CURRENT COMMENT

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Need for Ventilation During Closed Chest Cardiac Massage

Drs. Peter Safar and Warren Holtey of the University of Pittsburgh believe that avoiding thoracotomy in the treatment of sudden unexpected death has obvious advantages. Kouwenhoven, Jude and Knickerbocker (*J. A. M. A. 173: 1084, 1960*) have shown in dogs and man with ventricular fibrillation or asystole that rhythmic compression of the heart between sternum and spine can produce near-normal systolic arterial pressures. The above authors stated that "closed chest cardiac massages provides some ventilation of the lungs." Drs. Safar and Holtey report observations indicating that sternal compression cannot be relied upon to produce adequate ventilation.

Ventilation. Artificial circulation without oxygenation of the blood is obviously futile. Unfortunately most published illustrations to date on closed chest cardiac massage have failed to show a second operator providing airway patency and inflation of the lungs.

The tidal volumes measured during rhythmic sternal compressions, both in curarized adults with intact circulation and in agonal patients with apparent cessation of circulation, are shown in the table. There was no air exchange when the head was unsupported (without support, the head usually assumed a semi-flexed position). In the patients with cessation of circulation it is of interest that no air exchange could be measured even when a tracheal tube was used, while an average tidal volume of 156 ml. could be measured in the curarized patients with intact circulation. This inability to produce air exchange in the agonal patients may be due to collapse of bronchioles and alveoli caused by chest pressure in the presence of increased surface tension of alveolar fluid, which has been shown to occur when circulation through the lungs is interrupted (*T. N. Finley, and others: Physiologist 3: 56, 1960*). While tidal volumes of 100 to 200 ml. of air can sustain life in generally healthy anesthetized adults, such volumes cannot be expected to reoxygenate an already asphyxiated person, particularly in the presence of pulmonary edema, bronchial se-

VENTILATION DURING RHYTHMIC STERNAL COMPRESSIONS
Rate of Sternal-Compressions About 60/Minute

	Airway	Head Position	Tidal Volumes, Ml.* Range (Average)
30 healthy curarized adults			
(1)	Natural	Unsupported natural	0–0 (0)
(2)	Natural	Unsupported, tilted backward (shoulders elevated)	0–200 (53)
(3)	Tracheal or pharyngeal tube	Supported in backward tilt	0–390 (156)
12 apneic and pulseless agonal patients†	Tracheal tube	10 pts. 2 pts.	0–0 10–40

* Wright ventilation meter attached to face mask or cuffed tracheal tube.
† Tidal volumes measured during deep intermittent positive pressure inflations were over 1 liter.

cretions or atelectasis, all of which are common in moribund patients.

During the performance of closed chest cardiac massage spontaneous breathing movements have been observed very rarely, and then only when massage was started immediately. Therefore, sternal compressions must be accompanied by effective lung inflations.

Method of Combining Ventilation and Closed Chest Cardiac Massage. As some pulseless and apneic patients have recovered after artificial ventilation alone, and as closed chest cardiac massage has often produced fractures of the ribs and costal cartilages, we feel that the first step in the emergency treatment of apnea and pulselessness should not be sternal compression but positive pressure inflation of the lungs with air, or preferably, with oxygen. If after three to five effective lung inflations no pulse is palpable in a large artery, sternal compression should be added, preferably by a second operator. To prevent the two operators from interfering with each other we are teaching at present the following method:

The first operator ventilates the lungs with intermittent positive pressure ventilation (bag-mask or exhaled air resuscitation). Pressure-cycled automatic resuscitators are not suitable. The second operator kneels next to the patient's chest, places the heel of one hand over the lower half of the sternum along the midline and places the heel of the other hand on top of the first hand. He firmly presses the sternum downward towards the patient's back until firm resistance is felt, after which he then raises both hands to permit chest expansion. Sternal compressions by the second operator are repeated at 1 second intervals, 4 times after each lung inflation by the first operator. This results in approximately 48 heart compressions and 12 lung inflations per minute. A third operator monitors the pulse.

