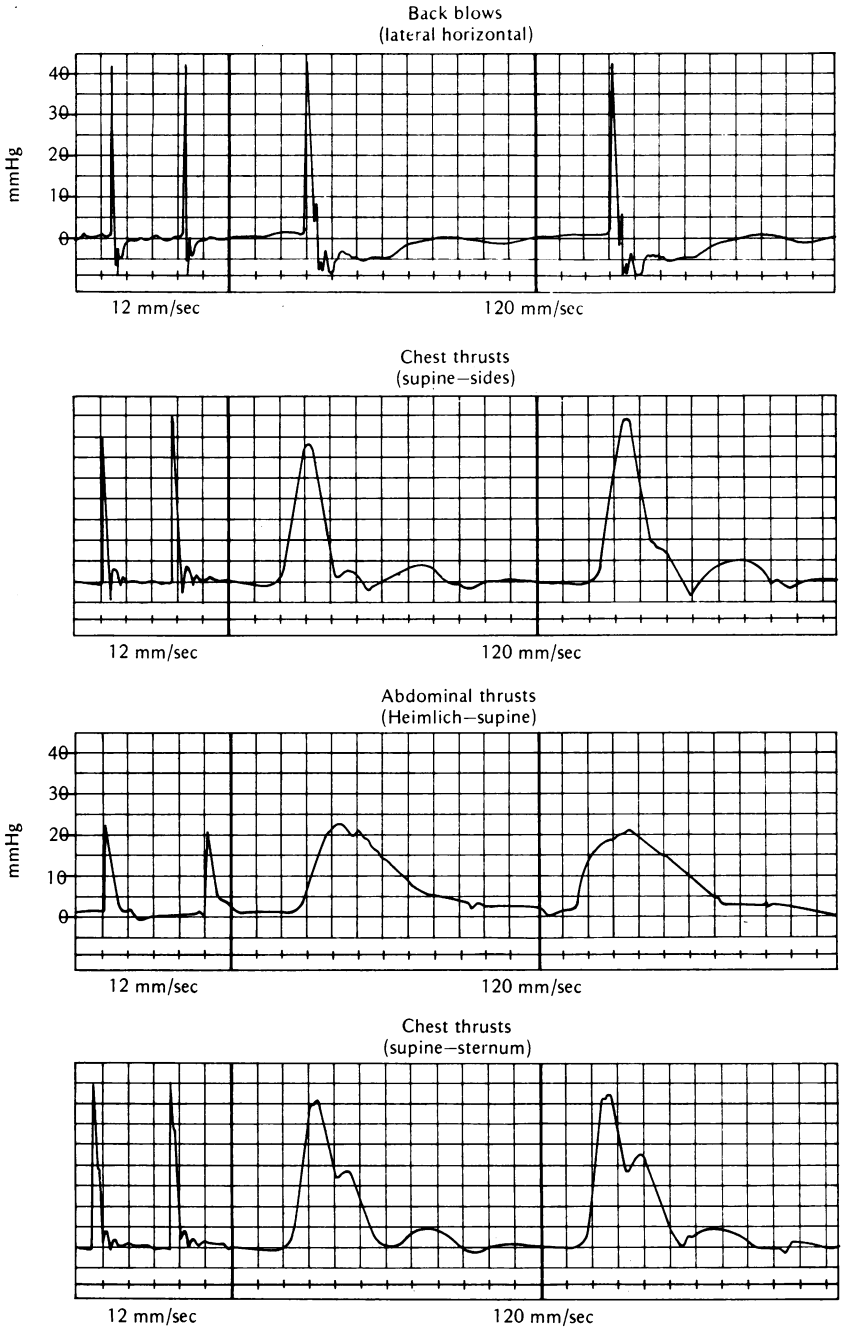


**Figure 1.**—Airway pressure during artificial coughs with airway blocked (humans). (Reproduced by permission from Gordon et al.[14])

his results that the instantaneous, rapid rises in intrathoracic pressure created by the back blow would be sufficient to disimpact foreign objects lodged at the level of the vocal cords, but would be insufficient to move such objects a great distance because of the small amount of air moved. Abdominal thrusts, on the other hand, along with chest thrusts, might on occasion deliver insufficient force to move objects impacted in the larynx (with high static resistance), but might move objects previously loosened by the back blow an appreciable distance in the posterior pharynx. He then suggests that a combination of these maneuvers, using the back blow first, should be superior to using any of the maneuvers alone. In a related study with both adult and infant baboons, he found that foreign bodies were in fact moved more successfully by a combination of maneuvers than by either back blows or abdominal thrusts alone.[25]

