Endobronchial Anesthesia for Resection of Aneurysms of the Descending Aorta

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Intrapulmonary bleeding is not rare during resections of thoracic aneurysms. Bleeding may be the result of sharp dissection of adherent lung from the aneurysm, of trauma to the lung secondary to severe retraction, or of forceful inflation of the lung against retractors, and occasionally it follows obstruction of a pulmonary vein by a retractor. Since left heart bypass is used during resection, intrapulmonary bleeding continues during the period of heparinization and contaminates the dependent lung, leading to severe postoperative pulmonary insufficiency. Contamination of the dependent lung can be prevented by endobronchial anesthesia, which would also permit complete collapse of the superior lung and decrease trauma to the lung. Since most patients with thoracic aneurysms are elderly, with impaired pulmonary function, gas exchange during surgical operation may not be adequately maintained by the dependent lung alone. To explore this, a trial of endobronchial anesthesia was undertaken in ten patients, with measurement of serial changes in blood gases.

METHODS

Nine men and one woman with aneurysms limited to the descending thoracic aorta were studied. Their ages ranged from 46 to 70.
years (mean 62.0 years). Preanesthetic medication consisted of conventional doses of morphine and/or pentobarbital with atropine. After induction of anesthesia with 300–500 mg thiopeental and 50 per cent nitrous oxide and oxygen, succinylcholine, 100 mg, was administered. After hyperventilation with oxygen, a Carlens double-lumen or left-sided Robert-Shaw tube was introduced. The position of the tube was verified with the patient in both the supine and the right lateral position by breath sounds after inflation through each lumen separately. Anesthesia was maintained with intravenous meperidine and 0.5–1.0 per cent halothane in oxygen in a semi-closed circle absorption system. Succinylcholine by infusion was used to maintain apnea while respiration was controlled manually.

In seven patients blood gases were measured two or more days before operation during breathing of air. In all patients blood was sampled before thoracotomy after both lungs had been ventilated with 100 per cent oxygen for at least 20 minutes with the patients in the lateral position. After thoracotomy, the left lung was collapsed by squeezing the air out manually and the left lumen of the tube remained open to the atmosphere. The right lung was ventilated at the maximum rate allowed by its rate of expiration. Arterial blood samples were taken at intervals after collapse of the left lung. Aneurysms were resected during partial left ventricular bypass without oxygenation after 3 mg/kg of heparin had been administered.

Arterial blood samples were drawn anaerobically from the right radial artery in heparinized syringes and placed immediately in ice slush. All were analyzed within two hours of sampling. PaCO₂ and PaO₂ were measured directly with appropriate electrodes. Since esophageal temperature did not fall more than 1.5°F during operation, blood gas values were not corrected for temperature.

**RESULTS**

During ventilation of one lung, persistent hypercarbia was present in four of the ten patients (table 1, Patients 2, 3, 4, and 5). Three of these patients were known to be hypercarbic before operation and remained hypercarbic after manual ventilation of both lungs in the lateral position. PaCO₂ tended to increase shortly after institution of one-lung respiration, but lower PaCO₂ values were obtained after 15 minutes of ventilation. In the other six patients PaCO₂ was maintained below 40 mm Hg at most sampling periods by maximum ventilation of the dependent lung.

PaO₂ values, measured before operation, were in the range anticipated for this age group (table 2). As expected, PaO₂ values decreased after institution of one-lung respiration and continued to fall during atelectasis. Although lower values were observed in patients who were also hypercarbic, these were not considered hypoxic. No attempt was

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<td>43.0</td>
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<td>Both lungs ventilated</td>
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made to relate individual values to changes in systemic circulation or to the variable degrees of compression of the atelectatic lung, which may have affected pulmonary shunting. The left pulmonary artery was not occluded during this period.

**DISCUSSION**

Endobronchial anesthesia for use in thoracic surgery was introduced by Bjork and Carlens to provide easy access to a quiet operative field and lack of contamination of the dependent lung. These advantages were apparent in these ten patients, none of whom suffered contamination of the right lung by blood.

