

CURARE AND NITROUS OXIDE ANESTHESIA FOR LENGTHY OPERATIONS * †

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As is the case in some teaching institutions, major surgical operations at the University of California Hospital are often lengthy procedures. Few intra-abdominal operations are performed in less than two hours, and many are prolonged to six or more. This adds to the responsibility of the anesthesiologist of providing adequate relaxation for the surgeons, many of whom are beginners requiring optimum operating conditions, and at the same time making sure that the patients' well being is not endangered by long periods of deep anesthesia.

This combination is somewhat difficult to achieve though the anesthetic and surgical technic may be above reproach. Patients who may require second and third plane ether anesthesia over a period of four hours or more frequently exhibit some signs of circulatory disturbance. Adequate muscular relaxation with cyclopropane can be obtained in practically all patients, but this can be done only by an expert. Here again, signs of physiologic disturbance frequently become manifest. Regional analgesia is satisfactory but prolongs the operation because of the necessity of repeating the injections as the anesthetic wears off. Continuous spinal analgesia provides excellent relaxation, but these same disturbances often occur as the operation progresses.

For the last seven months we have anesthetized a certain number of patients undergoing long surgical procedures, chiefly major abdominal operations, with nitrous oxide, using curare to produce the necessary muscular relaxation. This combination appears to be quite satisfactory. The surgeons are pleased with the operating conditions, the patients seem happy with the smooth induction and quick recovery, usually with little or no nausea, and their condition during and at the end of the operation has been very gratifying to the anesthesiologists.

The technic used in this series of cases differs considerably from that described by other writers on the subject, stemming as it does from our experience in administering curare ‡ to unanesthetized dogs rather than from attempts to use it to "pull ourselves out of a hole" during a poor anesthesia with an agent which is capable of producing adequate

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‡ Intocostrin (Squibb).

relaxation alone. We have used curare as the chief agent, nitrous oxide being given only to obtund consciousness and afford relief of pain. (We believe that curare has no analgesic properties.)

After ample medication, nitrous oxide and oxygen are administered by means of a face mask until the patient is in first plane anesthesia. A pharyngeal airway is inserted and the anesthetist's ability to inflate the lungs is tested. We consider it unwise to administer curare unless a perfectly free airway allowing inflation of the chest exists. A quantity of curare calculated to stop respiration is then injected intravenously. This usually amounts to 150-200 mg. No precautions in the speed of injection are taken. When muscular relaxation, with or without apnea, has occurred, the mask is removed and an orotracheal tube with an inflatable cuff is inserted under direct vision. The nitrous oxide mixture is then administered through this tube by means of the carbon dioxide absorption technic.

Administration of this amount of curare will usually result in twenty to thirty minutes of apnea. "Controlled respiration" is employed meanwhile by the anesthetist. As soon as spontaneous respiration has become sufficiently deep to afford adequate oxygen-carbon dioxide exchange, the patient is allowed to breathe for himself. Further amounts of curare are given as needed to produce the relaxation required at various stages of the operation. If the administration of such amounts of curare results in respiratory depression of apnea, "controlled respiration" is instituted. The amount of relaxation necessary and also whether or not apnea is maintained, depend entirely upon the surgical procedure. In operations just below the diaphragm, the surgical manipulations are facilitated by the absence of voluntary respiratory movements, but in most abdominal operations, adequate relaxation can be obtained with quantities of curare which are too small to produce apnea.

Certain points which we consider important for intelligent administration of curare have become manifest to us by the use of this technic. The patient's physiologic mechanisms are the same whether the muscles are relaxed by curare or not. Therefore, hypoxia will cause muscular rigidity even though the myoneural junctions have been paralyzed. Also, lack of oxygen or excess of carbon dioxide will cause respiratory efforts in patients who have received a dose of curare which would otherwise be ample to cause apnea. This means that the patient's lungs must be adequately ventilated at all times, either by himself or by the anesthetist. It must be remembered that once muscular paralysis has set in, the signs of anesthesia, all of which are muscular, are masked. Therefore, anesthesia must be continued with the same concentration of nitrous oxide and oxygen which was found to result in good first plane surgical anesthesia before the curare was administered. For this reason we do not believe that pentothal combined with curare is satisfactory since there is no indication of the depth of depression.

When the patient's medication wears off, it becomes manifest not by the ordinary signs of anesthesia, but rather by diaphragmatic contractions, slight muscular twitchings, movements of the facial muscles, or by a rise in the blood pressure level. These signs are indications not for more curare but for more analgesia, either by means of some opiate or by an increase in the concentration of nitrous oxide without lack of oxygen.

