Chapter 13: Anesthesia

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Anesthesiology is the art and science of rendering a patient insensible to pain while maintaining physiologic functions. Anesthesiologists most commonly practice within the environs of an operating room, but the last two decades have seen their increasing involvement in intensive care units, pain clinics, respiratory therapy units, and obstetric labor units.

History

Development of general anesthesia

The beginnings of surgical anesthesia are usually dated from "ether day" - October 16, 1846 - when William Thomas Green Morton of Worcester County, Massachusetts, publicly exhibited the use of diethyl ether for the first time at the Massachusetts General Hospital. The operation was for the excision of a tumor from the jaw of Gilbert Abbot by a noted surgeon of the day, Dr John C. Warren (Bigelow, 1846). Unbeknownst to the rest of medicine, Dr Crawford Williamson Long of Georgia had already successfully used ether for surgery - on March 30, 1842 (Long, 1849). However, as Sir Francis Darwin stated in 1914, "In science, the credit goes to the man who convinces the world, not the man to whom the idea first occurs".

Indeed the time was ripe for the introduction of anesthesia. The discipline of chemistry was developing apace. Henry Hickman's work in England on the anesthetic effects of carbon dioxide had preceded Morton's demonstration, and in 1845 Horace Wells had tried unsuccessfully to demonstrate in public the use of nitrous oxide for surgical anesthesia. Following Morton's demonstration, in 1847 James Young Simpson introduced chloroform into clinical use in Scotland (Simpson, 1847).

The need for a general term to describe this new state of insensibility for surgery was evidenced by the number of synonyms in use by 1847. Learned articles on the use of chloroform were referring to its effects with the term "etherization"! The word "anesthesia" was first suggested by Oliver Wendell Holmes. Holmes appears to have thought that he invented the word itself (Willet, 1894), but Plato's prior use of the word in the sense of "lack of philosophic perception" had preempted his claim.

The early development of anesthesia in the USA took a decisively different turn from its development in Britain and Europe. This was associated with the well-publicized controversy that surrounded the preeminence of claims to its discovery, and the fact that Morton, a dentist, tried to patent the use of ether under the name of "Letheon". Physicians on the other side of the Atlantic not only recognized the importance of the discovery, but also considered it an appropriate discipline for medical practice and investigation. The medical profession in anesthesia's country of origin, in the face of the early scandals, was, however, more circumspect in accepting its part in medical practice. This situation was not to be rectified until early in the twentieth century and only after the administration of anesthetics by nonphysicians had become established.

Thus the torch was passed to European physicians, who accomplished much of the initial development of anesthetic equipment and techniques. Britain was fortunate to have Dr. John Snow (1813-1858), a physician of established reputation who was interested in respiratory physiology; he took an immediate interest in anesthesia and devoted his professional life to its practice. His early, careful observations established the groundwork for clinical anesthesia, but the infrastructure for the widespread application of that knowledge did not exist. Britain at that time was approaching the height of its industrial power and was in a position to create the means for routine anesthetic administration. The principles for the controlled vaporization of agents were incorporated into the inhalers of Snow and Clover, which were soon in mass production. In 1862 Thomas Skinner, an obstetrician, invented a wire mask for the administration of chloroform, later improved by Karl Schimmelbusch. However, the introduction of the first practical anesthesia machine by Sir Frederick Hewitt in 1887 had to await the development of compressed gas cylinders in 1868 by the Medical Pneumatic Appliance Company in London. In 1880 Macewen introduced oral endotracheal intubation, and Kirstein described the first direct-vision laryngoscope in 1895. Boothby and Cotton introduced a sight-feed nitrous oxide and oxygen flowmeter in 1912, and in 1920 Guedel's first paper on the signs of anesthesia was published, which refined Snow's original signs (Little, 1966). At this time Magill and Rowbotham were refining the techniques of endotracheal anesthesia, and in 1923 Ralph Waters, in Wisconsin, first used carbon dioxide absorption on a human being.

The ideal general anesthetic

It was fortunate that diethyl ether inaugurated painless surgery, because this drug was physiologically safe and had a high therapeutic index. Its two major drawbacks were its flammability and its unpleasant after-effects for both patient and attendants. These shortcomings explained the sustained popularity of chloroform, which was much more pleasant to inhale and allowed a more dignified emergence because of the lower incidence of nausea and emesis. However, the toxic effects of chloroform on the heart and liver spurred the search for an ideal inhalational anesthetic agent, which has continued to this day.

The ideal inhalational anesthetic should allow a pleasant, rapid induction and a rapid emergence. It should be chemically stable when stored and should not decompose on contact with the materials used in anesthetic circuits. It should neither be flammable nor support combustion. It should be nontoxic and biochemically stable, undergoing no biotransformation in the body and being excreted unchanged through the lungs. It should be sufficiently potent to allow high oxygen concentrations to be delivered. It should exhibit neither chemical nor physiologic interactions with other drugs. If the target organs are not exclusively the brain and nervous system, the anesthetic should at least depress other organ activity to a lesser extent for a given dose of the drug. At this time such a drug has not been found.

A triad of properties are desirable in all inhalational anesthetics - narcosis, relaxation, and analgesia. The original choice of the word *analgesia* was probably a misnomer, since absence of pain implies the blocking of a sensation, which can only be perceived when a person is conscious. Because patients under general anesthesia are not conscious, the third desirable poverty of the triad is more correctly described as *reflex suppression.* The term *analgesia* is probably better confined to conduction block and infiltration anesthetic techniques.

Fortunately, the dose of diethyl ether required to achieve unconsciousness also achieved sufficient muscular relaxation and reflex suppression for operations on most parts of the body, without dangerous depression of brainstem vital functions. Ether's drawbacks remained, but as each new agent was introduced and investigated, it was found that although some were more acceptable in terms of flammability and patient comfort, none had the basic triad of properties in the same balance as ether.

Over the years many inhalation agents were introduced to clinical practice and enjoyed popularity among anesthesiologists for varying periods of time. The thrust of this work was to investigate newly discovered compounds for anesthetic and toxic properties in the hope of discovering a clinically useful drug. In 1951 C. W. Suckling, armed with the knowledge and techniques of modern organic chemistry, brought a new approach to fruition with the synthesis of halothane (Fluothane) in the laboratories of Imperial Chemical Industries, near Manchester, England (Suckling, 1957). In response to the request from anesthesiologists for an ideal agent with a predefined list of desirable properties, he succeeded in building the halothane molecule from the "atom up". This new agent was studied pharmacologically by Raventos (1956), and introduced to clinical practice by Johnstone (1956).

Halothane heralded a new era in anesthesia; this drug is four or five times more potent than diethyl ether and twice as potent as chloroform. Its vapor is pleasant to inhale and is not an irritant, but most important, it is nonflammable and nonexplosive when mixed with oxygen in any concentration. Here was a drug similar to ether in terms of its triad of properties, but with high patient acceptability, and it held out to the surgeon the promise of the unrestricted use of electrocautery and diathermy. That these were significant advantages was evidenced by the rapid spread of the use of halothane throughout anesthetic practice. However, amid the initial euphoria, it became evident that halothane was still not the perfect agent. Its potency demanded skill and the redesigning of equipment for its safe employment. Its poor analgesic properties were a relative drawback. Of interest is its propensity to sensitize the myocardium to catecholamines (Millar et al, 1958; Andersen and Johansen, 1963) and the rare occurrence of liver failure (Virtue and Payne, 1958) in association with its use. Therefore the search for the ideal agent continues.

Recently enflurane and its isomer isoflurane have been introduced, but in spite of claims as to their superiority, they are still only variations on the halogenated aliphatic compound theme (Fig. 13-1). Assessment of their place in anesthetic practice must await the same level of experience already achieved with halothane. Two new volatile agents, sevoflurane and desflurane, are undergoing clinical evaluation. These less soluble inhaled agents have achieved rapid induction and recovery from anesthesia in experimental animals and may prove to be of value in the future, particularly for outpatients.

Development of local anesthesia

Carl Koller (1858-1944) graduated from the University of Vienna in 1882 and went on to specialize in ophthalmic surgery. He soon became dissatisfied with the operating conditions and patient problems created by the general anesthetic techniques of the time, which prompted him to search for better methods of pain relief in ophthalmology. Koller had been interested in the properties of cocaine since medical school. After animal experiments, Koller tried topical use of cocaine on his patients with great success and reported his findings to the German Ophthalmological Congress in 1884 (Koller, 1884). In the same year, the noted American surgeon William Steward Halsted (1852-1922) performed the first successful nerve block - a block of the mandibular nerve with cocaine.

In 1891 Quincke in Germany and Essex Wynter in England had demonstrated lumbar puncture to be a practical clinical procedure. In 1898 August Bier (1861-1949) have the first deliberate spinal anesthetic (Bier, 1899). In addition to his many surgical achievements, he also developed the intravenous use of procaine to induce anesthesia (Bier, 1908). Tropococaine, isolated by Giesel in 1891, was the first alternative to cocaine, but a local anesthetic drug with relatively low toxicity was not found until 1904, when Alfred Einhorn synthesized procaine. Meanwhile, in 1890 Redard of Geneva introduced the ethyl chloride spray for topical analgesia, and in 1892 Karl Ludwig Schleich (1859-1922) introduced infiltration analgesia.

The scene was now set for Heinrich Friedrich Braun (1862-1934), the "father of local analgesia". His interest in local analgesia was developed while he was director of the Deaconess Hospital in Leipzig. In 1902 he added epinephrine to cocaine solutions to prolong analgesic action (Braun, 1902), and in 1905 he pioneered the use of the new drug procaine (Braun, 1905). The year 1905 also saw the publication of his classic textbook *Local Anesthesia.* It was Braun who first coined the term *conduction anesthesia.* A pupil of Braun, Arthur Lawen (1876-1058), went on to describe paravertebral conduction anesthesia and in 1910 demonstrated that extradural analgesia was a safe and practical technique for pain relief.

Fortunately for the development of local anesthesia, its successful clinical application did not have to generate its own equipment. The hypodermic syringe and hollow needle had been developed concurrently but independently. The principle of injection had been demonstrated as early as 1657, when Sir Christopher Wren and Robert Boyle, using a bladder attached to a sharpened quill, had injected tincture of opium intravenously into a dog. In 1827 von Neuner described one of the first practical hypodermic devices, which was used for veterinary ophthalmology. Zophar Jayne of Illinois patented an early device for human use in 1841 (McAuley, 1966). In 1853 Pravaz of Lyons (1791-1853) invented the syringe made of glass, and in the same year Alexander Wood of Edinburgh (1817-1874) introduced the hypodermic syringe and hollow needle as we know them today.

As might be expected, the development of local anesthetic drugs did not occur without problems. Natives of the Andean foothills had chewed the leaves of the coca shrub for their mood-elevating effect since time immemorial. Scientific expeditions to South America brought the shrub back to Europe, where chemists endeavored to separate the active principle. In 1855 Gaedicke isolated the alkaloid erythroxylin, but it was not until 1860 that Albert Niemann succeeded in isolating cocaine from the erythroxylin extract, remarking that the crystals numbed his tongue. Eight years elapsed before a monograph appeared, in 1868, by a Peruvian army surgeon, Thomas Moreno y Maiz, describing experiments with cocaine. This was probably the first publication suggesting cocaine's potential as a local anesthetic and coincidentally the first description of cocaine-induced seizures (von Oettingen, 1933), preceding Koller's definitive work by 16 years.

Although cocaine's benefits were beyond doubt, so were the toxic and addictive properties of the drug. These problems prompted the search for better drugs. Willstatter in

1895 succeeded in defining the chemical structure of cocaine, identifying it as the benzoic acid ester of ecgonine. Further investigation of the benzoic acid esters resulted in the introduction of Tropococaine by Giesel and Stovaine by Fourneau. However, both these drugs were toxic and irritant and did not supplant cocaine in practice. Not until the introduction of procaine did a benzoic acid ester of low toxicity become available to clinicians. Modifications of procaine's structure have since yielded many new agents, current examples being tetracaine and chloroprocaine.

Procaine and its derivatives held sway in clinical practice until 1948, when the Swedish chemist Lofgren discovered lidocaine during his investigations of aniline derivatives (Lofgren, 1948). The discovery of lidocaine was as important to local anesthesia as the discovery of a halothane was to be to general anesthesia. Lidocaine is a potent, stable drug with relatively low toxicity and high tissue penetration but without cocaine's habituating properties. It was the progenitor of many new "amide" local anesthetics, including prilocaine and bupivacaine (Fig. 13-2).

The Anesthetic State

The anesthetic state has three component properties: narcosis, relaxation, and reflex suppression. In the case of general anesthetic agents, all three components can be achieved with the use of a single drug, primarily by the central depression of brain activity. General anesthesia may be defined as a progressive, reversible depression of nervous tissue, leading to the controlled production of unconsciousness.

Theories of general anesthesia

The mechanism by which general anesthetics cause loss of consciousness is unknown. A number of theories have been advanced; each is based upon either the physicochemical properties of the drug or the localization of a site of action. Many compounds, with widely differing chemical structures, are capable of producing anesthesia, making a strictly structural theory untenable. The purely physical theories, based upon the intermolecular forces exerted between the drug molecules themselves and evidenced by proposed correlations between boiling points, vapor pressure, van der Waals constants, and so on, are not informative relative to the interaction between the drug and its site of action. Thus, recent thought has concentrated upon two main areas, solubility and sites of actions.

