

## PROBLEMS OF ANESTHESIA IN THORACIC SURGERY • †

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THE management of anesthesia for thoracic surgery is the most difficult task undertaken by the anesthesiologist (1). The patient suffers from a pathologic condition of the contents of the chest, which usually lowers the vital capacity and interferes with adequate oxygenation of the arterial blood. He often has profuse secretions in the tracheobronchial tree which interfere with respiratory exchange. Frequently, he is cachectic, anemic from chronic toxemia. These conditions make him a poor risk for any anesthesia or operation.

The patient is usually placed in the lateral position on the operating table, with the diseased side up. This tends to compress the good lung and aids the drainage of blood, pus and secretions from the operated lung to the sound one, with resultant spread of infection.

The use of various braces to hold the patient in proper position, and self-retaining, rib-spreading retractors reduces respiratory excursion.

The creation of an open pneumothorax collapses the uppermost lung, thereby reducing the alveolar surface available for oxygen and carbon dioxide diffusion by one half. With each inspiration, the mediastinum is pulled toward the unoperated side, thus reducing the intrapleural negative pressure, cutting down the effectiveness of the respiratory effort and producing some degree of paradoxical respiration. The net result is a reduction in the tidal volume and pulmonary ventilation of a patient whose respiratory reserve is already limited.

Thoracic operations are usually long and are associated with the loss of large amounts of blood. This makes the problem of blood and fluid replacement, to prevent shock, an important one.

Traction on the hilum of the lung will frequently produce cardiac abnormalities due to vagal stimulation. (2)

The literature contains reports of many different methods of anesthesia in use for thoracic operations (3-13). This emphasizes the fact that there is no ideal technic, and that the judgment and skill of the anesthesiologist are more important than the agent or method used.

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Our personal preference in most cases is inhalation anesthesia using cyclopropane and ether by the to-and-fro carbon dioxide absorption method through an endotracheal tube. A pentothal-curare induction is usually employed. In view of the factors previously listed, which interfere with the efficiency of respiration and predispose to hypoxia, it seems desirable that the patient receive the high concentration of oxygen available only with the use of these agents. The endotracheal tube, by maintaining an adequate airway, facilitates the delivery of this oxygen to the alveoli. It provides a path through which blood, pus and secretions can be aspirated. Positive pressure may be used to inflate the lung or to combat mediastinal movement. Respirations may be aided, compensated or controlled, depending on the judgment of the anesthesiologist. The plane of anesthesia can be lightened or deepened easily to conform with the surgical needs and length of the operation. In short, the anesthesiologist has better control of the situation in any eventuality. From the patient's viewpoint, he has a pleasant, rapid induction and is spared the mental and physical discomfort of being awake through a long operation.

However, we believe that each anesthesia should be considered an individual problem. The agent and method used should be selected in consideration of the safety of the patient, the convenience of the surgeon and the comfort of the patient, in that order (14). Pre-operative consultation with the surgeon and patient, and a study of the patient's hospital record will aid in the proper choice.

Supportive therapy is important in long chest operations. The anesthesiologist should not wait for evidence of circulatory depression before starting to replace the blood loss. The presence of a pile of bloody sponges is indication enough for transfusion. Shock is much easier to prevent than to combat once it is established. With a large bore needle in a vein from the start of the operation, fluid and blood replacement can be regulated to parallel their loss.

Positive pressure while the chest is open is recommended by many anesthesiologists to stabilize the mediastinum and to keep the un-operated lung inflated. However, it can be abused. Constant pressure keeps the alveoli from collapsing with each expiration and so reduces pulmonary ventilation. High pressures can force secretions into smaller bronchioles, causing areas of atelectasis. Pressures of 20 mm. of mercury and higher may rupture alveoli. Positive pressure interferes with the filling of the right side of the heart so that it frequently is accompanied by a lowering of the blood pressure. It would seem that intermittent pressure, seldom exceeding 10 mm. of mercury, is a more satisfactory solution to the problems produced by the open chest.