The final physiologic study comes from Dr. H. Ruben[15] of the University of Copenhagen. He used a silicone rubber cast of the human larynx, into which were placed various types of food pieces, to measure the amount of pressure necessary to move these foods. He subsequently measured pressures generated on both fresh cadavers and anesthetized humans following back blows, abdominal thrusts and chest thrusts. Finally, he attached the model larynx with the food fragments in place to the endotracheal tubes of intubated human subjects and analyzed the effectiveness of the various techniques.

Ruben found that the pressures required to remove food lodged in the model larynx varied with the type of food involved and with whether the food was wedged in an airtight manner or if an air leak was allowed. In general, pressures required to remove meat wedged in the larynx in an airtight position were far higher than those achieved with any of the artificial cough maneuvers. Partial obstructions, associated with air leaks, also required considerable pressures, though these were occasionally within the range of some of the maneuvers. Interestingly, ejection was easier if the model was inverted or if the pressure was applied in a series of jolts as opposed to steady pressure.

Ruben found that pressures generated by back blows were substantially higher than those generated by abdominal thrusts in both anesthetized human volunteers and fresh cadavers. Chest thrust also yielded higher pressure than did the Heimlich

TABLE 6.—*Highest Recorded Intratracheal Pressure in 12 Anesthetized Human Volunteers**

| | *Heimlich Maneuver median (range) (cm $H_2O$)* | *Sternal Thrust median (range) (cm $H_2O$)* | *Blow on Back median (range) (cm $H_2O$)* |
|---|---|---|---|
| Resting expiratory level ..... | 10 (4-20) | 20 ( 6-22) | 25 (12-30) |
| Inspiratory Volume 600 ml | 16 (6-22) | 30 (15-35) | 32 (20-35) |

*Reproduced by permission from Ruben & Macnaughton.[15]

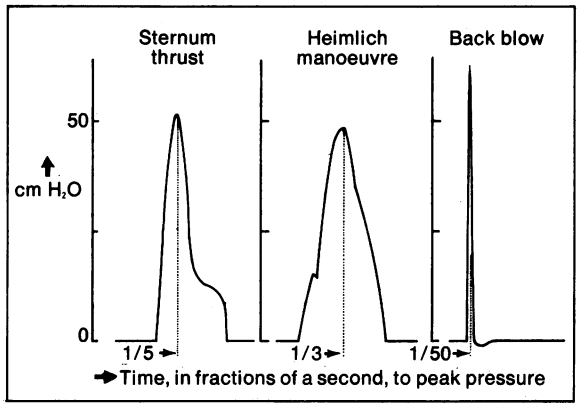


**Figure 2.**—Typical pressure waves recorded from chest thrust, Heimlich maneuver and back blow. (Reproduced by permission from Ruben & Macnaughton.[15])

maneuver, although these pressures were slightly lower than those achieved with back blows. Rate of pressure rise was also greatest with back blows and least with abdominal thrusts (see Table 6 and Figure 2).

When the model larynxes with the obstructing food were attached to the endotracheal tubes of intubated volunteers, successful removal was achieved only once, in a patient in whom an orange segment was attached to the model larynx, and only when the Heimlich maneuver in combination with the sternal thrust were aided by gravity.

Dr. Ruben concludes from his study that none of the maneuvers would be successful when a piece of meat is tightly wedged in a victim's larynx. With partial obstruction, back blows seem to be able to generate the type of rapid rise and total pressure necessary to move some types of food objects. Chest thrusts seem similarly able to do this, while abdominal thrusts generate considerably less pressure.