Solubility theories

Work on the physicochemical theories of general anesthesia has revolved around differentiating between their behavior in aqueous media and their behavior in nonaqueous media. The aqueous theories are based on the apparent relationship between the anesthetic partial pressure and the decomposition pressure of the gas hydrates (clathrates) formed by the anesthetics. The postulate is that anesthetic action occurs in the aqueous or hydrophilic areas of the central nervous system, where clathrates are stabilized with charged protein sidechains, impeding neural impulse conduction, while the ordering effect on adjacent water molecules interferes with neural membrane transport (Millar, 1961; Pauling, 1961). The aqueous theories are no longer tenable, since they fail to correlate the potency of the fluorocarbons and do not predict the additive effects of anesthetic potencies observed in clinical practice; in addition, some volatile agents do not form clathrates under the proposed conditions.

The nonaqueous theories have developed out of the Meyer-Overton fat solubility hypothesis (Meyer, 1899; Overton, 1901), which relates the onset of narcosis to the attainment of a certain molar concentration of the agent in the lipids of the cell, the effective concentration being dependent on the nature of the cell rather than on the agent. In other words, this theory accounts for the strong relationship between the anesthetic pressure of a compound and its lipid solubility. The correlation appears to hold true over a wide range of anesthetic agent potencies (Eger et al, 1979; Halsey, 1974). However, alkaloids do not fit the theory, and many fat-soluble substances have no anesthetic action. This approach does not address the mechanism of anesthetic action in the area of the nonaqueous medium.

Site-of-action theories

The surface tension theory of anesthesia holds that the adsorption of anesthetic agents by cell surfaces alters permeability and the dielectric constant, interfering with metabolic process and neural transmission (Clements and Wilson, 1962). The cell permeability theory holds that anesthetic agents stabilize cell membranes, thereby interfering with sodium transport mechanisms. The biochemical theories endeavor to explain the anesthetic state in terms of interference with subcellular enzyme systems. The decreased oxygen consumption observed with clinical concentrations of inhalation agents (Cohen, 1973) and barbiturates (Brody and Bain, 1954) suggests decreased enzyme activity, but whether this is a cause or an effect of anesthesia is moot. In fact, the same question of cause versus effect can be leveled at all the site-of-action theories.

Mechanisms of local anesthesia

Local anesthetics are drugs that reversibly block the initiation and propagation of nerve action potentials distal to the point of application. This is achieved by a combination of mechanisms. By hydrophobic bonding, the drug base is adsorbed by the cell membrane, thereby hindering sodium access. By virtue of lipid solubility, the drug base dissolves in the phospholipids of the cell membrane, causing swelling, which tends to obstruct the ion channels through the membrane. The base that penetrates to the axoplasm dissociates to the degree dictated by the particular drug's pK_a, and the cation, held in place by electrostatic forces, closes the inner mouth of the sodium channels (Ritchie, 1975). The cation from dissociated drug on the exterior membrane also binds to the dipole molecular coat on the exterior surface of the membrane, where its charge tends to repel sodium ions. Local anesthetic block is a nondepolarizing type of block (Strichartz, 1976). The resting potential of the axon is unchanged, as are its metabolic activity and the resting membrane permeability. These mechanisms apply equally to the saltatory conduction in myelinated axons, but since the exposure of the membrane at the nodes of Ranvier is small, a higher concentration of drug is required to block conduction in myelinated nerves than in nonmyelinated nerves. Also, because of the skipping of the impulse over one or more blocked nodes (Tasaki, 1953), it is necessary to expose several adjacent nodes to the agent in order to ensure a block.

Stages of general anesthesia

In 1920 Arthur Guedel published a systemized description of the signs of anesthesia. This description was based on observations of the use of diethyl ether as a single anesthetic agent. Ether is so soluble in blood that its uptake from the lungs to a sufficient dose to achieve and deepen anesthesia is slow. Guedel was, therefore, able to describe four stages of anesthesia, each of which is characterized by a distinct combination of signs:

1. Analgesic stage - from the beginning of induction to loss of consciousness; characterized by a varying degree of true surgical analgesia and the patient's ability to respond to commands.

2. Excitement stage - from loss of consciousness to the onset of automatic respiration; characterized by increased skeletal muscle tone and irregular breathing. Excitement and involuntary activity may be absent or marked. Hypertension, tachycardia, breath holding, laryngospasm, swallowing, and vomiting may occur.

3. Surgical anesthesia stage - from the onset of automatic respiration to respiratory paralysis; characterized by loss of skeletal muscle tone and eyelid and conjunctival reflexes.

4. Overdose stage - from respiratory paralysis to death. All reflex activity is lost and pupils are widely dilated.

Guedel originally described four progressive planes within stage 3 (surgical anesthesia), which were based on the progressive suppression of ocular signs and respiratory activity, but these may be condensed into three functional planes of surgical anesthesia.

a. Light anesthesia - until eye movement disappears

b. Medium anesthesia - increasing intercostal paralysis

c. Deep anesthesia - diaphragmatic respiration.

In otolaryngology - head and neck surgery, these stages may still be seen, because of the occasional need for the inhalation induction of anesthesia in the presence of airway problems. In anesthesia for most other branches of surgery, however, the original concept of anesthetic depth is outmoded, since combinations of drugs are used in balanced techniques. Newer agents to not follow such an orderly sequence. Thiobarbiturates may induce surgical anesthesia without stages 1 and 2 being evident. The muscle relaxants simulate most of the signs of anesthesia without rendering the patient anesthetic at all! However, the need to assess the patient's conscious state and degree of reflex suppression remains, and the orthodox stages have been restated in modern times (Laycock, 1953).

When the surgeon commences surgical preparation and positioning, the patient sometimes moves (much to the mortification of the anesthesiologist!). Movement does not necessarily mean that the patient is awake. The usual explanation is that the surgeon is stimulating the patient while he is still in stage 2, either because the intravenous induction agent's effects are wearing off before the inhalation agents have had sufficient time to replace them or because injected muscle relaxants have not yet achieved full effect. The surgeon should, therefore, always wait for the anesthesiologist to give the word to proceed. This precaution is even more important if an inhalation induction is being undertaken, since any stimulation of the patient, including auditory, may unleash the full excitation of stage 2, with vomiting and laryngospasm and their associated serious sequelae. It should be remembered that the stages of anesthesia are traversed on emergence as well as induction. Thus patients in the anesthesia recovery room should be allowed to awaken with as little stimulation as possible. In this context, mentioning the small problem associated with estimated surgical closing time is also worthwhile. The anesthesiologist usually asks for an estimate to gauge when to start to reverse anesthesia so as not to waste unnecessary time at the end of the operation. The surgeon who estimates 10 minutes and in fact requires 20 may find that the patient tends to make the final skin closure and dressings difficult!

Assessment of the Patient for Anesthesia

The purpose of this section is not to provide a comprehensive review of the basic clinical skills of eliciting a history or conducting a thorough physical examination, but rather to emphasize those areas in the preoperative assessment of the patient that are of particular importance to the conduct of anesthesia. All anesthetic agents are cellular poisons, some with a low therapeutic index, that give rise to potentially adverse physiologic changes even in healthy patients. There is such a thing as minor surgery, but there is no such thing as a minor anesthetic; the patient's life is always at risk when he is under the influence of anesthetic drugs.

Physical status assessment

The American Society of Anesthesiologists (ASA) has sponsored several attempts to develop a classification of anesthetic risk according to the preexisting diseases and conditions of the patient as well as the operation to be undertaken. These efforts have met with only partial success, since a positive correlation between these factors is not evident (Keats, 1978). What has developed from this work is the ASA physical status classification system, which may not directly reflect the anesthetic risk:

ASA 1 - a normal healthy patient

ASA 2 - a patient with a mild systemic disease

ASA 3 - a patient with a severe disease that limits activity but is not incapacitating

ASA 4 - a patient with an incapacitating systemic disease that is a constant threat to life

ASA 5 - a moribund patient not expected to survive 24 hours with or without operation.

Each of the classes may be modified with the letter *E,* denoting an emergency presentation and all that implies for the patient's preoperative preparation. The problems associated with the preoperative assessment of risk are evident if one considers the case of a young healthy adult with a minor deformity of the second branchial arch structures, which, while not being apparent in everyday life, poses significant anatomic problems for safe endotracheal intubation. Similarly, a young healthy patient with a family history of malignant hyperthermia, although at considerable risk from anesthesia, could still be classed as an ASA 1 patient. Thus the preoperative anesthetic assessment is aimed not only toward the assessment of the general physical status of the patient, which at best is an indicator of the general state of the patient's integrated physiologic systems, but also toward detecting specific problems posed by co-existing disease, the requirements of the operation, and any significant medication being taken, as well as problems and points in the history suggesting a true anesthetic risk. Of particular significance is a history of previous problems with anesthesia or a difficult intubation.

Physical status assessment requires that two major questions be answered: (1) What is the patient's general physiologic ability to respond to stress (both anesthetic and surgical)? (2) What currently existing disease conditions might modify or limit that response? The history of the patient's response to the level of physical activity undertaken in everyday living is usually the best guide to the patient's probable response to the iatrogenic stresses of the operating room. However, some individuals appear to lead perfectly satisfying lives without exposing themselves to a stress sufficient to gauge the appropriateness of the response from the history. Asking the patient to accompany the interviewer up several flights of stairs is usually sufficient to form a valid clinical impression (Greene, 1981). The heart rate and rhythm, blood pressure, respiratory pattern, and general state of distress may certainly suggest the need for quantitative laboratory investigation. Preexisting systemic disease would modify one's enthusiasm and the number of flights of stains, but in general the approach to physical assessment is the same. It is the patient's integrated response to stress that is being assessed, even if it is modified by disease, rather than any specific problems of management posed by the disease itself.

The presence of systemic disease necessitates the answering of a number of specific questions:

1. Is the disease process under the best medical control possible, or in the case of an emergency situation, has everything reasonable been attempted to stabilize the patient's condition?

2. What drugs are being used to control the disease, and do any of them interact with anesthetic drugs?

3. Does the disease process impose any limits on what may be undertaken surgically and anesthetically in terms of positioning, technique, and duration of the procedure?

4. Who will manage the disease during the perioperative period?

5. Have the expected gains of the surgical intervention been appropriately weighed against the estimated risks of anesthesia associated with the systemic disease under this degree of control?

6. Does this disease process pose any specific perioperative problems for surgical or

anesthetic management?

7. Does the anesthetic technique pose any problems for the perioperative management of the disease?

A patient with a poor physical status because of disease generally has impaired homeostatic control and is particularly vulnerable to the depressant effects of an inhalational anesthetic drug given as the sole anesthetic agent. This tends to necessitate the use of balanced anesthetic techniques with muscle relaxant drugs. In some operations the possible necessity of using a nerve stimulator might persuade the surgeon to delay elective surgery until the patient's physical status is improved. Should the anesthesiologist, in consultation with the patient and the surgeon, elect to proceed with conduction anesthesia or infiltration anesthesia with the anesthesiologist standing by, a new set of problems and limitations emerges. Will the patient's condition permit correct positioning for surgery? Can the patient breathe while lying flat? Can the patient tolerate lying on the operating table for sufficient time to complete the proposed procedure?

These alternatives are not particularly promising in the face of significant pulmonary, cardiac, or arthritic conditions. It is worth emphasizing that if a patient for elective surgery with a significant systemic disease is not considered to be in the best possible medical condition, stand-by local anesthesia is not an appropriate choice to "get away with surgery" on an improperly prepared patient. Long operation under local infiltration anesthesia frequently require local anesthetic drug dosages approaching or exceeding safe levels. Even then, general anesthesia still may be required if the patient cannot tolerate the duration of the procedure, thereby subjecting the patient to two sets of risks that could have been avoided. No anesthesiologist should allow this situation to occur because of misplaced concern for either patient or surgical convenience.

The anesthesiologist should be concerned not only about the effects of systemic disease on the conduction of anesthesia but also about the impact of the anesthetic on the subsequent course and management of the disease. A respiratory cripple imprudently paralyzed and ventilated for surgery may not be able to be weaned from the ventilator postoperatively. An association exists between the stress of surgery and anesthesia and exacerbation of multiple sclerosis. Anesthetic management may create significant problems in reestablishing the myasthenic or diabetic patient on stable medication postoperatively. Is the withdrawal of long-term medication to permit the safe use of one anesthetic technique really in the patient's interest when another, perhaps less ideal, technique would permit continuation of the medication? These are all necessary matters of judgment, only to be decided after consultation between the anesthesiologist, the surgeon, the appropriate internist, and the patient.

Systemic medication should always be reviewed at the preoperative visit, with particular attention being paid to possible interactions with anesthetic drugs. It is also important to remember that some patients will not volunteer information concerning over-the-counter drugs; since these drugs were not prescribed by a physician, some patients do not consider them "real" drugs. Similarly, a patient admitted for surgery with a serious systemic disease may neglect to mention drugs being taken for an unrelated, older chronic condition.

