

BALANCED ANESTHESIA FOR THORACOPLASTY* † ‡

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Received for publication October 3, 1947

PATIENTS undergoing thoracoplasty deserve special consideration in the selection of agents and technics used to obtain anesthesia. Such patients commonly have varying degrees of respiratory dysfunction in which the absorptive surface of the lung is diminished, vital capacity is limited and excessive secretions collect in the respiratory tract as the result of pulmonary lesions. All these conditions tend to make more difficult the production of general anesthesia and the maintenance of proper oxygen and carbon dioxide exchange. These patients generally have systemic manifestations of tuberculosis which may include secondary anemia, malnutrition, elevated metabolic rate and general debilitation. As a group they are not good anesthetic risks.

One must also consider that the surgical procedures used in thoracoplasty are, in themselves, problems from the standpoint of trauma, surgical shock and the production of undesirable reflexes. The detachment of muscles from their insertions, the stripping of periosteum and pleura from ribs, the traction and elevation of the scapula and the unavoidable loss of considerable amounts of blood during these operations make some other types of surgical procedures seem minor by comparison.

It is generally agreed by a number of writers (1, 2, 3) that anesthesia for thoracoplasty should fulfill the following requirements:

1. The anesthetic agents should be nontoxic to vital tissues and nonirritating to the respiratory tract mucosa.
2. Adequate oxygenation should be possible at all times.
3. Induction should be easy, rapid, and without excitement. The depth of anesthesia should be readily controllable.
4. Respiratory movements should be quiet and regular.
5. The recovery period should be short to allow the prompt return of cough and swallowing reflexes.
6. The agents and methods used should produce minimal postoperative complications.

* Presented before the Section on Anesthesiology, American Medical Association, Atlantic City, New Jersey, June 11, 1947.

† Published with the approval of the Surgeon General, U. S. Public Health Service.

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7. Surgical shock should be prevented by avoiding concentrations of anesthetic agents which might contribute to it and by appropriate supportive therapy.
8. If an electrosurgical unit is to be employed, the anesthetic agent should be nonexplosive.

Many types of agents and technics have been used to produce anesthesia for thoracoplasty. It is not the purpose of this paper to discuss the relative merits of these various agents or methods but rather to present a form of combined or "balanced" anesthesia which, in my experience, has served to satisfy the above requirements in a series of 146 operations on 75 patients.

"Balanced anesthesia" is the term coined by Lundy (4) in 1926 to designate the use of a combination of anesthetic agents and methods so balanced that the burden of the relief of pain would be borne in part by the preliminary medication, in part by local or regional anesthesia and in part by one or more of the general anesthetic agents. Undesirable effects which might result from the use of a single method or a single agent are thus avoided by the use of smaller doses of drugs which tend to complement each other in their action. Properly conducted balanced anesthesia should be ideal for patients undergoing thoracoplasty in order to avoid the use of toxic doses and concentrations of anesthetic drugs which might be harmful to these already handicapped patients. Wiggin and Schultz (2) have described the use of paravertebral nerve block administered after induction of general anesthesia with cyclopropane for this purpose. Others have mentioned the use of local infiltration combined with various types of general anesthesia.

For the past three years at the U. S. Marine Hospital, Staten Island, New York, we have utilized a system of balanced anesthesia for the majority of patients receiving posterolateral thoracoplasties. Our preference has been for a combination of preliminary medication, paravertebral block of the appropriate spinal nerves and light general anesthesia with intravenous pentothal sodium and 50 to 60 per cent nitrous oxide and 50 to 40 per cent oxygen administered in that sequence. This type of anesthesia is used for those patients who are psychologically suited to procedures for regional anesthesia and who do not have excessive respiratory tract secretions which would make operation under light general anesthesia hazardous. For this latter group we prefer paravertebral spinal nerve block supplemented with local infiltration.

