Introduction and History of Anesthesiology

In any human endeavor within the realm of faith, philosophy or science, history shows that new concepts are rarely accepted and applied. Many innovations in physiological condition are surely falling into this category. Dr. J. Leonard Corning, a medical specialist, was the first man who provided a spinal anesthetic in 1885. There are very little documents showing this claim because Corning never mentioned CSF. His intention was to inject the hard drug into the neighborhood of the funiculars. However, that attempt of CSF wasn't seen on body parts where the needle is inserted.

Introduction

Anesthesiology describes the field of interventions that bring about temporary and controlled physiological states that are characterized by the loss of sensation and awareness as well as prevention and/or relief of pain. The state of anesthesia is induced via the administration of gases or injectable drugs before surgical operations or other medical interventions. Anesthesia is intended to induce some or all of the following effects:

- Analgesia: Relief from or prevention of pain
- **Paralysis**: Adequate muscle relaxation
- **Amnesia**: Loss of awareness and/or memory of pain/experience
- **Hypnosis**: Temporary unconsciousness or absence of anxiety

During general anesthesia, supportive care is needed to maintain and monitor vital functions for the patient, such as breathing, heart rate and rhythm, blood pressure, and body temperature.

The typical team that is certified to perform and manage anesthesia includes anesthesiologists, certified registered nurse anesthetists (CRNAs), and anesthesia assistants (AAs). Anesthesia is performed in various settings: operating rooms (ORs), endoscopy suites, interventional radiology suites, interventional cardiology laboratories, post-anesthesia care units (PACUs), and intensive care units (ICUs).

Intraoperative anesthesia allows other healthcare professionals such as surgeons and interventionalists to diagnose, treat, and manage patients through procedures that would otherwise be too painful or complicated.

**History**

The practice of medicine was transformed in the middle of the 19th century with the discovery of general anesthesia. Up to that point, surgery was performed as a last resort and desperate measure due to the unbearable pain associated with it.

A young American dentist named William Morton discovered general anesthesia. He found that when he inhaled sulfuric ether, he became unresponsive. A few months after this discovery on October 16, 1846, Morton successfully anesthetized a patient at Massachusetts General Hospital (located in Boston, USA). A surgeon then removed a tumor of the left jaw while the patient remained unconscious. This highly significant discovery cleared the way for the development of many interventions of modern medicine.

As news of the discovery spread, James Simpson, a Scottish obstetrician, started using chloroform as a volatile general anesthetic, particularly to alleviate pain during childbirth. But there were risks associated with the use of these drugs. Because ether was highly flammable, it could not be used with electrocautery. The use of chloroform was associated with high death rates from cardiac arrest. Today, sulfuric ether and chloroform have been replaced by much safer and more effective agents like sevoflurane and isoflurane. The practice of general anesthesia has evolved to become 1 of the safest of all routine major medical procedures.