Examples encountered with some frequency in practice include elderly patients whose mild hypertension has been managed successfully for many years with reserpine and patients who may be taking long-acting anticholinesterases such as echothiophate for glaucoma. Both drugs have significant interactions with drugs used in anesthetic practice. Reserpine blocks peripheral adrenergic neurons by depleting synaptic norepinephrine stores; this is associated with supersensitivity to direct-acting and insensitivity to indirect-acting sympathomimetic amines, which may be used to counteract hypotension under anesthesia (Coakley et al, 1956; Gelder and Vane, 1962). Echothiophate iodide, a long-acting anticholinesterase, interferes with the hydrolysis of the depolarizing muscle relaxant succinylcholine by pseudocholinesterase, thereby prolonging its clinical action significantly.

As a general rule, if a patient is sufficiently ill to require systemic medication while awake, the same medication is required under anesthesia. The anesthesiologist's preoperative assessment should allow modifications to a proposed anesthetic technique in order to take into account the actions and interactions expected from these systemic drugs. This is particularly true for most antihypertensive drugs and drugs used to control cardiac and pulmonary disease. However, a few drugs have potential interactions so devastating that their withdrawal prior to anesthesia should be considered (Smith, 1981). A factor also to be considered is the possible effect of systemic medication on the usual biological clearance mechanisms of anesthetic drugs. Saturation of the normal enzyme detoxification pathways' capacity in the liver is thought to lead to detoxification of anesthetic drug metabolites by alternative pathways. Alternative degradation pathways are thought to be one of the possible mechanisms leading to "halothane hepatitis" (Ray and Drummond, 1991). Similarly, many drugs, such as the aminoglycoside antibiotics, are nephrotoxic and will impair renal clearance sufficiently to prolong the action of anesthetic drugs relying on that route for excretion.

Airway assessment

The airway and the general anatomy require particularly careful assessment at the preoperative visit, since these two factors are likely to impose limitations on surgical positioning and on the choice of technique for anesthetic induction and maintenance. An extremely obese patient not only may pose problems of access for the surgeon but also may cause difficulty for the anesthesiologist in intubation and choice of technique to minimize well-recognized post-operative sequelae (Putnam et al, 1974). The elderly patient with limitation of movement or with joint deformity requires careful attention to positioning and protection of pressure points, and when the temporomandibular joints are affected, access to the airway may be a problem. Of concern in the elderly patient with systemic vascular disease is the presence of carotid plaques with or without bruit. If the operation requires exaggerated rotation of the head, as for posterior auricular approaches, it is important to check preoperatively to see that the patient can do the rotation without fainting, in the hope of preventing a potentially fatal maneuver under anesthesia.

Airway compromise is usually evident from the general history and examination. However, to detect occult impending airway compromise requires detailed examination of the airway. Congenital anomalies of the airway may involve any part of the respiratory tract, but the most commonly underestimated ones occur in structures arising from the first and second branchial arch structures. The classic syndromes - Treacher Collins, Hallerman-Streiff, and so on - are obvious, but similar deformities of a lesser degree are not. These may occur in otherwise normal patients who compensate for their deformities with muscular effort. Premedication or induction of anesthesia modifies or abolishes this compensatory effort, leading to airway obstruction.

Anatomic variations also contribute to technical difficulties with laryngoscopy and intubation. A larynx easily visualized with indirect laryngoscopy may not be visualized as easily with direct laryngoscopy. Of particular interest in anticipating such problems is the presence of micrognathia, microstomia, macroglossia or relative macroglossia, unusual angulation of the larynx, a short, thick neck, or combinations of these conditions. In the clinical examination of the upper airway, attention should be paid to the patency and size of the nasal passages in regard to the potential use of nasal endotracheal tubes. The full facial view should be examined for symmetry, and a full lateral view should be examined for the size and position of the mandible relative to the maxilla. The state and presentation of dentition should be noted, as should the presence of a narrow, high-arched hard palate. A high-arched palate in association with closely spaced, parallel upper alveolar ridges can make the simultaneous manipulation of laryngoscope and endotracheal tube impossible (Fig. 13-3). The position of the larynx relative to the mandible should be identified. If the distance between the prominence of the thyroid cartilage and the lower border of the mandible admits one and one-half finger breadths or more (Fig. 13-4), a high larynx tucked under the base of the tongue will probably not be encountered. The mobility of the larynx should be observed by asking the patient to swallow, and the presence of induration or scarring in the base of the tongue and hypopharynx should be sought by palpation of the soft tissues beneath the mandible. Palpation of the neck will confirm the midline position of the trachea and identify the possibility of an awkward laryngeal presentation resulting from edema or scarring, together with the presence of any tumors impinging on the trachea, which might make the passage of an endotracheal tube difficult. Finally, the full and free movement of the cervical spine and the atlantooccipital joints should be confirmed, as well as the patient's ability to open the mouth without limitation. If the inability to intubate or ventilate the patient is encountered unexpectedly at anesthetic induction, the presence of a short, thick neck makes a safe rapid tracheostomy more difficult, thereby placing the patient's life in immediate jeopardy. The need for a thorough preoperative examination of the patient's airway cannot be overemphasized.

Laboratory testing

The use of the laboratory to document the obvious and the irrelevant in the preoperative patient has increased, is increasing, and should be diminished. Very few tests can be justified as "routine", and any test ordered to pander the attending physician's insecurities rather than further the patient's interest is to be condemned. A review of the cost-effectiveness of "routine" preoperative testing has been presented elsewhere (Roizen, 1981). It will suffice here to discuss a reasonable approach to the use of the laboratory for anesthetic purposes.

The first question to be asked before ordering a laboratory test is: "Will the result, anticipated or unanticipated, be likely to lead the anesthesiologist to change the anesthetic plan suggested by his or her clinical assessment?" If not, the test will serve no useful preoperative purpose and is therefore superfluous. This is not to suggest that the degree of impairment of physiologic functions resulting from a patient's preexisting medical conditions should not be quantified if, in the clinical judgment of the anesthesiologist, the anesthetic itself might be expected to cause a deterioration in the patient's condition intraoperatively or postoperatively. However, it does preclude the routine preoperative chest radiograph in the absence of clinical indications, as well as an electrocardiogram for most younger patients coming to operation. The prime purpose of anesthetic preoperative laboratory tests is to define the limits of anesthetic maneuvering intraoperatively. Because the anesthesiologist has two principal duties - to render the patient insensitive to pain and to maintain an adequate supply of oxygen to the tissues - preoperative testing should be aimed at ensuring the basis for these two functions in all patients.

The ability to render the patient insensitive to pain depends on the choice of anesthetic technique - local anesthesia, conduction blockade, or general anesthesia. Local anesthesia does not require preoperative testing to confirm patient suitability in the absence of a history of specific agent sensitivity. Conduction blockade poses more potential problems than local anesthesia, even in some ASA 1 patients. For example, the technical difficulties posed by significant kyphoscoliosis in an otherwise apparently healthy patient would certainly justify x-ray studies to define the extent of the anatomic problem and lung volume studies before one proceeds with a spinal anesthetic. Any situation in which abnormal coagulation might be expected, or in which the patient has been taking over-the-counter proprietary preparations containing aspirin, would justify preoperative coagulation studies to ascertain the likelihood of hemorrhage into the nerve trunk following the block. The major problem with general anesthetic techniques is introducing sufficient doses of anesthetic agents into the patient's circulation while still maintaining an adequate circulation. The fall in blood pressure resulting from a combination of decreased peripheral vascular resistance and decreased cardiac output in the presence of anesthetic agents is usually exaggerated by a preexisting reduction in circulating volume. Reduced circulating volumes may be anticipated, for example, in the previously undiagnosed mild hypertensive, the relatively malnourished elderly patient living alone, the young child with a fever who is starved overnight for surgery, and the fit young woman misguidedly trying to control her weight with diuretic preparations. Such presentations justify electrolyte and hematocrit studies, which in the case of diuretic use may uncover a clinically unacceptable hypokalemia. However, even in these situations, if the problem is recognized at the preoperative visit, the use of the laboratory is not mandated. An intravenous infusion of crystalloid solution can be started earlier than usual to preload such patients, or an alternative anesthetic technique can be chosen if appropriate.

The preoperative measurement of hemoglobin concentration and hematocrit can be more easily justified as routine in all patients, since these have a direct bearing on the oxygen supply to tissues. The term *available oxygen* refers to the quantify of oxygen passing through the root of the aorta each minute; this quantity can be determined from the oxygen transport equation:

Available oxygen = Cardiac output x Arterial saturation x Hb conc x 1.34

1000 mL/min = 5250 mL/min x 95/100 x 15 g/100 mL x 1.34 mL/g

In the normal patient who does not smoke, the oxygen-hemoglobin combining power 1.34 is a constant. The other three factors are variables; if any one is reduced while the other two remain constant, the available oxygen is reduced proportionately. However, if two of the variables are reduced simultaneously while the third remains constant, the effect on available oxygen will be the product of the individual changes. Thus, if cardiac output and hemoglobin saturation are both reduced by half, oxygen availability decreases to a quarter of the normal value, which in the case of the above example is approximately 250 mL/min, which is not compatible with life for any length of time.

It is evident that the only variable amenable to preoperative intervention in the healthy patient is the hemoglobin concentration. A fall in cardiac output occurs to some extent in all patients as a normal concomitant of anesthetic induction. Transient falls in excess of 30% of normal are not unusual. If any difficulty occurs in maintaining the airway and normal ventilation, the hemoglobin oxygen saturation will also fall, so the patient is always at risk during induction of anesthesia, regardless of ASA status. Should preexisting pathology cause the values for any of the variables to be below normal, the risk is increased. This is the physiologic basis for the long-standing 10 g/100 mL rule, which can be such a bone of contention between anesthesiologists and surgeons. Although anesthesiologists have become more liberal in their application of the rule to elective surgery over the years, it still rests on sounds principles. It has become known that patients with chronic anemia are better able to withstand the insult of anesthetic induction than those with acute anemia. The risks and questionable ethics of a rapid preoperative blood transfusion to raise the hemoglobin concentration above the 10 g/100 mL limit have become better defined. It remains imprudent, however, to perform elective surgery on a patient who is anemic, unless there is a well-defined medical reason to proceed other than convenience, and 10 g/100 mL still constitutes a reasonable reference point against which medical judgments can be made. On this basis the routine measurement of hemoglobin and hematocrit can be justified.

Of more recent interest is the thorny question of the use of volatile halogenated agents, such as halothane and enflurane, in the presence of liver dysfunction. "Halothane hepatitis", not unique to halothane, is a diagnosis made by exclusion of other possible causes. No direct causal relationship between halothane exposure and "halothane hepatitis" can be proved, nor is there a unique pathologic picture that can be considered pathognomonic of the condition. However, there is sufficient circumstantial evidence to make the prudent anesthesiologist hesitant in repeatedly exposing the same patient to halothane over a short period of time, and a history of jaundice following halothane exposure in the past suggests its avoidance altogether in the future. The real problem is whether or not to give halothane in the face of active liver disease. There does not appear to be an increased risk if halothane is given to a patient who has made a complete recovery from infectious hepatitis in the past, but common prudence would suggest its avoidance during active hepatitis. Recent studies have shown that a surprisingly large proportion of patients presenting for elective surgery are incubating hepatitis, and it is tempting to postulate that it is exposure to halothane under these circumstances alone that could explain the occurrence of "halothane hepatitis". Whatever the final answer may be, it would appear reasonable to screen a patient's liver function, perhaps with nothing more than an estimation of SGPT, and avoid halogenated agents when the level is significantly raised.

Informed consent

A California court has stated:

> A physician violates his duty to his patient and subjects himself to liability if he withholds any facts which are necessary to form the basis of an intelligent consent by the patient to the proposed treatment. Likewise the physician may not minimize the known dangers of a procedure or operation in order to induce his patient's consent. (Informed Consent, 1957).

The opinion then goes on to recognize the dilemma that sometimes full disclosure may not promote the patient's welfare because it may further alarm a patient who is already apprehensive. This dilemma has led to the existence of two competing rules - the "professional standard of consent", which holds that the amount of information disclosed is a matter of reasonable professional judgment, and the "lay standard of reasonableness", which holds that the crux of the matter is not what the physician thinks the patient should know, but what the patient should know to make an informed decision.

Anesthesiology has not had a high public profile in the past, and today patients still have only a vague idea of what anesthesia entails. The last thing that most patients consider is the possibility of being maimed or killed by the anesthetic process when they come to the hospital for surgery. There is something particularly poignant about an anesthetic catastrophe in a patient admitted for an operation that in retrospect he could have done perfectly well without. Since anesthesia cures little or nothing, it should not injure. Thus the anesthesiologist has a particular duty to inform the patient of serious adverse effects, even if the incidence is low. Because most of the serious adverse sequelae of anesthesia are rare, the physician seeking consent must be sufficiently conversant with the anesthetic literature to be aware of their existence and significance in the light of the condition of the individual patient. It is unwise, therefore, for the surgeon to seek consent for anesthesia at the same time as that for operation and certainly foolhardy to anticipate the choice of anesthetic technique unless he or she is willing to proceed with infiltration anesthesia alone. Informed consent can be obtained only by the physician who is responsible for administering the anesthesia. This is an increasing potential liability problem for surgeons working with nurse anesthetists without the aid of anesthesiologists.