Dr. Ruben emphasizes the positive effects of gravity and the seeming importance of the rate of pressure rise in conjunction with the total pressure achieved. He further warns against finger

TABLE 7.—*Comparative Effects of Cough and Artificial Cough Maneuvers*

| | Pressure (mm Hg) | Volume (cc) | Flow (L/min) |
|---|---|---|---|
| Cough | | | |
| Gordon et al[14] | 72/115* | 550/1,650* | 198/378* |
| Back Blow | | | |
| Guildner et al[24] | .. | ... | ... |
| Gordon et al[14] | 25/45* | 25 | 39 |
| Ruben & Macnaughton[15] | 18/24* | ... | ... |
| Abdominal Thrust | | | |
| Heimlich et al[6] | 31 | 940 | 205 |
| Guildner et al[24] | 19 | 380 | 65 |
| Gordon et al[14] | 11/15* | 283 | 264 |
| Ruben & Macnaughton[15] | 7/12* | ... | ... |
| Chest Thrust | | | |
| Guildner et al[24] | 32 | 520 | 99 |
| Gordon et al[14] | 18/19* | 240 | 276 |
| Ruben & Macnaughton[15] | 15/22* | ... | ... |

*Values of lung volume recorded at end inspiration.

probes in the posterior pharynx when unaided by direct visualization, as the possibility of even further wedging an object (however slightly) with digital pressure would seem to be associated with significantly greater difficulty in subsequently removing that object.

A comparison of the physiologic effects of each of the various maneuvers is made in Table 7. While the individual numbers generated seem to vary a great deal, it is reasonable to conclude that back blows produce higher and more rapid pressure rises than do the other maneuvers, while chest thrusts produce somewhat more substantial results than Heimlich maneuvers. Back blows produce the least effect in terms of flow rates and volume of air moved. Each of the maneuvers' effectiveness is enhanced when carried out at a higher lung volume, but none of the maneuvers approximates the effect of normal cough, particularly when cough is carried out at end inspiration.

## Side Effects

### *General Considerations*

Any of the maneuvers in question might be considered to have a deleterious effect on the basis of any or all of three possible mechanisms. The maneuvers may cause direct side effects, such as damage to vital organs. If they are ineffective, they may be deleterious by delaying other more effective maneuvers. Finally, they can directly and adversely affect the success of subsequent maneuvers by, for example, wedging the obstructing object even further into the larynx.

### *Back Blows*

Back blows have been associated with a very low incidence of minor side effects, including sore ribs and back, and occasional nausea and vomiting after the maneuver.[21] Back blows take less than several seconds to perform, and thus should not influence the results of anoxia. We know that unconsciousness occurs early following global anoxia, from 8 to 12 seconds after its onset,[26] while irreversible neurological damage does not occur for at least 2 to 4 minutes, and death likewise does not occur for approximately 4 minutes or more.[27,28] Obviously there is no advantage in delaying adequate therapy for even a matter of several seconds, but the likelihood that this will substantially affect the final outcome is in fact very small.

Perhaps of greater concern is the possibility that back blows will wedge objects further in the larynx. This claim has been made by Dr. Heimlich,[10,29] who states that it has been substantiated by individual case reports, wherein children who were evidently choking on a piece of food but were able to move air and remain conscious, deteriorated following application of back blows. Several such anecdotal cases have been described by Dr. Heimlich. Dr. Heimlich also refers to the writings of Dr. Samuel Gross on this subject.[29] Dr. Gross, a nineteenth century American physician, collected several hundred cases of foreign body aspiration.[30] He described several cases wherein back blows contributed to total obstruction at the level of the larynx. He also warned against the use of back blows in breathing, conscious victims, and said that they should be reserved for a "last resort" effort.

Dr. Gross's observations and conclusions do not in fact in any way suggest that back blows move objects distally, thus driving them further into the larynx. Dr. Gross's case reports of back blows causing obstruction despite inversion of the victim were of children who aspirated small foreign objects not to the level of the larynx, but rather past the larynx and vocal cords and into the right mainstem bronchus. Such children then had cough and irritative pulmonary signs, but no signs of upper airway obstruction. In several cases zealous family members attempted to treat the problem by turning the child over and administering blows to the back, which occasionally caused the object to