**Timeline of the history of anesthesia**

<table>
<thead>
<tr>
<th>Years</th>
<th>Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>4000 BCE - 0</td>
<td>The use of opium poppy, herbal remedies using <em>Hyoscyamus niger</em>, mandragora, and aconitum, acupuncture performed with bones, cannabis vapors, and carotid compression is documented in records from Ancient China, Greece, Egypt, and beyond.</td>
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<tr>
<td>0 - 1800</td>
<td>Herbal mixtures of opium, mandrake, henbane, and/or hemlock boiled in wine along with coca leaves are used in Ancient Greece, Rome, and the Incan Empire. Ether, diethyl ether, and injectable opium are used in Germany. Oxygen and nitrous oxide are discovered in England.</td>
</tr>
<tr>
<td>Year</td>
<td>Event</td>
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<tr>
<td>--------</td>
<td>---------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1800</td>
<td>Humphry Davy observes that nitrous oxide relieves physical pain.</td>
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<tr>
<td>1805</td>
<td>Friedrich Sertürner isolates morphine from opium.</td>
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<tr>
<td>1824</td>
<td>Henry Hill Hickman describes the use of carbon dioxide as a means of anesthesia for animals.</td>
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<tr>
<td>1842</td>
<td>William Clarke etherizes a patient for dental extraction.</td>
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<tr>
<td>1845</td>
<td>Horace Wells inhales nitrous oxide as anesthesia for his own dental extraction.</td>
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<tr>
<td>1846</td>
<td>William Morton becomes the 1st to publicly and successfully demonstrate the use of ether anesthesia for surgery.</td>
</tr>
<tr>
<td>1847</td>
<td>James Simpson administers chloroform for pain during childbirth.</td>
</tr>
<tr>
<td>1853</td>
<td>Charles Pravaz and Alexander Wood invent the hollow hypodermic needle and attach it to an earlier invention to create the syringe.</td>
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<tr>
<td>1853 &amp; 1857</td>
<td>John Snow popularizes obstetric anesthesia by using chloroform during Queen Victoria’s births of Prince Leopold and Princess Beatrice.</td>
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<tr>
<td>1863</td>
<td>Quincy Colton reintroduces nitrous oxide as an inhalation anesthetic.</td>
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<tr>
<td>1868</td>
<td>Edmund Andrews proposes mixing nitrous oxide and oxygen as an anesthetic.</td>
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<tr>
<td>1884</td>
<td>Karl Koller introduces cocaine as an ophthalmic anesthetic.</td>
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<tr>
<td>1889</td>
<td>Henry Dorr becomes the 1st professor of anesthesiology.</td>
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<tr>
<td>1891</td>
<td>The world’s 1st anesthesia journal, <em>The Dental and Surgical Microcosm</em>, is published.</td>
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<tr>
<td>1893</td>
<td>The world’s 1st society of anesthesiology is formed in London.</td>
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<tr>
<td>1894</td>
<td>Amory Codman and Harvey Cushing develop the 1st anesthesia recordings of respiratory and pulse rates.</td>
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<tr>
<td>1898</td>
<td>August Bier conducts the 1st spinal block using cocaine. He goes on to create the ‘Bier block’ (see below).</td>
</tr>
<tr>
<td>Year Range</td>
<td>Events</td>
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<tr>
<td>------------</td>
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<tr>
<td>1900 – 1925</td>
<td>1901: Caudal epidural analgesia is described. 1902: The words ‘anesthesiology’ and ‘anesthesiologist’ are coined. 1905: The 1st professional anesthesia society in the United States is founded. 1914: The USA’s 1st comprehensive textbook of anesthesia is published. 1920: Arthur Guedel publishes his observations on ether anesthesia, including eye signs, in the <em>American Journal of Surgery</em>. These findings are still used today. 1923: Isabella Herb administers the 1st ethylene-oxygen surgical anesthetic.</td>
</tr>
<tr>
<td>1925 – 1950</td>
<td>1927: Ralph M. Waters trains the 1st anesthesia residency class at the University of Wisconsin, Madison. 1929: John S. Lundy popularizes the use of the intravenous anesthetic thiopental (Pentothal). 1935: Emery A. Rovenstine is an early leader of the American Society of Anesthetists, which later becomes the American Society of Anesthesiology (ASA). 1937: Robert R. Macintosh introduces his curved laryngoscope. 1940: The American Board of Anesthesiology is granted independent board status. 1942: World’s 1st successful anesthetic use of muscle relaxant is recorded. 1944: Lidocaine is introduced as a local anesthetic.</td>
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</table>
Preoperative Evaluation

Focused evaluation and planning for anesthesia should be completed in advance for all surgeries, interventions, and procedures. However, low-risk patients can be evaluated immediately prior to anesthesia on the day of the procedure. Patients are classified as low-risk if they are less than 65 years of age, have medical conditions that are stable and adequately treated or controlled, and are undergoing low-risk surgeries or procedures.

The goals of a preoperative evaluation include:

- Assessing medical status and readiness for the planned procedure
- Reducing the risks of anesthesia and surgery
- Creating an anesthetic plan and preparing the patient

The typical components of a preoperative evaluation by an anesthesiologist include clinical evaluation, risk assessment, optimizing comorbidities and diseases, preoperative testing, patient education, informed consent, creating a plan for anesthesia, and postoperative care.

- **Clinical evaluation** of a patient undergoing anesthesia should include a patient interview focusing on past surgeries and personal history of receiving anesthesia; a focused review of pertinent medical history, conditions, and records; identification of medication allergies; relevant physical exams including vital signs, BMI, head, neck, airway, lung, heart, and basic neuro; and consultations with specialists if necessary.

