

CLINICAL EXPERIENCE WITH CHLOROFORM ANESTHESIA

MARY F. POE, M.D., AND JAMES R. MAYFIELD, M.D.

CHLOROFORM anesthesia has obvious advantages and recent evidence suggests that there has been overemphasis of its disadvantages. It is safe within reasonable limits if the proved hazards are recognized and proper precautions are observed.^{1, 2, 3} It is nonflammable. The advent of the new halogenated drugs has revived interest in this maligned anesthetic agent. We initiated this study to reassess the application and usefulness of chloroform combined with other anesthetics and adjuvants as a nonflammable technique.

METHOD

Chloroform in combination with other drugs was administered to seventy patients who were selected only on the basis of a need for a nonflammable anesthetic. Chloroform was considered in the choice of agents whenever cautery, roentgenographic or electro-surgical units or motor-driven instruments were to be used during the proposed operation. The drug was not given to patients with known or suspected liver disease. The patients ranged in age from 3 months to 84 years, half of them being under age 30 and ninety per cent under age 60. The physical status⁴ was judged to be 1, 2 or 5, with three exceptions. Two neurosurgical patients were listed as physical status 6, and one urological patient as physical status 3.

The duration of the operative procedures ranged from 20 to 255 minutes; forty-five per cent were 90 minutes or less in length. Only four operations exceeded 180 minutes. The operations performed with chloroform anesthesia are shown in table 1.

The cephalin-cholesterol flocculation test of Hanger was used in some cases as a measure

of liver function before and after anesthesia. This test was selected because alterations in values indicate parenchymal changes in hepatic tissue. The blood samples for the test were drawn at the time of the venipuncture in the operating room, and again on the third postoperative day.

Intravenous fluids were administered during operation and usually in the recovery room as well. The solution most commonly used was 0.09 per cent sodium chloride in 5 per cent dextrose.⁵ Cardiac rhythm was monitored in the early cases to determine the incidence of arrhythmias. The preanesthetic medication varied with the physical status of the patient. In all cases, atropine or scopolamine was included as a part of the premedication.

In most cases induction of anesthesia was with thiobarbiturates and/or nitrous oxide-oxygen. The out-of-circuit vaporizer was preferred for chloroform, but the wick-type vaporizer was utilized often. A semiclosed, high flow technique with nitrous oxide-oxygen in the proportions of three to one or two to one was used for maintenance of anesthesia. The total flow rates of the gases were varied with the size of the patient; usually two liters per minute in infants and four liters per minute in adults. The carbon dioxide absorber was used. When endotracheal intubation was indicated, translaryngeal block and/or muscle relaxants were added as needed. Assisted respiration, preferably with hyperventilation, was employed to ensure adequate removal of carbon dioxide.

The maintenance concentration of chloroform was recorded in forty cases in which the out-of-circuit vaporizer was used. A flow calculator based on room temperature and vapor pressure of the agent was used to determine the concentration of chloroform. In twenty-nine cases, the concentration was one per cent or less. In ten cases, the concentration was 1.5 per cent to 1.75 per cent. In only one case was the maintenance concentration as high as 2 per cent.

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TABLE 1
OPERATIONS PERFORMED WITH CHLOROFORM ANESTHESIA

Type of Operation	Number	Procedure	
Orthopedic	31	10 closed reduction	21 open reduction
Urologic	10	4 circumcision 1 cystoscopy	2 kidney 2 urethral repair 1 suprapubic prostatectomy
Gynecologic	9	1 abdominal hysterectomy 8 vaginal procedures 1 dilation & curettage 1 cold knife cone 1 radium application	3 hysterectomy 1 labial tumor excision 1 Pomeroy sterilization
General surgical	8	1 radical mastectomy 4 breast biopsy 1 tendon repair	1 hernia repair 1 excision cyst of shoulder
Neurosurgical	7	3 craniotomy 2 laminectomy	1 ventricular-peritoneal shunt 1 seventh nerve exploration
Plastic surgical	3	2 skin graft	1 revision scar of axilla
Otolaryngologic	2	1 radical neck dissection and mandibulectomy 1 antrostomy with cauterization	

RESULTS

No serious complications related to the administration of chloroform occurred. Marked induction excitement was encountered in one patient. In the majority of cases, this difficulty was avoided by the intravenous injection of 100-250 mg. of thiobarbiturate prior to the introduction of chloroform. In one patient chloroform was discontinued when the surgeon decided to use epinephrine for hemostasis during a vaginal hysterectomy. In another patient, chloroform was inhaled when the patient required excessive amounts of thiamylal sodium (Surital) during the open reduction of a trimalleolar fracture of the ankle.

In one patient undergoing radical mastectomy with the electrosurgical unit in use, the hemostatic effect of chloroform* was utilized to decrease blood loss. This was the only case in which a concentration of 2 per cent was used during maintenance. Cardiac action was monitored and no arrhythmias developed.

Three chloroform anesthetics were unsatisfactory and necessitated a change to another agent. In two, one a kidney operation and

the other a four-hour suprapubic prostatectomy, muscular relaxation was inadequate. In the third case, intractable coughing occurred on attempted induction of anesthesia with chloroform.

There was no change in the postoperative values of the cephalin-cholesterol flocculation test as compared to the control values. Disturbances of cardiac rhythm were infrequent throughout the study and in no case was it necessary to discontinue the agent because of arrhythmias. In a six-year-old child undergoing craniotomy for a posterior fossa tumor, irregular cardiac rhythm and inverted T-waves were observed on the cardioscope. Forced transfusion of 50 ml. of whole blood was followed by return of a normal electrocardiographic pattern. We believe that the abnormality was due to blood loss rather than to the anesthetic agent.