Preparation of the Patient for Anesthesia

Preparations on the ward

The preparation of the patient for anesthesia begins with the anesthesiologist's preoperative visit and evaluation. The anesthesiologist has to try to establish rapport quickly with the previously unknown patient. Informed consent has to be obtained. Frequently any lingering questions and doubts concerning the proposed operation have to be addressed without contradicting or undermining what the surgeon has already told the patient. This is usually accomplished the evening before surgery, but with the developing practice of "day-of-surgery admission", care must be taken not to detract from the thoroughness of the preoperative visit.

Apart from becoming familiar with the patient's medical problems and devising the appropriate anesthetic plan, the anesthesiologist may have a number of objectives to be achieved through preoperative medication:

1. The prime objective is always the relief of the patient's anxiety when it is judged to be significant. Methods used may range from reassurance with "light" anxiolytic medication, to time-consuming hypnotic suggestion, to "heavy" premedication with sedatives or narcotics. Some studies have suggested that the relief of anxiety before surgery is more dependent on the rapport the anesthesiologist establishes with the patient than on the choice for premedication.

2. When preoperative pain is present, it is important to prescribe analgesics in sufficient dosages to minimize exacerbation from the movements involved in transporting the patient from the bed to the operating table.

3. When a light, balanced anesthetic technique is contemplated, an amnesic drug should form part of premedication, to protect the patient's psyche from the trauma of awareness.

4. The inclusion of an antisialogogue is frequently required for head and neck surgery and endoscopy because the patient's airway is not accessible for manual suctioning by the anesthesiologist. The reduction in volume of secretions will also facilitate endoscopy.

5. When the suppression of cardiovascular reflexes is considered of importance for induction of anesthesia or the surgical procedure, sedation and vagolytic agents are indicated.

6. Depressant premedicant drugs can also facilitate the anesthetic technique itself by smoothing inhalation inductions and reducing the requirement for intraoperative agents.

7. Premedicant drugs can also be used to reduce the incidence of postoperative nausea and vomiting, although to achieve effective antiemesis for operations of the inner ear, premedicant effects must usually be reinforced with drugs such as droperidol just before the patient emerges from anesthesia.

The patient must eat nothing for at least 6 to 8 hours before anesthesia, although in any individual patient this time period does not guarantee an empty stomach. Even when "empty" the stomach contains approximately 200 mL of strong hydrochloric acid, which poses the ever-present risk of acid-aspiration pneumonitis at induction. This fact has led some anesthesiologists routinely to prescribe an H_2 histamine blocker (such as cimetidine). When hiatus hernia with acid reflux is suspected, the addition of an antacid by mouth on the morning of surgery has been recommended.

Preparation in the operating room

Before the patient is brought to the operating room, the anesthesiologist's first task, and probably the single most important one of the day, is to draw up the drugs and check the equipment. In this area the practice of anesthesia differs drastically from that of surgery. Whereas the surgeon relies on the operating room nurse to assemble instruments and perhaps draw up any local anesthetic that the surgeon is to use, the anesthesiologist has a duty to check everything personally. An anesthetic drug drawn up in the wrong syringe and injected intravenously cannot be retrieved, and malfunctioning equipment may lead to a rapid hypoxic disaster for the patient. The checking process must be obsessively thorough, and the anesthesiologist must not be distracted while it is going on.

When the patient arrives in the operating room, his identity is confirmed together with the site of operation. Then he is made comfortable on the operating table. An intravenous cannula is inserted under intradermal local anesthesia to provide a drug injection route. An intravenous infusion may be started if intraoperative hydration or blood replacement is anticipated. The appropriate clinical measuring instruments are applied according to the patient's condition, but a minimum standard of care now dictates the use of at least the following with every patient:

1. Indirect blood pressure measurement

2. Electrocardiogram

3. Temperature

4. Oxygen analysis, at least on the circuit supply line

5. More recently, expired carbon dioxide analysis and pulse oximetry.

While the final preparations are made for induction, the patient is "preoxygenated" by mask with 100% oxygen to create an oxygen reserve in the patient's functional residual capacity and thus increase the time available for maneuver in the event of a difficult induction. When all is prepared, the surgeon should be summoned before induction begins, if he or she is not already present.

The surgical outpatient

Persons having outpatient surgery require special mention, not because their preoperative evaluation differs significantly from that of the surgical inpatient, but because certain additional requirements must be considered. Since there is insufficient time for the full evaluation of significant systemic disease on the day of surgery, the surgeon must ensure that this is done thoroughly during the patient's outpatient clinic visit and that appropriate medical consultations are obtained at that time.

As outpatient surgery has developed in the USA, the emphasis has been on ASA 1 patients, to minimize the risks of postoperative recovery. This approach has been overly conservative. Modern anesthetic techniques, appropriately selected, permit rapid recovery and pose few problems for the patient discharged home. It is now feasible to include ASA 2 patients, together with carefully selected ASA 3 patients, as long as admission to hospital following surgery is available if anything untoward develops. As a general rule the following factors would militate against outpatient surgery:

1. The need for extensive medical preparation, rather than just "tuning up" the medical control of chronic disease.

2. The need for intravenous therapy of any sort.

3. The need for invasive monitoring during operation.

4. A nonconducive home situation for the patient; for instance, an elderly patient living alone or a patient living at great distance from the hospital, with difficult access to emergency care.

5. Procedures that are expected to produce significant postoperative pain, which may not be amenable to management with oral analgesics.

6. Conditions for which extensive postoperative medical management is requirement.

7. The patient's lack of ability to comprehend and follow postoperative instructions.

It is the surgeon's responsibility to ensure that the patient has fasted since the previous evening and is accompanied by a competent adult into whose care and protection the patient will be discharged. Premedication, if any, is usually given by the anesthesiologist intravenously after the patient has been evaluated and informed consent has been obtained. Before discharge, each patient must be given both written and oral instructions cautioning him against undertaking any activities that may pose a hazard to himself or others as a result of the "hangover" effect of anesthetic drugs still being cleared from the body over the following 24 to 48 hours, which can affect the patient's judgement and reflexes. Such warning should encompass driving, operating machinery, nursing infants, the hazards of the domestic kitchen, and signing any legal documents.

As its cost advantages become more widely appreciated, outpatient surgery is becoming more common. However, one must understand that the usual inpatient ratios of patient preparation space to operating rooms and staffing levels are not adequate for a safe, efficient outpatient program. Outpatient surgery is space and labor intensive, particularly in terms of requirements for patient preparation, recovery, and discharge.

Conduct of Anesthesia

Operating room setup

The anesthetic setup for otolaryngology - head and neck surgery is dictated by the competition for the airway between the anesthesiologist and the surgeon. In ophthalmic surgery and neurosurgery the anesthesiologist usually has some restricted access to the oral endotracheal tube. In otolaryngology, even if the surgeon is not working in the aero-digestive tract itself, the patient's head is usually draped completely.

The clustering of the surgeons, the scrub nurse, and the instrument tables about the patient's head usually means that the anesthesiologist and his or her equipment are forced toward the foot of the table. This situation dictates a meticulous setup following induction, with a well-secured airway (Fig. 13-5) and close monitoring of the anesthetic circuit's integrity throughout the operation. The situation demands close cooperation from the surgeon. Any changes in the surgical field, such as increased oozing, dark blood, or surgical manipulation around the carotid bodies, must be communicated to the anesthesiologist immediately. If the anesthesiologist in turn has any concern about the patient's condition, the surgeon should be informed and the matter resolved with good grace, by undraping the patient if necessary. There are no "points" to be scored between professionals in operating rooms.

Anesthetic induction is always undertaken with the anesthesiologist at the head of the patient. If a tracheostomy is to be undertaken, the anesthesiologist remains at the patient's head, where he or she has control of the endotracheal tube and can assist the surgeon. When the trachea is exposed, the tube cuff is deflated and the tube is advanced into the right mainstem bronchus. This prevents the cuff from being incised with the trachea and enables the anesthesiologist to seal the airway if the surgeon encounters bleeding problems. Once the window in the trachea has been made without incident, the anesthesiologist withdraws the tube until the surgeon informs him or her that the tip is level with the upper border of the window. The tube is never withdrawn from the larynx completely until after the surgeon has inserted and tested the correct position of the tracheostomy tube.

If the surgical intention is to undertake endoscopy or microsurgery of the larynx, the operating table is rotated 90 degrees and the anesthesiologist remains near but below the patient's head. This position allows the anesthesiologist to make and secure various ventilatory attachments to whatever endoscopes may be used, or permits him or her to ensure manually that the endotracheal tube is not inadvertently dragged from the larynx by the surgeon during endoscopic manipulation.

For most other procedures the anesthesiologists is to the side of the operating table and near the foot or actually at the foot (Fig. 13-6). The advantage of being off to one side is that this position permits the use of a standard circle circuit without modification, and some anesthesiologists feel more comfortable if the airway is at least within reach, if not immediately accessible. The disadvantage of the position is the crowding inherent if more than one surgeon is involved in the procedure. If the anesthesiologist sits at the foot of the table, this latter problem is overcome but special circuits must then be used. A "long" circle circuit may be used, but the increased volume of the circuit introduces additional compression and distension errors in ventilator settings, and although these may be compensated for in normal patients, in those with reduced chest compliance ventilation management may become difficult. These problems are largely circumvented by the use of coaxial circuits, such as the Baines (Fig. 13-7). The single tube is light and easy to secure; however, because the avoidance of expired carbon dioxide rebreathing is achieved by using high gas flows (Baine and Spoerel, 1972), the use of the coaxial circuit consumes more of the anesthetic agent than does the circle. Conservation of both heat and water is also lost unless an artificial "nose" is interposed between the endotracheal tube and the circuit. An additional advantage of the coaxial circuit is that the metal "head" containing the expiratory valve and various hose attachments can be clamped to the operating table itself, further minimizing the chance of circuit disconnection resulting from any changes in table position requested by the surgeon during the procedure (Fig. 13-8). The foot position affords a better, more symmetric view of the chest wall movement during anesthesia and gives the anesthesiologist access to both sides of the table.

Anesthetic techniques

Five main groups of anesthetic techniques are available to the otolaryngologic patient.

Infiltration anesthesia

Infiltration anesthesia, with or without standby for monitoring, sedation, and/or resuscitation by the anesthesiologist, is most commonly used for minor, superficial operations or operations in the middle ear. The surgeon is solely responsible for the use and dosage of whatever local anesthetic agent is selected and should ensure that the safe total dose with or without epinephrine is not exceeded. The surgeon should exercise care when selecting patients, so that the procedure planned can be completed in the time made available by the technique and the patient can tolerate the experience. The safety of the technique depends on not exceeding safe drug dosages and on frequent aspiration during injection with a constantly moving needle to minimize the risk of inadvertent intravenous injection. This is not a "second-best" technique to "get away" with surgery on inadequately prepared patients already rejected for general anesthesia.

Topical anesthesia

Topical anesthesia is used primarily for diagnostic or therapeutic endoscopy - particularly when patient cooperation is required, as with Teflon injection of the vocal cords. Again, attention to total drug dosage and the careful selection of those patients who will tolerate the experience are important. The secret of consistent success is to take sufficient time at each step to allow full analgesia to develop. The lip and gums are "painted" first and then tongue, epiglottis, and larynx in turn under direct or indirect vision. Rather than spraying the larynx, some may prefer to achieve laryngeal anesthesia by applying cotton pledgets soaked in local anesthetic to the piriform fossae using Krause forceps or by percutaneous injection through the neck. At the conclusion of paintup, a small amount of viscous lidocaine is given to the patient to gargle and swallow.

Conduction anesthesia

Conduction anesthesia is the technique whereby a local anesthetic agent is introduced via needle to the immediate proximity of a specific nerve, series of nerves, or nerve trunk in order to produce analgesia over the sensory distribution. Anesthesiologists use the technique for head and neck surgery infrequently. The common technique of spinal anesthesia theoretically can be used for analgesia of the head and neck, and indeed has been used in the past (Koster, 1928). However, achieving a sensory block high enough to be of use to the surgeon results in a simultaneous motor block of the muscles of respiration. This requires control of the patient's respiration, necessitating general anesthesia, which somewhat defeats the purpose of conduction blockade in the first place! Blockade of the cervical nerves is a more viable technique, which creates a very favorable operating field - one that can be used to advantage for thyroid surgery or lymph node dissections. However, the two fundamental disadvantages of conduction blockade are encountered. The duration of surgical analgesia depends on the accuracy of initial injection and the properties of the drug injected. Therefore if the surgical procedure takes longer than anticipated and the block wears off, general anesthesia with its concomitant risks has to be superimposed. The other major drawback is the time required for the block to be executed and for analgesia to develop. It is because of the induction time and the inflexibility of a "one shot" technique that these blocks are not used more frequently. In spite of these considerations, conduction blockade still has two well-established roles in head and neck surgery: blockade for surgery on the teeth, supporting structures, and oral mucous membrane (Martof, 1981) and the control of the chronic pain syndromes (Carron, 1981).

Monitored anesthesia care

Monitored anesthesia care (MAC) refers to the situation wherein an anesthesiologist is present to supervise and monitor patient sedation during a local anesthetic technique. Sedation is desirable for a patient who is concerned about recall of intraoperative events and to minimize the systemic stresses associated with the experience. This may be required with any form of local technique whether it be topical, infiltration, or conduction blockade. Indeed, it is sometimes desirable for procedures where no local anesthetic drugs are used and it is the patient's medical condition that is the only concern. It must be emphasized that the anesthesiologist must ensure that the operation is not performed under an inadequate local anesthetic resulting in progressive depression of the patient's cerebrum and brainstem with increasing doses of intravenous drugs. Such a situation demands either abandonment of the procedure or conversion to a formal general anesthetic, which in turn implies that the patient has undergone preoperative evaluation and preparation with the eventuality in mind.

