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ETHER ANESTHESIA WITH IMPROVISED APPARATUS FOR INTRATHORACIC OPERATIONS UNDER EMERGENCY CIRCUMSTANCES *

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ALTHOUGH a technic of anesthesia for intrathoracic operations using cyclopropane has been described (1) and is presently preferred at Stanford University Hospital, an improvised simplified apparatus for ether or chloroform endotracheal anesthesia was developed for general and possible military use.

This need for further simplification of apparatus, in order that the physiologic principles of anesthesia and ventilation might be followed with a minimum of equipment, was expressed by medical officers sent to us for instruction in thoracic surgery and anesthesia. Accordingly, experiments were made on dogs using various kinds of improvised apparatus. The most primitive effective method was found to be endotracheal ether anesthesia in which an ether tin was made to serve as a vaporizer and the anesthetist's lungs as the bellows for the rhythmic, intermittent, inflation of the animal's lungs.

The development of a valve of simple construction, which would effectively separate the phases of respiration so that a bellows might be substituted for the anesthetist's lungs as a means of inflating the lungs,

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was next given our attention. The present apparatus has been used with success in 10 clinical cases of pneumonectomy during which the chest has been held widely open for periods up to four and one-half hours. Ether vaporized with air, at no time enriched with oxygen, was the sole anesthetic. We believe that if the patient will not be able to obtain postoperative oxygen therapy the enrichment of the atmosphere with oxygen during the operation is a questionable procedure. When postoperative oxygen therapy is possible no one will deny the desirability of its use during anesthesia. Oxygen may be added to the atmosphere when it is available but the lack of it does not render intrathoracic surgery impossible if satisfactory ventilation is effected with air.

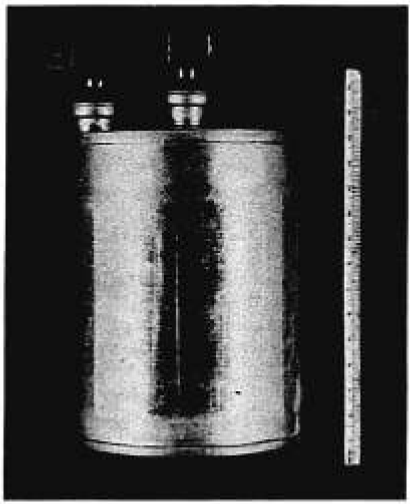

FIG. 1. Ether tin prepared with extra spout and metal elbows fitted into corks.

THE VAPORIZER

A simple and efficient vaporizer may readily be prepared from two 1 pound ether tins plus some pieces of rubber tubing and connections of glass or metal which are usually available. The vaporizer may be constructed in the following manner:

1. Select a 1 pound ether tin and bore a hole of approximately the same diameter as the center spout through the top at the edge of the can. Remove the spout from another tin, fit and solder it into the new

opening. The can now has two identical spouts, one in the center and the new one at the edge.

2. Prepare two corks which accompany ether containers by boring holes through them of sufficient diameter to admit ⅜ inch tubing. When metal elbows are available they may be soldered directly into the largest part of the tapered spout, thus rendering the use of corks unnecessary and permitting the employment of tubing with a larger bore (½ inch).

3. Construct two elbows of ⅜ inch tubing of glass or metal, preferably the latter. These are passed through the holes in the corks until the end of the tubing projects only ¼ inch beyond the tapered end of the cork. The corks with the enclosed elbows are placed in the spouts. Smaller tubing should not be used (fig. 1).

FIG. 2. Ether tin vaporizer with soldered in copper elbows and a copper "T" of same diameter.

4. A "Y" or "T" piece of ½ inch diameter is needed and again the standard copper "T" is the most satisfactory because there is no worry about breakage (fig. 2).

5. A wick of string is made using a form constructed from the cylinder which remains after the top and bottom are removed from the can which was used to secure the extra spout. The top and bottom are easily removed by heating and tapping. The form is cut with an old pair of scissors and bent into shape by hand (fig. 3). After the form has been strung with string (fig. 4), the bottom of the vaporizer is

removed and the wick is inserted (fig. 5). Care must be taken to insure that the wick does not occlude the orifices. The bottom is then replaced and sealed.