The chief untoward effects of chloroform were hypotension and tachypnea. Our experience was at variance with most reports in which tachypnea was mentioned, since it was seen in most of the patients anesthetized with chloroform. Hypotension was commonly ob-

served with higher concentrations of the drug. In fact, the blood pressure level was a fair criterion of anesthesia depth.

In the immediate postoperative period, there were three deaths, none of which were related to the anesthesia. One patient succumbed to pulmonary embolus on the third postoperative day; one died of surgical complications following mandibulectomy and radical neck dissection; one died of a pre-existing intracranial lesion.

DISCUSSION

Chloroform has come to be known as the most dangerous of all anesthetic agents, but it seems likely that this assessment was based upon incomplete knowledge and misconceptions. With the publication of the exhaustive study of chloroform by Waters and associates,² overemphasis of the dangers of the drug was recognized. Since that time, there has developed an appreciation of the contraindications (specifically liver disease) and a realization of the necessity for refined techniques of administration. It is imperative that adequate pulmonary ventilation be provided for the safe use of chloroform, and that the depth of anesthesia be limited. Careful selection of patients and of operative procedures is essential. These recent clarifications could open the way to the re-acceptance of chloroform for definite purposes. Chloroform has the advantages of nonflammability, low cost, high potency and pleasant smooth induction. It can be used in the presence of soda lime. It tends to reduce blood loss, even without a fall in blood pressure.⁶ The disadvantages of chloroform include its cardiovascular effects and the possibility of liver damage. However, many anesthetic agents, including some of the newer drugs, are not without these hazards.

All halogenated hydrocarbons may cause hepatic damage, but if adequate removal of carbon dioxide and proper oxygenation are provided this disadvantage is minimized.^{3, 7, 8, 9} Chloroform resembles vinyl ether in relative hepatotoxicity among inhalation anesthetics.¹⁰ In laboratory studies, interference with hepatic function was shown after the administration of chloroform when carbon dioxide was allowed to accumulate during anesthesia.⁷ However, significant

alteration in hepatic function was not produced in patients studied subsequent to chloroform anesthesia provided that hyperventilation and hypotension was avoided.⁷ Hypercarbia is more dangerous than hypoxia in regard to liver damage.⁸

Chloroform may cause cardiac arrest in three ways; vagal inhibition, ventricular fibrillation and direct myocardial depression.^{2, 11, 12} It is likely that when primary cardiac syncope occurs in the early induction stages of anesthesia with chloroform, it is due to vagal inhibition,^{11, 12} possibly as the result of a sudden increase in the sensitivity of the baroreceptors,¹² although reflexes arising from the respiratory tract cannot be entirely excluded. For this reason, full therapeutic doses of vagal depressants should be used in the premedication prior to chloroform anesthesia,^{11, 12, 13} and the potentially dangerous induction stage should be accomplished with an intravenously administered thiobarbiturate.¹¹ The degree of cardiac sensitization caused by chloroform is no more, possibly less, than that caused by cyclopropane or trichloroethylene,^{14, 15} and the dangerous degree of myocardial depression probably is a manifestation of overdosage.^{2, 3} Sudden increased concentrations of the inhaled vapor can produce dangerously deep levels of anesthesia very quickly. Direct myocardial depression and hypotension resulting from too deep anesthesia may precipitate circulatory failure.^{2, 3, 11, 13} Careful administration of the agent is required to prevent cardiovascular depression.^{2, 3, 6, 9, 11, 13}

Until a nonflammable volatile agent with more definite advantages than any now available is developed, anesthesia may be conducted with chloroform in carefully administered combined techniques with safety equal to that of many other drugs.^{1, 2}

SUMMARY

Chloroform has been used in combination with other drugs in seventy patients. It is useful when nonflammable techniques are required, particularly for short procedures and for these requiring minimal muscular relaxation, e.g., work in the fracture clinic and the cystoscopy room. Chloroform anesthesia requires care in administration and the observance of certain precautions: use of atro-

pine or scopolamine premedication; induction of anesthesia with an intravenously administered thiobarbiturate; avoidance of sudden increased concentrations of the vapor; use of combined techniques and limitation of the concentration of the drug to the range of 0.5-1 per cent; maintenance of adequate ventilation to ensure carbon dioxide removal; and avoidance of the use of chloroform in patients with liver disease.

The chloroform used in this study was supplied by Mallinckrodt Chemical Works, St. Louis 7, Missouri.

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AIR EMBOLISM Fatal air embolism still occurs during the use of "air-in-the-bottle" type of pressure transfusion. At present there are several different types of apparatus commercially available for use in the rapid transfusion of blood with no danger of producing air embolism. Their use in pressure transfusion is feasible and completely safe and should be encouraged. The clinical diagnosis of pulmonary air embolism is based upon: (1) a possible site of entry of air into the blood stream; (2) a loud "mill-wheel" cardiac murmur; (3) increased venous pressure; (4) fall in peripheral arterial blood pressure; (5)

cyanosis; (6) dyspnea; (7) cardiac arrest. Therapy consists of (1) closure of air entry site; (2) lowering of patient's head; (3) placing patient in left-lateral head down position (right side up); (4) if necessary, performance of an emergency thoracotomy (which can probably be carried out as well through the right chest as through the left); (5) artificial respiration with 100 per cent oxygen; (6) use of vasopressors to restore arterial blood pressure. (*Ruesch, M., and others: Continuing Hazard of Air Embolism During Pressure Transfusions, J. A. M. A.* 172: 1476 (April 2) 1960.)