A 27-year-old white male was scheduled for a mediastinoscopy of an anterior mediastinal mass. The patient was induced with thiopental and succinylcholine, in anticipation of possible difficulty managing the airway. There was no distortion of the airway, and he was easily intubated with a No. 8.5 anode tube and given 20 mg of atracurium.

The extent of tumor growth was greater than expected and, as a result, biopsies of the neck were taken without the need for mediastinoscopy. The atracurium was reversed with atropine and edrophonium. Although respirations were being assisted, the SaO$_2$ decreased significantly, and end-tidal CO$_2$ was greatly increased.

When the drapes were removed, the patient was found to be cyanotic, with vein distention in the neck and upper extremities. All anesthetic agents were discontinued, the patient was hyperventilated with 100% oxygen, 100 mg of lidocaine was given for coughing and breath-holding, and the patient was placed in the reverse Trendelenburg position. The SaO$_2$ then increased, and the end-tidal CO$_2$ decreased. Respirations were spontaneous, and the patient could be extubated.

The probable cause of this episode was obstruction of the superior vena cava by the muscle relaxant was reversed, the increase in intrathoracic pressure caused the mass to compress the superior vena cava. The compression was released by placing the patient in a reverse Trendelenburg position, which caused the mass to shift.

In addition to superior vena cava compression, other complications of anterior mediastinal masses include airway obstruction, distortion of anatomy, impaired cerebral circulation and myasthenic syndrome. Complications of mediastinoscopy include hemorrhage, pneumothorax, recurrent laryngeal nerve injury, infection, tumor implantation of the wound, phrenic nerve injury, esophageal injury, chylothorax, air embolism, and transient hemiparesis.

The complications of anterior mediastinal masses and mediastinoscopy are equally life-threatening. The anesthetist must anticipate these potentially disastrous complications and be ready to diagnose and treat them.

Key words: Airway, mediastinal mass, mediastinoscopy, position.

In patients with an anterior mediastinal mass, the procedure for mediastinoscopy and its anesthetic management present a unique challenge to the anesthetist. There are several factors involved that are...
potentially life-threatening, starting with induction and continuing into the postoperative period. Successful management requires knowledge of anatomy and physiology and the procedure for mediastinoscopy, as well as possible complications, not only as a result of the procedure, but also because of the anterior mediastinal mass itself.

The anesthetic management of a patient with an anterior mediastinal mass and mediastinoscopy will be discussed in detail.

Case study

A 27-year-old white male presented to the emergency room with a sudden onset of a severe, colicky pain in the right inguinal area that radiated to the scrotum. The patient also complained of nausea and dysuria. His vital signs were within normal limits, except for a slightly elevated temperature (99.9°F).

The physical examination revealed a well-nourished 27-year-old white male, alert and oriented. His lungs were clear to auscultation and percussion. His heart rate and rhythm were regular, with a grade I/VI systolic ejection murmur. Further examination of the chest revealed a few nontender 1 cm lymph nodes in the left axilla and a few smaller ones on the right. The abdomen was soft, and bowel sounds were present. The rest of the physical examination was unremarkable.

The patient's past medical history included ethanol abuse; however, he denied any alcohol consumption since 1978. The patient had experienced a 10-pound weight loss over the previous year and attributed it to excessive sweating while at work. He denied fever or night sweats. The patient also smoked one pack of cigarettes a day. He was not on any medications and had no known allergies.

While he was in the emergency room, a flat plate of the abdomen was ordered, which was negative. A chest x-ray was also done which revealed a large mass occupying the entire mediastinum and extending into the left and right thorax. There was either pleural thickening or pleural effusion at the right costophrenic angle. There was also right apical pleural thickening or pleural effusion.

While the computed tomography (CT) scan of the abdomen was negative, the CT scan of the chest revealed an extensive infiltration of the anterior mediastinum by tumor, which contoured to the great vessels and most of the cardiac silhouette superiority. There also appeared to be a small amount of pericardial fluid. The lung parenchyma was essentially clear, and bilateral fluid was noted.

An intravenous pyelogram was negative, and blood work was within normal limits.

The findings on the chest x-ray and CT scan necessitated the consultation of an oncologist, thoracic surgeon and cardiologist.

The patient's ECG showed normal sinus rhythm, with rightward axis deviation and a T-wave abnormality representing possible anterolateral ischemia. A 2-D and M-mode echocardiogram revealed a large echo-free space in the entire anterior segment of the left and right ventricles, suggestive of either pleural or significant pericardial effusion. The right ventricular systolic function was somewhat abnormal, but appeared well preserved.

Following cardiology clearance, the patient was then scheduled for a left axillary node biopsy and a possible mediastinoscopy. The surgeon and oncologist conferred with the anesthesia team. It was decided that the best way to proceed would be to do an axillary node biopsy under local anesthesia. If the axillary node biopsy was benign, a mediastinoscopy would be performed under general anesthesia.

The patient had undergone general anesthesia 2 years earlier for wisdom teeth extraction with no apparent complications. There was no history of anesthetic reactions in his family, and he had never received any blood transfusions.

The evening before surgery, the patient was visited by a staff anesthesiologist, who discussed the plan with the patient and his wife. The patient agreed to axillary node biopsy and possible mediastinoscopy. Informed consent was obtained.

The patient received nothing by mouth for 8 hours prior to the scheduled surgery. He was given 5 mg diazepam 1 hour preoperatively.

The patient had a left axillary node biopsy done under local anesthesia. The biopsy sample was compatible with reactive hyperplasia, so it was decided to perform a mediastinoscopy.

Anesthetic agents were selected after carefully considering the disease pathology involved and the possible consequences under general anesthesia. Fentanyl was used prior to induction for its analgesic effect, because the patient had just undergone an axillary node biopsy and to attenuate the sympathetic response to laryngoscopy. Thiopental and succinylcholine were used in anticipation of possible difficulty in managing the airway, since both drugs are ultrashort-acting.

Lidocaine was used to attenuate the sympathetic response to laryngoscopy and for its antitussive effect. Atracurium was used for pretreatment to prevent fasciculations and again after intubation to control ventilation and minimize the risk of venous air embolism. Isoflurane was used for maintenance. Edrofonium and atropine were used at the conclusion of the case to reverse the effects of the atracurium.
The patient was brought to the operating room suite, identified and interviewed. His chart was reviewed. After the patient was on the operating room table, a 3-lead ECG was placed to monitor Lead II. A Dinamap® blood pressure cuff was placed on his left arm, and a conventional blood pressure cuff was placed on his right arm. Lactated Ringer's solution was infused using a 16-gauge angiocath in his right wrist, and 5% dextrose/lactated Ringer's solution was infused using an 18-gauge angiocath in his left arm. A pulse oximeter secured to his left index finger read 95% prior to preoxygenation. A Doppler was positioned and secured over the right radial artery to detect any compression of the innominate artery.

The patient was then preoxygenated and given 2 cc of fentanyl. SaO₂ prior to induction was 100%. Atracurium, 5 mg, was given for pretreatment, and a bolus of 400 mg of thioental was given rapidly. Cricoid pressure was maintained as the patient lost consciousness. This was followed by a 100-mg bolus of succinylcholine and 75 mg of lidocaine. The patient was atraumatically intubated with a No. 8.5 anode tube. No tracheal deviation was noted. Bilateral breath sounds were equal and clear. The anode tube was then secured, and the patient was maintained with 1% isoflurane, 50% nitrous oxide, and 50% oxygen.

Atracurium, 20 mg, was administered, and the patient was placed on a ventilator with a tidal volume of 550 cc and a respiratory rate of 10. Surgical positioning followed.

A transverse incision was made immediately above the sternal notch. As the surgeon was dissecting the pretracheal fascia, he discovered that the tumor had invaded the neck. This had not been indicated on the chest x-ray or CT scan. He decided it would be unnecessary to carry out the mediastinoscopy, since an adequate biopsy of the mass could be taken from the neck. However, three biopsies were taken over the course of 60 minutes because of difficulty in making a diagnosis. Finally, the wound was irrigated, suctioned, and closure begun.

