The Difficult Airway in Head and Neck Tumor Surgery

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I. Introduction

The first public demonstration of ether anesthesia took place in the Bullfinch Amphitheater of the Massachusetts General Hospital in 1846. Dr. William Morton anesthetized a patient with diethyl ether while Dr. John Warren excised a vascular tumor from the left side of the patients neck and jaw. Anesthesia for head and neck tumor surgery was at the very beginning of surgical anesthesia.[1]

Since 1846, much has changed and yet much remains the same. While airway management in general and for head and neck surgery has undergone remarkable transformation and sophistication, it is still the airway which demands special focus. Now, as then, problems concerning the airway lead to some of the most frequent and major morbidity and mortality in head and neck surgery patients. Given the rapid progression and development of airway management it is important to periodically review some of these problems and to suggest some current solutions.

Detailed knowledge of tumor types, workup, and subtleties of tumor location may not initially seem important to anesthetic care but insofar as this understanding fosters a better grasp of airway anatomy and an appreciation of several factors such as tumor location, size, and vascularity which may relate directly to airway management, it is in fact critical.

From an epidemiologic and societal standpoint, head and neck cancer continues to be very prominent. Malignant tumors of the larynx, pharynx, and oral cavity rank sixth in overall incidence behind breast, colon and rectum, lung, uterus and cervix, and prostate and bladder. Squamous cell carcinoma composes 90% of head and neck malignancies. Adenocarcinoma, which develops in the major and minor salivary glands, is the next most common type. All other pathologic varieties comprise less than 1%. Patients with head and neck cancer are more prone to develop a second primary malignancy. Thus, the patient cured of cancer must remain under

surveillance for the rest of his life--to detect metastases as well as to detect a new malignancy.[2,3,4]

II. Basic Forms of the Difficult Airway in Head and Neck Surgery Patients

Airway management remains central to perioperative care. Over the past decade, the American Society of Anesthesiologists has conducted a closed claim study of anesthetic disasters and malpractice awards arising from them. Over one third of these were related to respiratory events, most occurring during the induction of anesthesia with failed intubation. Of these respiratory events, eighty-five percent resulted in death, either whole body or brain death.[5]

What is a difficult airway and how frequently is it encountered? The difficult adult airway can be attributed to problems with mask ventilation and/or problems with direct vision laryngoscopy and intubation.[6] Mask ventilation can range from zero difficulty to infinite difficulty and maneuvers necessary to maintain airway patency can range from simple jaw thrust to oro or nasopharyngeal airway placement and two person jaw thrust.

Direct vision laryngoscopy and intubation also ranges in difficulty from zero to infinite and can be independent of difficulties with mask ventilation. Cormack and Lehane have defined four grades of laryngoscopic view:[7]

Grade I: Visualization of the entire laryngeal aperture.

Grade II: Visualization of the posterior portion of the laryngeal aperture only.

Grade III: Visualization of the epiglottis only.

Grade IV: Visualization of the soft palate only.

While the frequency of each of these has been estimated [6], the potentially catastrophic episodes of either unsuccessful intubation (cannot intubate/can ventilate) or failed intubation

with inability to ventilate (cannot intubate/cannot ventilate) occur quite infrequently, about 0.05-0.35 and 0.0001-0.02%, respectively.[8],[9],[10],[11] In these situations it is interesting and instructive to note that the incidence of airway complications appears to strongly correlate with the degree of *anticipated* airway difficulty.[12]

III. Recognition of the Difficult Airway

Central to our management of the difficult airway is being able to recognize it. It has been estimated that 90% of difficult intubations can be anticipated[13] yet as many as 50% of these are not.[14] This disparity is probably the most frequent cause of catastrophe related to the airway. [8,13,15,16],

One of the first airway management goals in the head and neck tumor surgery patient is to detect obstructive symptoms. This is critical because if patients with subtle obstructive lesions become apneic, clinically obvious airway obstruction can be unmasked, mask ventilation can be difficult or impossible, and hypoxemia can rapidly ensue. It is for this reason that the detection of obstructive symptoms by history is especially important. Is the patient hoarse or stridorous? Hoarseness can be an early manifestation of glottic carcinoma but is often delayed with supraglottic or subglottic tumors. Stridor during forced exhalation frequently indicates upper airway pathology and inspiratory stridor may suggest very dramatic airway stenosis. In general, inspiratory stridor is indicative of a subglottic lesion, expiratory stridor a supraglottic lesion, and biphasic stridor a glottic lesion. Further, is there a history of sleep apnea, dyspnea, dysphagia, or odynophagia? Dyspnea from upper airway obstruction must be distinguished from chronic obstructive pulmonary disease, for which these patients are also at high risk. Flow volume loops may be useful in differentiating the two. Specifically, a decrement in the inspiratory portion of the flow-volume loop can indicate an extrathoracic lesion and a decrement in the expiratory portion indicates an intrathoracic one.[17],[18] Flow volume loops

can be especially useful in evaluation of the pediatric airway and specifically in the determination of a fixed stenosis versus a dynamic stenosis.

Many methods to recognize the difficult adult airway and to predict difficult tracheal intubation have been suggested. These include radiographic assessment[19] as well as assessment of oropharyngeal structure[20] or external anatomic airway structure.[21] None is flawless as a predictor of significant intubation difficulty. On the physical exam, there are four questions that must be considered in every patient coming to the operating room--especially in the head and neck tumor surgery patient who has pathology in or near the airway. [6] None is fail-safe alone but together they are powerful predictors of the difficult airway. [10]

1. How well can the patient open his mouth? Normal mouth opening is about 5-6 cm. Patients must usually be able to open at the mouth maximally at least 3 cm for successful laryngoscopy.

2. Can the soft palate, uvula, and faucial pillars be visualized? The ability to do so embodies the so-called "Mallampati test" and has been correlated with ease of laryngoscopy.[20,22 23] The Mallampati classes are as follows:

Class I: soft palate, uvula, faucial pillars visualized.

Class II: soft palate, faucial pillars visualized, uvula masked by base of tongue.

Class III: only soft palate visualized

While this examination alone does provide valuable information as to tongue size in relation to the size of the oral cavity and is a useful predictor of intubation difficulty, it has been associated with both false positive[24] and false negative[25] results and should not, by itself, be considered fail-safe.

3. What is the size of the mandibular space? This is the area from the inside of the submentum to the hyoid bone. If this distance is greater than 6 cm and the horizontal length of the mandible greater than 9 cm, the line of vision to the glottic opening will likely be

relatively straight (with sufficient room for the tongue to move into the mandibular space during laryngoscopy) and direct laryngoscopy probably easy.[23] If the mandibular space is small, the larynx is usually anterior, the curve to it therefore greater, and intubation more difficult. In general, 2 fingerbreaths or more bodes-well for successful intubation.

4. Can the patient assume the sniffing position, which is moderate flexion of the neck on the chest and extension of the neck about the atlantoaxial junction? Ability to assume the sniffing position is predictive of a relatively straight axis to the glottis.[26],[27]

In addition, other physical evaluations and tests are warranted in the head and neck tumor surgery patient. These physical examinations are crucial because a high percentage of head and neck malignancies can be seen or palpated by a careful head and neck evaluation. They include indirect mirror nasopharyngoscopic and/or flexible nasopharyngoscopic examination of the laryngeal cartilage, tongue base, and cervical soft tissue. [28] Depending upon the findings, fine needle aspiration of cervical lymph nodes, angiography, chest X-ray, CT scan, and magnetic resonance imaging may be necessary. Complete tumor mapping requires endoscopy under general anesthesia, including direct laryngoscopy, esophagoscopy, and bronchoscopy.[29] It should be understood that there is an approximately 10% incidence of synchronous malignancies in head and neck cancer patients.[30]

Radiographic study has played an increasingly greater role in the airway evaluation of the head and neck tumor surgery patient.[31] CT scanning is especially valuable in evaluating the size and extent of lesions and in detecting any erosion of the bony or cartilaginous structure. Axial plane images of a patient in a supine position can be difficult for the anesthesiologist to interpret, but improvements in CT software promise reconstruction in the sagittal plane in the future. In addition, three dimensional reconstruction with projection on a two dimensional screen has been developed and will only further improve the ability to more fully evaluate head and neck tumors. C-arm fluorography may also offer great promise in both airway and

head and neck tumor evaluation by revealing dynamic changes in the airway with inspiration, swallowing, and jaw and neck movement.[31] The MRI offers multiplanar views of cartilage and soft tissue and may be useful in evaluating tumor extension but it is expensive and this information is usually obtainable in other less costly and more expeditious ways.[32] Laryngography and plain film tomography are modalities that have largely been supplanted by CT and MRI technology.

The difficult airway in head and neck tumor surgery patients occurs in five general situations: the recognized difficult airway in both emergent and nonemergent settings, the unrecognized difficult airway in both of these settings, and the iatrogenic difficult airway. We have encountered case examples of all of these in head and neck cancer surgery patients during the past four years. A review of some of these provides a useful vehicle for discussion.

IV. The Recognized Difficult Airway: Nonemergent Setting

The most appropriate awake intubation technique in a given head and neck tumor patient may vary depending upon the specific problem, but whichever one is chosen the first goal in an awake intubation is to anesthetize the airway thoroughly and expeditiously. There are many ways to achieve this and only one method will be described here. After antisialagogue premedication, so that local anesthetics can better contact/remain upon the mucosa, one should begin about one-half hour prior to the planned intubation by having the patient gargle Dyclone (0.5% dyclonine HCl). One bottle can be split into four or five parts, with each gargled about one minute before it is swallowed. Next, if a nasal intubation is planned, place a cotton cylindrical swab impregnated with 10% cocaine into each nostril. Then start at the patients tongue and move systematically posteriorly while administering a dense cloud of atomized 4% Lidocaine which the patient can partially inhale. Alternatively, excellent topical anesthesia of the airway can be obtained with nebulized local anesthetics.[33]

Often adding to the time and difficulty of the awake intubation is the persistence of the gag reflex. Because pressure receptors are submucosal, spraying alone may not quiet this reflex. A very effective and safe way to overcome this problem is to block the lingual branch of the glossopharyngeal nerve at the lateral base of the tongue. The tongue can be held laterally with a 2 cm X 2 cm gauze patch exposing the lateral tongue base at its junction with the glossopalatine arch. The trough of this sweep, where the tongue meets the glossopalatine arch, is the target for local infiltration, performed with a 25 gauge spinal needle and 1-2 cc of local anesthetic. This block effectively quiets the gag reflex as it anesthetizes the posterior one third of the tongue and the vallecula.[6] Other approaches to glossopharyngeal nerve block have been suggested.[3,4]

With the ninth nerve blocked, attention can be directed at the sensory and motor supply of the larynx and trachea, the superior and the recurrent laryngeal nerves--branches of the vagus.