- **Risk assessment** is based on a number of methods. The Mallampati airway assessment is used to identify potentially difficult ventilation and/or intubation in a patient. It is an objective observation that is commonly used by the anesthesiology team to create ventilation and intubation plans.

Image: I: The soft palate, fauces, uvular, and pillars are visible. II: The soft palate, fauces, and part of the uvula are
Another classification system commonly used across all healthcare fields to assess the overall health status of a patient is the American Society of Anesthesiologists physical status (ASA-PS):

<table>
<thead>
<tr>
<th>ASA-PS Classification</th>
<th>Definition</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASA I</td>
<td>A normal, healthy patient without known disease</td>
<td>Healthy, nonsmoker, minimal alcohol use</td>
</tr>
<tr>
<td>ASA II</td>
<td>A patient with mild systemic disease</td>
<td>Current smoker, mild HTN, mild lung disease, etc.</td>
</tr>
<tr>
<td>ASA III</td>
<td>A patient with severe systemic disease</td>
<td>Poorly controlled HTN or DM, COPD, etc.</td>
</tr>
<tr>
<td>ASA IV</td>
<td>A patient with severe systemic disease that is a constant threat to life</td>
<td>Recent MI, severely reduced ejection fraction, sepsis, ARDS, etc.</td>
</tr>
<tr>
<td>ASA V</td>
<td>A patient who is not expected to survive without the intended operation</td>
<td>Brain bleed, ruptured aneurysm, massive trauma, etc.</td>
</tr>
<tr>
<td>ASA VI</td>
<td>A patient declared brain dead whose organs are being harvested</td>
<td></td>
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</table>

Other aids in risk assessment include prognostic biomarkers, such as B-type natriuretic peptide, glomerular filtration rate, and C-reactive protein and the functional status/ability to engage in daily activities as reported subjectively by the patient.

- **Optimization of diseases and comorbidities** includes adequately managing and treating prior to surgery and anesthesia diseases that increase morbidity and mortality, including hypertension, heart failure, obstructive sleep apnea, diabetes mellitus, thyroid disease, and anemia. It is also particularly important to encourage patients who smoke to stop smoking for at least two weeks prior to undergoing anesthesia and surgery.

- **Preoperative testing** is patient specific. If a blood transfusion is anticipated, blood type and screen with crossmatch are imperative prior to surgery and anesthesia. If a female of childbearing age is to undergo surgery and anesthesia, a pregnancy test is indicated to avoid fetal loss. Diagnostic testing for preexisting conditions and comorbidities is essential to obtain preoperatively in order to monitor conditions postoperatively:

<table>
<thead>
<tr>
<th>Preexisting disease/condition</th>
<th>Diagnostic testing</th>
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<tbody>
<tr>
<td>Age &gt; 65</td>
<td>Albumin, creatinine, hemoglobin</td>
</tr>
<tr>
<td>Alcohol abuse</td>
<td>ECG, electrolytes, hemoglobin, LFTs, platelet count, PT/INR</td>
</tr>
<tr>
<td>Anemia</td>
<td>CBC, creatinine, ferritin, iron, transferrin saturation, TSH, T3, T4, Vit B12</td>
</tr>
<tr>
<td>Cardiac disease</td>
<td>BNP, ECG</td>
</tr>
<tr>
<td>Diabetes</td>
<td>Creatinine, HbA1c, glucose</td>
</tr>
<tr>
<td>Liver disease</td>
<td>Albumin, BUN, creatinine, electrolytes, hemoglobin, LFTs, platelet count, PT/INR</td>
</tr>
<tr>
<td>Pulmonary disease</td>
<td>Chest radiograph</td>
</tr>
<tr>
<td>Thyroid disease</td>
<td>T3, T4, TSH</td>
</tr>
</tbody>
</table>

**Patient education** is essential to patient satisfaction and safety. Education should cover how to reduce risks of surgery and anesthesia, such as cessation of eating and drinking.
by midnight the night before the procedure to prevent pulmonary aspiration of gastric contents. The involvement of the patient in decision-making and planning is encouraged along with answering all patient questions and addressing all patient concerns.