The term *MAC* has been defined and approved by the ASA (ASA, 1986) but other terms are still in use, such as *local standby anesthesia, intravenous amnesia, conscious sedation,* and *MAPS (monitored anesthesia and pharmacologic support).* The term MAC should not be confused with the same term used in two other contexts by anesthesiologists: (1) *Mac* is also the slang abbreviation for the curved anesthetic laryngoscope blade first described by Sir Robert Macintosh and still in common use; (2) MAC is also the acronym for the minimum alveolar concentration in stable state of an anesthetic gas or vapor that blocks reflex response in 50% of a group of animals to a standardized noxious stimulus. Although the concept is used with respect to patients by anesthesiologists, it was originally developed as a standardized laboratory measure to compare the potencies of different anesthetic agents.

Monitored anesthesia care implies that an anesthesiologist is providing specific anesthesia services to a patient undergoing a planned surgical procedure and is in control of his or her nonsurgical medical care, including being available to perform immediate resuscitation, administering additional anesthetics, or providing other medical care as appropriate. The ASA specifically includes MAC in the Standard for Basic Intraoperative Monitoring, thereby requiring the same level of care for MAC as is required for all other anesthetic procedures. Therefore, the term should be limited to the practice of anesthesiologists observing the standards of care promulgated by their specialist society. The American Dental Association has also adopted definitions and standards related to "conscious sedation" in dental practice.

Over the years dentists have become particularly aware of their vulnerability in the face of patient disaster when a single dentist has tried to act as both operator and monitoring anesthetist simultaneously. Thus, when a patient requires anything greater than the lightest level of sedation and in the absence of an anesthesiologist, a second dentist should to be in attendance to monitor the patient's condition during continuing sedation. Unfortunately this is not the case with many medical specialties where patients are still occasionally oversedated for invasive and diagnostic procedures by physicians acting as operator/anesthetists. These physicians sometimes miss the signs of impending central nervous system depression because they are concentrating on the procedure in hand. However, the realities and demands of daily practice must also be acknowledged. There is an insufficient supply of anesthesiologists and nurse anesthetists to staff the many minor operative and diagnostic procedures that require some level of sedation in the many outpatient clinics and office practices across the country. Fortunately few of the patients undergoing procedures in such environments come to any harm. Therefore, to avoid the occasional disaster and while keeping within the bounds of reasonable cost, it is suggested that certain precautions be considered where the surgeon uses sedation outside the operating room environment.

1. *Prepare* for the unexpected patient collapse by keeping within reach an office resuscitation box, including the means for high-volume suction, artificial ventilation, supplementary oxygen, and drugs suitable for treating hypotension, cardiac dysrhythmias, anaphylactic reactions, bronchospasm, and local anesthetic seizures. Several companies produce such ready-stocked cases at a reasonable cost. Ensure that the contents are checked regularly.

2. *Train* office or clinic staff in advance concerning their duties in an emergency. Ensure that the appropriate telephone numbers for use in an emergency are known, posted, and updated.

3. *Select* patients carefully to exclude those with severe obesity and those with significant pulmonary or cardiac function impairment or significant hypertensive disease, and also other patients who do not have a responsible adult to accompany them to and from the office. Even with these exclusions, patients remaining will fall into ASA classes I through III.

4. *Monitoring* of the patients selected is predicated on the rigor of the exclusion criteria adopted in any individual practice. The more physiologic modalities to be monitored, the more the need for an independent observer such as a trained nurse. The maximum intensity of monitoring in a nonoperating room environment should encompass no more than four indirect modalities. The most informative are probably end-tidal CO_2 ($ETCO_2$), pulse oximetry (PO), blood pressure (BP), and single-channel ECG, in descending order of importance. Capnography, although the most useful early warning monitor of apnea, requires practice to obtain a usable trace in conscious patients who are not intubated. Nasal oxygen prongs attached to the sampling tube and secured with tape to the patient nose or lower lip are usually effective, but sometimes a small sampling catheter passed a little way into the nostril is required. One must determine whether the patient breathes primarily through the mouth or nose. If the surgeon is alone, these monitors should be automated with easily visible and interpreted displays together with audible limit alarms that have distinctive sounds and an audible beat-to-beat monitor on the pulse oximeter. Any patient who requires more than this should be cared for in a hospital operating room under formal MAC.

Such automated monitors are not cheap, but their costs are dwarfed by the costs of chronic dependency following a patient accident. The purpose of these monitors is to detect the occurrence of one of the four common clinical scenarios that may result from patient sedation:

(1) The onset of apnea ($ETCO_2$ first; PO later).

(2) Hypoventilation leading to hypoxia (PO first - $ETCO_2$ may not trigger its apnea alarm).

(3) Hypotension or cardiovascular collapse (BP first ± ECG and PO).

(4) Dysrhythmia (ECG ± PO).

In each situation, if the PO alarm sounds, *it is a late warning* because desaturation is already occurring, requiring immediate response. The types of monitors used in operating rooms are robust but bulky and may not be ideal for the more limited space in clinics and offices. However, recently, miniaturized compact "compound" monitors designed for transporting patients in hospitals have become available; these may prove far more suited to the office environment.

5. *Technique* and the choice of sedatives and analgesics to be used is very much a question of personal preference and experience. It is probably far more important to be intimately familiar with the scope and limitations of the pharmacology of a few drugs rather than to have a wide variety of less well understood techniques available.

The object of the procedure is to establish good analgesia with whatever local anesthetic technique has been chosen and then to sedate the patient to a satisfactory level. Although sedation may be established first, it is then very difficult to judge whether satisfactory local anesthesia has been achieved. But what is satisfactory sedation? The reader will appreciate that any agent capable of achieving satisfactory sedation is also capable of achieving general anesthesia if given in sufficient quantity. Therefore the final point lies somewhere on the continuum between normal consciousness and stage 4 general anesthesia. Since stages 2 through 4 are inimical to patient safety outside the operating room environment, stage 1 or lighter anesthesia should be the objective for office procedures. The patient should be conscious, able to respond to commands, with some degree of amnesia and systemic analgesia. The onset of snoring, irregular breathing, the loss of swallowing and the ability to handle secretions, confusion, and increasing reflex activity all suggest that the patient is becoming too sedated. Therefore the surgeon should establish a satisfactory local anesthetic and then pause to induce and confirm an appropriately stable level of sedation before proceeding further. If, during the procedure, further sedation appears to be required, it should first be established that the local block is still effective. It is the administration of supplemental doses of sedatives and narcotics during the procedure, when the surgeon's attention is concentrated elsewhere, that most often leads to overdose. The surgeon should also guard against the patient who appears to be properly sedated during a stimulating procedure but lapses into a dangerous state of sedation during recovery when the stimulus is removed. The elderly patient is particularly at risk, and it raises the need for monitoring into the recovery period.

In one cross-over study of the use of sedation in out-patients (Lundgren and Rosenquist, 1983), 85% of patients preferred sedation with local anesthesia over local anesthesia alone. Patient satisfaction is reported to be higher with more profound sedation irrespective of the route of administration (Lundgren and Rosenquist, 1984). However, increasing sedation leads to increasing ventilatory depression and risk for the patient; therefore the use of supplemental oxygen via nasal prongs should be considered as a routine. Of patients in one study who did not receive supplemental oxygen during local anesthesia with sedation, 40% showed clinically significant oxygen desaturation (White et al, 1989); hypoxia also occurred in some patients receiving only local anesthesia. Information concerning the relative safety of different techniques is scarce; however, one large review of outpatient procedures (Federated Ambulatory Surgery Association, 1986) involving more than 83.000 cases reported the following general incidence of postoperative complications:

Local anesthesia only	1/268
Local anesthesia with sedation	1/106
General anesthesia	1/120
Regional block	1/277.

Many drugs and drug combinations are being used for the sedation of surgical patients. The most popular techniques are probably those involving the use of combinations of benzodiazepines (eg, diazepam, midazolam) and opioid analgesics (eg, fentanyl, sufentanyl). Certainly among anesthesiologists involved in performing MAC, the midazolam/fentanyl combination has achieved considerable popularity. But even with an anesthesiologist in attendance and one who is free to concentrate on achieving a safe level of patient sedation, a recent study (Bailey et al, 1990) has sounded a note of caution.

More than 80 deaths in the USA have been reported to the Department of Health and Human Resources (DHHS, 1989) associated with the use of midazolam in sedating patients during various diagnostic or therapeutic medical and surgical procedures. Most of the deaths occurred in patients who were breathing spontaneously, usually without supplemental oxygen. In many cases opioids had also been administered. However, similar accidents may be expected with any combination of depressant drugs injudiciously used, whether opioids with the older barbiturate sedatives or the newer ultra-short-acting combinations such as propofol and alfentanil. The latter combination, although effective and gaining widespread acceptance amongst anesthesiologists for MAC, should under no circumstances be used by the surgeon working alone. The combination is administered most effectively as a continuous IV drip, which requires continuous informed attention because complete general anesthesia may be achieved with ease and speed.

In conclusion, surgeons working alone should limit themselves to a few drugs with which they are familiar, should supply supplemental oxygen for all patients undergoing sedation, and should insist on appropriate monitoring. If a trained nurse is available to watch the patient during the procedure, so much the better. It is prudent to select procedures that require only one episode of sedation so that surgeons can be certain that appropriate levels of sedation have not been exceeded before they concentrate on surgical manipulations. Where the length or nature of a planned procedure is such that continuing adjustment of sedation is likely to be required, it is probably wiser to schedule such a patient for formal MAC with the assistance of an anesthesiologist.

General anesthesia

Despite the availability of a rapidly increasing variety and number of anesthetic drugs, general anesthetic techniques can still be divided into two broad categories: single-agent techniques and balanced techniques. The fundamental difference between the two categories lies in the use of muscle relaxants to diminish or abolish skeletal muscle tone.

A single agent can achieve all three properties of the anesthetic triad, but profound degrees of skeletal muscle relaxation are achieved only by a relative overdose of the agent in comparison to that required for narcosis and reflex suppression. This means that maintenance of the circulation becomes more difficult with greater degrees of muscle relaxation. The problem is overcome with muscle relaxant drugs. These drugs, however, mandate the full control of the patient's ventilation with an endotracheal tube and, by definition, convert the normal negative intrathoracic pressure to positive with the associated implication for venous pressure and surgical field oozing. With single-agent anesthesia, spontaneous respiration through a mask or endotracheal tube can be maintained, albeit with some intermittent support of ventilation for the longer surgical procedures to minimize peripheral lung gas absorption collapse. Even with spontaneous respiration, however, the problem of oozing in the surgical wound is not completely overcome because the anesthetized respiratory center requires a higher driving tension of carbon dioxide than normal (45 to 55 mm Hg as opposed to 38 to 42 mm Hg), and hypercapnia itself can lead to increased oozing. Since otolaryngology - head and neck surgery always requires a secure airway, an endotracheal tube is indicated for most procedures anyway, no matter which type of technique is being used. Thus the choice of preferred technique for surgery, in the absence of specific patient medical problems, is reduced to a consideration of a few general advantages and disadvantages in different surgical situations.

Singe-agent technique	**Balanced technique**
1. Simple: reduces number of potential adverse reactions to drugs	Complex: more drugs, more potential adverse reactions
2. Control of circulation more difficult; patient usually requires fluid "loading"	Can be tailored to maintain circulation more easily
3. Cardiac dysrhythmia with exogenous catecholamines more common	Can be tailored to minimize catecholamine dysrhythmias
4. Nerve stimulator use unaffected	Response to nerve stimulator abolished or diminished
5. With stable state, patient immobility can be nearly guaranteed	Even with blockade monitoring, patient immobility cannot be guaranteed without excessive paralysis

6. Muscle relaxant reversal not required	Muscle relaxant reversal required; may be incomplete and "re-curarization" can occur postoperatively
7. Anesthetic effects completely reversible as long as patient is breathing with a clear and renal excretion,	Excretion of intravenous drugs depends primarily on airway liver which may be impaired
8. Awareness during anesthesia extremely rare	Awareness occurs
9. Spontaneous respiration an option with or without a mask	Controlled respiration; use of mask ill advised
10. Particularly suited to initial management of difficult airway	Contraindicated for initial management of difficult airway
11. Involves use of halogenated hydrocarbon agents	Volatile agents can be excluded with hepatitis risk
12. Increases cerebral blood flow and intracranial pressure	Can be used to decrease intracranial pressure
13. Associated risk of malignant hyperthermia	Can be tailored to avoid known triggers of malignant hyperthermia.

These are the major considerations that influence the selection of technique. The list is not exhaustive because specific diseases may favor choice of the technique opposite to that which might be chosen for a healthy patient undergoing the same surgical procedure. A knowledge of the general approach that anesthesiologists use in choosing anesthetic technique should, however, assist the surgeon in anticipating problems in individual patients during the initial outpatient visit. This assistance should in turn permit the surgeon to consult with the anesthesiologist earlier than the preoperative visit in order to avoid any last-minute cancellations and delays, which, in the minds of patients, always diminish the reputation of those physicians involved.