Controlled respiration is frequently recommended (15-17). Its advantages are: more efficient removal of carbon dioxide, a quiet field

for the surgeon and the abolishment of paradoxical respiration. Nosworthy stated that controlled respiration abolishes the dangers of the open pneumothorax.

Others have pointed out the disadvantages of controlled respiration (17-19). Beecher objected to its use because it deprives the anesthesiologist of the best sign of overdosage of the anesthetic agent. Burstein and Rovenstine pointed out that the pressures often used in conjunction with controlled respiration are high enough to rupture alveoli in some cases, and they also keep the lung on the operated side inflated, thus reducing the field of exposure. They recommended the technic of compensated respiration. Mousel, in a series of intrathoracic operations performed in army hospitals, found that all the deaths occurred in the centers in which controlled respiration was used.

Copious secretions in the tracheobronchial tree frequently present a problem. Endobronchial intubation is used (20) to prevent their drainage to the sound side. This is fairly successful for right pneumonectomies, but for an operation on the left side, it is difficult to intubate the short right main bronchus without occluding the eparterial bronchus. In any case, there is no substitute for eternal vigilance and frequent catheter aspirations of the endotracheal tube. Immediate postoperative bronchoscopy of the "wet" cases will insure the removal of secretions from the airway.

#### REVIEW OF CASES

This report covers a series of 320 consecutive anesthetics for thoracic operations. All but the last twelve were administered at the University of Kansas Medical Center. Table 1 lists the operations with the hospital mortality rates for each. The miscellaneous respir-

TABLE 1  
OPERATIONS AND MORTALITY

Operation	Number	Hospital Deaths	Mortality, per cent
Lobectomy	57	4	7.0
Pneumonectomy	14	0	0.0
Thoracoplasty	31	2	6.4
Resection of Esophagus	18	5	27.8
Esophagogastrotomy	11	2	18.2
Exploratory Thoracotomy	69	5	7.2
Ligation of Patent Ductus Arteriosus	21	0	0.0
Blalock Operation	11	1	9.1
Thoracolumbar Sympathectomy	34	2	5.9
Miscellaneous			
Respiratory	28	0	0.0
Mediastinal	14	0	0.0
Gastrointestinal	12	0	0.0
Total	320	21	6.6 (av.)

atory operations included 8 instances of drainage of lung abscesses, 5 plumbages, 3 closures of lung abscesses, 2 decortications, 4 rib resections for drainage of empyema and 1 each of the following: closure of bronchopleural fistula, closure of tracheoesophageal fistula, marsupialization of lung cyst, excision of lung cyst, removal of a safety pin from a bronchus and segmental lung resection. The miscellaneous mediastinal operations included 8 excisions of mediastinal tumors, 2 subclavian-aortic anastomoses for coarctation of the aorta, 2 drainages of

TABLE 2  
AGE OF PATIENTS

	Number
3 days to 9 years	45
10 to 19 years	35
20 to 29 years	25
30 to 39 years	49
40 to 49 years	58
50 to 59 years	51
60 to 69 years	42
70 years and over	15

mediastinal abscesses, 1 pericardiectomy and 1 removal of a pericardial tumor. The miscellaneous gastrointestinal operations included 6 transthoracic gastrectomies, 3 repairs of diaphragmatic hernias, 2 transthoracic vagotomies and 1 transthoracic splenectomy. There were 21 hospital deaths in the series for an over-all mortality rate of 6.6 per cent. The ages of the patients ranged from 3 days to 82 years.

TABLE 3  
PREOPERATIVE CIRCULATORY COMPLICATIONS

Hypertensive Heart Disease	51
Arteriosclerotic Heart Disease	50
Congenital Heart Disease	47
Cor Pulmonale	14
Rheumatic Heart Disease	4
Pericarditis	2
Esophageal Varices	2
Pericardial Tumor	1
161 patients, 14 hospital deaths, 8.7 per cent mortality	

The number of patients in each decade of life is given in table 2. The greatest number were between 30 and 60 years of age. There were 161 males and 159 females.

