Introduction
A *very* short history of anesthesia

Every now and then, you run into a high school student who did a paper on the history of anesthesia, or the teacher who assigned it. Here are a few facts and dates that should keep you out of acute embarrassment.

God was first: "And the Lord God caused a deep sleep to fall upon Adam, and he slept." (Genesis 2:21). A date is not given.

Anesthesia as we know it started in the early to mid 1840s.

Crawford Long of Jefferson, Georgia, removed a small tumor from a patient under diethyl ether anesthesia. That was in 1842. Crawford Long failed to publish this event, and he was denied the fame of having been the first to use diethyl ether as a surgical anesthetic. Ether was not unknown; students inhaled it during the so-called ether frolics.

Horace Wells had used nitrous oxide in his dental practice. In 1844, he failed to demonstrate the anesthetic effects of N_2O in front of a critical medical audience. The patient, a boy, screamed during the extraction of a tooth, and the audience hissed. Later, the boy said that he had not felt anything. Excitement under light nitrous oxide anesthesia is common. Horace Wells died young and by his own hand.

William T. G. Morton, another dentist in anesthesia's history, successfully etherized a patient at the Massachusetts General Hospital in Boston on *October 16, 1846*. The news of this event spread worldwide as rapidly as the communication links permitted. Morton tried to patent his discovery under the name of Letheon. An English barrister later wrote: ". . . a patent degrades a noble discovery to the level of a quack medicine."[1]

Oliver Wendell Holmes, only 2 months after Morton's epochal demonstration of surgical anesthesia, suggested the term "anesthesia" to describe the state of sleep induced by ether. Holmes was a physician, poet, humorist and, fittingly, finally dean of Harvard Medical School.

John Snow, from London, became the first physician to devote his energies to anesthetizing patients for surgical operations. His earliest experiences with ether anesthesia date to late 1846. In 1853, he administered chloroform to Queen Victoria for the delivery of her son Prince Leopold. This shook the

acceptance of the divine command: "in sorrow thou shalt bring forth children" (Genesis 3:16) and thus powerfully furthered the use of anesthesia to alleviate the pain of childbirth. Incidentally, while anesthesiologists admire John Snow for his publications and the design of an etherizer, epidemiologists claim him as one of their own because he had recognized the source of a cholera epidemic, which he traced to a public pump. By removing the pump's handle, he stopped the spread of the infection. That was in 1854.

Those were the beginnings. By now, the two earliest anesthetic vapors, diethyl ether and chloroform, have been modified hundreds of times. Many descendants have come and gone, but their great-grandchildren still find daily use. Intravenous drugs have secured an increasingly prominent place in anesthesia, among them neuromuscular blockers – hailing back to South American Indians and their poisoned arrows shot from blowguns. A steadily growing pharmacopeia of analgesics, hypnotics, anxiolytics, and cardiovascular drugs now fill the drug cabinets.

We still listen for breath sounds, we still watch color and respiration, and we still feel the pulse, but today we are helped by the most subtle techniques of sensing invisible signals and the most invasive methods with tubes snaking through the heart.

When we reduce the history of anesthesia to a few dates and facts, we do not do justice to the stories of the age-old and arduous struggle to alleviate pain. In one of the more comprehensive books on '*The Genesis of Surgical Anesthesia*', you will find a superb description of the interesting personalities and the many events that eventually paved the way to one of the greatest advances in medicine, the discovery of anesthesia.[2] The book brims with anecdotes, for example the story of a woman in 1591 accused of witchcraft. One of the indictments was for her attempt to ease the pain of childbirth. She was sentenced to be "bund to ane staik and brunt in assis (ashes), quick (alive) to the death". Why society's acceptance of pain relief changed and how obstetrical anesthesia eventually developed is the subject of another great historical book by Donald Caton.[3]

NOTES

1. You will find this quotation in one of the three delightful volumes entitled *Essays of the First Hundred Years of Anaesthesia* by W. Stanley Sykes who relates the most wonderful stories having to do with anesthesia. For example, did you know that to be eaten alive by a lion and the like might not be painful? (Sykes, W.S. (1961). *Essays on the First Hundred Years of Anaesthesia*. Volume 2, pp. 75–79, E&S Livingstone Ltd, Edinburgh.)
2. Norman A. Bergman (1998). Wood Library – Museum of Anesthesiology, Park Ridge, Illinois.
3. Donald Caton (1999). *What a Blessing She had Chloroform*, Yale University Press, New Haven and London.