Discussing the pharmacology of each anesthetic drug is not possible in a general chapter such as this, therefore the reader is referred to a standard anesthetic textbook for the answers to questions of detail concerning individual drug dosage, precautions, and usage (Vickers et al, 1991).

Special Anesthetic Techniques

Microsurgery of the ear

When using an operating microscope, the otologist requires a patient who remains still and a relatively bloodless field, and he or she must consider the possible effects of nitrous oxide in the anesthetic carrier gas mixture. The operating microscope magnifies everything it sees. The slightest patient movement becomes an earthquake; blood oozing into the field looks like a flood. Therefore the anesthesiologist must pay particular attention to providing an adequate depth of anesthesia, in the case of a single-agent technique, or an appropriate level of muscle blockade, in the case of a balanced technique, to ensure that the patient does not move.

To prevent significant oozing into the wound, meticulous attention to the airway is required in order to avoid an inadvertent positive end-expiratory pressure. Airway pressure should equal atmospheric pressure during the end-expiratory pause, whether the patient is breathing spontaneously or being ventilated, in order to avoid a raised venous pressure. Venous drainage from the area can be facilitated by a slight head-up tilt of the patient, but this increases the risk of occasional air embolism from the wound. If this position is adopted, the standard precautions of a chest Doppler and a central venous line for aspiration are suggested. Expired carbon dioxide and nitrogen analysis will also give warning of the condition. With any technique, allowing the blood pressure to fall somewhat from normal values is useful when this is deemed safe for the individual patient. Some surgeons and anesthesiologists believe that formal controlled hypotensive techniques have much to offer in improving the operative field further. In the shorter operations on the middle ear - such as tympanoplasty, in which oozing may lift a technically successful graft - the shorter-acting agents such as sodium nitroprusside or trimethaphan, given by intravenous infusion, are indicated. When a longer operation on the structures of the inner ear and neural canals is contemplated, better conditions can be maintained with the older, longer-acting ganglionic blockers such as pentolinium.

Air under pressure in the closed middle ear cavity is usually vented passively through the normal eustachian tube. Nitrous oxide in the anesthetic carrier gas mixture, although relatively insoluble in blood, is still much more soluble than nitrogen, the major constituent of air. Therefore, more nitrous oxide molecules will present themselves in the walls of the cavity and slide down the diffusion gradient into the contained gas than can be compensated for by the removal of nitrogen molecules down their own diffusion gradient by the same blood. In fact, for every molecule of nitrogen leaving the cavity, 10 molecules of nitrous oxide are available. With time this net increase in molecules leads to increasing intracavity pressure. If for any reason normal passive venting is impaired, pressure can rise rapidly to levels that can rupture the normal tympanum and disrupt tympanic grafts. Since nitrous oxide is a relatively insoluble gas, its uptake and washout from the blood is rapid. Turning the gas off approximately 30 minutes before a tympanic graft is placed is, therefore, usually sufficient to avoid the problem.

Also, the rapid diffusion of nitrous oxide out of the middle ear cavity may cause subatmospheric pressures and retraction of the tympanum or graft. Occasional cases of irreversible sensorineural hearing loss in patients who have undergone previous stapedectomies have been attributed to the pressure effects of nitrous oxide (Patterson and Bartlett, 1976). Of more recent interest are the possible beneficial effects of the agent in evacuating fluid from the middle ear and elevating retracted membranes preparatory to ventilation tube insertion.

Microsurgery of the larynx

When a laryngologist has declined to operate on a conscious patient, several methods are available for the management of general anesthesia. The major problem is the difficulty of securing the airway against contamination because of the close proximity of surgical activity. If a small standard cuffed endotracheal tube is used, normal inhalation techniques are feasible. However, the surgeon's access to the structures of the larynx is restricted, which may be unacceptable if work is to be done on the posterior vocal folds, where the tube comes to lie naturally. If laryngeal polyps are the reason for surgery, difficulty in working around the tube may be insurmountable, and some consider the risk of passing the tube through such a glottis in the first place unacceptable.

An alternative is the use of venturi jet ventilation as part of a balanced technique. Jet ventilation may be achieved by using a rigid injector protruding below the larynx and attached to the laryngoscope or by using the cuffed Carden tube (Fig. 13-9) placed below the larynx and independent of the laryngoscope. Each is attached to a high-pressure gas source, either oxygen or a nitrous oxide-oxygen mixture from a high-pressure blender, and intermittent pulses of gas are used to inflate the patient's lungs by means of a manual or automatic pneumatic switch. The high-pressure gas stream in theory entrains room air from the pharynx. In practice, entrainment is slight, and when a nitrous oxide-oxygen mixture is used, anesthetic tensions can be achieved. The patient must be fully paralyzed to facilitate ventilation, and the surgeon must ensure a clear expiratory pathway at all times to prevent pressure injury to the lungs. Intravenous adjuvants are used to ensure an adequate depth of anesthesia. The rigid jet used in modifications of the Toronto ventilating laryngoscope improves access in comparison with a standard tube but is still inflexible. The advantage of the Carden tube is that only the small cuff inflation tube and the jet tube protrude above the larynx, and since both are made of soft flexible material, the surgeon can lift them out of the way if necessary. With venturi jet techniques the surgeon must remember the risks of projecting blood and particulate matter into the unprotected tracheobronchial tree.

Laser surgery

The laser (the word is an acronym for "light amplification by stimulated emission of radiation") is finding an increasing number of applications as a tool for surgery. The lasers of particular interest in otolaryngologic surgery are the carbon dioxide laser, the argon laser, and the neodymium:YAG laser. Although each differs from the others in its physical properties and applications, the requirements for anesthetic management are similar:

1. Complete patient immobility to ensure that normal tissue is not hit accidentally.

2. Unencumbered surgical access to and visibility of the target area.

3. Protection of the patient from stray laser radiation or reflection.

When the use of a laser in the airway is contemplated, further precautions are needed:

1. Protection of the airway against blood and the products of vaporization.

2. Removal of smoke and debris.

3. Prevention of airway fires.

Although the use of lasers for stapedectomy, extirpation of base-of-skull tumors, and operations on the nose has been described, these applications must be considered under development, if not experimental. Applications in the airway, however, have already established the laser as an important treatment modality.

The need for absolute immobility demands the use of muscle relaxants and hence general anesthesia. The choice of the method of ventilation and the choice of the method for maintaining the airway depend on the site of the target lesion. The carbon dioxide laser is used with the microscope for susceptible lesions in the larynx. Here access for the surgeon is difficult, and two methods of ventilation are available: use of a small cuffed endotracheal tube or, if that restricts access to the lesion, venturi ventilation with the orifice of the injector attached to the laryngoscope sited below the cords. The positioning of the injector below the target minimizes the risk of blowing blood into the lungs, and the expired gases are very effective in removing smoke. However, the relaxed vocal cords balloon with ventilation, necessitating synchronization of surgical activity on the cords with the ventilatory cycle so as not to have to hit a moving target.

The use of an endotracheal tube introduces the risk of intratracheal fires. Initial efforts to minimize this risk involved wrapping standard tubes with dampened muslin or metallic tape to disperse or reflect the aberrant laser strike. This approach was not particularly successful because tubes still ignited. Energy would be transferred from the laser beam to the tube in the form of heat, and once the "flash point" for the material constituting the tube was reached, ignition occurred. The subsequent fire was fed by the anesthetic carrier gases, creating a reasonable facsimile of a blowtorch within the trachea. Different tube materials have been tried to minimize this risk, such as silicone and metal tape-wrapped red rubber, which do afford increased protection. However, it now seems clear that all-metal tube (Fig. 13-10) is the instrument of choice for ventilation (Norton and deVos, 1978). Even these tubes are not without problems because, with rough handling, metal burrs are created that can lead to direct trauma with placement, and the tube can still heat up with laser impacts and cause contact tissue burns. For full control of the airway a latex cuff is added, which can ignite. This risk is minimized by inflation with 1% aqueous lidocaine rather than air, so that if the cuff ignites and ruptures, the escaping liquid will tend to quench the fire and minimize any local tissue burn reaction.

For palliative procedures to relieve neoplastic obstruction of the trachea, when getting below the laser target is not possible, venturi ventilation through an uncuffed metal tube is indicated. For endobronchial procedures using an Nd:YAG laser through a fiberoptic bronchoscope, the airway may be maintained by using an old rigid ventilating bronchoscope with a Sanders venturi ventilation attachment (Sanders, 1967). If the patient already has a tracheostomy, the tube should be exchanged for a metal tracheostomy tube that has been suitably protected.

Additional general precautions are required for the conduction of laser surgery. Care should be exercised to ensure that the patient is electrically grounded. The patient's eyes should be protected with wet eye patches secured with canvas tape. The immediate area surrounding the operative site should be draped with wet linen towels. All personnel in the operating room should wear protective eye glasses appropriate to the laser, with side guards (See also Chapter 12.)

If in spite of precautions taken, a laser fire still occurs, the flow of anesthetic gases should be cut off and the laser discontinued immediately. The fire should be quenched with water held in readiness on the instrument table for such an eventuality. The standard therapeutic and respiratory support measures for severe airway burns must then be instituted (Schramm et al, 1981).

General endoscopy

The "paintup" technique discussed earlier for intubating the larynx in the awake patient is equally suited to laryngoscopy and bronchoscopy - although less so for esophagoscopy, because of patient discomfort. Therefore it only remains to add here a few points that can facilitate the technique. When the procedure is to be undertaken electively, starving the patient is wise because his or her reflexes will be obtunded and a light premedication with a benzodiazepine or barbiturate will facilitate the "paintup" if they are not contraindicated by an airway already compromised by disease. When the surgeon's practice requires large planned endoscopy clinics, the services of an anesthesiologist in preparing the second and subsequent patients while the surgeon is working speed matters considerably.

When the use of a topical technique is inappropriate, the following methods of management under general anesthesia are available:

1. *Laryngoscopy,* as far as the anesthesiologist is concerned, involves two types of surgical technique - suspension and manual. When the laryngoscope is suspended and manipulation kept to a minimum, venturi ventilation with or without a Carden tube is indicated, since it gives the surgeon the best possible access. The patient must be fully paralyzed, and maximum inflation pressures must be monitored with care. The surgeon must ensure a clear expiratory pathway at all times to avoid barotrauma to the lungs. Anesthesia is induced with a thiobarbiturate depolarizing relaxant sequence in the usual way, but the anesthesia is maintained with intravenous agents, since standard vaporizers cannot be used in high-pressure systems.

Should a "manual" laryngoscopic technique be used for diagnostic work, particularly when the surgeon is exploring the hypopharyngeal area, venturi ventilation should not be used, because intermittent interruption of the expiratory pathway occurs too frequently. If biopsies are being taken when the larynx is not in view continuously, the additional risk of blood contaminating the tracheobronchial tree has to be recognized. Therefore in this situation a small cuffed endotracheal tube is the best choice for securing the airway, with anesthesia being maintained by means of inhaled vapors.

2. *Bronchoscopy* allows four main variations in technique:

a. The rigid ventilating bronchoscope allows maintenance of anesthesia with a standard anesthetic vapor through a side arm with a 15-mm connector, which permits attachment to standard anesthetic circuits. Surgeons derive some protection from anesthetic gases by using glass eyepieces, but these must be firmly attached during positive-pressure ventilation, otherwise they can blow off into the eyes! An alternative is to use a Sanders venturi attachment and proceed with a balanced intravenous technique.

b. Fiberoptic bronchoscopy permits the passage of the instrument through the lumen of a standard endotracheal tube. This allows the airway to be secured against aspiration at all times while permitting standard anesthetic maintenance techniques. The connection between the circuit and tube is made with a right-angled swivel connector with a perforated rubber diaphragm that permits access for the bundle while maintaining a gas-tight seal. The limitation of the approach is the resistance to expiration, which is determined by the cross-sectional area of the instrument relative to the area of the lumen of the tube. Anatomy dictates the size of the tube lumen, but the size of the bundle is a matter of technology. The ability to manufacture ever-smaller fiberoptic bundles with satisfactory optical properties is improving rapidly, and now the technique may be considered even in small children.

c. Apneic oxygenation uses the principle of oxygenation by diffusion in a fully paralyzed patient. Intravenous drugs are used to maintain anesthesia. Once anesthesia is induced, profound hypocapnia is achieved with hyperventilation by mask. A small-gauge catheter is passed through the larynx to the carina under direct vision. A 1- to 3-L/min flow of oxygen is attached to the catheter, and the patient is turned over to the surgeon. The duration of uninterrupted access is limited only by the rate of rise of endogenous carbon dioxide to significant levels, as long as the patient remains fully paralyzed. The technique works well in patients without significant pulmonary disease, but the surgeon must be sparing and careful in the use of suction through the bronchoscope.

d. Deep inhalation anesthesia is another established technique; it is particularly helpful in small children. Anesthesia is induced, and the patient is allowed to breathe an anesthetic vapor in oxygen spontaneously. Any of the standard agents is suitable, but the most prolonged uninterrupted access to the airway is achieved with the highly blood-soluble, potent analgesic vapor of methoxyflurane. Anesthesia is taken to the deepest safe level. When the mask is removed, the surgeon proceeds while the patient lightens slowly, still breathing spontaneously. (Techniques c and d are both equally suited to flexible or rigid bronchoscopy.)