The superior laryngeal nerve (SLN) can be reliably and safely blocked by injecting local anesthetic through a 25 g needle just inferior to the greater cornu of the hyoid bone bilaterally. The goal is to block the internal branch which pierces the thyrohyoid membrane and provides sensation from the epiglottis to the vocal cords.

The segment of the upper airway that retains sensation following SLN block consists of the vocal cords, subglottis, and upper trachea - -innervated by sensory branches of the recurrent laryngeal nerve (RLN). The recurrent laryngeal nerve enters the larynx just posterior to the cricothyroid articulation and is best anesthetized by transtracheal injection. With the patients neck fully extended, the cricothyroid membrane is palpated in the midline and entered with a 20 gauge needle.

The key to successfully managing the difficult airway in the nonemergent setting is recognition by careful history and physical examination.

Case #1: Supraglottic Tumor of the Piriform Sinus. A 67 year old man presented to the head and neck surgery clinic with hoarseness and dysphagia of six months duration. He had an eighty pack-year smoking history and had lost 15 pounds since the onset of symptoms. Inspiratory stridor was noted bilaterally on chest auscultation. Significant on flexible fiberoptic laryngoscopy was a fungating, exophytic left piriform sinus mass approximately 6 cm in diameter. It did not appear to be hypervascular. Tumor extension was to the left false and true vocal cord, which was fixed. A panendoscopy and biopsy were scheduled to make a tissue diagnosis and to evaluate the extent of the lesion.

Airway Evaluation: Mouth opening 5 cm. Soft palate, uvula, faucial pillars visualized, Mallampati class I. Natural dentition, prominent upper front incisors. Three fingerbreadths between the submentum and the hyoid. Sniff position achieved.

Airway Pathology: The hypopharynx extends from the piriform sinuses to the posterior cricoid region. Lesions arising in the hypopharynx are most frequently located in the piriform sinus and can commonly grow to a size sufficient to cause airway obstruction. Delayed onset of symptoms coupled with a high rate of metastases contribute to the poor rate of long-term survival.[28] Presentation is most often characterized by a history of progressive dysphagia and odynophagia with the development of hoarseness usually being a late symptom. These lesions are not usually hypervascular and the central core can be avascular and necrotic.

Anesthetic Concerns: Airway obstruction with a tumor of this size and in this location is an obvious risk, especially with apnea. While these exophytic tumors are almost always friable and can be fractured and dislodged distally with instrumentation, they most often have a mucosal covering which somewhat protects against easy fracture or dislodgement. Nevertheless, whenever the larynx or pharynx are instrumented one must be aware of the possibility for significant bleeding.

Airway Management : Awake oral laryngoscopy. Topical anesthesia was established as described below. A Miller 2 blade was then inserted into the oropharynx and the full anterior and posterior extent of the vocal cords visualized. An 8.0 endotracheal tube was placed through the vocal cords, breaths sounds were bilateral with assisted ventilation, and the anesthesia bag was noted to move with inspiration. Narcosis was achieved with thiopental, fentanyl and isoflurane were added for amnesia and anesthesia, and a succinylcholine drip was used to facilitate rapid and quickly reversible relaxation. Several small biopsies were taken. Instrumentation of the airway was not excessive. When the patient responded to commands at the conclusion of the case and demonstrated good neuromuscular strength, he was extubated. His post-anesthetic course was uneventful.

Rationale, Critique, and Alternatives: Given the potential for airway obstruction with apnea, an awake intubation was an appropriate course. Awake oral laryngoscopy enables one to visualize and avoid disrupting a tumor in this location while keeping the patient spontaneously ventilating. A blind nasal technique could result in possible tumor disruption and considerable bleeding. A light wand technique would have the same theoretical disadvantage as the blind nasal approach, namely disruption of a potentially friable tumor. Blind intubation techniques would be relatively contraindicated in this setting. Awake fiberoptic intubation was an acceptable alternative. It was not necessary in this case, as the airway evaluation predicted.

As the above case underlines, tumors located in the airway often present obvious airway management risk. So, too, do those which while not actually located *in* the airway nevertheless *impinge* upon it externally.

Case #2. Large Goiter (Figure 1). A 45 year old 400 pound businessman presented with a longstanding goiter. He manifested symptoms of hyperthyroidism: palpations, sweating, anxiety, and a hyperdynamic circulation manifested by tachycardia and moderate hypertension. The serum thyroxine level was elevated. Preoperative fiberoptic

nasopharyngoscopy revealed normal vocal cord movement. The patient was scheduled for a subtotal thyroidectomy.

Airway Evaluation: Mouth opening 5-6 cm. Soft palate only visualized, Mallampati III. Natural dentition, normal sized incisors. Distance from submentum to hyoid difficult to assess secondary to tumor position and size. Sniff position not achieved secondary probably to tumor size.

Airway Pathology: Large goiters or cancers of the thyroid can be threatening to the airway by external airway compression, deviation, or distortion. Parathyroid adenomas present airway concerns that are frequently more theoretical than real. While a 60 gram adenoma was removed recently at the institution of one of us (NFJ), a mass three times the size of a normal thyroid, these lesions are usually sufficiently lateral so as to not compress or distort the airway. In contrast, a number of cancers of the thyroid can threaten the airway. These are primarily papillary and follicular cancers but occasionally are medullary, anaplastic, or lymphomatous. Such lesions can cause upper airway obstruction by local invasion of the trachea, softening of the trachea (tracheomalacia), mass effect causing distortion of the trachea, and through involvement of the recurrent laryngeal nerve. Involvement of this nerve may jeopardize an already compromised airway by causing additional narrowing at the glottic opening.

Concern about the status of the recurrent laryngeal nerve argues for routine preoperative indirect laryngoscopy to evaluate the vocal cords of all patients presenting for thyroid surgery and may be important for both medical and medicolegal reasons. Medically it is important to detect nerve palsy which may not be manifest by voice changes because of compensation by the nerve on the other side. This would emphasize the importance of special caution in terms of preservation of the contralateral nerve. Medicolegally, such evaluation demonstrates the presence or absence of nerve involvement preoperatively, a fact which is of importance in the evaluation of voice disturbance postoperatively.

Anesthetic Concerns: 1) Potential difficulty with standard laryngoscopy based upon the preoperative airway assessment 2) The risk of complete airway obstruction by extrinsic compression of the goiter 3) Obesity 4) Hyperthyroidism

Airway Management: Awake fiberoptic intubation. The patient was made euthyroid over a two week period. After thorough topical anesthesia to the upper airway but with no attempt to block the superior or recurrent laryngeal nerves because of the location of the tumor, an awake fiberoptic intubation was performed without difficulty. A large, presumed goiter weighing 180 grams was resected. The goiter proved to be papillary cancer of the thyroid. A total thyroidectomy was performed. The endotracheal tube was removed after the patient was fully awake and with neuromuscular function reestablished. No complications ensued following extubation.

Rationale, Critique, and Alternatives: An awake fiberoptic intubation was indicated. Awake fiberoptic intubation is a safe and expeditious approach to the airway in a patient of this type. It is unlikely given the airway examination that awake oral laryngoscopy would have been successful. Blind nasal intubation could have been performed but with the mass causing some compression and distortion of the airway, it may have been unsuccessful. A retrograde intubation was not a viable option given the size and location of the lesion. Light wand intubation would probably not have been successful due to inability to transilluminate neck tissues secondary to obesity and the location of the tumor.

As in these cases, if non-emergent obstructive symptoms are detected, or one has reason based upon the preoperative evaluation to suspect a difficult airway in the nonemergent setting, an awake intubation is appropriate. The usual options: blind nasal, awake oral laryngoscopy, fiberoptic, either oral or nasal, or awake tracheotomy by the surgeon.

Of the common options for performing an awake intubation direct laryngoscopy and fiberoptic bronchoscopy provide perhaps the greatest reliability. First introduced for this

purpose in 1967,[35] fiberoptic bronchoscopy has become central to airway management.[36] Success rates are high, 92% -98.5%.[37],[38],[39] Failure rates are low, 2.1%.[40] Other specific causes and cures have been addressed.[36,41]

Large, external lesions, especially in the midline, should engender caution with respect to airway management. So, too, should more lateral lesions. Until proven otherwise by direct examination, including awake laryngoscopy, they must be viewed as a threat to the integrity of the airway.

Case #3 Right Submandibular Mass (Figure 2): A 65 year old man was referred for evaluation from a local emergency room with a right neck mass. The patient had worn a full beard and it wasn't until a family member called attention to neck swelling that the mass was noticed. The patient denied dysphagia, hoarseness, or weight loss but, retrospectively, had right jaw pain for the preceding two months. He reported a long-term smoking history. On physical exam a right submandibular mass was noted. It measured 8 X 15 cm, was indurated, immobile, erythematous, slightly tender, and erosive through the skin centrally in a 2 X 2 cm area. On manual exam the base of the tongue was not involved. Examination of the hypopharynx and larynx were negative. The CT scan (figure 3)showed a 7 X 10 cm right submandibular mass eroding through both mandibular cortices at the body of the mandible and extending to the anterior cheek. Medially the tumor extended to the floor of the mouth and posteriorly to the retromandibular space. It was slightly hypervascular. There was no evidence of hypopharyngeal or laryngeal involvement and the vocal cords were not deviated nor apparently involved. The patient was scheduled for panendoscopy and biopsy.