FIG. 3. Metal form cut from ether tin. The cylindric form is shortened ¼ inch to permit insertion of wick in vaporizer.

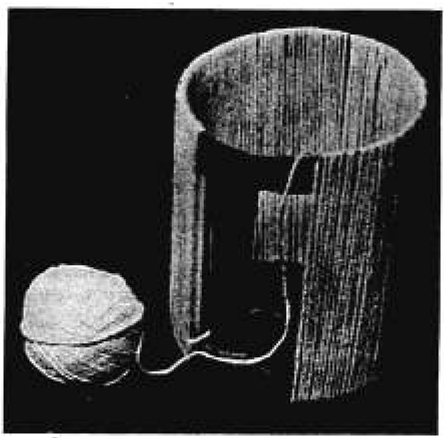

FIG. 4. The edges are serrated and wound with string.

6. Place standard adjustable tubing clamps on the rubber connections as illustrated. Any ordinary surgical spring clamp partially or completely closed will afford a satisfactory substitute for the adjustable clamp.

FIG. 5. The wick is folded to facilitate insertion.

The vaporizer described is satisfactory for the conduct of anesthesia by endotracheal inhalation with a snug fitting endotracheal catheter. The vaporizer will accept the pressure required for inflation of the lungs by mouth to tube breathing on the part of the anesthetist. No other apparatus is required to accomplish emergency anesthesia and ventilation in a patient with a wide open chest wound. When the anesthetist rhythmically and intermittently inflates the patient's lungs he should see that a piece of rubber tubing is attached to the air intake which he may pinch off after each inflation for the fraction of a second required to direct the exhaled anesthetic atmosphere away from his own face. We have demonstrated many times in dogs the practicality of this maneuver in not only keeping the animals alive but in maintaining satisfactory anesthesia. The method has been employed for brief periods of time during the course of intrathoracic operations in patients with sufficient success to warrant the opinion that it could have been continued with safety to the patient if not pleasure to the anesthetist. The degree of expansion of the lungs is under the direct observation of the anesthetist. The carbon dioxide from the anesthetist's exhaled air did not appear to harm the patient but undoubtedly would have done so if the procedure had been continued long. The desirability of inflating the patient's lungs by means of a bellows instead of the mouth-to-vaporizer-to-endotracheal tube technic was always recognized. This, however, had to be accomplished without appreciably complicating the necessary equipment.

VALVE ASSEMBLY FOR SEPARATION OF THE RESPIRATORY PHASES

In addition to the prerequisite of mechanical simplicity, any apparatus for the dual purposes of anesthesia and ventilation in patients with a large chest opening must fulfill certain physiologic requirements.

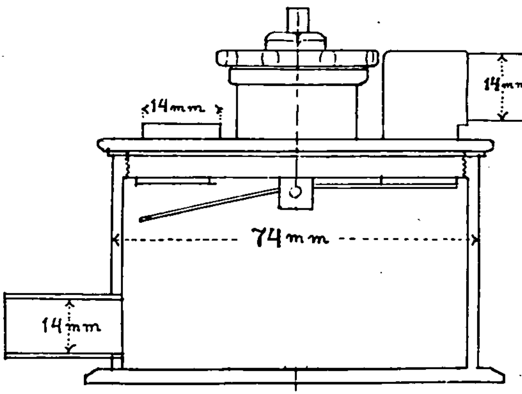

FIG. 6. Diagram of valve assembly. Ether vapor from bellows at upper right forces open pivot valve and is directed through channel at lower left to lungs. Exhalation passes unimpeded, through orifice at upper left, to air.

The apparatus must permit the inflation of the lungs without danger of overdistention. It must permit an unimpeded expiratory phase. It must not allow carbon dioxide accumulation. Several valve assemblies devised on entirely different mechanical principles but with the single purpose of meeting the above criteria were built and tried in the laboratory and the surgical theater. The one which we have found to be the most satisfactory will be described.