move, not distally but proximally, down the trachea, where it was then wedged against the underside of the larynx. In several instances, this caused total obstruction of the upper airway and subsequent deterioration. This does not mean that back blows cause distal movement of foreign bodies, nor is it applicable to a discussion of upper airway obstruction. Anecdotal cases described by Dr. Heimlich where breathing and conscious children evidently deteriorated following back blows serve to emphasize the generally agreed upon point that patients with partial upper airway obstruction who are able to move adequate amounts of air should not in fact have any artificial cough techniques administered. These patients should be encouraged to take a deep breath and then cough. If this effort is unsuccessful in removing the object, the patient should be taken to a medical facility where instrumental removal of the foreign object can be done under direct visualization. Dr. Gross's recommendations that back blows be used only as a last resort, that is, in patients in whom airway obstruction is sufficient to occlude the airway and preclude adequate air movement, are still cogent today and hold true not only for back blows but also for all other artificial cough techniques. On the other hand, there is no theoretic or empiric reason to suspect that the back blow, which raises pressure in the thorax distal to the obstructing object, should cause any object to move retrograde and become more deeply wedged at the level of the vocal cords.

*Abdominal Thrust*

Dr. Heimlich notes that 11 cases of broken ribs secondary to abdominal thrust were reported in his first approximately 500 cases. He ascribes these to improper performance of the procedure. Other reported side effects include several instances of abdominal tenderness and nausea and vomiting; one case of retinal detachment; one case of a ruptured stomach and associated small laceration of the spleen with satisfactory outcome following surgical repair of the stomach and splenectomy, and one case of clinically insignificant pneumomediastinum.[21,31,32] Theoretic concerns have been raised about significant intra-abdominal organ damage and about the possibility of pulmonary aspiration, if and when the obstructing food bolus is cleared from the larynx following the forceful pressure delivered to an often full stomach by the Heimlich maneuver. Neither of these potential complications has been reported, nor have any other major adverse effects. It is worth noting that the Heimlich maneuver might well take considerably longer to perform than back blows.

*Chest Thrust*

Experience with the chest thrust is much more limited than with either the Heimlich maneuver or back blows. No substantial side effects have been reported, although chest soreness following chest thrust was reported in the American Heart Association series.[21] Concern has been raised about the possibility of not only broken ribs and sternal fractures, but of any and all of the side effects noted during external CPR. These include myocardial contusions, pneumothoraces and intra-abdominal organ damage, among others.[13] On the basis of these proposed potential complications, Dr. Heimlich and others have suggested that the chest thrust is too dangerous to use routinely. While a number of noteworthy complications have in fact been reported with external CPR, they have occurred following many thousands of applications of external CPR. Not only has external cardiac massage been done on an extremely large number of patients (a group many times the size of the group that has received any of the artificial cough maneuvers), but multiple external compressions are done during each single resuscitation. Thus the true incidence of side effects with external CPR is extremely small and may not in fact exceed that of any of the external cough maneuvers. It is difficult, therefore, to exclude chest thrust from our therapeutic armamentarium for the treatment of upper airway obstruction on the basis of assumed similarity to another procedure that is, from all we know, extremely safe.

*Finger Probe*

Attempts to manually extract foreign bodies from the back of the throat have not been discussed in detail in this paper. These attempts, whether with the rescuer's fingers or with some form of instrument, are the method of choice when there is direct visualization of the object. However, in the absence of visualization, these methods, though moderately successful according to clinical reports,[21] seem to be quite dangerous.[15] Not only have they caused minor side effects such as loose teeth and pharyngeal abrasions,[21] but there is a substantial risk of further impaction of the foreign body, with resultant inability to remove it by any of the artificial cough techniques. Drs. Ruben and Macnaughton's study indicates

that slightly increased wedging of an object into the larynx requires greatly increased pressures to remove that object.

## Artificial Cough Techniques—Summary

*Back Blows*

At this point, all available evidence suggests that the back blow is an easily and rapidly executed maneuver that seems to have moderate clinical success. It increases intrathoracic pressures, which should result in effectively removing tightly wedged foreign bodies from the larynx. Back blows should be followed by other maneuvers, such as the abdominal thrust or chest thrust, to move the object out of the larynx. While there has been speculation about possible adverse effects of this maneuver, there is no evidence at this point that the procedure carries any major risk.