Although uninterrupted positive pressure ventilation administered simultaneously with continuous sternal compressions can produce some ventilation, we feel it is important that the massaging operator pause at intervals in order to permit the ventilating operator to detect any airway obstruction and to evaluate the adequacy of chest movements.

Alternating periods of ventilation with periods of sternal compression by a single operator was found to be difficult, but possible in some instances.

There are several ways of combining ventilation and sternal compression. Regardless of which method is chosen, the teaching in any given organization should be uniform in order to avoid confusion when an emergency arises.

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Contamination During Cold Sterilization

Major Max K. Mendenhall, Captain Frederick K. McCune, Lt. Col. John A. Jenicek, and Mr. John M. Bryant from Brooke General Hospital, Texas, note that much has been written to condemn cold sterilization of local and regional anesthetic agents by the use of antiseptic solutions. However, the practice persists in some areas. Several years ago, cases of anesthetic accidents due to faulty sterilization techniques were common in the literature (*Kennedy, F., and others: Surg. Gynec. Obstet. 91: 385, 1955*). Fortunately, these reports are now becoming rare. They could be virtually eliminated if procedures such as those recommended by the American Society of Anesthesiologists (Subcommittee on Standardization of Anesthetic Equipment 1956) were followed.

The authors offer experimental evidence to show how contamination may occur during cold sterilization of local anesthetic agents by the "soaking" technique.

Many of the antiseptic solutions in use contain formaldehyde in high concentration as the primary bactericidal agent. Their objective in this experiment was to determine the conditions under which formaldehye could enter a container of local anesthetic agent being sterilized by immersion in this type of solution.

Material and Method. The solution they employed is one which is in common use in the Armed Forces and civilian installations. With only minor variations in the formula, it has the following content:

Formaldehyde	8%	(figures are approximate)
Isopropyl alcohol	70%	
Sodium nitrite	0.5%	(anti-rust)
Distilled water qsad	100%	

The anesthetic agent and container exposed to the solution was a commonly used local anesthetic solution supplied in 50 ml. rubber-stoppered vials. The rubber stopper was held in place by a crimping ring over which there was a metal cap held in place by a second removable crimping ring.

The vials were soaked in the antiseptic solution for varying lengths of time. The cap and outer crimping rings were removed and in some instances the rubber stoppers were punctured with a 20-gauge needle. A partial vacuum was left in selected bottles. The table summarizes the results and conditions of the experiment.

Vial No.	Punctures in Stopper	Soak Time (days)	Cc. Vacuum (30 cc. fluid remain)	HCHO (µg. ml.)
1	0	2	0	0
2	0	5	0	0
3	0	9	0	0
4	1	5	0	0
5	1	7	5	0
6	2	2	5	trace
7	2	3	0	20
8	4	2	10	25

A vial of the same solution at 24 C. (room temperature) was emptied two-thirds and the pressure over the remaining solution was allowed to equilibrate with that of the atmosphere. The vial was then immersed in sterilizing solution. It cooled to 21.5 C. and developed an internal negative pressure as high as 7 cm. of water. This procedure indicates a simple mechanism for producing a partial vacuum within the vial, a factor already implicated as conducive to contamination.

Discussion. It can be seen from the table that formaldehyde enters the vial in significant amounts when the rubber stopper has been punctured and a partial vacuum is present in the vial. It is not uncommon in actual practice to use large gauge needle in withdrawing solution. It can be presumed that this would lead to even greater contamination of the contents.

It is common to use "warm" unopened vials and then place them into cool sterilizing solutions before reuse. The potential danger of this practice has been shown by the second simple experiment.

In summary, cold sterilization of local anesthetic agents by the soaking method is known to be fraught with danger from chemical contamination. A condition under which rubbered-stoppered vials of local anesthetic solution may become contaminated is shown experimentally.

The views and opinions expressed herein do not necessarily represent those of the Surgeon General, The Department of the Army, or the Department of Defense.