TECHNIC

Preparation of Patient.—On the day preceding the surgical procedure the patient is seen by the anesthetist who explains the type of anesthesia to be used and emphasizes to the patient that he will be asleep during the operative procedure. This helps to allay appre-

hension and enables the anesthetist to detect those patients who might not be psychologically suitable for regional block anesthesia. Since many of our patients are foreign seamen, an interpreter may be necessary. Preliminary medication on the day of operation consists of pentobarbital 0.1 Gm. by mouth one hour before operation, morphine 10 to 15 mg. and scopolamine 0.43 mg. subcutaneously, about thirty minutes before regional block anesthesia is begun or about one hour before induction of general anesthesia. Before starting general anesthesia, an evaluation of the effect of the preanesthetic medication is made and an additional dose of morphine, 8 to 10 mg., is given intravenously at that time if it is deemed advisable.



FIG. 1. Lateral view. Needles in position for blocking the first five thoracic nerves.

Paravertebral Thoracic Spinal Nerve Block.—The technic of paravertebral spinal nerve block, which I use, is essentially that described by Lundy (5). Ordinarily, the first five thoracic nerves on the side to be operated on are blocked for first stage thoracoplasty, the third to and including the seventh thoracic nerves are blocked for the second stage operation and the fifth, sixth, seventh and eighth thoracic nerves are blocked for the usual third stage thoracoplasty.

One per cent freshly prepared metycaine in physiologic saline solution, warmed to body temperature, containing 1:260,000 concentration of epinephrine, is preferred as the local anesthetic agent.

The patient is placed face down on the operating table with the chest resting on a small pillow and arms extended alongside the body. The neck can then be flexed forward to bring the spinous processes of the lower cervical and upper thoracic vertebrae into prominence where they can readily be palpated and identified. After the usual prepara-

tion of the skin and draping, the interspaces between the spinous processes of the appropriate thoracic vertebrae are identified. There are several means of ascertaining the identity of these interspaces. The spinous process of the seventh cervical vertebra is usually described as being the most prominent, but in my experience, that of the first thoracic vertebra often appears equally as prominent. Labat (6) pointed out that a horizontal line drawn between the spines of the scapulae will pass through the third thoracic interspace, while a line connecting the inferior angles of the scapulae will pass through the seventh thoracic interspace. In the position described, the patient's scapulae are in the approximate anatomical position so that these landmarks may be quite helpful.

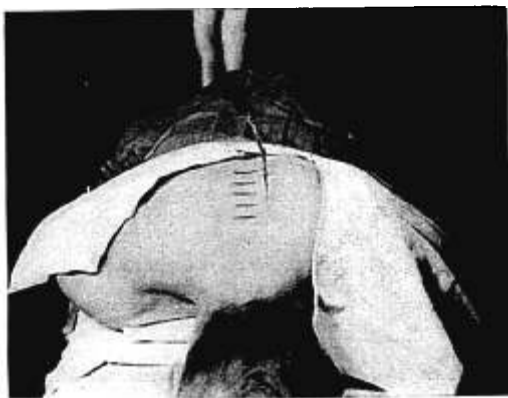


FIG. 2. Paravertebral block of upper five thoracic nerves. Needles parallel with saggital plane of body.

Skin wheals are placed lateral to the interspaces between the tips of the spinous processes, about $1\frac{1}{4}$ inches (3 cm.) from the midline, over the spinal nerves as they emerge from the intervertebral foramina. These wheals are made opposite the upper border of a finger tip, placed in the interspinous space, when blocking the upper four thoracic nerves, to facilitate the insertion of the needles, and opposite the middle of the finger tip when blocking the other thoracic nerves. Infiltration of the subcutaneous, muscular and ligamentous tissues superficial to the transverse process is carried out with a small quantity of anesthetic solution. The needles preferred for this procedure are 20 gauge, short beveled, and 4 inches (100 mm.) in length to enable them to be readily grasped. The first needle is inserted perpendicularly to the skin through the upper wheal until it impinges upon the trans-

verse process of the vertebra whose spinous process forms the inferior boundary of the interspace. The needle is then withdrawn slightly, directed cephalad and introduced into the paravertebral region in the vicinity of the intervertebral foramen. The proper depth for insertion of the needle is determined by noting the depth at which the needle contacts the transverse process and then inserting the needle about 1 cm. deeper. Rubber markers may be placed on the needle for this purpose. Other needles are similarly inserted paravertebrally in the vicinity of the other spinal nerves to be blocked.