The assembly consists of a double action pivot valve (fig. 6), one leaf of which is weighted in such a manner that the valve when at rest is in the expiratory position, thus permitting an uninterrupted flow between the patient's lungs and the outside. The valve leaf over the inspiratory orifice which communicates with the bellows is consequently closed. The valve leaf which guards the inspiratory orifice must therefore be forced open by the anesthetist compressing the bellows containing the ether-laden air which has been previously passed through the vaporizer. The simultaneous closure of the expiratory valve leaf with each compression of the bellows renders inflation of the lungs. Release of the pressure by the anesthetist as the bellows is being refilled allows the weighted valve leaf to fall open, closes the inspiratory valve leaf and makes possible an unobstructed expiratory phase.

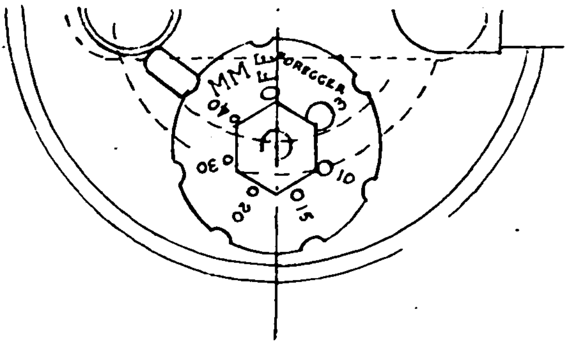

FIG. 7. Valve assembly—top view showing adjustable maximum pressure release (blow-off valve).

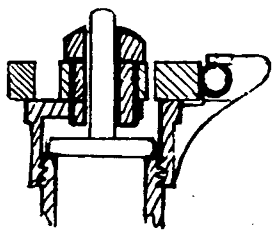

FIG. 8. Section of blow-off valve.

The valve chamber has on its roof another simple valve (figs. 7 and 8) which is not absolutely necessary to the satisfactory performance of the unit but is rather a refinement which prevents overdistention of the lungs by physicians less experienced in giving anesthetics. This valve consists of a weight released by various pressures from 3 mm.

to 40 mm. of mercury, depending upon the size of the orifice which obstructs its exit. The use of this valve which has been found to be most useful when set to release at 10 mm. of mercury is needed more during the early hours of the operation because the anesthetist tends to become less vigorous as the hours roll on.

The complete assembly performs admirably with the Oxford Vaporizer (fig. 9) which the Viscount Nuffield has so generously supplied to the British Armed Forces. When the unit is attached to the Oxford Vaporizer it is highly desirable that the metal sleeve with attached flap valve be removed because the "suck-back" through the

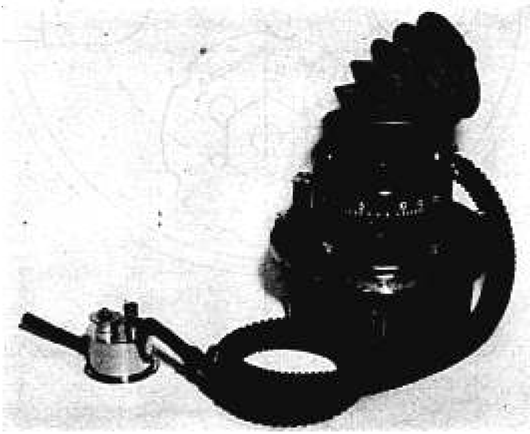

FIG. 9. Valve assembly attached to Oxford Vaporizer.

corrugated tubing aids in the closure of the inhalation orifice of the attached unit. Actually, this "suck-back" of air as the bellows is filled initiates the closure of the inhalation valve leaf and the weight on the expiratory leaf carries the action to completion.