Intravenous Halothane in Dogs

Drs. Joseph G. Murphy, Charles Vassallo and Raymond E. Bradley of the Saint Vincent Hospital in Worcester, Massachusetts, report on the use of halothane intravenously. In the past, many investigators have attempted to dissolve the volatile anesthetics in aqueous solutions in order to give them intravenously. These attempts have been, on the whole, unsuccessful. The volatile agents are rather poorly soluble in aqueous solutions available for intravenous use. To obtain satisfactory anesthesia required very large quantities of fluids. Today, an emulsion—Lipomul—is available which appears quite safe for intravenous use. Lipomul is a milky-white emulsion of 15 per cent cottonseed oil, 4 per cent dextrose and certain emulsifying and stabilizing agents. It is isotonic. The cottonseed oil is in the form of droplets, 90 per cent of which are one micron or less in diameter, and almost

100 per cent are less than 1.5 microns in diameter (information supplied by manufacturer). This size will easily pass through capillaries of the body. There have been few allergic reactions to its use for nutritional deficiency. Chills may appear in 1 per cent of cases (*Smith, M. E.: Metabolism 6: 717, 1957*). To keep the droplet size stable, Lipomul should be refrigerated, and under these conditions is stable for one year.

Methods. Halothane was dissolved in Lipomul, 10 and 20 per cent concentrations, in rubber stoppered 50-ml. vials. Vigorous shaking for 2 to 3 minutes caused all visible halothane to disappear, the 10 per cent mixture being easier to dissolve. With insufficient shaking the halothane was visible as a separate layer at the bottom of the vial. Lipomul alone and Lipomul with 10 and 20 per cent halothane were compared microscopically, and we observed no apparent difference in droplet size. The Upjohn laboratories also reported no difference (*Upjohn, H. L.: personal communication*). The mixtures were refrigerated when not in use, as recommended by the manufacturer for Lipomul.

Ten per cent halothane in Lipomul was used intravenously in 20 dogs, averaging about 30 to 35 pounds in weight. Major surgical procedures were done by surgical residents, including arterial grafts, gastrectomies, partial hepatectomies, Potts procedures, and other operations. Usually there were two or more of these in each animal, lasting about three hours. Blood loss was not replaced.

Results. Induction of anesthesia was accomplished with 10 to 15 ml. of the mixture (containing 1.0 to 1.5 ml. of halothane). There was a short excitement period, following which the dog's tracheas were intubated with a cuffed endotracheal tube. Succinylcholine, 3 to 5 mg., was used in some for intubation. The dose used was small because it has been reported that the dog is about six times more sensitive to succinylcholine as man per pound of body weight (*Hoppe, J. O.:* ANESTHESIOLOGY *16: 117, 1955*). *d*-Tubocurarine was avoided because its ganglionic blocking effect in conjunction with halothane results in marked hypotension (*Stephen, C. R., and others: Canad. Anaesth. Soc. J. 4: 246, 1957*). One dog, in which this combination was inadvertently used, suffered cardiac arrest at the time of intubation.

Most dogs received atropine premedication at the same time as anesthetic induction. Intravenous drip, 5 per cent dextrose in water, was used in all cases. Unfortunately arterial blood pressure was not monitored. Occasional signs of poor circulation (seen in the animal's tongue), such as paleness and poor arteriocapillary refill were treated with methoxamine.

After intubation, the cuff was inflated and attached to a Harvard respirator which had been modified to produce a closed system containing soda-lime. All exhaled halothane was therefore rebreathed. Repeated small doses 1–3 ml. of 10 per cent halothane every 5 to 20 minutes maintained the anesthesia. Oxygen was added to the closed system to keep the breathing bag filled. Total dosage in a 20 to 40 pound dog was 30 to 40 ml. of the 10 per cent halothane in a period of three hours. This is only 3–4 ml. of liquid halothane. Relaxation was excellent in most cases. If the closed system was discontinued, the animals rapidly awakened. On the other hand, a large dose (10 ml. of 10 per cent mixture) at the end of a three-hour procedure, with the blood volume depleted, could kill the animal.