$P_{A_{O_2}}$ during ventilation of one lung tended to decrease with time without a similar pattern of change in $P_{A_{CO_2}}$. Most investigators who have studied the effects of endobronchial anesthesia on blood gases did not report this progressive change, since $P_{A_{O_2}}$ was not measured serially. Zimberg and Lynch, however, did report a progressive fall in $P_{A_{O_2}}$ during acute unilateral atelectasis in five dogs and one patient. Elebute et al., who measured pulmonary blood flow directly in dogs during acute atelectasis, reported an increasing shunt with duration of atelectasis. They stated “Both the venous admixture studies and the electromagnetic flowmeter recording demonstrated a 20 to 25 per cent increase in relative blood flow through the collapsed lung during the first hour of atelectasis. The electromagnetic flowmeter studies showed further that after blood flow had increased to a maximum within the first hour, a gradual diminution then occurred.” Except, perhaps, for Patient 1, we did not observe this secondary change in our patients.

The low $P_{A_{O_2}}$ in these patients after one hour of lung collapse should caution against the use of inspired gas mixtures containing less than 100 per cent oxygen in such patients. Other investigators who have reported $P_{A_{O_2}}$ values of 50–59 torr during pulmonary surgery utilizing endobronchial anesthesia with $F_{O_2}$ 0.5 or less did not record the duration of lung collapse. Considering the frequency of impaired pulmonary function in patients with thoracic aneurysms and the duration of lung collapse required for resection and graft, the use of inspired gas mixtures with less than 100 per cent oxygen would be justified only if the left pulmonary artery was also occluded to decrease the pulmonary shunt. In any case, inspired oxygen concentrations should be guided by blood gas measurements. As expected, elimination of carbon dioxide was a problem only in patients who were hypercarbic before operation. Occlusion of the left pulmonary artery might have improved CO$_2$ elimination in these patients. The blood gas values observed here were considered acceptable in return for elimination of postoperative respiratory failure from contamination of the lung by fresh blood.

A limitation of this technique was its lack of applicability to some patients with large aneurysms which distorted the tracheobronchial tree. During the course of this study of
ten patients, an endobronchial tube could not be satisfactorily placed in two additional patients with large aneurysms. Use of right double-lumen endobronchial tubes might improve the success rate. We consider the use of endobronchial tubes during resections of thoracic aneurysms to be a significant contribution to the surgical treatment of this disease.

REFERENCES

Comparison of Three Clinical Peripheral-nerve Stimulators

WILLIAM T. ROSS, JR., M.D.*

Epstein recently reported his observations of the electromechanical response of muscle to peripheral nerve stimulation with the Block-Aid Monitor nerve stimulator. He noted that this nerve stimulator delivers a biphasic stimulus. This is, in effect, paired stimuli of opposite polarity, separated by 4 to 5 msec. This interval is of the same order of magnitude as the neuromuscular refractory period. In a subsequent report, Epstein also showed that the mechanical twitch tension developed by muscle in response to paired stimuli applied to a peripheral nerve is dependent upon the interval between the two stimuli of the pair. He further showed that nondepolarizing muscle relaxants and anticholinesterases alter the neuromuscular refractory period, and that this alteration of the refractory period has a marked effect on twitch tension produced by paired stimuli of a given pair interval. From the information in these two reports, a stimulator used clinically to evaluate twitch tension in the presence of agents which alter the neuromuscular refractory period should have the following stimulus characteristics: 1) The stimulator should produce a single square-wave stimulus pulse; 2) The stimulus pulse should be of short duration (less than 0.3 msec); 3) The output voltage should be sufficient to deliver a supramaximal stimulus. With these characteristics in mind it seemed reasonable to examine the stimulus pulses delivered by several clinical peripheral-nerve stimulators.

MATERIALS AND METHODS

Three commercially-available clinical peripheral-nerve stimulators were studied: 1) The Block-Aid Monitor (Burroughs-Wellcome & Co., Inc., Tuckahoe, New York); 2) The Meditron Nerve Locator-Stimulator (Crescent Engineering & Research Co., 5440 North Peck Road, El Monte, California); 3) The Churchill-Davidson Peripheral Nerve Stimulator (R. G. Wakeling & Co., Ltd., Medical Electronics, Holly Road, Twickingham, Middlesex, England).

Fresh batteries were used in each nerve stimulator examined. Output of the stimu-