INDUCTION OF ANESTHESIA AND ENDOTRACHEAL INTUBATION

A suitable face mask (fig. 10) which may be connected directly to the vaporizer may also be constructed from a 1 pound ether tin. The can should be cut around its circumference about 2 inches from the top. One side is then notched to allow for the nose, and the wall directly opposite cut slightly elliptical to accommodate the chin. The cut edges should be turned under to render them smooth. This is best accomplished by cutting into the edge to a depth of ¼ inch at ½ inch intervals along its entirety and turning back the individual tabs. Stretching the wrist portion of a rubber glove over the top, allowing it to cover the wall and edge, completes the improvised mask. The rubber diaphragm over the nasal notch allows almost leak proof conditions to be maintained when the mask is applied to patients with

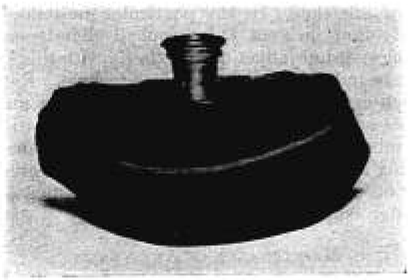

Fig. 10. Improvised face mask.

Fig. 11. Face mask attached to vaporizer.

noses of various shapes and sizes. A short piece of tubing of large caliber is used to connect the top (spout) with the vaporizer (fig. 11).

Induction is begun with the air intake proximal to the face mask wide open and the air intake to the vaporizer occluded by the anesthetist's finger. The finger is then removed so that some air passes over the ether while the greater amount does not. The intake of air near the mask is decreased progressively until the tube is completely closed and all the air passes into the ether vaporizer. The vaporizer is filled to the two-third to three-fourth level with ether which will insure against the inhalation of liquid ether under all circumstances. When the desired depth of anesthesia is obtained, the proximal air intake is opened partially or completely as may be necessary to maintain a given level of anesthesia in the particular individual. The rapid vaporization of ether incident to a tropical climate enhances rather than impedes the speed of induction anesthesia with this system. Anesthesia may also be induced by the open drop technic. Regardless of the method by which anesthesia is induced, endotracheal intubation should be performed as soon as satisfactory muscular relaxation is attained. A snug fitting tube is desirable and the average adult male trachea will admit one having a bore of number 40 French or greater. The use of inflatable cuffs on endotracheal tubes to seal the trachea is considered impractical under emergency circumstances.

MAINTENANCE OF ANESTHESIA

Following endotracheal intubation anesthesia is continued by connecting the tube directly to the vaporizer. The depth of narcosis is regulated by so adjusting the clamp that a lesser or greater amount of air passes through the vaporizer.

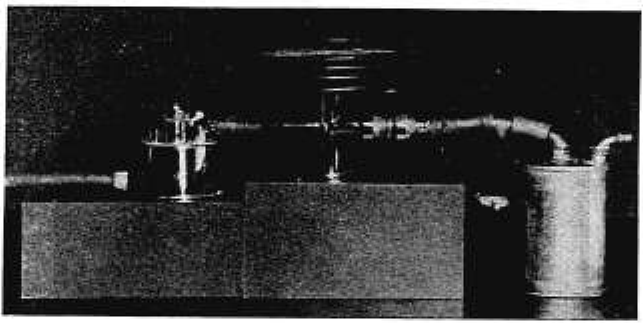

FIG. 12. Complete apparatus—valve assembly, bellows and vaporizer.

CONTROL OF VENTILATION

The use of the bellows to inflate the lungs artificially is begun immediately when the pleura is entered. Just prior to the entrance into the chest the vaporizer should be disconnected and the special valve unit with bellows attached joined in its stead (fig. 12). The ether vaporizer should then be attached to air intake on the bellows. A unidirectional valve on the bellows causes the ether vapor to enter the special valve unit and ultimately the patient's lungs with each compression.

The anesthetist should regulate the inflation of the lungs to synchronize with the patient's own respiratory efforts. Direct observation is the only manner in which this may be accomplished when the bellows and valve unit are used. This contrasts with the carbon dioxide absorption method in which the patient's respiration may be followed by the anesthetist's hand on the breathing bag. However, moderate over-ventilation with either method abolishes the carbon dioxide stimulus to respiration and permits the employment of controlled respiration.

RECOVERY

After the chest wound has been closed, artificial ventilation is discontinued. The vaporizer is again placed next to the endotracheal tube and depth of anesthesia is regulated as before.