Some of the dogs, sacrificed at the end of the procedure, had their livers and kidneys removed for study. These organs were found to be normal in both gross and microscopic examinations.

Discussion. According to physical laws there is a partition of the halothane in the injected mixture with 330 times (oil-water solubility) as much halothane in the fat droplets as in the same volume of the aqueous phase. When this mixture is injected into the blood stream it is in equilibrium. The aqueous part is diluted by the "aqueous" part of the blood stream and the equilibrium is destroyed. The oil droplets are not diluted. The halothane then moves from the oil droplets into the "aqueous" part of the blood as long as a new equilibrium is not reached. So, for all practical purposes, we have a continuous movement of halothane from the oil droplets into the "aqueous" part of the blood. Only with great overdosage will the level of

halothane in the "aqueous" part of the blood rise high enough to interfere with this continuous movement of halothane from the oil droplets.

Again, according to the physical law of partial pressures and to the pressure gradient, the aqueous-dissolved halothane must appear in vapor phase in the lungs, and also move into the tissues of the body. Now the halothane is present in three phases (oil dissolved, aqueous, and gaseous).

Because of the small amount of halothane used, the "aqueous" blood level cannot be maintained high enough for anesthesia if the gaseous phase is lost by respiration. Therefore, the subject must be on a closed carbon dioxide absorbing system to maintain anesthesia with the dosages used. Apparently some equilibrium is reached between the rebreathed vapor phase and the aqueous phase in the blood. This is evidenced by the rapid awaking of the animals when the closed system was discontinued.

If this animal work is repeated by other investigators, it is hoped that measurements can be made of the amount of halothane in the aqueous phase of the blood with the oil droplets separated, and of the amount of halothane in the vapor phase in the lungs. We were not equipped to do these measurements.

Summary. This method of intravenous injection of known amounts of halothane provided a potent, but easily controlled anesthesia in dogs. The anesthesia could be lightened quickly, by changing from the closed rebreathing system to a nonrebreathing system. We believe that this method merits repetition in animals and with other oil-soluble agents (10 per cent ether-Lipomul mixture is easily prepared), and if satisfactory, a cautious trial in patients.

Lipomul and partial financial support was provided by the Upjohn Company. Halothane (Fluothane) was provided by Ayerst Laboratories. This study was presented at the Annual meeting of The American Society of Anesthesiologists, Inc., New York, New York, October 6 1960.

GADGETS

Alarm Device for Respirators

Dr. Karol Hoffmann, M.D. of the Baltimore City Hospitals notes that with the use of any positive pressure respirator complications must be recognized promptly if death from interrupted ventilation is to be prevented. Moment to moment observation of each patient by trained personnel although desirable, is not always possible. The constant monitoring of ventilation in a respirator center therefore had to be improvised.

An alarm system was devised, primarily for use with fixed volume piston respirators, to detect changes in the mean pressure between the nonrebreathing valve and the tracheotomy tube.

The following complications lead to a *decrease* in the mean pressure at the tracheotomy tube: (1) power failure; (2) mechanical failure of respirator; (3) obstruction of connecting tube; (4) leakage, *e.g.*, accidental disconnection of tubings, excessive leakage around tracheotomy tube, leaking valve.

The following complications lead to an *increase* in the mean tracheotomy tube pressure: (1) partial or complete airway obstruction at the tracheotomy tube or in the bronchial tree, for instance due to secretions; (2) decreased lung-thorax compliance; (3) accidental increase in stroke volume in fixed volume respirators or in pressure of pressure sensitive respirators.

Description of the "Vent-Alarm." The basis of this alarm system lies in the transformation of pressure changes within the breathing tubing into movements of a bellows, which in turn triggers an electrical alarm circuit. The "Vent-Alarm" is connected via a plastic tubing to a 13 gauge needle inserted into the tubing between the nonrebreathing valve and the tracheotomy tube, as close as possible to the nonrebreathing valve (in order also to permit recognition of a kink in the tube leading to the tracheotomy). The "Vent-Alarm" consists of 2 components: