Anesthesia for Special Operations

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Anesthesia as science is considered safer today than in the past. Despite advancements in medicine and technology, however, administering anesthesia is not a risk-free procedure and requires careful patient screening and assessment for risk factors. There are also various types of anesthesia, and some are more appropriate than others depending on the type of procedure for which it is being administered. This article encompasses discussion on thoracic anesthesia, endobronchial tube positioning, complications, and other issues, cardiac anesthesia, and neuro-anesthesia.

Thoracic Anesthesia

Thoracic anesthesia as a practice requires detailed knowledge of respiratory physiology, anatomy, pharmacology, and surgical techniques for patients having frequent, major comorbidities. The field of thoracic anesthesia continues to evolve because of new surgical developments and enhanced technologies in anesthesia. Progress in lung isolation techniques, ventilation management, and pain control strategies has collectively culminated in improved patient outcomes. Airway management is also continually improving as more sophisticated advances and devices upgrade the feasibility of lung isolation, ease surgical access, enhance intra-operative visibility, and optimize access to the operative field.

Definition of thoracic surgery

Thoracic surgery, also referred to as *cardiothoracic surgery*, is a field of medicine characterized by the surgical treatment of organs inside the thorax (chest). Thoracic surgery generally involves treatment of conditions involving the lungs (lung disease) and the heart (heart disease).

Right- or left-lung anesthesia and double-lumen endotracheal tubes

Patients undergoing thoracic surgery often require isolation of the right or left lung that will be operated on during surgery. The isolation leaves only 1 lung ventilated, and it is vital that this lung be able to provide adequate oxygenation and ventilation to support life. Management of one-lung anesthesia is considered one of the most difficult skills required by anesthesiologists.

The right mainstem bronchus is shorter than the left, and the distal cuff of a right endobronchial tube must be placed so that ventilation occurs separately to the right and left lungs (see image). It is essential that both endobronchial tubes ventilate each bronchus separately. In cases where a right-lung resection is necessary, the left lung is ventilated and the right lung is suctioned. The presence of leaks preventing positive-pressure ventilation is a complication that may be difficult to manage and may lead to hypoxia. The anesthesiologist must be an expert at using a fiber-optic bronchoscope to position the tube.

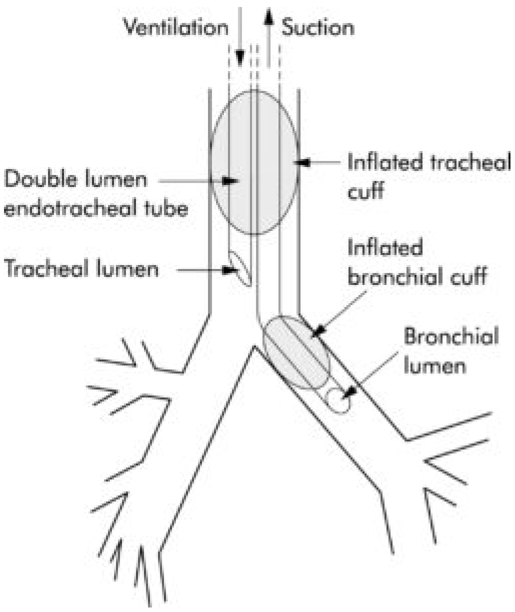

Image: “Positioning of the endobronchial tube for right-lung ventilation.”

Bronchial blocker

A **bronchial blocker**, also known as an *endobronchial blocker*, is a device that can be inserted down a tracheal tube, after tracheal intubation, to block off the right or left main bronchus of the lungs. This procedure enables the achievement of controlled one-sided ventilation of the lungs in thoracic surgery. The lung tissue distal to the obstruction will collapse and allow an improved surgeon's view and access to relevant structures within the thoracic cavity.

Bronchial blockers are used to achieve lung separation and one-lung ventilation as an alternative to double-lumen endotracheal tubes (DLTs). This is also a method of choice in pediatric patients, for whom even the smallest DLTs may be too large. Again, the use of a fiber-optic bronchoscope is essential for positioning of the blocker.

Complications and other issues

Some potential concerns or problems during thoracic anesthesia are described in the following table:

Complications	Explanation
Dislodgement of the endobronchial tube or blocker	Common complication; aggressive use of a bronchoscope to reposition is the key
Hypoxemia (low oxygen in the blood)	Can be minimized by correct tube placement and by the addition of PEEP to the non-operated lung and CPAP to the operated lung
Massive hemorrhage	Blood can contaminate the ventilated lung, thus impairing gas exchange.
Post-operative ALI	Potentially lethal complication
Post-operative pain management	Post-operative pain can be one of the most challenging areas for patients undergoing thoracic surgery. The placement of a thoracic epidural for pain relief allows patients to be comfortable, ambulate early, and take deep breaths and cough when necessary.

Cardiac Anesthesia

Cardiac anesthesia refers to the anesthesia subspecialty that provides care to patients during cardiothoracic surgery procedures involving surgery of the chest. **Cardiothoracic surgery** describes nearly any type of surgery involving the thorax (chest).

Many patients require placement on cardiopulmonary bypass (CPB) during cardiothoracic surgery. A cardiopulmonary bypass can present additional risks and concerns and may complicate the surgery. Cardiac anesthesia with CPB can complicate the tasks of ensuring analgesia, amnesia, and adequate muscle relaxation. When the bypass is not necessary, special concerns with chest surgery may still arise; however, using a cardiac anesthesia specialist can help to reduce the risks of complication.

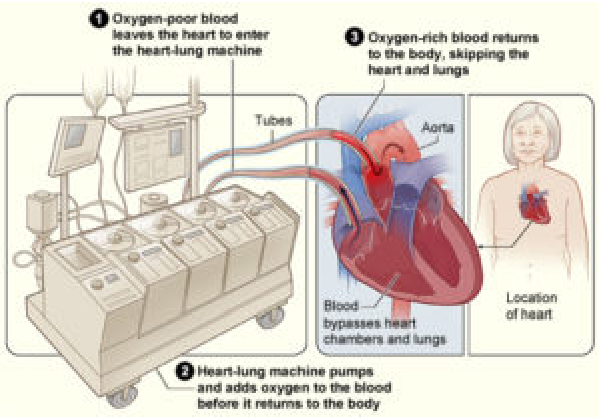

Image: "The image shows how a heart-lung bypass machine works during surgery." By: National Heart, Lung, and Blood Institute (NIH). License: Public Domain

Cardiopulmonary bypass

Cardiopulmonary bypass is a technique that temporarily takes over the heart and lung functions during surgery and maintains the circulation of blood and oxygen content of the body (see image). The CPB machine allows the patient's blood to bypass the heart and lungs during surgery but be pumped back into the patient to ensure perfusion to other organs. The heart is at a standstill during bypass and allows the surgeon to work on a stable target. For certain procedures such as valvulotomy and coronary bypass, some surgeons prefer to operate on a beating heart.

The CPB technique, however, is not free of complications. CPB can result in pharmacodynamic and pathophysiologic changes that perturb the usual homeostasis of the body. Some examples are as follows:

- **Postperfusion syndrome** (also known as "pump head")
- **Hemolysis**
- **Capillary leak syndrome**
- **Clotting of blood in the circuit,** which can block the circuit (particularly the oxygenator) or send a clot into the patient
- **Air embolism**
- **Leakage,** whereby a patient can rapidly exsanguinate, or lose blood perfusion of tissues, if a line becomes disconnected

Approximately 1.5% of patients who undergo CPB are at risk of developing acute respiratory distress syndrome (ARDS). These complications can make CPB a major challenge.

Left ventricular assist device

The **left ventricular assist device** (LVAD) is a type of mechanical heart pump placed inside a patient's chest to assist the heart with pumping oxygen-rich blood throughout the body. The LVAD does not replace the heart, as an artificial heart does. Instead, the LVAD provides assistance to the heart. Some patients with advanced heart failure are considering the LVAD as a type of destination therapy (DT) since it has been approved as a bridge to heart transplantation (BTT). The following table summarizes some significant LVAD issues:

Issue	Explanation

Induction of LVAD flow	May unveil right ventricular dysfunction demanding aggressive management, sometimes to the extent that a right ventricular assist device (RVAD) might be indicated as well
Recirculation forced by aortic insufficiency	May acutely stress the flow capacity of the LVAD and reduce its functional life potential
Systemic “vasoparesis”	May necessitate the administration of adrenergic agonists, vasopressin, or methylene blue to achieve optimal systemic arterial pressures
Complex coagulation disturbances with subsequent re-exploration for bleeding	Sometimes seen in the early postoperative period

Valves

Valve replacement procedures have been used frequently and successfully and are generally safe and standardized. Any superiority of a particular genre of the valve is equivocal. Post-operative management depends on the valve type used. Some important differences between types of valves are summarized in the following table:

Valve type	Benefits	Risks
Metal valves	Longevity: last about 20 years	Lifelong anticoagulation is needed, to prevent strokes and embolic phenomena.
Tissue valves	Short life span: last about 10 years	Anticoagulation is not needed.

Technological advances in the field of valve surgery have yielded the genesis of an indigenous percutaneous device—the MitraClip. This device potentially ameliorates mitral regurgitation by transatrial septal placement of a “double alligator” clip that reduces the size of the leaky opening of the mitral valve. Intra-operative, 3-dimensional transesophageal echocardiography (TEE) provides a great advantage in the accurate placement of the MitraClip.

Anesthetic responsibilities

The need for near-continuous TEE combined with the anticipated duration of the procedure favors general endotracheal anesthesia.

The use of cardiac anesthesia should ensure the absence of bradycardia, vasoconstriction, optimum fluid management, and observant monitoring.

Short-acting, potent inhalational anesthetics are preferred; neuromuscular blockers are not necessary. The need for inotropic agents frequently arises before bypass and when patients are coming off bypass.

When reversed from the bypass, unstable vital parameters often demand that patients be transferred to the intensive care unit (ICU). These patients are usually ventilated electively and transferred from the ICU only once they are stable.

Complications

Cardiac surgery and CPB had high morbidity rates in the past. Advances in technology and better optimization of the heart during CPB have dramatically improved patient outcomes. The following table lists some significant complications:

Complication	Explanation

Failure to come off bypass	This is now relatively rare but used to cause many deaths.
Heart failure when coming off bypass	May require LVAD or RVAD
Massive hemorrhage both from the use of anticoagulants and the effects of the CPB device	Nearly lethal
Cardiac arrhythmias, particularly atrial fibrillation	Early detection followed by aggressive rapid reversal is critical.
Cardiac tamponade	Potentially life-threatening; immediate correction is critical; usually requires the transport of an unstable patient back to the operating room (OR)
Pain from sternal movement post-operatively	Occasionally severe; requires treatment
Recall during anesthesia	Much less frequent during modern anesthesia; use of high doses of opioids for this surgery must be accompanied by amnestic drugs.
Cardiac arrest in the OR or the Cardiac Surgery ICU	The chest should be opened and open cardiac massage used; external cardiac massage on an unstable chest wall is ineffective.
Heart block	Requires the insertion of a pacemaker.

Neuro-anesthesia

Neurosurgical anesthesiology is a subspecialty of anesthesiology that primarily focuses on the anesthetic management of patients with diseases of the central nervous system (CNS), which also includes the brain and spine. Most neurosurgical procedures require general anesthesia, but some can be done with deep sedation. One of the most critical aspects of neuro-anesthesia is the control of intracranial pressure (ICP). If ICP is lowered too aggressively, cerebral blood flow can be reduced, and ischemic brain damage can occur. The table below lists drugs and their effects on ICP as well as on cerebral blood flow.

Drug	Effect on cerebral blood flow	ICP
Vapors	Increase	Increase
Propofol	Decrease	Decrease
Ketamine	Increase	Increase
Etomidate	Little effect	Decrease
Narcotics	Little effect	Little effect

Alternative measures are available to reduce ICP, such as having the patient hyperventilate before induction and providing mild hyperventilation once intubated. Osmotic diuretics (mannitol) and loop diuretics (furosemide) reduce the water load of the brain and can be used as cerebral decongestants.