After inspection of the needle hubs for evidence of blood or cerebrospinal fluid and after careful aspiration for the same purpose, 2 cc. of the metycaine-epinephrine solution are injected through each needle. The patient is observed for a period of at least five minutes, the needles being left in place. This will enable the anesthetist to detect the possible inadvertent injection of the solution into a blood vessel or into the subarachnoid space by way of the prolongation of the dural sheath around the spinal nerve as it emerges through the intervertebral foramen. If no undesirable reactions occur from this test dose, an additional 6 to 8 cc. is injected through each needle and the needles are withdrawn. A definite hypoesthesia usually develops in the region of cutaneous distribution of the nerves blocked even after the small test doses. More or less complete anesthesia is present by the time the incision is made, usually about twenty minutes after completion of the block.

General Intravenous-Inhalation Anesthesia.—Combined intravenous pentothal sodium and inhalation of 50 to 60 per cent nitrous oxide with oxygen are used to maintain light general anesthesia during the operation. After the regional block, the patient is placed in position on his side and an 18 gauge needle is introduced into a convenient vein in the arm. A two-way adapter is attached to permit the simultaneous administration of intravenous fluids and the intermittent injection of a 2.5 per cent solution of pentothal sodium as required. Just before the start of the surgical procedure the patient is asked to count out loud; sufficient pentothal sodium is administered to produce unconsciousness. Nitrous oxide, 50 to 60 per cent, with oxygen is then administered with a semiclosed system apparatus with carbon dioxide absorption. The oxygen flow is maintained at 500 cc. per minute or more and the nitrous oxide is adjusted accordingly to give the desired concentration. The reader is referred to Knight's (7) valuable observations concerning the control of safe mixtures of nitrous oxide and oxygen. Additional pentothal is given to produce light surgical anesthesia. Particular attention is given to obtaining quiet, regular respiratory movements. Since stimulation of respiration by surgical manipulation is to be expected in first plane anesthesia, the regional nerve block aids materially in reducing the respiratory response during the stripping of the periosteum and the resection of ribs. Eleva-

tion of the inferior angle of the scapula during resection of the upper ribs may produce painful sensations through the cervical nerves which are not blocked. Deepening of general anesthesia may be necessary during this procedure. Artificial airways are not usually required. The soft rubber nasopharyngeal type is preferred if an airway is necessary. Oropharyngeal airways are poorly tolerated by patients under light anesthesia with this combination of agents. Fluids are replaced routinely during the operation with glucose in saline solution and whole blood to aid in the prevention of surgical shock.

RESULTS

Combined paravertebral spinal nerve block, pentothal and nitrous oxide-oxygen anesthesia was used for 75 patients in 146 posterolateral thoracoplasties. The average age of the patients was 35.1 years, the youngest being 17 years of age and the oldest 60 years of age. All patients except one were males, most were merchant seamen by occupation and their disease was of relatively short duration.

Table 1 gives the data concerning the types of operations, the average operating time, the thoracic spinal nerves blocked in each type of operation and the average amount of pentothal required to maintain satisfactory anesthesia in combination with the other agents.

TABLE 1
146 POSTEROLATERAL THORACOPLASTIES ON 75 PATIENTS UNDER BALANCED ANESTHESIA

Operation	Number of Procedures	Average Operating Time, minutes	Paravertebral Block of Spinal Nerves	Average Amount of Pentothal Required, milligrams
First stage thoracoplasty	69	110	T1, T2, T3, T4, T5	908
Second stage thoracoplasty	60	75	T3, T4, T5, T6, T7	682
Third stage thoracoplasty	13	65	T5, T6, T7, T8	631
Fourth stage and revision thoracoplasty	4	77	Variable	1,206

The average operating time for all operations was ninety-one minutes. The average dose of pentothal sodium administered was 803 mg.