COMMENT ON THE USE OF THE APPARATUS

During the course of anesthesia with ether-air for intrathoracic procedures the anesthetist will be impressed with the fast onset of cyanosis following respiratory obstruction. He will therefore be alert to the hindrance to ventilation caused by accumulated secretions. The mechanical obstruction of a bronchus with intact blood supply will result in cyanosis which the surgeon may frequently relieve by the adjustment of a retractor. Anesthesia so light that the patient tends to resist the endotracheal tube will adversely affect the patient's color. In general it may be stated that disturbances in the mechanics of respiration are more quickly detected when ether-air is used than during cyclopropane or ether-oxygen anesthesia. The anesthetist is certain that the percentage composition of the atmosphere used to inflate the patient's lungs, being air, is constant. This knowledge is never present when the carbon dioxide absorption technic is employed.

The average rate of consumption of ether is about ¼ pound per hour during the period that the valve unit and bellows are used. The amount of ether consumed when the vaporizer alone is used is somewhat greater. The passage of the inspired air only through the vaporizer when the valve unit is used compared with the passage of both respiratory phases when it is not accounts for the difference in the rate of ether consumption.

The vaporizer works admirably for endotracheal anesthesia in general surgery and, although it is foreign to the purpose of this paper, it might be stated that sufficient ether concentration to produce profound anesthesia in vigorous subjects has been obtained. Increased depth of anesthesia may be more rapidly effected by imparting the warmth of the administrator's hand to the vaporizer. Agitation of the vaporizer to promote vaporization has not been found necessary.

Restriction of the air intake through the vaporizer renders it satisfactory for the administration of chloroform.

SUMMARY

Apparatus of very simple construction for the dual purposes of ventilation and anesthesia in intrathoracic surgical operations has been described wherein ether vaporized with air, without enrichment with oxygen, was successfully employed.

REFERENCE

1. Neff, William; Phillips, Wilson, and Gunn, Grace: Anesthesia for Pneumonectomy in Man, Anesthesiology 3: 314–322 (May) 1942.

ANESTHESIA ESSAY CONTEST

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THE AMERICAN SOCIETY OF ANESTHESIOLOGISTS, INC.

A prize of $100 is offered for the best original essay, not published previously, on some phase of anesthesiology or on a subject closely related to it. The rules of the contest are enumerated below.

RULES OF THE CONTEST

1. The contest is open to postgraduate medical students (residents, fellows, etc.) of anesthesiology anywhere. It is also open to postgraduate medical students in other specialties who have devoted some of their time to the pursuit of anesthesiology or to some phase of clinical or experimental work which is related to anesthesiology. It is not open to men or women in the practice or teaching of anesthesiology.
2. Manuscripts shall be typewritten in English. They shall bear, at the top of page 1, the name of the contest for which the essay is submitted. The only means of identification of the author shall be a motto, or nom-de-plume in the upper right hand corner of each page; this motto or nom-de-plume shall in no way indicate the author's identity. The essay shall be accompanied by a sealed envelope bearing on the outside the same motto or nom-de-plume and containing a card showing the name and address of the contestant.
3. Manuscripts must contain not less than 2000 words and not more than 6000 words. They must be double-spaced, typed on one side of the sheet and with ample margin. Illustrations shall be restricted to such as are required for clear exposition of the thesis.
4. Four copies of all manuscripts and of all illustrations must be in the hands of Dr. McKinnie L. Phelps, Secretary of the American Society of Anesthesiologists, Inc., 745 Fifth Avenue, Room 1503, New York 22, N. Y., before October 1, 1945.
5. If the committee considers that no essay is worthy of a prize, it will not be awarded.
6. Any essay that may win the prize becomes the property of the American Society of Anesthesiologists, Inc., to be published as it may direct. Unsuccessful contributions will be returned promptly to their authors.
7. The first prize will be awarded at the Annual Meeting of the American Society of Anesthesiologists, Inc., in December, 1945.

ADDITIONAL INFORMATION

If additional information is desired, it can be obtained by writing to the Secretary of the Society, whose address has been given, or to one of the members of the Committee on Awards and Honors of the American Society of Anesthesiologists, Inc. This committee is composed of the following.

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