Role of local anesthesia and sedation in neuro-anesthesia

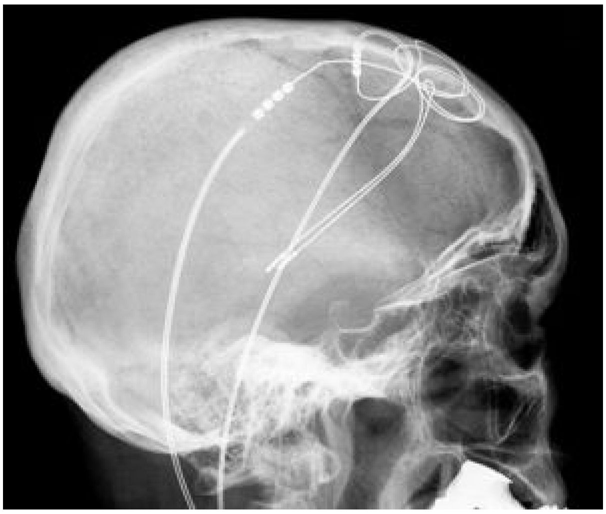

Image: “Deep brain stimulation in a Parkinson’s patient.” by Hellerhoff – Own work. License: CC BY-SA 3.0

Burr hole surgery, a procedure in which one or more arachnoid openings is made over both cerebral hemispheres or in the skull to relieve bleeding, had been common practice without anesthesia for centuries. This type of surgery is now often administered with local anesthesia to help relieve pressure on the brain due to fluid buildup or collection.

More modern procedures (e.g., deep brain stimulation for patients with Parkinson’s disease) can be done almost exclusively with local anesthesia and a little sedation. The surgeon inserts probes deep into the brain and stimulates ganglia associated with Parkinson’s disease (see image).

Complications of neuro-anesthesia

In some cases, neuro-anesthesia can prove to be a challenging area of anesthesiology. It is necessary to maintain the critical equation between ICP and cerebral perfusion. Complications may include, but are not limited to, those listed in the following table:

Complication	Explanation
Massive hemorrhage	Very difficult to treat
Cerebrovascular accidents (strokes)	Often lead to permanent morbidity
Failure to awaken from anesthesia	A thorough search for a surgical cause and/or a disease cause and/or an anesthetic cause must be conducted.
Increased ICP	Permanent damage to the brain

Neuro-anesthesia necessitates customized management. Some relevant clinical scenarios are described in the following table:

Issue	Explanation
Airway management in patients with acromegaly	Acromegaly is characterized by macroglossia, prognathism, and hypertrophy of pharyngeal and laryngeal tissues. As a result, mask fit, mask ventilation, laryngoscopy, and correct tracheal tube placement may be difficult. The Mallampati classification, which employs degrees of visualization of the pharynx when the patient opens their mouth, is used for objective assessment and further management.
Neuroendoscopic procedures	Cardiac arrhythmia, hemodynamic changes, cranial nerve dysfunction, and intracranial hemorrhage are anesthetic concerns.

Sitting position	This has fallen out of favor in many practices; cerebral hypoperfusion, pneumocephalus, and venous air embolism with hypotension are potential issues.
Intracranial lesions located around the speech areas	Fascinating and equally challenging; “awake craniotomy” is often used in these patients.
Pain management	The brain lacks pain receptors, but the rich innervation of the skin, periosteum of the skull, and the meninges challenges the former belief that minimal pain management is required in intracranial surgeries.

Summary

Anesthesia continues to benefit from advancements in technology and medical discovery. One of the most complex branches, thoracic anesthesia, may involve one-lung ventilation, the use of endobronchial tubes and blockers, and pain management. Cardiac anesthesia incorporates preservation of the heart during the use of a cardiopulmonary bypass machine. Neuro-anesthesia can be equally complex and require customized management. All of these specialized areas of anesthesia can include varying levels of complications. Constant vigilance and effective management are needed to ultimately foster effective patient care and recovery.

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Notes