During the case the vital sign averages were:
- Blood pressure 105/55, pulse 70, respirations 10 and temperature 35.9° C. SaO₂ averaged 98, and end-tidal CO₂ was 32.

As the wound was being closed, the atracurium was reversed with 1 mg of atropine and 55 mg of edrophonium. The patient was then taken off of the ventilator and manually ventilated. Within 2 minutes, the patient began to have spontaneous respirations and was assisted.

The patient was tachypneic, with a respiratory rate of 30-35, and his tidal volume was shallow, 75-150 cc. Assisted respirations were continued.

The end-tidal CO₂, which had been in the low 30s began to climb into the 50s. Inadequate reversal or mucous plug was considered; however, it had been more than an hour since the atracurium and a full reversal dose of edrophonium had been given and a train of four had been observed with a nerve stimulator.

The patient was also easily ventilated. The SaO₂ began to drop precipitously as the end-tidal CO₂ climbed to 70. All anesthetic agents were discontinued, and the patient was hyperventilated with 100% oxygen.

As the drapes were removed from his upper body and head, the patient was cyanotic, and vein distention was observed in his neck and both upper extremities. There was venous backflow into both IVs, even though they were wide open.

As hyperventilation continued, the SaO₂ returned to the 80s, and the end-tidal CO₂ decreased. The patient was also experiencing episodes of coughing and breath-holding. Lidocaine, 100 mg IV, was given. Although there was still an impediment of venous return, the IVs were now running.

The patient was placed in a reverse Trendelenburg position. SaO₂ increased to 98%, and end-tidal CO₂ decreased to 45. The patient's blood pressure was 150/82, pulse 135 and respirations 35, with a tidal volume of 300-400 cc. He was slightly agitated but awake enough to maintain his protective airway reflexes. The decision was made to extubate. The SaO₂ remained 98%, end-tidal CO₂ measured 45, and respirations were spontaneous.

The patient was placed in a high Fowler's position after extubation and taken to the recovery room. His vital signs upon admission to the recovery room were blood pressure 158/92, pulse 129, and respirations 32. The patient was placed on a 40% face tent.

During the entire case, including the episode on emergence, the radial pulse was never lost or showed a decrease on the Doppler, indicating that the innominate artery was not compressed.

A probable cause of the reported episode was obstruction of the superior vena cava resulting from the following:

1. The administration of muscle relaxants decreased the intrathoracic pressure.
2. When the muscle relaxant was reversed, the intrathoracic pressure increased, causing the mediastinal mass to compress the superior vena cava.
3. Obstruction of the superior vena cava was compounded by the episodes of coughing and breath-holding.
4. Placement of the patient in a reverse Trendelenburg position caused the mass to shift, releasing the compression of the superior vena cava.
The patient was observed in the recovery room overnight. His recovery room stay was uneventful, and he was transferred to a regular floor the next day.

The patient was subsequently diagnosed as having Hodgkin's disease, and chemotherapy was begun. His original complaint of pain in the right lower quadrant subsided the first day after admission and was thought to have been a renal calculus that passed spontaneously. The patient was allowed to go home 12 days after surgery.

**Anatomical considerations**

The mediastinum is the extrapleural space within the thorax that lies between the two pleural cavities. It is bound superiorly by the thoracic outlet, inferiorly by the diaphragm and anteriorly by the sternum. The posterior border is the anterior surface of the vertebral bodies, but it also includes the paravertebral zones and posterior gutters. The mediastinum has three compartments: anterior, middle and posterior (Figure 1).¹

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Figure 1

**Anatomy of the mediastinum**

![Diagram of the mediastinum](image-url)

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The middle compartment contains the pericardium, heart, ascending and transverse portions of the aorta, trachea and main bronchi, superior and inferior vena cava, phrenic and vagus nerves, brachiocephalic arteries and veins, and pulmonary arteries and veins. Enlarging structures in this compartment can invade or compromise the tracheal lumen.¹