Part I

Clinical management

1

Pre-operative evaluation

Surgery and anesthesia cause major perturbations to a patient's homeostasis. The risk of potentially life-threatening complications can be reduced with appropriate pre-operative evaluation and therapy. Because cost concerns have virtually eliminated pre-operative hospital admission, today the visit may occur just moments before the operation in the case of an emergency or a healthy outpatient, but is better managed in pre-anesthesia clinics to which patients report one or several days before their operation. Surgeons and primary-care physicians can do much to avoid operative delays and cancellations, as well as to reduce the patient's cost and risk by identifying patients who need a pre-operative anesthesia consultation and by sending all pertinent information, e.g., recent ECG, echo studies, etc., with the patient. The pre-anesthetic evaluation appears to be just another routine of eliciting a history, reviewing all systems, performing a physical examination, and checking laboratory studies. However, this traditional approach provides the structure that enables us to ferret out information that can affect anesthetic preparation and management. A widely accepted shorthand, the famous ASA Physical Status classification (Table 1.1), summarizes a thorough patient evaluation into a simple scheme, found on every anesthesia record. The six Physical Status classes do *not* address risk specifically, but do provide a common nomenclature when discussing patients in general. That much more than the ASA physical status classification need be known will become apparent from the following.

History

We begin with the "H" in "H&P," obtaining a medical and surgical history. We are particularly concerned with the cardiopulmonary system, and exercise tolerance is a good measure of current status. We also search for evidence of chronic diseases of other systems. For elective procedures, patients should be in the best condition possible, e.g., no exacerbation of chronic bronchitis or unstable angina. Below, we describe the pre-operative evaluation of some common medical conditions. When patients with these, or other rarer, conditions require an anesthetic,

Table 1.1. ASA Physical status classification

I	A normal healthy patient
II	A patient with mild systemic disease
III	A patient with severe systemic disease
IV	A patient with severe systemic disease that is a constant threat to life
V	A moribund patient who is not expected to survive without the operation
VI	A declared brain dead patient whose organs are being removed for donor purposes

We append an "E" if the patient comes in as an emergency.
ASA = American Society of Anesthesiologists

a pre-anesthesia clinic visit a week or so in advance of anesthesia allows time to seek additional information, e.g., study results from the patient's private physician, perform studies, e.g., cardiac pacemaker interrogation, or obtain consultation from a specialist. Such planning helps keep the operating schedule running smoothly.

We inquire about any previous anesthetics, particularly any untoward events such as bleeding or airway difficulties. It is reassuring to learn a patient has tolerated previous anesthetics without difficulties. Next, we ask specifically about any family history of anesthetic complications. A patient might not realize that a remote event, such as his Aunt Edna dying with a raging fever soon after an anesthetic many years ago, might mean that malignant hyperthermia runs in his family. We need to ask specific questions to learn about inherited conditions, including those related to plasma cholinesterase (see Pharmacology: succinylcholine).

Medications

With surprising frequency, review of the patient's current medications reveals previously unmentioned medical problems: "Oh, the digoxin? Well I don't have a heart condition *now*." Many medications influence the anesthetic, particularly those with cardiovascular or coagulation-related effects. Some need to be discontinued for some period prior to surgery (see below), others must be converted from oral to parenteral form to continue their effect. Many patients do not think of herbal compounds when asked about their use of medicines and drugs. Therefore, we need to ask specifically about herbals, some of which may present us with problems.[1]

Allergies

Common are patients with allergies to latex and to drugs. Questions about such sensitivities need to be asked of every patient lest we get confronted with a

Table 1.2. Considerations in the latex-allergic/sensitive patient

Latex-free gloves!
Remove drug vial caps, rather than puncturing the rubber top to draw up drugs.
Confirm latex-free equipment:
manual breathing bag
ventilator bellows
blood pressure cuff
esophageal/precordial stethoscope tubing
intravenous tubing access ports
epidural access port
syringe plunger caps (LF (latex free) should appear on the top of the plunger).

life-threatening anaphylaxis during anesthesia. A distinction must be made, however, between sensitivities and true allergies. For example, a patient who "thought he was going to die" in the dentist's chair is probably not allergic to local anesthetics; rather, he likely had an intravascular injection, or rapid absorption of epinephrine. Similarly, a patient who gets nauseated from codeine can still receive fentanyl, which is chemically quite different from the morphine-derived drugs. When an allergy is reported to a particular class of drug, there are often other classes available to accomplish the same task. We benefit our patients when we investigate these agents for potential cross-reactivity. For example, a penicillin-allergic patient with a mild reaction in childhood *might* receive a cephalosporin safely (8% cross-reactivity); when determining the risk: benefit ratio, you must take into consideration their reaction and the indication for the cephalosporin.

Latex allergy deserves special mention as its recognition has grown substantially in recent years. The allergy to this natural rubber[2] occurs after repeated exposure (as in the spina bifida patient who must frequently catheterize his bladder). Its sudden rise in healthcare workers coincides with the 1980s admonition of "Universal Precautions" by the US Occupational Safety and Health Administration – healthcare workers were required to wear gloves to prevent transmission of AIDS and other viral illnesses.