Airway Evaluation: Mouth opening 6 cm. Soft palate, faucial pillars visualized, Mallampati II. Extremely poor dentition with front teeth missing and incisors badly decayed. Two fingerbreadths between the submentum and hyoid. Sniff position achieved.

Airway Pathology: The major salivary glands are the parotid, submandibular, and sublingual glands. Tumors of the salivary gland account for only 3% of all malignant and benign tumors.[42] As in this case, these tumors can be large and the associated swelling painless.

Anesthetic Concerns: 1) Unappreciated tumor extension, perhaps to the base of the tongue causing tongue fixation and difficulty with laryngoscopy and intubation 2) Tooth loss with laryngoscopy and panendoscopy, given very poor dentition

Airway Management: Awake oral laryngoscopy and intubation. Topical anesthesia to the oro and hypopharynx were established as noted above. Superior laryngeal nerve blocks were not performed. On the right side, the landmarks could not be palpated secondary to tumor extension. A recurrent laryngeal nerve block was performed, as described above. Awake oral laryngoscopy was performed with a Miller 3 blade. The vocal cords were visualized from the midline to the arytenoids. The anterior commissure was not seen. Anesthesia was induced with thiopental and, following the establishment of ventilation, succinylcholine administered. The patient was intubated without difficulty. A cheek incision was made and a biopsy obtained. Panendoscopy was negative. At the conclusion of panendoscopy, the right incisor was noted to be missing. It was retrieved during further laryngoscopy in the tonsillar fossa. The patient was awakened and extubated without difficulty. The biopsy revealed squamous cell carcinoma and more extensive surgical resection was planned.

Rationale, Critique, and Alternatives: Sometimes the "recognized difficult airway" proves not to be difficult at all--much to our relief. The anesthesiologist here believed that topical anesthesia and an awake intubation was indicated. The attempt to avoid the potentially catastrophic cannot intubate/cannot ventilate scenario justifies such caution.

Even with this concern satisfied, airway management should never be considered rote. In this case, for example, a decayed, dislodged tooth discovered during a routine check following panendoscopy proved to be as potentially dangerous as the large, ominous neck tumor.

Sometimes the recognized difficult airway can be so narrowed, tenuous, and threatening that any manipulation, even that required for an awake fiberoptic intubation or an awake tracheotomy, is hazardous. Other less standard, innovative approaches must then be considered.

Case #4 Pharyngeal Carcinoma with Metastases to an Old Tracheostomy Site:[43] A 65 year old man presented with marked inspiratory and expiratory stridor of several hours duration. He had a long-term smoking history and an 8 lb weight loss during the past few months. Significant on manual examination and nasopharyngoscopy was an approximately 1-2 cm hard, rubbery tumor of the oropharynx which did not apparently involve other hypopharyngeal, supraglottic or glottic structures. The CT, however, showed extensive tumor occupation of the anterior tracheal space from the larynx to the sternum. There appeared to be some intratracheal extension of the tumor, at least to the anterior tracheal wall. Respiratory distress was progressive over one to two hours of observation and semi-emergent surgical intervention was planned.

Airway Evaluation: Mouth opening normal, 6-7 cm. Soft palate, uvula, faucial pillars visualized, Mallampati I. Edentulous. Only one fingertip could be inserted between the tumor and the sternal notch. Sniff position inadequate.

Airway Pathology: This case, as well as more than one below, requires a knowledge and appreciation of pharyngeal anatomy. The pharynx is divided into three regions: oropharynx, nasopharynx, and hypopharynx. The anterior border of the nasopharynx is the nasal choanae. The posterior border extends from the hard and soft palates to the skull base. The oropharynx extends from the plane of the hard palate superiorly to the plane of the hyoid bone inferiorly. Laterally it encompasses the tonsils, tonsillar fossa, and faucial pillars. The hypopharynx extends from the plane of the hyoid bone above to the plane of the cricoid cartilage below and consists of three parts: pharyngo-esophageal junction (postcricoid area), pyriform sinus, and posterior pharyngeal wall. Approximately 90% of cancers of the oral cavity and pharynx are squamous cell carcinomas. While they represent about 3% of all

carcinomas in the United States, they represent nearly one-half of all cancers in some Asian countries.[29]

Anesthetic Concerns: 1) Conversion of partial (by the tumor) to complete obstruction of the airway (by edema and/or secretions) with upper airway or tumor manipulation 2) Risks of tracheotomy

Airway Management: Although transtracheal jet ventilation via one 12 gauge catheter was planned, the plan evolved into spontaneous ventilation via two transtracheal 12 gauge catheters followed by awake fiberoptic intubation. The patient was brought into the operating room with the surgeon standing by for a possible emergent tracheotomy. Pre-oxygenation and only minimal sedation were administered. After the tracheal lumen was entered with a small finder needle, a #12 g catheter was placed between the caudad end of the tumor and the sternal notch. Greatly improved spontaneous ventilation was possible, but to facilitate ventilation further a second #12 g catheter was inserted intratracheally beside the first.

The airway above the tumor was then anesthetized topically, a fiberoptic bronchoscope was passed through the nose, larynx, and tracheal stricture, and a 7.0 endotracheal tube was passed without difficulty over the bronchoscope and into the trachea.

The patient was taken intubated to the intensive care unit but returned several days later for laser removal of the intratracheal tumor and placement of a tracheal stent. His lesions were treated by radiation therapy.

Rationale, Critique, and Alternatives: This patient apparently had recurrrence of his tumor which involved both the oropharynx and pretracheal space. The case suggests that in some cases safe airway management involves the need to prophylactically guarantee the airway before attempting a definitive airway and avoidance of any manipulation or instrumentation of the pathology. It further demonstrates that anesthesiologists, who are generally skilled with transtracheal puncture and block techniques, can adapt these existing skills to secure a means to ventilate and oxygenate patients while more definitive maneuvers are performed.

The work of breathing through such large gauge catheters has been estimated[44] and suggests that while they don't constitute a definitive airway (because of large increases in the work of breathing) they do provide potentially lifesaving time to establish one. This is especially true if one uses the catheter to institute jet ventilation, the initial plan in the above case and one that was abandoned only when the patient demonstrated easy spontaneous ventilation after insertion of the #12 g catheters.

A number of transtracheal appliances are commercially available to assist placement of a tube through the cricothyroid membrane. Such percutaneous dilational tracheostomy devices may, however, lead to devastating complications especially by those unskilled in their use. Large bore catheters are probably safer in the hands of the anesthesiologist, who usually is skilled in the percutaneous needle cricothyrotomy to anesthetize the trachea.

V. The Recognized Difficult Airway: Emergent Setting

Sometimes time and circumstances simply don't permit a slow, deliberate approach to airway management in head and neck tumor surgery patients. Patients sometimes arrive at the clinic or the operating room in extreme respiratory distress; a life-saving airway is the goal and time is the critical factor. Case #4 represents an example of a case that had an urgency intermediate between purely elective and truly emergent.

The most common causes of acute airway obstruction are foreign body, infection, and trauma. Tumors are another cause, albeit relatively uncommon, for acute airway obstruction. Sometimes they have been ignored or only recently discovered by the patient, as in case #3 above, and sometimes they have been diagnosed and enlarge more rapidly than anticipated (Case #4) while awaiting further treatment.

Case #5 Piriform Fossa Tumor: 61 year old patient with known vocal cord squamous cell carcinoma with extension to the piriform fossa presenting in respiratory distress. The patient had been scheduled for a laryngectomy. He was stridorous, dusky, using accessory muscles of

respiration, and preferred a sitting position. The piriform sinus tumor was known to be large, exophytic, and friable. An emergency laryngectomy was planned.

Airway Evaluation: Mouth opening 5 cm. Soft palate only visualized, Mallampati III. Full dentition. Thick neck. Two and one half fingerbreadths between the submentum and the hyoid. Sniff position poor.

Airway Pathology: See Case #1.

Anesthetic Concerns: 1) Complete airway obstruction

Airway Management: Tracheostomy under local anesthesia

Rationale, Critique, and Alternatives: Emergency laryngectomies are fortunately very uncommon. They are often reserved for individuals with airway obstructing tumors presenting with an acutely compromised airway who have a known histologic tumor diagnosis (based upon previous panendoscopy and biopsy) and a negative metastatic workup who have previously consented to laryngectomy. One rationale for the emergency laryngectomy versus performance of a tracheostomy only is that tumor seeding and metastatic spread may be more likely with tracheostomy alone.

Options for establishment of the airway include awake oral laryngoscopy, awake fiberoptic intubation, rigid bronchoscopy, and local tracheostomy. Awake oral laryngoscopy and awake fiberoptic bronchoscopy are not appropriate in the setting of acute respiratory distress in a patient with a large, friable airway tumor. The patients thick neck, full dentition, and poor neck extension did not portend well for successful rigid bronchoscopy. A tracheotomy under local anesthesia permitted spontaneous ventilation and acceptable oxygenation, although tenuous, while a definitive airway was surgically secured.

Successful emergent tracheotomy often makes everyone breathe easier--the patient, the anesthesiologist, and the surgeon. Sometimes, however, the tracheotomy can *cure* acute airway obstruction and then later *cause* it (see Case #6 below); i.e. the tracheotomy can itself be the source of the recognized difficult airway in the emergent setting.

Case #6 Obstructed Tracheostomy Stoma. This 58 year old patient was rushed from the head and neck surgery clinic to the operating room with acute airway compromise. He was status post partial pharyngectomy and tracheostomy for squamous cell carcinoma of the right tonsillar fossa two years previously and had completed a course of radiation therapy. He had removed the intercannula from his Jackson tracheostomy tube about 2 hours ago. He was combative, cyanotic, in extreme respiratory distress, unable to adequately ventilate secondary to an obstruction distal to his tracheostomy stoma.

Airway Evaluation: Mouth opening not assessed. Mallampati class not assessed. Edentulous. Thin neck. Two and one half fingerbreadths between the submentum and the hyoid. Sniff position not assessed.

Airway Pathology: The exact nature of airway pathology in this case was unclear; the progression of edema (from a variety of causes) and/or presence of a foreign body are the most common etiologies.