Thirty-six patients of this series also had a total of 48 additional thoracoplastic operations performed under regional anesthesia alone or some form of general anesthesia. Balanced anesthesia was not used for these operations for a number of reasons. The lack of available personnel skilled in paravertebral nerve block technic, the nonuse

of the electrosurgical unit for hemostasis, and the nature of the operation, i.e. anterior and revision type thoracoplasty, influenced our selection of other types of anesthesia in these instances.

Complications During Anesthesia.—There were no untoward reactions associated with the regional block procedure. In 2 cases, early in the series before I had had very much experience with paravertebral block technic, needles were inadvertently inserted within the subarachnoid space, but this fact was recognized immediately before the injection of anesthetic solution. Moderate adduction of the vocal cords producing partial respiratory obstruction occurred in a few cases, but responded readily to deepening of anesthesia and the ad-

TABLE 2
POSTOPERATIVE COMPLICATIONS

Complications	Number	Per Cent Based on Patients	Per Cent Based on Operations	Remarks
Nausea, vomiting	2	2.7	1.4	Short duration
Atelectasis	3	4	2	Uneventful recovery
Spread of infection (within 3 months)	1	1.3	0.7	Death 5 days after operation (tuberculous pneumonia)
Postoperative shock	2	2.7	1.4	Short duration; responded to usual therapy
Pleural effusion	2	2.7	1.4	Uneventful recovery
Tension pneumothorax	1	1.3	0.7	Aspirated; good recovery
Deep wound infection	3	4	2	Eventual recovery
Early deaths; after operation (within 3 months)	3	4	2	(1) 7 hours (2) 5 days (3) 7 days

ministration of atropine intravenously. True laryngospasm was not observed. Systolic blood pressure fell to a level below 80 mm. of mercury occurred in one case. Supportive therapy consisting of intravenous fluids and whole blood, small doses of a vasoconstrictor drug and inhalation of 100 per cent oxygen restored the blood pressure level to normal within fifteen minutes. Vomiting during early anesthesia occurred in one patient who had eaten a full meal shortly before. Language difficulty prevented this information from being known to the anesthetist at the time of induction.

Postanesthetic Period.—The patient usually regained consciousness in the operating room within a few minutes after the inhalation

anesthesia was discontinued. Nausea and vomiting were rarely seen upon emergence from anesthesia. The regional block seemed to diminish considerably the immediate postoperative pain from the operative site.

Postoperative complications are summarized in table 2. The postoperative complications observed in this series of cases are not remarkable and compare favorably with those reported by other authors using the usual forms of anesthesia.

There were three early deaths in this series. One patient with a diagnosis of bilateral, far advanced pulmonary tuberculosis and tuberculosis of the larynx and intestine underwent an uneventful first stage thoracoplasty but died suddenly seven hours later of causes unknown. A routine check by a medical officer thirty minutes before the patient's death had revealed him to be in apparently good condition.

A second patient with bilateral disease developed dyspnea and paradoxical respiration on the third postoperative day following a first stage thoracoplasty; he improved for a few days but died suddenly on the seventh postoperative day.

The third patient had bilateral disease with tuberculous empyema preoperatively. Following a first stage operation he ran a septic course and died with a tuberculous pneumonia of the contralateral lung on the fifth postoperative day.

DISCUSSION

Paravertebral spinal nerve block is not a technically difficult procedure for those with a basic knowledge of the anatomy of the region concerned and some experience in other forms of regional anesthesia. With the technic described, care must be taken to keep the block needles parallel to the sagittal plane of the body. If the needle is directed too far medially, subarachnoid anesthesia may result; if too far laterally, the spinal nerve may not be bathed with the injected solution. Pneumothorax may also result if the needle is inserted too deeply in a lateral direction. This has not happened in my experience.