While some patients merely note skin irritation from rubber gloves (probably not a real allergy, but a precursor), of great concern is the patient who has experienced throat swelling, for example when blowing up a balloon or painting a room with latex paint. Latex is found in much of our medical equipment – from breathing bags, to syringe plungers, to the puncturable tops on drug vials. In a patient with latex allergy, we must eliminate all latex-containing products from contact with the patient, including indirect contact such as drawing up drugs through a latex plug (Table 1.2).

We mentioned that healthcare workers are at risk. In fact, about one-third will develop a contact dermatitis to latex gloves, while 10% or more may develop

a full-blown allergy, even more frequent in those who have other allergies, the so-called atopic individual. We can reduce our risk of developing this allergy by using non-latex gloves, or at least avoiding latex gloves containing cornstarch. While the cornstarch makes the glove easier to don and remove, it solubilizes the latex protein, increasing the chances of making its way through the skin – particularly through skin already irritated by the cornstarch; it also helps the latex protein become aerosolized (and breathed in) upon glove removal.

Habits

Moderate tobacco and alcohol intake are not of great concern, but the chronic alcoholic patient who has experienced delirium tremens, or the smoker who suffers severe pulmonary disease confronts us with serious problems. Patients who take street drugs also challenge us. On the one hand, they may not tell the truth about their habits; on the other hand, if they do take drugs, their response to anesthetics can be quite abnormal and troubling. These street drugs are known by colorful names to some of their devotees. Anesthesia affects the respiratory and cardiovascular systems; therefore, street drugs that depress the CNS can exaggerate respiratory depression, while CNS stimulants such a cocaine can cause fatal cardiac complications.

Physical examination

In addition to the cardiopulmonary examination, we carefully evaluate the patient's airway to predict whether it will be easily intubated (see Airway management). The physical examination should also seek pre-existing neurologic deficits, particularly if regional anesthesia, e.g., spinal, epidural or nerve plexus block, is considered, and any limitations to flexibility that may present difficulties with positioning the patient. If we plan on regional anesthesia, we need to inspect the anatomy, for example, does the patient have a scoliosis that would make a lumbar puncture difficult, or is his skin infected over the site where we would place the needle?

Laboratory evaluations and studies

Here we must ask the question, "Can the results from additional tests influence my anesthetic and post-anesthetic management?" In the majority of cases, the answer turns out to be "No," but there are many exceptions. Among them might be a determination of serum potassium if we fear that the patient is hyperkalemic, in which case a succinylcholine-induced release of potassium would be dangerous.

Coagulation studies would be needed if we plan regional anesthesia and have reason to worry about a bleeding diathesis or thrombocytopenia. Uncontrolled bleeding into the nerve plexus can cause permanent damage. In general, laboratory and other studies should be ordered as indicated from the medical history, and only if they might have an effect on intra- or post-operative management, or perhaps if the risk analysis may suggest canceling or altering the procedure itself. For example, suppose we detect a carotid bruit during the pre-anesthetic evaluation of a patient scheduled for elective hip replacement. While an asymptomatic bruit may not be an indication for operative repair, a significant carotid stenosis may temper our enthusiasm for induced hypotension (intentional blood pressure reduction to reduce intra-operative blood loss).

NPO status

During induction of general anesthesia, the gag reflex is necessarily abolished. Should the patient "choose" that most inopportune time to suffer gastroesophageal reflux (or worse yet, emesis), there is a high likelihood the stomach contents could end up in the lung, causing a chemical pneumonitis or even acute suffocation from the lodging of solid particles in the bronchial tree. In addition to pharmacologic means (see Pharmacology), we minimize this risk by having the patient report for surgery with an empty stomach. Patients are asked to refrain from eating solid foods for 6–8 hours prior to elective surgery. While there is evidence that clear liquid ingestion is cleared rapidly and not dangerous in those patients with normal digestion (it may even *raise* the pH of the stomach contents above the pH 2.5 danger zone), it remains customary to tell patients who are scheduled for an elective operation in the morning not to eat or drink anything for at least 6 hours (for infants about 2 to 3 hours) before the operation. If the patient is already in the hospital, we write the order "NPO after midnight"[3] to achieve the same results. Here, we can also order "maintenance i.v. fluids" overnight to keep the patient hydrated. Therefore, on the day of surgery we ask every patient about their most recent intake of food and liquids. Avoid asking: "When did you have your last meal?" If the patient's history identifies risk factors for aspiration, e.g., gastroesophageal reflex disease (GERD), diabetes, increased intra-abdominal pressure, hiatal hernia, and requires general anesthesia, we use a rapid sequence induction (see General anesthesia). Pre-operatively, we also consider pharmacologic means to reduce stomach volume and strengthen the lower esophageal sphincter with a prokinetic agent and/or raise gastric pH with H_2 blockers or a proton pump inhibitor.