Anesthetic Concerns: 1) Complete airway obstruction 2) Full stomach

Airway Management: 1) External oxygen by mask with only marginal increase in oxygen saturation from X to Y. 2) Suctioning of tracheostomy stoma with a flexible catheter resulting in momentary profound desaturation to Z_1%. 3) Attempted placement of anode tube in tracheostomy stoma again resulting in momentary profound desaturation to Z_2%. 4) An index finger was placed into the tracheostomy stoma, which stimulated a forceful cough and closed the airway so that the patient could build sufficient intrathoracic pressure to expel the foreign body. This resulted in the expulsion of 1.5 X 2.0 cm mass of hard, desiccated tissue which had obstructed the airway. Airway compromise resolved completely.

Rationale, critique, alternatives: The second and third steps above were performed in an effort to remove and/or bypass the source of the obstruction. A suction catheter may have solved the problem had it been related to secretions or had it dislodged a foreign body from the trachea into a mainstem bronchi. Passing an anode tube may have been successful had the problem been airway edema, a tracheal stenosis, or a mobile foreign body which could have

been pushed aside or into one of the mainstem bronchi. As it was, the patient experienced rapid and marked desaturation with each of these maneuvers. This strongly suggested a mass lesion which could not be bypassed or pushed distally. If an effective cough had not cleared the airway, perhaps the best course of action would have been to temporize with oxygen insufflation by mask while a flexible fiberoptic endoscope was inserted through the stoma and used to remove or advance any foreign body. It is unlikely a rigid scope could have been inserted orally because of the anatomic deformity of his cancer operation or through the stoma because of limitations presented by stoma size and the angles involved in entering it. A Heimlich maneuver with a finger in the stoma while positive intrathoracic pressure was generated may theoretically have been successful. Alternatively one could attempt to place a jet stylet beyond the source of the obstruction. In this way oxygenation and ventilation could be maintained while the airway was anesthetized and endoscopy undertaken. Success with the jet stylet was not likely though given the failure earlier to pass the the suction catheter. An inhalation induction followed by endoscopy was not reasonable here given the degree of airway obstruction.

In the case above the head and neck cancer patient presented with an airway emergency which was a complication of previous treatment. Sometimes these patients present with airway compromise that has origins independent of both previous disease and previous treatment.

Case # 7: Angioneurotic Edema (Figure 4): A 57 year old man presented to the emergency room with apparent progressive angioneurotic edema. He was two years status post resection of a cancer of the retromolar trigone. He was in extreme respiratory distress; stridorous, dusky, using accessory muscles of respiration, combative, and preferred the sitting position. His lips and tongue were massively swollen.

Airway Evaluation: Mouth opening 2-3 cm. Mallampati class not assessed. Poor natural dentition. Two and one half fingerbreadths between the submentum and the hyoid. Sniff position not evaluated.

Airway Pathology: Angioneurotic edema is an immune mediated, usually self-limited phenomena characterized by massive edema of the aerodigestive tract. It may cause life-threatening laryngeal obstruction.[45]

Anesthetic Concerns: 1) Complete airway obstruction

Airway Management: Emergent tracheotomy. If saturations are adequate, the patient should be escorted expeditiously with supplemental oxygen in place to the operating room by the anesthesiologist and the surgeon. The patient should be allowed to assume a position most comfortable for him, usually sitting. Sedatives should be avoided. Anxiety should be assumed secondary to hypoxemia, and drugs which may depress respiratory drive not administered.

In this case, the patient was deteriorating too rapidly for transport. The tracheotomy was performed in the emergency room.

Rationale, Critique, Alternatives: Swelling may have precluded adequate visualization of the glottic opening with standard laryngoscopy. Blind nasal or lightwand techniques would be less than optimal and potentially dangerous in this setting of massive airway edema. A fiberoptic technique would likely be too time consuming and inability to topically anesthetize the airway may have created difficulty for successful fiberoptic intubation.

As was done in this case, the surgeon can perform an emergency tracheotomy or cricothyrotomy--two of the oldest surgical procedures with track records of at least 3, 500 years--but with the patient often hypoxic and surgical conditions less than optimal, this is not always successful in averting hypoxic cardiac arrest.[46] In addition, the complications of these procedures are not trivial and increase 3-5 fold when performed emergently versus electively.[12,47,48,49 50]

Transtracheal or transcricothyroid jet ventilation[9,51] or a simple needle cricothyrotomy have demonstrated worth in such situations. They allow us to oxygenate and partially ventilate a patient while a surgical airway is created in somewhat more controlled circumstances. Transtracheal jet ventilation is quicker and simpler than percutaneous cricothyroidotomy or tracheostomy and permits effective ventilation. Such a device should probably be immediately available in every anesthetizing location.[9] Another simpler alternative is a 14 or 12 gauge intravenous catheter attached to the barrel of a 3 cc syringe and a 7.0 endotracheal tube connector and placed through the cricothyroid membrane. This may not allow us to ventilate a patient as effectively as we would like, but when connected to the flush valve of an anesthesia machine at 50 psi it may provide lifesaving oxygen while the surgeon secures a more definitive airway.

While these techniques may be lifesaving, they must be undertaken only with extreme caution. There are many complications (see below) but one of the most likely and devastating is jetting into subcutaneous tissue planes, causing massive subcutaneous emphysema. This would make securing an emergency airway by any means very difficult.

VI. The Unrecognized Difficult Airway: Nonemergent Setting

The need to carefully assess the airway of a head and neck surgery patient to anticipate a difficult intubation has been emphasized. If this assessment is incorrect we confront the difficult airway unexpectedly in either the emergent situation (the cannot intubate/cannot ventilate scenario as described above) or in the nonemergent situation (e.g. in the patient who cannot be intubated but <u>can</u> be ventilated).

<u>Case #8 Lateral Base of Tongue Lesion</u>: A 72 year man presented with a lateral base of tongue lesion. Presenting symptoms were dysphagia and oropharyngeal pain of 6 months duration. He had a 50 pack year smoking history. There was no history of dysphonia, hoarseness, or sleep apnea. An 8 pound weight loss had occurred over the preceding two months. On physical examination a hard, indurated, 2 X 2 cm mass was palpated at the lateral base of

the left tongue. On flexible nasopharyngoscopy the mass did not apparently involve either the lingual or laryngeal surface of the epiglottis. The CT exam confirmed this finding and showed no mandibular extension of the tumor.

Airway Evaluation: Mouth opening 4-5 cm. Soft palate only visualized. Mallampati III. Prominent upper front teeth and incisors with significant overbite. One and one half fingerbreadths between the submentum and the hyoid. Sniff position good.

Airway Pathology: Lateral base of tongue tumors are not usually obstructive and, especially on the left side, do not usually significantly impede oral laryngoscopy. However, if one underestimates the size of these potentially friable tumors and/or their midline extension the airway can be compromised.

Anesthetic Concerns: 1) Possibility of difficult intubation with only marginal mouth opening, Mallampati III, prominent teeth, significant overbite, and short distance between the submentum and hyoid

Airway Management: Induction of anesthesia was achieved with thiopental, mask ventilation, and Pavulon. The patient could be ventilated and oxygenated but, even after four attempts, could not be intubated. A blind nasal intubation was attempted three times without success. The fiberoptic nasal approach was successful in gaining access to the trachea but the endotracheal tube repeatedly became caught at the arytenoids, despite much maneuvering and manipulation to pass it through the glottic opening.

The answer in this case proved to be a modified retrograde intubation. A 0.25 cm diameter-125 cm length wire was obtained from the cardiac catheterization laboratory. A twenty gauge needle was inserted through the cricothyroid membrane and the wire was threaded through the needle and through the glottic opening in a retrograde fashion. The wire was visualized with a laryngoscope and extracted from the pharynx with McGill forceps. It was then used in an attempt to guide the endotracheal tube into the glottic opening. Despite several attempts, and, again, much maneuvering, the tube could not be passed into the trachea.

Success finally came when the retrograde wire was threaded through the suction port of a bronchoscope, which was used to visually follow the wire and facilitate access through the glottic opening to the trachea.[52],[53],[54] The endotracheal tube was then inserted over the fiberoptic bronchoscope. The possible role of the fiberoptic bronchoscope emphasizes the need for a long wire when retrograde techniques are used.

Rationale, Critique, and Alternatives: The following were options: First, wait until the neuromuscular block was reversible, reverse it with an anticholinesterase, and awaken the patient. Second, blind nasal intubation. Third, fiberoptic oral or nasal intubation. Fourth, tracheotomy. Fifth, retrograde intubation. The lightwand intubation technique was probably not appropriate in this setting of an intraoral tumor. With the immobility of the tongue the success of this technique would be lessened.

First described by Waters in 1963,[55] the retrograde intubation requires percutaneous entry through the cricothyroid membrane and passage cephalad of a guide for the endotracheal tube. A variety of needle sizes, wire, and catheter types have been used successfully. Causes of failure with the retrograde technique include the following: the use of too large an endotracheal tube, kinking of the tube, too much guiding catheter tension leading to tracheal tube impingement on the epiglottis, and laryngospasm in an inadequately anesthetized glottis.[56] Another cause of failure can be tumor distortion of the larynx, impeding the passage of the endotracheal tube over the wire. This can be addressed in the manner described above, with insertion of the proximal end of the retrograde wire through the suction port of the fiberoptic bronchoscope and then visually guiding the fiberoptic bronchoscope along the wire through anatomically distorted areas.

Lightwand intubation, not tried here, is still unfamiliar to many anesthesiologists. It involves transillumination of neck tissues to guide endotracheal tube placement with a guided-lighted-stylet. These techniques were developed in the 1950's but they remain relatively uncommon.[57],[58],[59] The success rates with "lightwands" compares very favorably with that of direct vision laryngoscopy for orotracheal intubation[60] and is even successful in the

management of known anatomically difficult airways, such as Treacher Collins and Pierre Robin syndromes,[61],[62],[63] However, the technique can be limited where laryngeal illumination is inadequate such as in cases of obesity, edema, or tumor but even in this setting relatively good success has been achieved.[64] It is relatively contraindicated in cases of intraoral or laryngeal tumor, airway compromise, or laryngeal trauma--as, in general, are other blind techniques.[65]

VII. The Unrecognized Difficult Airway: Emergent Setting

The unrecognized difficult airway in the emergent setting (cannot intubate / cannot ventilate) lead to airway management challenges that are as difficult as any.