The posterior mediastinal compartment lies between the pericardium and the anterior aspect of the vertebral column and contains the descending aorta, esophagus, thoracic duct, azygos and hemiazygos veins, sympathetic chain and posterior group of mediastinal lymph nodes.¹

The superior mediastinum lies above the aortic arch and is usually subdivided into the anterior, middle and posterior mediastinum.¹

**Pathology**

Specific preoperative pathology that should be anticipated in the patient with a mediastinal tumor includes superior vena cava syndrome, airway obstruction or distortion of anatomy, impaired cerebral circulation and, if a lung carcinoma is present, evidence of myasthenic syndrome.²

The superior vena cava syndrome is most often caused by a malignant mediastinal tumor that obstructs the venous return to the heart. Less often, it is the result of benign conditions, such as idiopathic mediastinal fibrosis, mediastinal granuloma, and multinodular goiter.

The classic features of the superior vena cava syndrome include dilated, distended veins in the upper half of the body because of increased peripheral venous pressure; edema of the head, neck and upper extremities; dilated venous collateral channels in the chest wall; and cyanosis.

Venous distention is most prominent in the recumbent position, but in most instances the veins do not collapse in the normal manner with the patient upright. In some cases the superior vena cava becomes occluded quite slowly, and the signs and symptoms may be insidious in onset.

When the occlusion occurs relatively rapidly, all clinical manifestations are more prominent. Facial edema may be so severe that it prevents the patient from opening his or her eyes. Moreover, rapidly increasing venous pressure in the cerebral circulation may lead to neurologic impairment as cerebral perfusion pressure is decreased.²

The same degree of edema that is present externally in the face and neck can be expected in the mouth, oropharynx and hypopharynx.²

Airway obstruction resulting from a mediastinal mass will vary with the respiratory cycle and the position of the patient. General anesthesia will ex-
acerbate extrinsic airway compression in at least three ways:

1. During general anesthesia, lung volume is reduced approximately 500-1,500 cc, secondary to an increase in abdominal muscle tone and a decrease in inspiratory muscle tone.

2. The bronchial smooth muscle is relaxed during general anesthesia, the compressibility of the large airways increases, and a decrease in expiratory flow rate ensues, exacerbating the effects of extrinsic compression.

3. Paralysis eliminates the movement of the diaphragm in the caudal direction normally found with spontaneous respiration. The normal transpleural pressure gradient, which dilates the airways during inspiration, will be reduced; the caliber of the airways will be decreased; and the effect of extrinsic compression will be increased.

Obstruction during inspiration is more typical of an extrathoracic mass. However, during emergence a diaphragmatic mode of respiration with minimal chest wall motion can cause an intrathoracic mass to obstruct the airway during inspiration in the supine position. As the intercostal component becomes more prominent, the obstruction is minimized.

Cerebral circulation may be impaired if a mediastinoscopy is performed. This is secondary to compression of the innominate artery by the mediastinoscope and results in diminished blood flow to the right carotid and right subclavian arteries (Figure 2). This can be detected by palpat ing the right radial pulse by plethsmography or by arterial cannulation.

The myasthenic syndrome or Eaton-Lambert syndrome is associated with carcinoma, usually of the bronchus, but these may be thoracic tumors from the prostate, breast, stomach, or rectum. The symptoms of such patients mimic those of myasthenia gravis, except that they improve with activity. At times, the weakness may occur for 1-2 years before the diagnosis of carcinoma is made. Removal of the tumor does not affect the weakness. The patients are extremely sensitive to nondepolarizing and depolarizing muscle relaxants, and weakness may last for many days after their use. Therefore, muscle relaxants should be avoided in these patients (Table I).4

Relative contraindications to mediastinoscopy are superior vena cava syndrome, severe tracheal deviation and thoracic aortic aneurysm.2

Absolute contraindications to mediastinoscopy are recurrent laryngeal nerve involvement, cardiac status precluding anesthesia and previous mediastinoscopy. Previous mediastinoscopy eliminates the plane of dissection because of scarring (Table II).2