In other words, poor anesthesia is not to be tolerated any more in combination with curare than without it; it requires much more curare to keep a poorly anesthetized patient in a satisfactory state of relaxation and quietude than for a patient who is well anesthetized and well oxygenated.

TABLE 1
CURARE-NITROUS OXIDE AND OTHER ANESTHETIC AGENTS: A COMPARISON

	Age			Duration of Operation (in minutes)			Dose of Curare (in mgm.)			Complications During Surgery		
	Average	Oldest	Youngest	Average	Longest	Shortest	Average	Greatest	Least	Pulse rate of 20+	B.P. fall to below 80	In frank shock at end
Curare N ₂ O (38 Patients)	46	76	17	190	425	50	237	480	90	18%	5%	0%
All Other Agents (38 Patients)	42	67	6	183	500	32				46%	27%	13%

	Complications Post-Operative				Average Day of Ambulation	Average Day of Discharge	Condition on Discharge	
	N + E	Pulmonary	Circulatory	Miscellaneous			Alive	Dead
Curare N ₂ O (38 Patients)	18%	18%	46%	18%	2.7	13*	95%	5%
All Other Agents (38 Patients)	21%	19%	56%	41%	4	11	92%	8%

* 2 patients kept in hospital for over 40 days: 1 for B of draining bladder fistula, 1 for X-ray therapy.

During the first of our series of cases, dilatation of the intestine was an embarrassing complication in a few instances. Since the publication of the article by Gross and Cullen (1), we have considered this phenomenon an indication for morphine, administration of which has resulted in very satisfactory constriction of the intestine. Occasionally, after the administration of morphine, extreme constriction of the intestine has even forced us to add a little more curare to overcome it.

INCIDENCE OF COMPLICATIONS*

	Curare	Control
1. PULMONARY		
Empyema	0	8%
Bronchopneumonia	0	3%
Atelectasis		
Massive	3%	3%
Partial	15%	5%
Pulmonary Embolus		3%
Obstruction		3%
Laryngitis		8%
2. CIRCULATORY		
Tachycardia	46%	46%
Heart Failure		5%
Shock	3%	8%
Arrhythmias		3%
Coronary Insufficiency		3%
Hemorrhage		3%
3. MISCELLANEOUS		
A. Gastro-Intestinal		
Distention	15%	18%
Hepatitis		3%
Peritonitis		3%
Bowel Obstruction		3%
Hematemesis		3%
B. Nervous		
Irrational		3%
C. Genito-Urinary		
Urinary Retention	3%	8%
Hematuria		3%
Pyelitis		3%
Oliguria		3%
D. Mediastinitis		
	3%	

Note: The discrepancy in the percentages between this and the total percentage of patients developing complications is due to the fact that some patients developed several complications.

In addition, during our work on dogs with curare, it was noted that it is absolutely essential that the intercostal muscles be capable of vigorous contraction before the anesthetist leaves the patient if post-operative atelectasis is to be avoided. This is usually not difficult to achieve, since closure of an abdominal incision requires considerable time in this hospital.

In table 1, 38 patients to whom curare and nitrous oxide were administered are compared with a similar number of unselected patients comparable in type and duration of operation, who were anesthetized with other agents: continuous spinal, ether, and cyclopropane.

As can be seen from the table, patients who received anesthesia with curare and nitrous oxide have remained in better condition throughout the operation and have had fewer postoperative complications than patients anesthetized with other agents. Also, practically all the patients in the first group were awake and talking before leaving

the operating room. It is always gratifying to have a patient still on the operating table after six hours of abdominal surgery tell the surgeon that he "feels fine." However, most patients have considerable muscular weakness, persisting for several hours, which makes good postoperative nursing care, with frequent changes of position, imperative.

So far, both the anesthesiologists and the surgeons in this hospital are enthusiastic about the combination of curare and nitrous oxide for long operations. However, in spite of much experimental and clinical material which has been published on the subject, we believe that too little is known about curare to be certain that it is as completely harmless as it appears to be. During the period of eighteen months of experimental work by this Subdivision of Anesthesia, we have scarcely begun to solve the problem of physiologic changes produced by this drug. Only when the completion of this work has proved curare to be without permanent deleterious effects will we be able to use it in this manner with a quiet mind and a clear conscience.

REFERENCE

1. Gross, E. G., and Cullen, Stuart C.: The Action of Curare on the Smooth Muscles of the Intestine and on the Blood Pressure, *Anesthesiology* 6: 231-238 (May) 1945.

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