Case # 9 Base of Tongue Lesion: A 100 kg. 62 year old presented with a base of tongue lesion. History was positive for long-term smoking and alcohol abuse. Presenting symptoms were dysphagia, odynophagia, and a 10 pound weight loss over the preceding three months. On palpation a base of tongue lesion was noted which was friable, ulcerative, and indurated. It was not possible to evaluate the full length of the base of the tongue, the vallecula, nor the epiglottis on manual exam. Fiberoptic nasopharyngoscopic evaluation was difficult secondary to poor patient compliance. The vallecula was not visualized. No CT evaluation was performed. He was scheduled for panendoscopy and biopsy.

Airway Evaluation: Mouth opening 6 cm. Soft palate, uvula, faucial pillars visualized, Mallampati I. Prominent upper teeth. Three and one half fingerbreadths between the submentum and the hyoid. Sniff position excellent.

Airway Pathology: Lesions on the lateral aspect of the tongue generally present no real difficulty for airway management. Base of tongue, and particularly large midline base of tongue lesions which may involve the vallecula, certainly can. Such tumors frequently extend to and fix the epiglottis.

Anesthetic Concerns: 1) Midline base of tongue lesion 2) Obesity

Airway Management: IV induction followed by oral laryngoscopy. No airway problems were anticipated preoperatively by either the surgeon or anesthesiologist. Narcosis and paralysis was achieved with thiopental and succinylcholine. Oxygenation and ventilation were maintained by mask and two attempts were made to intubate the patient, neither successful. There was considerable bleeding after the first attempt, probably from friable tumor in the region of the epiglottis.

A second anesthesiologist was called to attempt to intubate the patient and failed on two attempts to visualize the vocal cords or even the arytenoids. The problem seemed to be a larynx that was very anterior to the rest of the upper airway in an obese patient with unappreciated tumor extension to a fixed epiglottic area. Mask ventilation was established, the oropharynx suctioned, a stylet placed in the tube, the blade on the laryngoscope replaced by another type, and external laryngeal pressure established over the cricoid. During laryngoscopy, there was considerable bleeding and still no cord structures were seen.

The saturation suddenly began to fall: 70....60....50....40%. The ability to ventilate via mask was momentarily lost. The head was repositioned, jaw thrust was established by an assistant, and mask ventilation was reestablished. Momentarily, there was a return to acceptable saturations.

After four attempts by two separate laryngoscopists and with swelling and bleeding apparently progressive, the anesthesiologist asked the surgeon to create a surgical airway. His initial plan was a cricothyrotomy but with the patient now oxygenated and ventilated adequately by mask , he performed a tracheostomy over 5-10 minutes. The patient experienced no further complications or morbidity from either the tracheostomy, the attempted laryngoscopy, or the brief period of hypoxemia.

Rationale, Critique, and Alternatives: The preoperative workup was apparently inadequate. In the setting of an incompletely evaluated base of tongue lesion an intravenous induction with neuromuscular relaxation is questionable. Rigid tissue fixation or bleeding from the tumor often preclude successful oral laryngoscopy and intubation. Not all patients will

cooperate for thorough fiberoptic nasal pharyngoscopy, as was the case here, but their inability to do so, especially in the setting of a base of tongue lesion, signals the need for noninvasive evaluation such as a CT scan. A CT scan may have revealed the presence of what ultimately proved so difficult from an airway management standpoint, namely a large tumor occupying a significant portion of the hypopharynx and extending to and fixing the epiglottis. Intubation with standard laryngoscopy in this circumstance is predictably difficult.

Awake fiberoptic-endoscopy and intubation with the patient responsive and spontaneously ventilating would have been appropriate. Awake oral laryngoscopy after topically anesthetizing the airway would probably have been unsuccessful due to the friability of the tumor and the fixation of the tissues but it clearly would have alerted the anesthesiologist to the potential for airway management difficulty. An awake blind nasal technique may very well have been successful but may also have led to bleeding and further airway compromise. A lightwand technique, given fixation of the tongue and epiglottis, was inadvisable.

There are several other lessons, two of which deserve special attention. First, the anesthesiologist and otolaryngologist must always be ready to confront the difficult airway. In this case, neither of the two most experienced groups of physicians in airway evaluation recognized a difficult airway preoperatively. Second, one should never deny that there is a failure to oxygenate and ventilate a patient. Remember the adage: patients usually do not die from our failure to intubate them, they die because we can't stop trying (and therein do not ventilate them). Bleeding and edema are progressive with each attempted intubation and a patent airway can be lost if we continue unsuccessful instrumentation of it.

In the life threatening cannot intubate / cannot ventilate situation, three methods to ventilate and oxygenate the patient have recently been described: transtracheal jet ventilation (TTJV), the esophageal tracheal combitube (ETC), and the laryngeal mask airway (LMA).

Percutaneous transtracheal jet ventilation is highly effective, safe, and well-tested. Provided a high pressure oxygen source (50 psi) is available and the connections to it are prepared, a large bore catheter through the cricothyroid membrane is probably quicker, more efficacious, and safer than hurried surgical cricothyroidotomy or tracheotomy. In head and neck surgical patients especially, anatomic distortion of the trachea could obviously limit the effectiveness of this technique just as it could add to the safety and effectiveness of surgical cricoidthyroidotomy or tracheotomy.

The esophageal tracheal combitube may prove very useful in the presence of some types of lesions but not others. A relatively new device which can be used in esophageal and endotracheal positions, it is a twin lumen tube-- one resembling an endotracheal tube and the other an esophageal obturator airway. A proximal balloon seals the mouth and nose. A distal balloon seals either the esophagus or the trachea. It does not matter whether the ETC enters the trachea or the esophagus. If it enters the trachea, the tracheal lumen is used to ventilate the lungs. If it enters the esophagus, perforations in the esophageal lumen above the level of the esophagus allow ventilation of the lungs.[66]

The laryngeal mask airway was first described by Brain in 1983[67] and received FDA approval in 1991. A tube connects to an elliptical mask with an open center and an oval rim. With the patient anesthetized and with the head in a sniff position, the mask is inserted blindly into the pharynx. The cuff can now be inflated, forming a low pressure seal[68] around the larynx (usual positive pressure pop-off pressures are 15-20 cm H_2O) through which the patient can breath spontaneously.[69] The LMA works in approximately 90% of cases[3] but its applicability and usefulness in many types of head and neck surgery may be limited by anatomic distortion of the airway.

While such cannot intubate/ cannot ventilate episodes are obviously best avoided,[70] the incidence of cannot intubate/ventilate is 0.01-2.0/10,000 anesthetics[71,72,73,74,75] and because of the high associated morbidity, 50-75% of the cardiac arrests during of anesthesia, it further emphasizes the need for rapid action. This episode was a catalyst for the permanent

installment of a transtracheal jet system in this anesthetizing location. The available systems and their advantages, disadvantages, and costs have recently been reviewed.[9]

VIII. The Iatrogenic Difficult Airway

With the surgeon and anesthesiologist sharing the airway, there is usually greater airway manipulation and probably a greater risk of subsequent airway compromise. When this occurs, with compression, distortion, deviation, and edema of the airway dynamic rather than static processes, a patent airway one moment can be obstructed the next. Therefore, the iatrogenic difficult airway in head and neck tumor surgery patients is often an emergency, sometimes a life threatening one.

Such emergencies can be sudden and unexpected. For example, the most serious danger during any laser surgery is an endotracheal fire, the incidence of which is about 1.5% in patients undergoing laryngeal surgery with the CO2 laser[76]. Jet ventilation has been thought to represent one solution to the problem of airway fires, since there is no combustible endotracheal tube in the airway. Unfortunately, as this case shows, endotracheal tube fires but not necessarily airway fires can be avoided by the use of jet ventilation.[77]

Case # 10. Recurrent Vocal Cord Papillomata : A 35-yr-old man presented with recurrent vocal cord papillomata for laser ablation. He had hoarseness and dysphonia. On physical exam there were no intercostal muscle retractions or evidence of respiratory distress but indirect laryngoscopy revealed a moderately sized left vocal cord papilloma, encroaching somewhat into the laryngeal aperture.

Airway Evaluation: Mouth opening 6-7 cm. Soft palate, uvula, faucial pillars visualized, Mallampati I. Full natural dentition. Slight overbite. Three fingerbreadths between the submentum and the hyoid. Sniff position achieved.

Airway Pathology: The etiology of laryngeal papillomatosis is most often viral. Recurrence occurs because surgical treatment is not curative. Symptoms range from mild hoarseness to marked stridor and severe respiratory distress.

Anesthetic Concerns: 1) Airway obstruction with apnea 2) Risks to patient and OR personnel, especially corneal injury, with carbon dioxide laser use

Airway Management : Supraglottic jet ventilation. Anesthesia was induced with thiopental and vecuronium was administered for relaxation. The surgeon inserted an adult Dedo laryngoscope and jet ventilation was instituted via a 13 gauge needle inserted in the left light-carrier channel of the laryngoscope. A thumb controlled valve and 50 psi oxygen from the piped-in system powered the jet. Precautions against a laser strike were taken, including shielding the patients face with wet towels.

Despite these precautions, suddenly, bright blue and orange flames erupted from around the laryngoscope during lasering. Lasering was stopped and the patients blazing moustache was covered with wet towels. The surgeon was burned upon several fingertips and the patient was burned upon his nose, nasal rim, and periorally (figures 5, 6). Bronchoscopy revealed no carbonaceous material in the trachea. Muscle relaxation was reversed, the patient was awakened from anesthesia, and the recovery was otherwise unremarkable.