While overall mortality from mediastinoscopy is low (0.1%), serious complications can occur that the anesthetist must be prepared to diagnose and treat. In a series of 6,490 patients undergoing mediastinoscopy, the major complications reported were

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<tr>
<td>Complications of anterior mediastinal masses</td>
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<tr>
<td>Superior vena cava syndrome</td>
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<td>Airway obstruction</td>
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<tr>
<td>Impaired cerebral circulation</td>
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<td>Distortion of anatomy</td>
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<tr>
<td>Myasthenic syndrome (if a lung carcinoma is present)</td>
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Relative contraindications to mediastinoscopy
Superior vena cava syndrome
Severe tracheal deviation
Thoracic aortic aneurysm

Absolute contraindications to mediastinoscopy
Recurrent laryngeal nerve involvement
Cardiac status precluding anesthesia
Previous mediastinoscopy

Significant, occasionally massive, hemorrhage has been the most frequent major problem encountered during mediastinoscopy. If it occurs, the surgeon should attempt to control it by compressing the bleeding site. However, the relative inaccessibility of the operative field may make this maneuver difficult or ineffective and necessitate a thoracotomy.

Operative procedure
The suggested technique for mediastinoscopy requires a short, transverse incision above the suprasternal notch to expose the pretracheal fascia. Division of the pretracheal fascia, which lies immediately anterior to the tracheal wall, is crucial to entering the proper plane of dissection. Once the pretracheal fascia is entered, the tissue anterior and lateral to the trachea can be easily swept away with the index finger.

It is important that a complete digital dissection of the mediastinal structures be completed before the mediastinoscope is introduced, so damage to vital structures if avoided. Little or no dissection would be necessary after the mediastinoscope has been inserted, and it should be used for observation and biopsy only (Figures 3 and 4).

The aspirating needle and suction cautery are two special instruments vital to safe mediastinoscopy. No mediastinal tissue, however benign it appears, should be biopsied without a preliminary needle aspiration. A biopsy forceps is inserted through the scope and a tissue specimen excised. A bronchus sponge on a holder may be used to apply pressure to the excisional site. The mediastinoscope is withdrawn, and the subcutaneous tissue is closed with suture on a cutting needle.

Anesthetic management
If hemorrhage occurs during mediastinoscopy, the anesthetist should:
1. Rapidly begin volume replacement through one (or more) large bore intravenous cannulae that have been placed prior to the induction of anesthesia.
2. Transfuse blood if it becomes necessary.
3. Pharmacologically support the circulation until volume replacement is achieved.
4. Ensure adequate oxygenation and ventilation.

5. Administer an anticholinergic if reflex bradycardia occurs from aortic compression.

6. Discontinue or reduce the dose of all anesthetic drugs until normovolemic reestablished.

On rare occasions, it may be necessary to induce deliberate hypotension to control bleeding. Should hemorrhage originate from a superior vena cava tear, volume replacement and drug treatment may be lost into the surgical field unless they are administered using a peripheral intravenous line rapidly placed in a lower extremity.

Pneumothorax is another complication encountered relatively frequently in mediastinoscopy. It is usually not apparent until the postoperative period, and the majority of patients do not require chest tube decompression. All patients should be monitored for signs of pneumothorax during the postoperative period, and a chest roentgenogram should be obtained when doubt exists.

Pneumothorax that occurs intraoperatively, as evidenced by increased peak inspiratory pressure, tracheal shift, distant breath sounds, hypotension, and cyanosis, requires immediate treatment by chest tube decompression.

When mediastinoscopy causes a recurrent laryngeal nerve injury, it becomes permanent in approximately 50% of patients. If injury to the recurrent laryngeal nerve is suspected, the vocal cords should be visualized while the patient is breathing spontaneously (usually at the time of extubation). If the vocal cords do not move and/or are in midline position, consideration should be given to the problem of postoperative laryngeal obstruction.