**Informed consent** is based on patient autonomy and all risks and complications associated with the procedure and undergoing anesthesia should be discussed with the patient.

The creation of a plan for anesthesia involves the consideration of the surgery requirements, the duration of surgery, comorbidities, postoperative considerations, patient preference, and the preferences of the surgeon and the anesthesiologist.

**Postoperative care** considerations include pain management, hemodynamics, pulmonary toilet, early interventions, and placement into ICU versus outpatient care for recovery.

## Types of Anesthesia

Several different types of anesthesia are used for surgery or other medical procedures. Choosing which type of anesthesia to use is based on the procedure that is being done, procedure requirements, the area that needs to be anesthetized, the duration of surgery, patient-specific comorbidities, postoperative anesthesia plans and considerations, patient preference, and the preferences of the provider and the anesthesiologist.

**General anesthesia** is a type of anesthesia that is appropriate for most major surgical procedures. The goals for general anesthesia include unconsciousness with amnesia, analgesia, muscle relaxation with immobility, and noxious stimuli blockage during surgery. There are 3 distinct phases of general anesthesia:

- **Induction** is accomplished via inhalation or intravenous agents listed below. Airway management is integral 1st via a facemask with the transition to endotracheal intubation.

<table>
<thead>
<tr>
<th>Induction agent class</th>
<th>Common agents used</th>
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<tbody>
<tr>
<td>IV sedative-hypnotic</td>
<td>Propofol, etomidate, ketamine</td>
</tr>
<tr>
<td>IV adjuvants</td>
<td>Opioids, lidocaine, midazolam</td>
</tr>
<tr>
<td>Inhalation agents</td>
<td>Nitrous oxide, halothane, isoflurane</td>
</tr>
<tr>
<td>Neuromuscular blockers</td>
<td>Vecuronium, rocuronium, succinylcholine</td>
</tr>
</tbody>
</table>

- **Maintenance** is typically achieved via a primary inhalation technique with accompanying IV agents. The goal is to reduce the total dosage used for any one agent so combinations of anesthetics are most common.

- **Emergence** involves removing anesthetic agents and reversing residual effects for the return of consciousness and movement. Extubation occurs when the patient can protect his or her own airway, follow simple commands, and ventilate without assistance.

**Neuraxial anesthesia** involves anesthetizing the nerves of the central nervous system. This type of anesthesia is commonly used for lower abdominal and lower extremity surgeries/pain relief. There are 2 main types:

1. **Spinal anesthesia** is when a needle is inserted between vertebrae so the anesthetic can be injected directly into the subarachnoid space.
2. **Epidural anesthesia** is when a catheter is inserted between vertebrae so the anesthetic can be injected directly into the epidural space.
Epidural anesthesia is commonly used during childbirth. Anesthesiologists place a catheter between the L3 and L4 vertebrae into the epidural space for the continuous delivery of local anesthetics. Common epidural agents include lidocaine, bupivacaine, and ropivacaine. By BruceBlaus, License: CC BY-SA 4.0

Peripheral nerve blocks are commonly used for upper and lower extremity surgeries where the anesthesia targets nerves of the peripheral nervous system. Ultrasound guidance is used for needle or catheter insertion and placement. Long-acting local anesthetics provide prolonged postoperative analgesia.

Image: This ultrasound demonstrates a needle (row of white arrowheads) and an anesthetic solution (the dark area)
surrounding the ulnar nerve) injected around the ulnar nerve for a successful peripheral nerve block. Anesthetic blockade of a nerve bundle blocks all nerves downstream, providing adequate analgesia for a procedure. Notice how the anesthesiologist identified the ulnar artery in order to avoid puncturing it. By Richard Amini et al., License: CC BY 4.0

**Intravenous regional anesthesia** is an alternative to peripheral nerve blocks for shorter procedures of the hand and forearm where analgesia is needed for only 30–45 minutes. The procedure, which is less invasive, is also known as a ‘Bier block’.