Many patients have not been fasting for several hours, or their stomach did not have time to empty. Labor pains, narcotics, or trauma can stop gastric peristalsis for hours on end. Of course, in the presence of an ileus, we assume the stomach

not to be empty even if the patient had nothing by mouth for many hours or even days.

Planned procedure

The planned surgical, diagnostic, or therapeutic procedure influences the anesthetic management, sometimes producing problems for which we must be prepared. For example, the neurosurgeon may trigger a wild release of catecholamines when destroying the trigeminal ganglion in a percutaneous procedure that lasts only minutes. How are we going to protect the patient from the expected sympathetic storm? Or, how can we guard against a sudden and substantial rise in peripheral arterial resistance when the surgeon clamps the aorta in preparation for the resection of an aortic aneurysm? The planned procedure also has implications for, among other things, intra-operative positioning of the patient, potential need for blood replacement, anticipated severity of post-operative pain (is a regional anesthetic an option?), and need for intensive care after surgery.

Anesthetic choice

In addition to the above assessment, the anesthetic plan must consider the wishes of both patient and surgeon, as well as *our* individual skill and experience. Does the patient have special requests that need to be taken into account? For example, some patients would like to be awake (maybe the President so he doesn't have to pass control of the US to the Vice-President), others asleep, and others do not want "a needle in the back."

Some patients present special problems, for example Jehovah's Witnesses who do not accept blood transfusions, based on their interpretation of several passages in the Bible (for example Acts 15:28, 29). A thoughtful and compassionate discussion with the patient usually finds the physician agreeing to honor the patient's wishes, an agreement that may not be violated. The caring for children of Jehovah's Witnesses brings an added concern and may require ethics consultation and perhaps even referral to a court. Again, these issues are best brought out days prior to surgery at a scheduled pre-anesthetic evaluation.

Numerous studies have failed to demonstrate that a particular inhalation anesthetic, muscle relaxant, or narcotic made for a better outcome than an alternative. Yet, over the years, actual or perceived differences and conveniences have caused some drugs to disappear and others to establish themselves. Given an array of options, we can often consider different approaches to anesthesia, which we can discuss with the patient. We should always recommend the approach with which

we have the greatest experience and which we would select for ourselves or a loved one.

The choices depend on several factors, first of which is the surgical procedure. For example, the site of the operation, e.g., a craniotomy, can rule out spinal anesthesia. The nature of the operation, e.g., a thoracotomy, can compel us to use an endotracheal tube. For the removal of a wart or toenail or the lancing of a boil, we would not consider general anesthesia – unless the patient's age or psychological condition would make it preferable. The preferences of the surgeon might also be considered.

This introduces the patient's condition as a factor in the choice of anesthesia. For example, a patient in hemorrhagic shock depends on a functioning sympathetic nervous system for survival and therefore cannot tolerate the sympathetic blockade induced by spinal or epidural anesthesia. A patient with an open eye can lose vitreous if the intra-ocular pressure rises, as might occur with the use of succinylcholine. Vigorous coughing at the end of an eye operation might do the same and must be avoided. Respiratory depression and elevated arterial carbon dioxide levels can increase intracranial pressure with potentially devastating effects in patients with an intracranial mass or hemorrhage. In obstetrical anesthesia, mother *and* child have to be considered. Here, we do not wish to depress uterine contraction nor cause prolonged sedation of the newborn child. Some agents used in anesthesia rely on renal excretion, others on hepatic metabolism, thus tilting our choice of drugs in patients with renal or hepatic insufficiency.

In the majority of patients, however, it makes little difference what we pick. We could choose one or the other technique for general anesthesia, using one or the other intravenous induction drug and neuromuscular blocker, and relying on one or the other inhalation anesthetic. We can supplement such a technique with one of a number of narcotic drugs available to us, or we can use total intravenous anesthesia. When we use general anesthesia, we can intubate the patient's trachea and let the patient breathe spontaneously, or we can artificially ventilate the patient's lungs. Instead of an endotracheal tube, we have available the laryngeal mask airway, preferably used in spontaneously breathing patients or, in the very old-fashioned approach, we might use only a face mask.

In many instances, we have options, the choice of which will be influenced by our own experience and expertise. For example, anesthesiologists with extensive experience in regional anesthesia will select that technique in preference to general anesthesia in cases where either technique can prove satisfactory for patient and surgeon. Examples include many orthopedic operations or procedures on the genitourinary tract.

In summary, many factors can influence the choice of anesthesia. In the majority of patients, however, we have the luxury of making the choice influenced by our own preference and routine (Fig. 1.1).