During mediastinoscopy the tip of the mediastinoscope is located intrathoracically and, therefore, directly exposed to pleural pressure. Venous air embolism (when venous bleeding is present) can occur much more easily if patients are breathing spontaneously, because of the development of negative intrathoracic pressure during inspiration. Therefore, controlled positive-pressure ventilation during this procedure minimizes the risk of air embolism.

The mediastinoscope can exert pressure against the innominate artery and result in diminished blood flow to the right carotid and right subclavian arteries. This phenomenon may be of special significance in patients with preexisting compromised cerebral circulation.

Compression of the right carotid artery has been proposed as the cause of a left hemiparesis that occurred in one patient and subsequently cleared 48 hours after the procedure. In another patient, compression of the right subclavian artery caused loss of the pulse and blood pressure in the right arm and was misdiagnosed as an intraoperative cardiac arrest.

In another study, blood pressure in the right arm was significantly decreased for periods of 15-360 seconds in four of seven patients who underwent mediastinoscopy. This last report recommended that blood pressure be measured in the left arm and that the right radial artery be continuously monitored by palpation or finger plethysmography during mediastinoscopy.

A right radial arterial line would be very sensitive and continuously monitor the occurrence of innominate or right subclavian artery compression. An oxygen saturation monitor used for this purpose would be less sensitive (Table III).

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<th>Monitoring devices and equipment for mediastinoscopy</th>
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<tr>
<td>Electrocardiograph</td>
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<tr>
<td>Pulse oximeter</td>
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<tr>
<td>Capnograph</td>
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<tr>
<td>Nerve stimulator</td>
</tr>
<tr>
<td>2 large bore IVs</td>
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<tr>
<td>Lower extremity IV</td>
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<tr>
<td>Anode tube</td>
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<tr>
<td>Blood pressure cuff</td>
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<tr>
<td>Right radial arterial line, finger plethysmography, or Doppler</td>
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</table>

Any decrease in right radial artery pressure requires repositioning the mediastinoscope, especially in patients with cerebrovascular insufficiency. Excessive extension of the neck which might contribute to pinching of neck vessels, should be avoided in this patient group.

Autonomic reflexes may occur as a result of compression or stretching of the trachea, vagus nerve, or great vessels. Sudden changes in pulse and/or blood pressure during mediastinoscopy may initially be treated empirically by repositioning the mediastinoscope. Atropine is given for persistent bradycardia (Table IV).

All these factors contribute to a different school of thought on the anesthetic management of a patient with an anterior mediastinal mass. It is felt that if any diagnostic studies, such as a CT scan, echocardiography or an upright and supine flow volume loop study are positive, then general anesthesia should be avoided. Biopsies should be performed under local anesthesia.

However, if general anesthesia is necessary,
Table IV
Complications of mediastinoscopy
Hemorrhage
Recurrent laryngeal nerve injury
Tumor implantation of the wound
Esophageal injury
Air embolism
Pneumothorax
Infection
Phrenic nerve injury
Chylothorax
Transient hemiparesis

some references suggest that it should be carried out with the patient in a semi-Fowler's position. Spontaneous ventilation should be maintained, and muscle relaxants should be avoided. The anesthetist should be able to quickly change the patient's position from supine to lateral or prone, and a rigid bronchoscope should be available.3

When positioning the patient, the neck should be extended only slightly, since hyperextension decreases the space between the sternum and the trachea and increases the chance that the mediastinoscope will compress the innominate artery.8

Advocates of this school of thought also suggest awake fiberoptic bronchoscopy to assess the degree of obstruction. The airway distal to an obstruction and also the femoral vein to femoral artery cardio-pulmonary bypass should be available at the time of induction.1

Conclusion
Compression of the superior vena cava was encountered during this particular case. It was resolved by placing the patient in a reverse Trendelenburg position. The complications of anterior mediastinal mass and mediastinoscopy are numerous and life-threatening. Successful management of such cases and treatment of their complications depends upon the skill, knowledge and vigilance of the anesthetist.

REFERENCES

AUTHOR
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