3. *Esophagoscopy* requires full control of the airway when the procedure is performed under general anesthesia. With a large, rigid esophagoscope, some difficulty may be experienced in passing the instrument past the posterior tracheal bulge of the tube cuff. Therefore the anesthesiologist should be ready to deflate the cuff transiently to assist the surgeon. As the instrument passes the arch of the aorta, an occasional patient will develop profound reflex bradycardia requiring intervention. However, the major risk is perforation of the esophagus, so the patient must remain immobile. Some surgeons maintain that if the patient is breathing spontaneously, the residual muscle tone, particularly in the inferior pharyngeal constrictor, permits them to judge more accurately the amount of force they are using to pass the instrument.

The mentally retarded patient

Otolaryngology is one of the specialties that involves frequent contact with mentally retarded patients. Mental retardation is often associated with congenital abnormalities resulting in multiple otolaryngologic problems, particularly with hearing.

Anesthetic evaluation of these patients is frequently difficult. The history obtained is often sketchy and unreliable, and a disproportionate reliance must be placed on the opinions of available lay observers. Rapport may be impossible to establish, and the physical examination can bear more resemblance to a wrestling match than a dignified medical procedure. Nonetheless, associated congenital deformities of the cardiovascular system, airway, and skeletal system must be identified, if present, in order to formulate an anesthetic plan. It is particularly important in institutionalized patients to remember their high exposure to infectious hepatitis, necessitating liver function studies preoperatively.

The anesthesiologist should develop a healthy skepticism concerning the adequacy of the standard preoperative safety precautions in these patients. The retarded patient's stomach is never assumed to be empty, even when he has been starved. Some patient manage to thwart the efforts of even the most dedicated ward nurse, and a very interesting variety of objects, other than food, has been retrieved from their stomachs during the course of anesthesia.

Premedication also poses problems. Some form of sedation is usually indicated, but persuading the patient to take it is another matter. The severely retarded, like children, do not take kindly to needles, which should be reserved for use in the operating room. Many of these patients are already taking behavior-modifying medication, and enzyme induction is to be expected, with unpredictable implications for the effects of standard premedicant drug dosages. The standard drug mixtures may or may not work. I have come to rely increasingly on an orally administered combination of a butyrophenone (haloperidol) and a benzodiazepine (diazepam) mixed with a small amount of fruit preserve, if necessary, on the basis of trial and error only.

If the patient is tranquil on arrival in the operating room, the choice of anesthetic technique may be made in the usual way. However, if the patient is not cooperative, the problem of how to prepare the patient for anesthesia has to be faced. Reasoning with the patient is rarely an effective option. The surreptitious intramuscular use of ketamine (4 mg/kg), injected into whichever limb muscle may conveniently present itself for a few seconds, is suggested. The niceties of removing clothing and of skin preparation prior to injection may have to be dispensed with in the face of patient counterattack. The assistance of able-bodied operating room staff is invaluable. Once the drug has taken effect, monitors and an intravenous infusion can be set up and a modified anesthetic induction begun. Because of the possibility of a full stomach, cricoid pressure should be used with all such inductions.

Some retarded patients frequently swallow foreign objects and, consequently, make frequent visits to the hospital. The anesthesiologist experiences brief glory if he or she is able to retrieve a foreign object from the hypopharynx at induction without surgical assistance. The anesthesiologist must be aware of the possibility of hypopharyngeal location to avoid pushing the object into a less favorable position. Multiple visits of this nature should not lead the patient's attendants to relax the normal standards of care. These patients are rarely legally competent, so time should be taken to ensure that the person signing the consent is the legal guardian and not merely the patient's custodian.

Cancer surgery

The only factors that justify the separate consideration of anesthesia for cancer surgery of the head and neck are the propensity for large blood loss and the requirement for fine dissection around nerves and vessels. These factors necessitate an increased capacity for intravenous infusion and the more direct measurement of blood pressure; in addition, the use of controlled hypotension may be considered in order to limit blood loss and provide a drier surgical field. The use of controlled hypotension is still a matter of controversy even after some 50 years of experience (Enderly, 1975).

Many techniques have been described for the deliberate lowering of blood pressure under anesthesia (Larson, 1964), but only a few are suitable for use in head and neck surgery. The advantages claimed for the technique may be summarized as follows:

1. Reduced bleeding leads to better visualization of the field for fine dissection, especially with the shallow depth of focus on an operating microscope. This statement has two implications:

a. Better visualization diminishes the risk of accidental damage to important structures (for example, facial nerve in parotidectomy).

b. Better visualization encourages more definitive dissection, thereby improving the chances of success in cancer surgery.

2. Reduced bleeding reduces the need for blood transfusion, with its associated risks. This claim has been clearly substantiated for selected operations (for example, the commando procedure).

3. For some operations, reduced bleeding makes the "impossible" possible (for example, resection of a juvenile angiofibroma).

4. It is also claimed that reduced bleeding results in less of the surgeon's time being spent in securing hemostasis. This has a number of advantages. There is less necrotic tissue in the wound from diathermy use, less foreign material in the form of hemostatic ligatures, and less tissue handling in the first place. These factors are said to result in less wound infection and breakdown, and to lead to better wound scars. It is further claimed that the reduced time spent on hemostasis maneuvers results in shorter surgical procedures, but on this point the literature is equivocal.

5. The continuation of blood pressure control into the postoperative period is said to reduce the incidence of rebound hypertension and wound hematomas.

Before deciding to use controlled hypotension, one must set these advantages against the supposed risks for the individual patient. Those who have experience in the technique cite various contraindications, but one fact has been clear from the technique's inception:

institutions that use controlled hypotension frequently have a far lower complication rate attributable to the technique itself than those that use it only occasionally. The complications associated with the improper use of the technique are serious, and it should not be undertaken lightly (Hampton and Little, 1953). For the details of the various drugs and methods available, refer to the extensive literature on the topic. The remarks that follow will be confined to the general standard of care applicable to the use of the technique in head and neck surgery.

All patients require a large-volume line for fluid infusion and transfusion if necessary. A second, low-dead-space line is required for the administration of the potent hypotensive agents. The recent advances and general availability of sophisticated monitoring equipment now mandate the direct measurement of arterial pressure, as well as electrocardiography. Arterial blood samples should be taken at frequent intervals for blood gas analysis and hematocrit and hemoglobin-oxygen saturation determinations to confirm pulse oximetry. Core temperature should be monitored in all patients - although no measures should be taken to warm the patient actively, because of the risk of thermal burns over pressure points as skin circulation pressure falls. Particular care must be taken in older patients with atrophic skin, since mere body weight on pressure points will produce damage more quickly with controlled hypotension; placing a synthetic sheepskin under the patient is a suitable precaution.

Recent advances in the understanding of the changes that occur in ventilation/perfusion ratios in the lungs at low pulmonary perfusion pressures mandate the full control of ventilation with a cuffed endotracheal tube and intermittent positive-pressure ventilation by machine. To avoid excessive cerebral vasoconstriction, however, care must be exercised to maintain $PaCO_2$ at close to normal levels. This frequently requires an artificial dead space between the tube and the anesthesia circuit. Patients at the extremes of age are "vagal dominant", but those in between tend to respond to attempts to lower their blood pressure with a compensatory tachycardia. This may prove troublesome if it is allowed to become established, so beta-adrenergic blocking drugs are indicated early in the case. The availability of a fully staffed recovery room with nurses trained in the specific condition of the patient is a *sine qua non* of safe practice. The remaining points of technique are still a matter of opinion based on the anesthesiologist's personal experience.

From the point of view of the surgeon, it is suggested that the procedures most likely to benefit from controlled hypotension are the major cancer dissections of the head and neck, the fine dissection required with operations on the parotid gland, and a few ear procedures, such as tympanoplasty. The classic indication is the intranasal juvenile angiofibroma. All these operations require a reduced blood pressure held stable for an extended period of time. This requirement is best met with longer-acting ganglionic blockers and with a slight degree of head-up tilt on the operating table.

The surgeon should be cautioned, however, that arteries still bleed profusely when cut and that tissues are more susceptible to injury from careless handling. In particular, the surgeon must guard against "retractor ischemia" when nerves or vessels are retracted. The technique has much to offer the competent surgeon but will not improve pedestrian efforts.

Difficult airway

Attorneys tell us that the anesthesiologist is the hospital's expert in the management of the airway. Unfortunately, nothing is quite so humbling for our expert than finding that, having induced anesthesia, he or she is unable either to ventilate the patient by mask or secure the airway with an endotracheal tube. Luckily the truly difficult airway is rare, but since death or serious morbidity may result from mismanagement, the anesthesiologist is obliged to master the several techniques that may be used to avert disaster. Anesthesiologists working in otolaryngology have more than their fair share of difficult airways to contend with, but at least they are working with surgeons who are skilled in tracheotomy.

It is useful to divide patients with airway problems into three distinct groups in order to discuss their management:

1. Patients in extremis with severe airway obstruction and hypoxia. These patients will have accompanying hypercapnia, delirium, or unconsciousness. The situation is an emergency, and cardiac arrest will occur if the airway is not cleared immediately.

2. Patients with respiratory distress. These patients represent the largest group requiring anesthesia. They may exhibit stridor, tracheal tug, intercostal retraction, labored breathing, and agitation. Although increasingly fatigued, they are able to compensate sufficiently to maintain adequate oxygenation and remain alert and cooperative.

3. Patients with occult impending obstruction. Such patients volunteer little information in their history to suggest airway difficulties, and a cursory physical examination reveals little to warn of the management problems that are to follow the induction of anesthesia.

The management of the first group is self-evident. Oxygenation must be reestablished immediately. If the patient is unconscious and relaxed, it is worthwhile to use a few seconds to attempt rapid laryngoscopy and intubation, but no time should be wasted. If intubation is obviously not going to be easy, the surgeon or anesthesiologist should perform an immediate cricothyroidotomy to reestablish the airway before moving the patient to the operating room for formal tracheotomy. (It is exceedingly rare that a so-called emergency tracheotomy is done under unfavorable conditions by an inexperienced surgeon in the hospital environment.) If the patient is still moving some air into his or her lungs, laryngoscopy should be omitted, as this could lead to total obstruction. The patient should have his or her airway supported and be transferred to the operating room breathing 100% oxygen by mask. A cricothyroidotomy (Weis, 1983) is indicated should the patient's condition deteriorate in transit.

An alternative to cricothyroidotomy is transtracheal jet ventilation (Cummings et al, 1984). This technique requires access to a line with 100% oxygen at 50 psi and a Luer-Lok connector. The airway is controlled by puncturing the trachea or cricothyroid membrane with a 16-gauge plastic-sheathed needle. The needle is withdrawn, leaving the sheath in the trachea; the sheath is then attached to the high-pressure line, and ventilation is accomplished using a manual interruptor switch. As with any technique for emergency management, it must be practiced in a controlled setting, and the equipment must be available and personnel familiar with its use. This technique has proved valuable in the management of infectious and neoplastic obstruction of the upper airway and can be relied on to support ventilation for as long as 30 to 60 minutes while arrangements for more formal airway management are being undertaken.

The second two groups of patients permit the anesthesiologist and the surgeon the luxury of planning airway management in advance. The purpose of the management plan is to achieve full control of the airway to guarantee oxygenation while sealing it against contamination. The ideal method is to achieve control from above the larynx by inserting an oral endotracheal tube, under direct vision, into a relaxed anesthetized patient. This is assumed to cause the least trauma to both the patient's anatomy and psyche. This of course is the normal configuration for the majority of general anesthetics. However, when pathology intervenes, the patient's best interests may be served by deviations from the ideal; the choices to be made are represented by the "decision tree" in Fig. 13-11.

If the problems involved are very severe, the surgeon may elect to do a tracheotomy under local anesthesia without an endotracheal tube. But this is less desirable than doing a tracheotomy after the protection afforded by an endotracheal tube cuff is in place, even in an awake patient. Similarly, visualized manipulations are always preferable to blind, and oral approaches are preferable to nasal, with their increased risk of damage to the structures of the nasal cavity and the posterior pharyngeal wall and associated bleeding. The height of folly is to undertake surgery under general anesthesia with a totally uncontrolled airway, but even this has been tried with the use of ketamine as the all-purpose single-agent anesthetic, and is the not uncommon result of the poorly conducted local anesthesia "standby" case. In the second group of patients - those with respiratory distress - it is the technical skill of the anesthesiologist that determines both the airway control plan and its success. In patients with occult impending obstruction, the anesthesiologist's diagnostic abilities in detecting that a problem is present in the first place are paramount.

Most occult problems result from subtle congenital anatomic abnormalities for which the patient compensates with muscular effort. The only clue to the condition may be a history of obstructive sleep apnea. However, under direct questioning the patient may admit only to early waking, and the true sequence of events is frequently obtained only from the patient's bedmate, who is awakened by heavy snoring and then hears the onset of obstruction or "choking", followed by the patient's awakening. The normal anesthetic induction abolishes all muscle tone and promptly precipitates complete obstruction, which, because of the anatomic abnormalities involved, is usually not amenable to the normal methods of reestablishing the airway. Premedication alone may be sufficient to precipitate the crisis. Besides congenital conditions, some carcinomas of the base of tongue behave in this manner, as does epiglottitis.