We have found the addition of paravertebral spinal nerve block to light general anesthesia with pentothal sodium and nitrous oxid-oxygen to be advantageous in several ways. First, the amount of pentothal required to maintain satisfactory anesthesia is reduced. The recovery period is thereby shortened and there is less tendency toward prolonged postoperative depression seen with large doses of pentothal. Of equal importance is the control of undesirable reflexes such as breath-holding and straining which may be elicited by the stripping of periosteum from ribs and other surgical manipulations. Regular, quiet respirations are readily maintained, facilitating the work of the surgeon and making the spread of the disease less likely. McCann (8) has described the advantages of combining intercostal nerve block with

pentothal sodium anesthesia for radical mastectomy in reducing the dosage of pentothal and in obtunding undesirable respiratory reflexes aroused by surgical trauma in the thoracic segments.

The selection of pentothal combined with safe concentrations of nitrous oxide for the production of light general anesthesia, after regional nerve blocking, is based upon the relative ease with which these agents satisfy the requirements of anesthesia for patients handicapped with pulmonary tuberculosis. Pentothal and nitrous oxide in the dosages indicated are nonirritating so the mucosa of the respiratory tract, are nontoxic to vital tissues and do not interfere with the physiologic exchange of oxygen and carbon dioxide. Induction is easy and rapid; the desired depth of anesthesia is readily maintained and quiet, regular pulmonary ventilations are usually produced. Excessive respiratory movements, in the absence of a rigid thoracic wall following rib resection, may lead to mediastinal shift with each respiratory cycle and the partial ventilation of the lung on the unoperated side with the contents from the contralateral lung. Paradoxical respiration leads to hypoxia, with all its serious consequences. Krueger (9) Randolph and Kober (10) and Paquet (11) have reported these advantages when using pentothal alone for anesthesia for thoracoplasty. The advantages of combining relatively safe concentrations of nitrous oxide, 50 to 60 per cent, with pentothal are well known. Knight (7) and Barton, Wicks and Livingstone (12) emphasized the value of nitrous oxide-oxygen mixtures in reducing the dose of pentothal. The latter authors showed that the addition of oxygen or nitrous oxide-oxygen to pentothal anesthesia produced a definite increase in the blood arterial oxygen and that this might be valuable in overcoming mild anoxic states which are so poorly tolerated by patients whose oxygen carrying mechanism is below normal. Patients with pulmonary tuberculosis are likely to be in this category. By avoiding large doses of pentothal, the characteristic prolonged depressant effects of this drug can be circumvented.

The nonexplosive properties of this combination of agents make it ideal for use in this hospital where an electrosurgical unit is routinely used to secure hemostasis during thoracoplasty. This would automatically exclude the use of cyclopropane, ethylene and ether, commonly advocated for these operations.

SUMMARY AND CONCLUSIONS

A form of balanced anesthesia combining the use of adequate preliminary medication, paravertebral block of appropriate thoracic spinal nerves, intravenous pentothal sodium and nitrous oxide-oxygen, administered in that sequence, has been described. The use of this type of anesthesia for a group of 75 patients in 146 posterolateral thoracoplasties seems to warrant the following conclusions:

1. Balanced anesthesia, as outlined, provides a safe and satisfactory method of anesthesia to meet the special requirements of patients undergoing thoracoplasty.

2. This type of anesthesia is nonexplosive and is therefore suitable for use with the electrosurgical unit.

3. Paravertebral nerve block is a safe procedure in the hands of those trained in regional anesthesia. Its concurrent use with general anesthesia has the advantage of abolishing undesirable respiratory reflexes and reducing the dose of pentothal required.

4. The incidence of postanesthetic and postoperative complications appears to be no greater with this type of anesthesia than with other agents and methods.

ADDENDUM

Since this paper was submitted for publication, an additional 44 posterolateral thoracoplasties have been carried out on an additional 22 patients utilizing balanced anesthesia. The average operating time was 91 minutes; the average amount of pentothal sodium required was only 644 mg. There were no deaths or spread of infection postoperatively in this group. Two patients developed atelectasis; both responded to conservative treatment.

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