Rationale, Critique, and Alternatives: There are four common approaches to the airway in a case of this type: 1) Nasopharyngeal insufflation with spontaneous respiration. 2) Endotracheal intubation with a special laser tube or a red rubber tube wrapped in aluminum foil. 3) Jet ventilation with a cannula applied to a suspension laryngoscope.[78] 4) Apneic technique whereby a patient is intermittently intubated and ventilated and then extubated momentarily while the surgeon operates. 5) Intermittant ventilation via a mask.

Supraglottic jet ventilation is an effective way to oxygenate and ventilate patients undergoing laser ablation of certain glottic and subglottic tumors. The inability to safely deliver volatile anesthetics has largely been overcome by the emergence of short acting muscle relaxants, hypnotics, and opiates.

Laser excision of vocal cord lesions requires recognition of and respect for several concerns. First, it requires adequate laryngoscopic exposure. Second, it requires that no combustible objects come in the path of the laser. Third, it requires a special endotracheal tube if the patient is to be intubated.

The laser may be employed for definitive resection of selected minimally invasive T1 squamous cell carcinomas located in the mid to anterior vocal cord. Once the resection is complete, the intralaryngeal wound is allowed to granulate and a pseudocord forms. Laser surgery may also be useful to debulk larger tumors or in patients at high medical risk who have failed radiation therapy.

The size of the lesion and the presence of obstructive symptoms or respiratory distress are critically important in anesthetic management. In the presence of obstructive symptoms, regardless of the anesthetic methods chosen, the patient should not be made apneic with anesthetic drugs until the airway is secured. This may necessitate either an awake intubation with an endotracheal tube or intubating while the patient is spontaneously breathing nitrous oxide, oxygen, and a volatile anesthetic. Again, only if the lesion is relatively small, asymptomatic, and not encroaching upon the laryngeal inlet should the patient be made apneic before the airway is secured.

As this case demonstrates, airway fires can occur, even in the absence of endotracheal tubes. Emergent airway management steps include the following: stop ventilation, discontinue oxygen, remove the burning endotracheal tube, and extinguish the fire with sterile saline. Bronchoscopy should be performed to determine the extent of the damage and to remove any debris. Ventilation can be maintained with either bag and mask or a substitute endotracheal tube of small diameter, to minimize further airway trauma.

Anesthesiologists are trained to manage and solve airway management dilemmas and difficulties. Sometimes, however, we create or exacerbate airway difficulty.

Case # 11: Subglottic Hemangioma A three month old child presented with a one month history of stridor and an intermittent barking cough. Lateral radiographic study revealed subglottic swelling consistent with a hemangioma. The child was scheduled for endoscopic exam and possible CO2 laser treatment of a subglottic hemangioma.

Airway Evaluation: Neck extension normal. Mouth opening normal. Tongue size normal for age. No congenital abnormalities by history suggesting airway management difficulty. No retrognathia or macrognathia. No evidence of cleft palate, either open or submucous.

Airway Pathology: Laryngeal hemangiomas are congenital malformations of vascular tissue which most frequently occur in the subglottis. They appear in both infants and adults. Infants typically have stridor or "pseudocroup" within the first six months of life. A lateral radiograph of the neck reveals soft tissue swelling. Other symptoms include a barking cough, hoarseness, and failure to thrive. Unrecognized or untreated cases have a relatively high mortality from complete airway obstruction. Many therapies have been tried but expectant treatment, steroid therapy, or laser excision is favored.[79],[80]

Anesthetic Concerns: 1) Ensuring the adequacy of oxygenation and ventilation while providing the surgeon with a clear view and an immobile field[81]

Airway Management: Intermittent jet ventilation, percutaneous route. Surgery was uneventful and upon completion of the procedure, as the catheter was removed, the toggle switch on the jet was inadvertently depressed, resulting in jetting into the paratracheal tissue planes and a bilateral pneumothorax. Hypoxemia rapidly ensued. The trachea was intubated and bilateral chest tubes were required. The patient was discharged after 5 days in the hospital. There was no long-term morbidity.[82]

Rationale, Critique, Alternatives: The subglottic location of the tumor, its vascularity, and the need to provide an unencumbered surgical field argued for a technique involving either no endotracheal tube or only intermittent use of one. Further, jetting directly at the tumor would not be desirable. Therefore, since the tumor was subglottic but above the cricothyroid membrane

and not large enough to prevent the egress of jetted gas, the decision was made to institute jet ventilation via the cricothyroid membrane was appropriate.

Venturi jet ventilation allows for the achievement of many anesthetic and surgical goals for microlaryngscopy: a clear view, an immobile field, and good ventilation and oxygenation. Ventilation begins with pressures of about 30 psi in an adult and about 10 psi in a child. These can be adjusted based upon chest excursion. The inspiratory time is about 1.0-1.5 seconds, passive expiration about 5-6 seconds, and ventilatory rate 6-7 breaths / min.[72]

While we extoll the virtues of jet ventilation, we must also recognize its risks. In theory, the technique sounds almost fail-safe. In practise it can be associated with several major complications: pneumothorax, pneumomediastinum, massive subcutaneous emphysema, and gastric distension to name just a few.

Several varieties of high frequency ventilation have been described.[83] These include high frequency jet ventilation (HFJV)[84], high frequency positive pressure ventilation (HFPPV)[85], high frequency flow interruptors (HFFI)[86], and high frequency oscillation (HFO)[87].

Other options included:[88]

1) Insufflation of anesthetic gases at high flows. Disadvantages include motion of the vocal cords, inability to provide positive pressure ventilation, and high concentrations of inhaled gases to overcome entrainment dilution.

2) Apneic technique whereby a patient is intermittently intubated and ventilated and then extubated while the surgeon works.

3) Intermittent mask ventilation.

While there are often many options to manage the airway and safely anesthetize our patients, this case should remind us that there are frequently unexpected challenges and constant dangers.

Intraoperative or postoperative problems, as the previous and following cases demonstrate, can occur suddenly. The signs are clear and rapid action is required. Sometimes airway problems from head and neck tumors are delayed and therefore difficult to anticipate.

Case # 12. Glomus Tumor. A 43 year old female presented with a six week course of headaches and tinnitus. On physical exam there was no palpable neck mass but a bruit was audible over over the area of the left internal carotid artery. The patients left face was noted to be slightly drooping. Blood pressure and other vital signs were normal on serial checks. A CT scan revealed a 4 X 4 cm mass below the floor of the left middle ear near the temporal bone. Carotid arteriography and retrograde venography demonstrated a highly vascular lesion within the adventitia of the jugular bulb. Surgical resection of a suspected glomus jugulare tumor was planned.

Airway Evaluation: Mouth opening 5 cm. Soft palate and faucial pillars visualized. Mallampati II. Edentulous. Three fingerbreadths between the submentum and the hyoid. Sniff position achieved.

Airway Pathology: Glomus tumors were first reported and named by Guild in 1941[89]. They are a benign, highly vascular collection of epithelioid cells in or near the temporal bone in association with the adventia of the jugular bulb. About 80% occur in women.[90] Symptoms include unilateral pulsatile tinnitus, hearing loss, aural fullness, pain, vertigo, facial nerve palsy or palsies of cranial nerves V, VII, IX, X, XI, and XII.[79] Palsies of cranial nerves IX and X may predispose to patient difficulty in clearing secretions and increased susceptibility to upper airway obstruction. These tumors may secrete catecholamines and cause symptoms similar to those of a pheochromocytoma.[91]

Anesthetic Concerns: 1) Increased intracranial pressure secondary to tumor mass 2) Preoperative and postoperative aspiration and/or airway obstruction secondary to cranial nerve palsy from tumor compression or nerve injury from surgery 3) High blood catecholamine levels producing symptoms and risks similar to a pheochromocytoma as well as elevated cholecystokin levels which may impair gastric motility postoperatively 4) Intraoperative

blood loss from resection of these highly vascular lesions, which can be rapid and massive 5) Venous air embolism, especially if the procedure is performed in the sitting position 7) Patient temperature and specifically hypothermia during 8-15 hours of surgery[91]

Preoperative management must focus upon the possible presence of high serum catecholamine levels. Suspicions are raised and formal serum levels drawn if the patient has suggestive symptoms. These closely mirror those seen with a pheochromocytoma and the preoperative preparation should reflect similar principles and constraints.[92]

Airway Management: An important goal is to prevent further increases in intracranial pressure, if it is raised. To achieve this, one anesthetic technique would be as follows: induction of anesthesia and paralysis with thiopental, pavulon, fentanyl, moderate hyperventilation with oxygen, nitrous oxide, and isoflurane, and assessment/check of hemodynamics with laryngoscopy and laryngotracheal anesthesia (4% lidocaine-intracheal injection) followed by orotracheal intubation. Case duration was eight hours, 4 units of blood were administered, and no surgical or anesthetic complications were encountered. The patient was extubated fully awake in the surgical intensive care unit at the conclusion of the case. She was observed by the anesthesiologist for signs of airway obstruction and subsequently by the the critical care resident throughout the night. She was transferred to the floor the following morning and placed on a regular diet that evening. Unfortunately, she then vomited and aspirated. After two weeks in the intensive care and on the ward, her pneumonia resolved and she was discharged.

Rationale, Critique, and Alternatives: Preoperatively, the presence of cranial nerve palsies may signal the need for extra caution in extubating the patient postoperatively, and thus may impact plans for preoperative patient education and postoperative patient disposition. If the tumor is large the risk of nerve damage is greater and a tracheostomy should be planned. Intraoperatively, the anesthesiologist must be concerned and aware of surgical difficulty and/or inadvertent damage to cranial nerves. If new injury to cranial nerves is suspected, a cricopharyngeal myotomy at the time of tumor resection has been recommended to

improve postoperative dysphagia and lessen the risk of aspiration. Postoperatively, one needs to anticipate the potential for postoperative airway compromise and/or aspiration due to inadvertant nerve damage. With damage to the vagus nerve, the risk of aspiration is increased. This risk is compounded by elevated levels of plasma cholecystokinin which may slow gastric emptying and lead to prolonged postoperative ileus. Parenteral nutrition in such patients may be judicious.[93]

A glomus tumor is obviously not a routine or frequent case but it does involve several potentially important considerations, including possible intracranial hypertension, airway obstruction, venous air embolism, and massive blood loss. These necessitate the importance of appropriate anesthetic preparation. Concern about inadvertant injury to cranial nerves, especially in the setting of possible prolonged ileus, must raise concerns about airway obstruction and aspiration well into the postoperative period.