*Abdominal Thrust*

The abdominal thrust, or Heimlich maneuver, is associated with a large number of documented clinical successes. While we should be somewhat cautious about interpreting these anecdotally reported successes, the Heimlich maneuver has a strong place in the treatment of upper airway obstruction. Nevertheless, experimental studies showing that it is incapable of substantially increasing intrathoracic pressures, and that it is particularly incapable of producing a rapid rise in pressure, suggest that its success will be greatest if it follows another maneuver, such as back blow, that might loosen or dislodge a wedged object. While there are potential complications to the Heimlich maneuver, current experience indicates that it is a fairly safe procedure.

*Chest Thrust*

There are fewer anecdotal data regarding the clinical effectiveness of the chest thrust, though in terms of percentages of success, it is roughly as successful as the Heimlich maneuver. Experimental evidence demonstrates that the chest thrust produces higher intrathoracic pressure than does the abdominal thrust and, in the absence of any hard evidence that the chest thrust is associated with notable morbidity, it may well be preferable to the abdominal thrust. At this point, however, we probably do not have enough data to clearly recommend one of these maneuvers over the other.

*Finger Probe*

While the finger-probe technique, along with other attempts at directly removing an obstructing object, has had some success clinically, in light of its potential for worsening the situation, it probably should be employed only under direct visualization or as an absolutely last resort.

## Conclusions and Recommendations

There has been much sound and fury regarding the appropriate treatment of foreign body obstruction of the upper airway, but there is a paucity of hard data. The limited clinical data that we do have are retrospective, anecdotal and testimonial and, for the most part, poorly reported by lay rescuers. The data suggest mixed results with reasonably high success with thrust techniques. They also suggest that a combination of maneuvers is superior to any single maneuver.

Most attempts at treating foreign body upper airway obstruction are performed not in the setting of a professional office or hospital environment, but rather by civilians in public places such as restaurants. Thus, our energy should be directed to appropriately teaching the lay public how to treat upper airway obstruction. We have learned in our attempts to teach CPR that there is a tremendous and rapid attenuation of skills following complex courses for citizens.[33-36] Citizen CPR providers are able to remember cognitive details such as how to recognize cardiac arrest, but rapidly lose their ability to remember exact performance details, such as compression and ventilation rates and ratios. It seems unreasonable, therefore, to ask the public to memorize complicated treatment sequences for the management of upper airway obstruction, such as those presently suggested by the American Red Cross and the American Heart Association. Rather, it might be more effective to teach the public a limited number of important facts about the subject. We should stress the recognition of upper airway obstruction and a variety of techniques for dealing with it, such as the back blow (which is obvious and very easy to learn) and one of the thrust techniques, as well as external CPR.

We should encourage people to refrain from doing any of these maneuvers if the victim is breathing and spontaneously able to cough. We should suggest that they do each of these maneuvers in whatever sequence they can remember, and with successive repetitions, when they are confronted with a patient with a totally obstructed airway, while simultaneously contacting their emergency medical service system. Repeated attempts should be continued until professional

help arrives, as initial failure may be reversed when laryngospasm abates with the onset of coma. Nevertheless, some cases may require direct laryngoscopic visualization and instrumental removal of the foreign body.

## REFERENCES


1. Heimlich HJ: Pop goes the cafe coronary. Emergency Med 6:154-155, 1974

2. Haugen RK: The cafe coronary: Sudden death in restaurants. JAMA 186:142-143, 1963

3. National Academy of Sciences, National Research Council: Cardiopulmonary resuscitation. JAMA 198:372-379, 1966

4. Eller WC, Haugen RK: Current concepts: Food asphyxiation —Restaurant rescue. N Engl J Med 289:81-82, Jul 12, 1973

5. Heimlich HJ: A life-saving maneuver to prevent food choking. JAMA 234:398-401, 1975

6. Heimlich HJ, Hoffman KA, Canestri FR: Food-choking and drowning deaths prevented by external subdiaphragmatic compression—Physiological basis. Ann Thorac Surg 20:188-195, Aug 1975

7. Committee on Emergency Medical Services, Assembly of Life Sciences: Report on Emergency Airway Management. National Research Council, National Academy of Sciences, 1976

8. Heimlich HJ: Back blows or death blows. Emerg Med Srvs 8:88-95, 1979

9. Heimlich HJ: The Heimlich maneuver versus back blows for choking victims. Emerg Med Srvs 9:11-37, 1980

10. Heimlich HJ: Controversial panel on the Heimlich maneuver. American College of Emergency Physicians Scientific Assembly, Las Vegas, Nevada, 1980