Preoperative circulatory complications are listed in table 3. They included 51 cases of hypertensive heart disease, 50 of arteriosclerotic heart disease and 47 of congenital heart disease. There were 161 patients in this group. Fourteen hospital deaths occurred, or a mortality of 8.7 per cent.

The 47 patients with congenital heart disease are listed in table 4. The 21 patients with patent ductus arteriosus were operated on with-

TABLE 4  
PATIENTS WITH CONGENITAL HEART DISEASE

Condition	Number	Deaths	Mortality, per cent
Patent Ductus Arteriosus	21	0	0.0
Tetralogy of Fallot	22	3	13.6
Coarctation of Aorta	4	1	25.0

out mortality. Of the 22 patients with the tetralogy of Fallot, Blalock operations were completed in 11, 9 were found to be inoperable and the operations were abandoned in 2 others because of cardiac arrest. One of the 11 patients having the Blalock operation died in the hospital, a mortality rate of 9.1 per cent. In all of 9 inoperable cases in which operation could not be done the patients recovered from their thoracotomies and were discharged ambulatory. One patient who had a cardiac arrest died in the operating room and the other, although normal heart action was restored following cardiac massage and artificial respiration, never regained consciousness and died thirty hours later. The over-all mortality for 22 patients with the tetralogy of Fallot was 13.6 per cent.

TABLE 5  
PREOPERATIVE RESPIRATORY COMPLICATIONS

Bronchiectasis	53
Lung Tumor	40
Active Tuberculosis	40
Lung Abscess	20
Empyema	15
Emphysema	11
Atelectasis	9
Bronchial Asthma	5
Miscellaneous	17

199 patients, 10 deaths, 5.0 per cent mortality

There was 1 hospital death, on the eighteenth postoperative day, in a patient who was operated on for coarctation of the aorta. Cardiac arrest occurred in 1 case while the chest was open, soon after a subclavian-aortic anastomosis had been completed. Normal heart action was promptly initiated by means of cardiac massage and artificial respiration with pure oxygen. The patient recovered fully and was discharged ambulatory two weeks later.

All 3 instances of cardiac arrests occurred in patients under cyclopropane anesthesia and were preceded by marked slowing of the pulse. In some of the other patients with congenital heart disease, a similar slowing of the pulse was frequently observed to follow the administration of cyclopropane. Bradycardia or cardiac arrests were not similarly encountered in patients who were under ether anesthesia.

A total of 199 patients had some type of respiratory complication before operation. These complications are listed in table 5. The 17 conditions listed as miscellaneous were as follows: 3 cases of arrested tuberculosis, 2 of cystic disease of the lung, 2 of pulmonary congestion, 2 of mediastinal abscesses, and 1 case each of bronchitis, bronchopleural fistula, tracheo-esophageal fistula, broncho-esophageal fistula, foreign body in the bronchus, pulmonary fibrosis, limited chest expansion owing to fractured ribs and pulmonary hemorrhage with bronchial obstruction. There were 10 deaths in this group, a mortality rate of 5 per cent.

During operation the systolic blood pressure dropped below 90 mm. of mercury in 44 patients. There were 10 hospital deaths in this group, a mortality of 22.7 per cent, or more than three times the mortality for the entire series of 320 cases.

#### SUMMARY AND CONCLUSIONS

The problems associated with anesthesia for thoracic surgery are many. The patients are usually poor risks with many factors predisposing to hypoxia. To combat this, it is important to create an airway by means of an endotracheal tube, to keep the airway open by frequent aspirations and to assist in the delivery of oxygen through the airway by the use of compensated respiration.

Multiple transfusions are frequently necessary to replace blood lost during operation.

A series of 320 anesthetics for thoracic operations was reviewed. The over-all mortality was 6.6 per cent. The mortality for patients with circulatory disease was 8.7 per cent and for those with preoperative respiratory complications was 5.0 per cent.

The mortality for patients in whom hypotension developed during operation was more than three times the over-all mortality for the series.

Ether anesthesia for patients with congenital heart disease was accompanied by fewer cardiac complications than was cyclopropane anesthesia.

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