A more frequent but no less challenging problem involving extubation concerns the postlaryngoscopy/bronchoscopy patient with an airway tumor and some degree of bleeding and/or developing edema from the surgical procedure. More frequently than perhaps we realize, extubation fails and the patient develops severe, acute respiratory distress.

Case # 13 Epiglottic Tumor. A 64 year-old man presented with a two month course of dysphagia and hoarseness and a 7 pound weight loss over the past six months. He had a long history of smoking. On physical exam there was no stridor, tachypnea, or labored respirations. On flexible nasopharyngoscopy, an approximately 2 X 2 cm exophytic mass was present on the lingual surface of the epiglottis. The tumor appeared necrotic and apparently extended into the vallecula. The patient was scheduled for a panendoscopy and biopsy.

Airway Evaluation: Normal mouth opening, 6-7 cm. Soft palate, uvula, faucial pillars visualized, Mallampati I. Edentulous. Two and half fingerbreadths between the submentum and the hyoid. Sniff position achieved.

Airway Pathology: Midline supraglottic tumors of the larynx present obvious airway risk. With apnea or even significant loss of intrinsic laryngeal muscle tone, airway obstruction can occur. Moreover, these tumors can be friable and frequently fragment, bleed, and/or lead to significant airway edema with instrumentation. Therefore, an epiglottic tumor presents definite preoperative, intraoperative, and postoperative airway management risks.

Anesthetic Concerns: 1) Airway obstruction with apnea or excessive sedation 2) Swelling of the airway with biopsy and instrumentation leading to respiratory obstruction postoperatively

Airway Management: Awake oral fiberoptic laryngoscopy. Topical anesthesia was established as described above. With the patient in the supine position and an intubating airway in place the fiberoptic bronchoscope was inserted. The epiglottic mass with extension into the vallecula was visualized. With the fiberscope in the trachea to a level just above the carina, a 7.5 tube was inserted over it. Narcosis was achieved with thiopental, anesthesia with fentanyl and isoflurane, and neuromuscular relaxation with a succinylcholine drip. The surgery was without complication. Several biopsies were taken. Laryngoscopy, bronchoscopy, and esophagoscopy were otherwise uneventful. At the conclusion of surgery the patient was awakened on the endotracheal tube. His strength was excellent as demonstrated by hand grip, as were qualitative assessments of his tidal volume and vital capacity. With respiratory mechanics, oxygenation, and ventilation judged to be adequate the patient was extubated.

Following extubation he rapidly developed stridor and severe respiratory distress. Attempts to mask ventilate the patient were unsuccessful. His oxygen saturation was inadequate and falling. Two attempts to reintubate the patient with oral laryngoscopy failed, secondary largely to hypopharyngeal swelling and bleeding. A tracheotomy was performed emergently and the patient was oxygenated and ventilated. There was no long-term morbidity.

Rationale, Critique, and Alternatives: Excellent preoperative evaluation and full recognition of the potential for airway compromise by the anesthesiologist, as in this case, are

of no comfort to a patient dying from hypoxemia secondary to premature removal of a patent airway.

The nature and extent of postoperative edema was not properly respected in this case. Swelling and edema are dynamic, not static, processes. The patient had a friable and potentially obstructive epiglottic lesion, of significant size and in the midline, with clear risks for significant swelling. Yet, the endotracheal tube was removed both too early and, perhaps more importantly, without proper contingency planning. This may have included the prior placement of a tube changer, jet stylet catheter, or fiberoptic bronchoscope.

Such situations, in part, stimulated the development of the jet stylet catheter.[94] The jet-stylet catheter is of value in many clinical situations, including intubation and reintubation of the patient with a severely compromised airway. The specific advantage of the jet stylet is as a pathway for positive pressure or jet ventilation after removal of the endotracheal tube and as an intubation guide should another endotracheal tube be required emergently. In such cases, the trachea can be extubated after the catheter has been placed through the existing endotracheal tube, with oxygen administration then possible (with either jet ventilation or IPPV). If it is determined that the patient needs an endotracheal tube, then the proximal adapter is removed from the jet stylet and reintubation performed over the stylet. The intratracheal location of the jet stylet can be maintained while concurrently confirming tracheal tube placement.[95] If, on the other hand, the patient demonstrates no sign of fatigue or respiratory distress, the catheter can be used to suction secretions before removal.

Alternatively, the fiberoptic bronchoscope itself can be used as a jet stylet.[6,96] After a patient has been extubated by withdrawal of the endotracheal tube to the proximal end of FOB, either oxygen insufflation, jet ventilation, or suctioning can be accomplished via the suction port and the extent of airway swelling can be visually assessed. The latter may prove particularly advantageous in the head and neck cancer surgical patient with the frequent, concomitant presence of airway edema.

Airway edema does not just occur in the operating room immediately post-extubation. It also can occur progressively postoperatively with the patient on the ward. In treating this problem, as this case shows, others sometimes unfortunately arise.

Case # 14 Postoperative Airway Edema: 73 year old man 1 year status post resection of a right retromolar trigone carcinoma treated with a composite resection, a neck dissection, and a radial forearm free flap presented with tumor recurrence to the infratemporal fossa. He had a long term history of smoking. Resection of the recurrent infratemporal fossa tumor was planned.

Airway Evaluation: Mouth opening, 5 cm. Soft palate, uvula, faucial pillars visualized, Mallampati I. Edentulous. Two fingerbreadths between the submentum and the hyoid. Sniff position achieved.

Airway Pathology: Unexpectedly severe airway swelling, especially after a long case with substantial fluid administration in a patient with deformed airway architecture from previous surgery, is a real threat. This can occur even when the airway is not involved either with tumor or surgical manipulation.

Anesthetic Concerns: 1) COPD, given long history of smoking

Airway Management: An intravenous induction followed by intubation was performed without difficulty. The intraoral mucosa was not violated during the resection of the infratemporal fossa tumor, which took some 14 hours. The patient was extubated but on postoperative day one he developed severe respiratory distress, especially with inspiratory effort. Nasopharyngoscopy showed an enlarged, omega shaped epiglottis which seemed to prolapse into the airway with inspiration. He was taken to the surgical intensive care unit and after spraying topical anesthesia to his upper airway, awake oral fiberoptic intubation was performed without difficulty. Because of respiratory fatigue which the patient had experienced, the decision was made to sedate and relax him with morphine, midazolam, and Pavulon and to institute mechanical ventilation. Two hours later, while on mechanical ventilation, he experienced a rapid and profound desaturation. The endotracheal tube was

first suctioned and then removed and replaced. The saturation did not improve. The patient had a cardiac arrest. Chest compressions were begun and resuscitative drugs administered. A needle was placed in the second intercostal space, midclavicular line. A large amount of air escaped from the needle. The tension pneumothorax was relieved but the patient could not be resuscitated and died.

Rationale, Critique, and Alternatives: Given the degree of airway swelling in this case, awake fiberoptic intubation was certainly a good option. But whatever approach is used to secure the airway, the basics of managing the hypoxic episode must never be overlooked. Anesthesiologists must have a systematic, rapid, and complete approach in managing this scenario which includes a quick check of the wall oxygen supply and connection, anesthesia machine or ventilator function, circuit and endotracheal tube integrity, and lung function. Clearly, in this case, too much time elapsed before the chest and lungs were properly evaluated, the tension pneumothorax diagnosed and treated, and the hypoxemia corrected. Upper airway compromise in the head and neck surgery patient must never allow us to lose focus upon the distal airway and to respond inappropriately to the problem of hypoxemia.

IX. Conclusion

Patients with head and neck tumors present airway management problems as difficult as any we confront. Our knowledge, skills, and judgment are routinely and rigorously tested in our care of these patients. The history and physical examinations are crucial in determining the presence of the difficult airway and need for an awake intubation. Specifically, obstructive symptoms, a constellation of findings on physical exam, and use of the CT scan enable us to evaluate head and neck tumors and alert us to the potential for airway management difficulty. Current knowledge of available airway management alternatives allows us to fully explore various options and deliver more safe and expeditious airway care.

Figure Legends

Figure 1. 45 year old patient with a longstanding goiter.

Figure 2. 65 year old man with a large right submandibular mass.

Figure 3. Axial CT scan showing a large right submandibular mass eroding through both mandibular cortices at the body of the mandible and extending to the anterior cheek. Medially the tumor extends to the floor of the mouth and posteriorly to the retromandibular space.

Figure 4. 57 year old man with progressive angioneurotic edema and characteristic massive swelling of the lips and tongue.

Figure 5. Surgical glove burned during airway fire during supraglottic jet ventilation.

Figure 6. 35 year old man burned upon his nose, nasal rim and periorally from a CO_2 laser fire during supraglottic jet ventilation.