11. Statistical abstracts of the U.S.—1978, ed 99. United States Dept of Commerce, Bureau of Census, 1978, p 75

12. Accident Facts. National Safety Council, Chicago, 1977

13. Standards and Guidelines for Cardiopulmonary Resuscitation (CPR) and Emergency Cardiac Care (ECC): Part II.—Adult basic life support. JAMA 244:460-471, Aug 1, 1980

14. Gordon AS, Belton MK, Ridolpho PF: Emergency management of foreign body obstruction, chap 6, Safar P (Ed): Advances in Cardiopulmonary Resuscitation. New York, Springer-Verlag, 1977

15. Ruben H, Macnaughton FI: The treatment of food-choking. Practitioner 221:725-729, Nov 1978

16. Patrick EA: Controversial panel on the Heimlich maneuver. Presented at the American College of Emergency Physicians Scientific Assembly, Las Vegas, Nevada, 1980

17. Standards for Cardiopulmonary Resuscitation (CPR) and Emergency Cardiac Care (ECC). JAMA 227(Suppl):837, 1974

18. Cullen W: A letter to Lord Cathcart concerning the recovery of persons drowned and seemingly dead. Edinburgh, William Creech, 1791

19. Ramsey D: A review of the improvement and state of medicine in the XVIIIth century. Charleston, WP Young, 1801

20. Hughes T: Comparative analysis of Dr. Henry J. Heimlich's data on 536 case reports of the application of the Heimlich maneuver. Submitted to National Research Council, July, 1976

21. American Heart Association Subcommittee on Emergency Cardiac Care: Reaffirmation of the American Heart Association's Position on the Emergency Treatment of the Obstructed Airway. American Heart Association document COM/SI 80-511B, Jan 1979

22. Redding JS: The choking controversy: Critique of evidence on the Heimlich maneuver. Crit Care Med 7:475-479, 1979

23. Patrick EA: Choking—A questionnaire to find the most effective treatment. Emerg Med Srvs 9:59-64, 1980

24. Guildner C, Williams D, Subitch T: Airway obstructed by foreign material: The Heimlich maneuver. JACEP 5:675-677, 1977

25. Gordon AS: Emergency airway management. Presented at the 3rd annual UCLA School of Medicine Postgraduate Institute on Emergency Medicine, 1978

26. Rossen R, Kabat H, Anderson JP: Acute arrest of cerebral circulation in man. Arch Neur Psych 50:510-528, 1943

27. Cole SL, Corday E: Four minute limit for cardiac resuscitation. JAMA 161:1454, 1956

28. Lund I, Skullberg A: Cardiopulmonary resuscitation by lay people. Lancet 2:7988, 1976

29. Heimlich HJ, Uhley MH: The Heimlich maneuver. Clin Symp 31:3-34, 1979

30. Gross SK: A Practical Treatise on Foreign Bodies in the Air Passages. Philadelphia, Blanchard and Lea, 1854

31. Visintine RE, Baick CH: Ruptured stomach after Heimlich maneuver. JAMA 234:415, Oct 27, 1975

32. Agia GA, Hurst DJ: Pneumomediastinum following the Heimlich maneuver. JACEP 8:473-475, Nov 1979

33. Weaver FJ, Ramirez AG, Dorfman FB, et al: Trainees' retention of cardiopulmonary resuscitation: How quickly they forget. JAMA 241:901, 1979

34. Alvarez H III, Cobb L: Experiences with CPR training of the general public, *In* Proceedings of the National Conference on Standards for Cardiopulmonary Resuscitation (CPR) and Emergency Cardiac Care (ECC). Dallas, American Heart Association and National Academy of Sciences, National Research Council, 1975, p 33

35. Banasik Z, Sledzinski Z, Arciszewski B, et al: The usefulness of Resusci-Anne mannequin in teaching modern methods of resuscitation. Anaesth Resusc Intensive Ther 4:131-137, 1976

36. Vanderschmidt H, Burnap T, Thwaites J: Evaluation of cardiopulmonary resuscitation course for secondary schools. Med Care 13:763, 1975