Having assessed the patient, the anesthesiologist must consider the means of achieving airway control. If the desirable condition is oral intubation under general anesthesia, alternatives have to be decided by a process of exclusion. Ludwig's angina, with its large upwardly swelling tongue, precludes the use of an oral tube, but passage of a nasal tube with fiberoptic visualization may be feasible. However, the leukemic coagulopathy resulting in a large tongue would also render any nasal intubation attempt unwise. Similarly, although micrognathia might preclude the desirable oral visualization of the larynx and the passage of an oral tube, blind nasal intubation may be easily achieved. Any friable hemorrhagic tumor above the larynx or a large pointing abscess in the pharynx would be an absolute contraindication to any blind technique and could dissuade most from visualized techniques as well. This would leave local anesthesia for awake tracheotomy as the only viable alternative.

Regardless of the approach chosen, certain precautions should be observed. Patients with airway compromise should receive no depressant premedicant drugs. The neck is prepared for tracheotomy before any intubation procedures are started. The patient is fully preoxygenated. The surgeon, fully scrubbed, remains in the operating room until the airway is secured by whatever means. If general anesthesia is to be induced, an inhalation technique is elected so that in the event of the development of difficulties in the maintenance of airway patency, the induction process may be reversed and the patient awakened. Once given, intravenous drugs cannot be retrieved in the face of developing obstruction. Sudden obstruction can still occur, and if a pharyngeal airway or rapid laryngoscopy does not resolve the problem, immediate tracheotomy is indicated. If the induction is successful, numerous methods are available to persuade tubes to pass into the trachea in various situations; these have been described elsewhere (Brown, 1985). The prerequisites of consistent success in the management of the difficult airway are, however, thorough preoperative assessment, good planning, and full cooperation between the anesthesiologist and the surgeon.

Postoperative Recovery

Patients recovering from general anesthesia traverse the stages of anesthesia in reverse and must be watched closely throughout the process. If the patient is still in the third stage, without an endotracheal tube or tracheostomy, continued airway support is needed. As stage 2 is traversed, muscle tone progressively returns and the patient becomes irritable and salivates, which can lead to coughing and swallowing. External stimulation should be kept to a minimum to avoid the risk of laryngospasm or vomiting (which are not mutually exclusive). In stage 1 the patient is rousable but in a state of analgesia. However, some time may elapse before normal mental faculties and spatial and temporal orientation are regained. It is during this period that the perception of postoperative pain first intrudes.

All forms of anesthesia potentially reduce cardiac output and peripheral vascular resistance. This leads to increased ventilation/perfusion mismatch in the lungs and a reduced PaO_2. Therefore, all postoperative patients must be supported with supplemental oxygen administered by mask (nasal prongs are not reliable without PaO_2 determination), giving an inspired oxygen concentration of at least 30% to 35%. This is equally true for patients who are still intubated and being ventilated. All patients benefit from humidification of the inspired gas, particularly those with an irritable airway.

The effects of anesthetics on the circulation at the end of an operation may be masked by the release of endogenous catecholamines in response to the final surgical maneuvers. By the time the patient reaches the recovery room, the catecholamine response has usually subsided, exposing the true degree of anesthetic depression or inadequate fluid replacement. Both conditions can usually be treated with a fluid load rather than with vasopressors; it should always be remembered that blood pressure, even with adequate circulating volume, will not return to normal preoperative values until the initial phases of anesthetic recovery are complete.

Depression of respiration also continues into the recovery phase. Patients who have received a single volatile agent may be relied on to progressively return to normal as long as spontaneous respiration with a clear airway is maintained. This is not so true for patients undergoing a balanced technique, in which the timing of the last dose of muscle relaxant or narcotic drug is of importance. All nondepolarizing relaxants should be reversed with a mixture of anticholinesterase, such as neostigmine, and an anticholine drug, such as atropine, to block the undesirable muscarinic effects of the former. The reversal is effected by overriding the competitive inhibition of neuromuscular transmission. The degree of override is governed by the law of mass action, and the final balance in individual patients is unpredictable, although the nerve stimulator gives a useful indication. However, the reversed state is itself reversible, and changes in body temperature or pH can cause bound inactive relaxant drug molecules to ionize and become active again, leading to recurarization.

The surgeon should also be aware of the risk associated with the use of some of the antibiotics he or she may prescribe postoperatively. Most of the "mycin" antibiotics are weak muscle blockers in their own right and can act in synergy with residual anesthetic relaxants to a degree that poses a serious risk to the patient. If this situation should develop, rather than attempting reversal of the block with additional anticholinesterases, thereby incurring the risk of dual blockade, the anesthesiologist should reintubate the patient and ventilate him or her until normal excretion takes care of the problem.

The narcotics pose parallel difficulties in terms of circulatory and central respiratory depression, and injudicious use of additional postoperative analgesics can lead to profound depression. Therefore, the need for additional narcotics should be carefully evaluated, with small intravenous doses being given until the patient's overall clinical condition is better defined. If significant narcotic depression is suspected, narcotic antagonists such as naloxone may be used, but it must be remembered that the duration of action of the narcotic usually exceeds the duration of action of the antagonist, so late renarcotization can occur.

Once these potential "normal" emergence problems have been overcome, the patient's continued presence in the recovery unit is not justified. The following criteria are of use in determining patient's readiness for discharge to general care:

System	**Observation**	**Score**
Respiration	Patient is able to breathe freely	2
	Respiratory effort limited (splinting or dyspnea)	1
	Absence of spontaneous respiration	0
Blood pressure	Systolic pressure ± 20% of preoperative level	2
	Systolic pressure ± 20% to 50% of preoperative level	1
	Systolic pressure ± 50% of preoperative level	0
Consciousness	Fully alert and orientated	2
	Only rousable when called by name	1
	Auditory stimulus fails to produce response	0

Color	Normal "pink" mucous membranes and nail beds	2
	Discoloration - anything but pink or blue	1
	Frank cyanosis	0
Activity	Able to move all four limbs on command	2
	Able to move only two limbs	1
	Unable to move extremities	0.

The score for each section is summed, and patients having a total score in the range of 8 to 10 are considered ready for discharge to general care. It is unlikely that a patient can achieve a top score in four sections and a zero in the fifth; the one exception is the patient with chronic respiratory paralysis, in which case continued ventilatory support would require admission to intensive care rather than general care for initial convalescence.

Several additional factors must be considered in the discharge of outpatients. The patient must not only be stable, but also "street ready". Activity assessment must include the return of the postural reflexes required for standing and walking safely. Postoperative pain must be under good control. The patient must demonstrate the ability to micturate before discharge. Immediate postoperative surgical problems must be excluded, and significant nausea and vomiting must be controlled. Last but not least, the outpatient may be discharged only into the care of a competent adult for transport home and should remain under supervision at home for the first 24 hours following anesthesia.

Anesthetic Complications and Mortality

A recent survey of the English-language literature on anesthesia safety concludes that the risk of death attributable to anesthesia has dropped from 1 in 2680 to about 1 in 10.000 over the last 20 years (Davies and Strunin, 1984). Those who have studied the subject believe that all Western nations experience similar mortality rates. If this rate is applied to the approximately 20 million patients to whom anesthetics are administered annually in the USA, at least 2000 deaths may be anticipated. Put another way, the average practicing anesthesiologist will lose 2 or 3 patients to causes directly attributable to anesthesia during his or her practice lifetime. Some authorities have suggested, with the benefit of hindsight, that between 50% and 90% of these deaths could be prevented.

Studies of individual cases suggest that the causes of death may be attributed to three broad categories of factors: human factors, patient factors, and technology-related factors.

Of the three, human factors, such as failure to detect disconnection of the anesthetic circuit, are thought to play the decisive part in approximately 70% of the incidents reported. This belief has stimulated the rapid development of "smart", microprocessor-controlled monitoring and measuring devices to supplement the vigilance of the anesthesiologist. Patient factors, such as malignant hyperthermia and anaphylactic anesthetic drug reactions, are much rarer. Technology-related factors are involved in the incidents related to the quality of design and manufacture of anesthesia equipment. One by one, specific problems with anesthesia equipment have been identified and corrected until the equipment manufactured today is very much safer than that used even 10 years ago, but vigilance is still required because the more complex a machine is, the more prone it is to malfunction.

Serious complications of anesthesia by which the patient is not killed are rare but devastating because most involve variable degrees of hypoxic brain damage and the high medical costs of chronic dependency. The problem is not limited to short periods of anoxia associated with an acute airway or circuit accident but also included prolonged "suboxygenation", which may occur in several ways in patients of poor physical status undergoing major surgery. The line between adequate and inadequate tissue oxygenation may be very fine indeed, and the situation is not easily measured or monitored.

In spite of this depressing cataloging of serious problems, the average patient still has less chance of sustaining a serious injury from anesthesia than of being killed or seriously injured in a traffic accident.

Of more interest to the patient are the chances of experiencing the minor complications of anesthesia. Much work remains to be done to quantify the true incidence of these complications. Existing studies show a wide range of variation in incidence (Riding, 1975). This fact results in part from different patient populations undergoing different operations with varying anesthetic techniques, but it also appears to be related to differences in elapsed time between the end of anesthesia and the patient interview. For example, the reported incidence of postanesthetic nausea varies from 27% of patients interviewed within 24 hours of anesthesia to 70% of patients interviewed after 3 days.

The common side effects of general anesthesia that the patient should be warned of are as follows:

Complication	**Reported incidence**
Headache	2% to 60%
Sore throat	6% to 38%
Muscle pains (following suxamethonium)	0% to 100% (muscled males susceptible)
Nausea and vomiting	27% to 70%
Venous complications (following intravenous drugs)	1% to 11%.

In addition, minor complications associated with specific techniques or surgical procedures must be remembered. These complications can result from poor positioning and poor protection measures of the patient under anesthesia. Nerve compression (for example, ulnar) and stretching (for example, brachial plexus in the abducted arm) can result from poor positioning. Corneal abrasions from lack of adequate eye protection and careless mask technique, as well as jaw and neck pain from overforceful laryngoscopy and head extension, have been reported recurring source of patient complaint is minor damage to the teeth and lips associated with laryngoscopy. Most of these incidents can be prevented with care, but the patient should still be warned of their possible occurrence in advance.

The surgeon should be particularly aware of the delayed complications that may develop after the patient has returned to his or her care. Manipulation of the airway, whether by surgeon or anesthesiologist, is the commonest cause of laryngospasm and acute airway obstruction in the recovery room. Recurarization and renarcotization, leading to hypoxia, must always be considered in the restless patient. Restlessness is usually due to pain, blood loss, or hypoxia, in that order of frequency, but *it must be assumed to be due to hypoxia until proved otherwise.* The persistence of nerve compression paresthesia, hypotension, urinary retention, or altered mental status into the postoperative period must always be taken seriously. A careful watch should be kept for the appearance of postoperative pulmonary complications and the development of jaundice. Such occurrences always warrant the courtesy of consultation with the anesthesiologist concerned when they are first recognized.

As we grow older

The population of the Western world, and of the USA in particular, is aging. Increasing numbers of elderly patients submit themselves for both minor and major surgery each year. As life expectancy increases, so does the need for pharmacologic "servicing" of the chronic controllable medical conditions acquired along the way. Many elderly patients no longer die of a disease but rather of total physiologic systems failure in the face of one pathologic, or therapeutic, stress too many. When that stress is likely to be surgical in nature, it is usually the anesthesiologist who is expected to get the patient off the table alive.

The walking pharmacologic "minefields", who constitute an increasing proportion of our patients, are effecting a subtle change in the practice of anesthesia. In the past the anesthesiologist, having satisfied himself or herself as to the patients' safety, would then concentrate on creating good operating conditions and generally facilitating the rapid and efficient conduct of the procedure in the operating room. Today the increasing complexity of coexisting medical conditions and associated therapeutic agents is restricting the anesthesiologist's ability to comply with some of the surgeon's requirements. Surgeons are finding that anesthesiologists appear less accommodating about accepting patients who are not quite as well prepared medically as they might be.

This reluctance should not be attributed to the assertiveness of a young specialty; the smaller margins for error in the patients we now care for must be considered. For some reason it appears to be difficult for surgeons to grasp why setting up the monitors and completing the anesthetic induction process required for an octogenarian with serious multiple-system disease sometimes takes longer than performing the operation itself.

As patient present more and more complex anesthetic management problems, the practice of surgery will become less efficient and more costly in terms of operations completed per unit of time. This is the new reality, and to minimize its effects, every surgical specialty must make an increasing commitment to achieving the optimum medical preparation of its patients to avoid cancellations and delays of planned operations.

The elderly patient population presents another problem: how to care for the patient when surgery can offer no more. Already the careful management of acute, time-limited postoperative pain can succumb to the pressures of a busy schedule and exaggerated fears of narcotic addiction. The patient with chronic terminal pain may fare even worse. The surgeon should endeavor to enlist the aid of a pain clinic before the patient acquires the reputation of a troublesome surgical failure.

These examples of the increasing requirements for complex medical-surgical management and time for patient clinical care are occurring against the background of the tighter regulation of the permissible costs and scope of medical practice. To ensure the maintenance of minimally acceptable medical standards in the future, care of our patients will require a renewed commitment to the traditionally close cooperation between the otolaryngologist and the anesthesiologist.