![Image: Intravenous regional anesthesia of the right arm allows for local peripheral anesthesia without circulatory involvement. The IV catheter is placed in the hand, the Esmarch bandage is placed around the arm for exsanguination (cannot see in this picture), the tourniquet is inflated (blue wrap), and lidocaine is injected via the IV catheter into the hand. By MrArifnajaf, License: CC BY-SA 4.0]

**Monitored anesthesia care (MAC)** involves monitoring a patient’s vitals and administering sedative, anxiolytic, or analgesic medications accordingly. It is commonly used in ambulatory/outpatient surgeries. Anesthesiologists must be able to convert to general anesthesia at any time if needed. A common example is administering propofol whenever an anesthesiologist deems necessary during an endoscopy based on the patient’s vitals and mobility.

**Perioperative Monitoring**

**Standard monitors** used by the anesthesiology team during a procedure include a pulse oximeter to measure oxygen saturation, an electrocardiogram (ECG) to monitor heart rhythm and potential ischemic changes, a noninvasive blood pressure device, core temperature devices, and integrated monitors and machines with alarms that sound for common and serious problems.

**Clinical monitoring** ensures patient safety and involves regular visual inspection, auscultation, and palpation.

**Ventilation monitoring** is essential during anesthesia due to the risk of respiratory depression, and it is monitored in several ways:
- **Clinically monitored**: Visualization of chest excursion, auscultation of breath sounds, and movement of the reservoir bag.
- **Capnography**: A graph that shows the respiratory rate and carbon dioxide concentration over time.

![Capnogram Image](https://example.com/capnogram.png)

**Image**: Normal capnogram reflecting appropriate carbon dioxide levels in a patient undergoing general anesthesia. Capnography reflects adequate ventilation during surgery. By Rschiedon, License: [CC BY-SA 3.0](https://creativecommons.org/licenses/by-sa/3.0/)

- **Other measures**: End-tidal carbon dioxide concentration, inspired oxygen concentration, and the quantitative volume of expired gas

In select cases, **electroencephalography (EEG)** can be used for neuromonitoring, and more accurate **hemodynamic monitoring** can be achieved via invasive approaches such as intra-arterial, central venous, pulmonary artery catheter (PAC), or transesophageal echocardiography (TEE) probes.

**Hemodynamics** are monitored through vitals, and fluids and vasoactive drugs can be administered to maintain optimal intravascular volume status throughout anesthesia.

**The depth of anesthesia** is monitored by end-tidal inhalation anesthetic concentrations. The goal of anesthesia is Stage II or III, depending on the type of anesthesia chosen. If the desired Stage II enters into Stage III, endotracheal intubation for airway protection is emergent. If the desired Stage III enters into Stage IV, prompt reversal is necessary.

<table>
<thead>
<tr>
<th>Stages of Anesthesia Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage I</td>
<td>Conscious and rational with decreased pain perception</td>
</tr>
<tr>
<td>Stage II</td>
<td>Unconscious and reflexive with irregular breathing pattern</td>
</tr>
<tr>
<td>Stage III</td>
<td>Unable to protect airway due to increased muscle relaxation</td>
</tr>
<tr>
<td>Stage IV</td>
<td>Cardiovascular and respiratory depression (medullary)</td>
</tr>
</tbody>
</table>

**Postoperative Care**

All patients are monitored postoperatively in a post-anesthesia care unit (PACU). These units follow a standard recovery assessment, reduce postoperative adverse events, and streamline discharge, transfer to an intensive care unit (ICU), or transfer to an observation floor.
General care that is commonly needed postoperatively includes:

- Antiemetics for postoperative nausea and/or vomiting
- Fluid administration and monitoring for the inability to void via strict Is/Os
- Respiratory, cardiovascular, and neurological monitoring
- Hypothermia or hyperthermia monitoring and control
- Pain control
- Reassurance, reorientation, and potential drug reversal for delayed emergence, which is the failure to return to a conscious state within 60 minutes of anesthesia cessation

References

**UpToDate**: Overview of Anesthesia and related articles within the section -
https://www.uptodate.com/contents/overview-of-anesthesia?search=anesthesia&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1

**PubMed**: Historical development of modern anesthesia -

**The UMHS Endeavour**: Discovery of anesthesia and timeline -
https://www.umhs-sk.org/blog/medical-milestones-discovery-anesthesia-timeline/

**Wood Library-Museum of Anesthesiology**: History of Anesthesia -
https://www.woodlibrarymuseum.org/history-of-anesthesia/

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