[1]Feinstein R, Owens WD: Anesthesia for ENT. *In* Barash PG, Cullen BF, Stoelting RK (eds): Clinical Anesthesia, London, JB Lippincott, 1990, pp1067.
[2]Cancer Facts and Figures: American Cancer Society, 1988.
[3]Rice DH, Spiro RH: Current Concepts in Head and Neck Cancer, American Cancer Society, 1989.
[4]CA: A Cancer Journal for Clinicians, 40:26, 1990.
[5]Caplan RA, Posner, KL, Ward, RJ, et al: Adverse respiratory events in anesthesia: a closed claim analysis. Anesthesiology 72:828-833, 1990.
[6]Benumof, JL: Management of the Difficult Adult Airway. Anesthesiology 75:1087-1110, 1991.
[7]Cormack RS, Lehane J: Difficult tracheal intubation in obstetrics. Anaesthesia 39:1105-1111, 1984.
[8]Samsoon GLT, Young JRB: Difficult tracheal intubation: A retrospective study. Anaesthesia 42:487-490, 1987.
[9]Benumof JL, Scheller MS: The importance of transtracheal jet ventilation in the management of the difficult airway. Anesthesiology 71:769-778, 1989.
[10]Bellhouse CP, Dore C: Criteria for estimating likelihood of difficulty with endotracheal intubation with Macintosh laryngoscope. Anaes Intensive Care 16:329-337, 1988.
[11]Tunstall ME: Failed intubation in the parturient (editorial). Can J Anaesth 36:611-613, 1989.
[12]Hirsch IA, Reagan JO, Sullivan N: Complications of direct laryngoscopy : A prospective analysis. Anesthesiology Review 17:34-40, 1990.
[13]Sia RL, Eden ET: How to avoid problems when using the fiberoptic bronchoscope for difficult intubations (letter). Anaesthesia 36:74-75, 1988.
[14]Latto IP, Rosen M: Management of difficult intubation. *In* Difficulties in Tracheal Intubation. London, Bailliere Tindall, 1985, pp 99-141
[15]King TA, Adams AP: Failed tracheal intubation. Br J Anaesth 65:400-414, 1990.
[16]Finucane BT, Santora AH: Evaluation of the airway prior to intubation. *In* Principles of Airway Management. Philadelphia, FA Norris, 1988, pp 69-83
[17]Marsh, HM: Anesthesia for patients with chronic pulmonary disease. *In* Hershey, SG (ed): ASA Refresher Course, vol. 12, chapter 12, Lippincott, 1984.
[18]Harrison, RA: Respiratory function in anesthesia. *In* Barash PG, Cullen BF, Stoelting RK (eds): Clinical Anesthesia, London, JB Lippincott, 1990, pp 902.
[19]White A , Kander PL: Anatomical factors in difficult direct laryngoscopy. Br J Anaesth 47: 468-473, 1975.
[20]Mallampati SR, Gatt SP, Gugino LD, et al: A clinical sign to predict difficult tracheal intubation: A prospective study. Can Anaesth Soc J 32:429-434, 1985.
[21]Wilson ME, Speigelhalter D, Robertson JA, et al: Predicting difficult intubation. Br J Anaesth 61:211-216, 1988.
[22]Cohen SM, Zaurito CE, Segil LJ: Oral exam to predict difficult intubations: A large prospective study (abstract). Anesthesiology 71:A937, 1989.
[23]Mathew M, Hanna LS, Aldrette JA: Preoperative indices to anticipate a difficult tracheal intubation. Anesth Analg 68:S187, 1989.
[24]Wilson ME, John R: Problems with the Mallampati sign. Anaesthesia 45:486-487, 1990.
[25]Charters P, Perera S, Horton WA: Visibility of pharyngeal structures as a predictor of difficult intubation (letter). Anaesthesia 42:1115, 1987.
[26]McGill IW: Technique in endotracheal anesthesia. Br Med J 2:817-820, 1930.
[27]Salem MR, Methrubhutham M, Bennett EJ: Difficult intubation. N Engl J Med 295:879-881, 1976.
[28]McGowan FX: Anesthesia for major head and neck surgery. *In* McGoldrick K (ed): Anesthesia for Ophthalmic and Otolaryngologic Surgery. Philadelphia, WB Saunders, 1992, pp 65.

[29]Eisele DW, Johns ME: Carcinoma of the oral cavity and pharynx. *In* Lee KJ (ed): Essential Otolaryngology-Head and Neck Surgery. New York, Elsevier Science Publishing, 1991, pp 493-500.
[30]Ibid
[31]Londy F., Norton ML: Radiologic techniques for evaluation and management of the difficult airway. *In* Norton ML, Brown ACD (eds): Atlas of the Difficult Airway. St. Louis, Moseby Year Book, 1991, pp 62-66.
[32]Londy F., Norton ML: Radiologic techniques for evaluation and management of the difficult airway. *In* Norton ML, Brown ACD (eds): Atlas of the Difficult Airway. St. Louis, Moseby Year Book, 1991, pp 57.
[33]Bourke DL, Katz J, Tonneson A: Nebulized anesthesia for awake endotracheal intubation. Anesthesiology 63:690-692, 1985.
[34]Barton S, Williams JD: Glossopharyngeal nerve block. Arch Otolaryng 93:186-188, 1971.
[35]Murphy P: A fiber-optic endoscope used for nasal intubation. Anaesthesia 22:489-491, 1967.
[36]Ovassapian, A: Fiberoptic-assisted management of the airway *In* Barash PG, Deutsch S, Tinker JH (eds): ASA Refresher Course, vol. 19, Lippincott, 1991.
[37]Delancy, KA, Hessler R: Emergency flexible fiberoptic nasotracheal intubation: A report of 60 cases. Ann Emerg Med 17:919-926, 1988.
[38]Stiles CM, Stiles QR, Denson JS: A flexible fiberoptic laryngoscope. JAMA 221:1246-1247, 1972.
[39]Ovassapian A, Yelich SJ, Dykes MHM, et al: Fiberoptic nasotracheal intubation: Incidence and causes of failure. Anesth Analg 62:692-695, 1983.
[40]Ovassapian A: Fiberoptic airway endoscopy in anesthesia and critical care. New York, Raven Press, 1990, pp 71.
[41]Edens ET, Sia R: Flexible fiberoptic endoscopy in difficult intubations. Ann Otol 90:307-309, 1981.
[42]LiVolsi VA, Merino MJ: Histopathology of salivary gland tumors. *In* Ariyan S (ed): Cancer of the Head and Neck. St. Louis, C.V. Mosby, 1987, pp 608.
[43]Dallen LT, Wine R, Benumof JL: Spontaneous ventilation via transtracheal large-bore intravenous catheters is possible (case report). Anesthesiology 75:531-533,1991.
[44]Fawcett W, Ooi R, Riley B: The work of breathing through large-bore intravascular catheters (letter). Anesthesiology 76:323-324,1992.
[45]Austin, KF: Disorders of immune-mediated injury. *In* Wilson JD, Braunwald E, Isselbacher et al (eds): Harrison's Principles of Internal Medicine. New York, McGraw Hill, 1991, pp 1425-1426.
[46]Rajchel JL, Scully JR: Emergency airway management in the traumatized patient. *In* Fonseca RJ, Walker RV (eds): Oral and Maxillofacial Trauma. Philadelphia, W.B. Saunders, 1991, pp 124.
[47]Griggs WM, Worthley LG, Gillegan JE, et al: A simple percutaneous technique. Surg Gynecol Obstret 170:543-545, 1990.
[48]Silk JM, Marsh AM: Pneumothorax caused by minitracheotomy. Anaesthesia 44:663-664, 1989.
[49]Toye FJ, Weinstein JD: Clinical experience with percutaneous tracheostomy and cricothyroidotomy in 100 patients. J Trauma 26:1034-1040, 1988.
[50]Wain JC, Wilson DJ, Mathisen DJ: Clinical experience with minitracheostomy. Ann Thorac Surg 49:881-886, 1990.
[51]Holmgreen WC: Difficult intubation: Unsuspected. *In* Bready LL, Smith RB (eds): Decision Making in Anesthesiology. Philadelphia, B.C. Decker, 1987, pp 16-17.
[52]Carlson CA, Perkins HM, Veltkamp PS: Solving a difficult intubation (letter). Anesthesiology 64:537, 1986.

[53]Lechman MJ, Donahoo JS, Macvaugh H: Endotracheal intubation using percutaneous retrograde guidewire insertion followed by antegrade fiberoptic bronchoscopy. Crit Care Med 14:589-590, 1986.
[54]Gupta B, McDonald JS, Brooks JHJ, et al: Oral fiberoptic intubation over a retrograde guidewire. Anesth Analg, 68:517-519, 1989.
[55]Waters DJ: Guided blind endotracheal intubation for patients with deformities of the upper airway. Anaesthesia, 18:158-162, 1963.
[56]Akinyemi OO: Complications of guided blind endotracheal intubation. Anaesthesia 34:590-592, 1979.
[57]Berman RA: Lighted stylet. Anesthesiology 20:382-383, 1959.
[58]Yamamura H, Yamamoto T, Kamiyama M: Device for blind nasal intubation. Anesthesiology 20:221-222, 1959.
[59]MacIntosh R, Richards H: Illuminated introducer for endotracheal tubes. Anesthesia 12:223-225, 1957.
[60]Ellis DG, Jakymec A, Kaplan RM, et al: Guided orotracheal intubation in the operating room using a lighted stylet: A comparison with direct laryngoscopic technique. Anesthesiology 64:823-826, 1986.
[61]Fox DJ, Castro T, Rastrelli AJ: Comparison of intubation techniques in the awake patient: The flexi-lum surgical light (lightwand) versus blind nasal approach. Anesthesiology 66:69-71, 1987.
[62]Rayburn RL: 'Light wand intubation' (letter). Anaesthesia 34:667-668, 1979.
[63]Holzman RS, Nargozian CD, Florence FB: Lightwand intubation in children with abnormal upper airways. Anesthesiology 69:784-787, 1988.
[64]Robelen GT, Shulman MS: Use of the lighted stylet for difficult intubations in adult patients. Anesthesiology (abstract) 71:A439, 1989.
[65]McGoldrick K: Managing difficult intubations. *In* McGoldrick K (ed): Anesthesia for Ophthalmic and Otolaryngologic Surgery. Philadelphia, WB Saunders, 1992, pp 33.
[66]Frass M, Frenzer R, Mayer G, et al: Mechanical ventilation with the esophageal tracheal combitube (ETC) in the intensive care unit. Archives of Emergency Medicine 4:219-225, 1987.
[67]Brain AIJ: The laryngeal mask--a new concept in airway management. Br J Anaesth 55:801, 1983.
[68]Brain AIJ: Three cases of difficult intubation overcome by the laryngeal mask airway. Anaesthesia 40:353-355, 1985.
[69]Grebenik CR, Ferguson C, White A: The laryngeal mask airway in pediatric radiotherapy. Anesthesiology 72:474-477, 1990.
[70]Stone DJ. Transtracheal Jet Ventilation II (letter). Anesthesiology 72:774, 1990.
[71]Keenan RL, Boyan CP: Cardiac Arrests due to anesthesia. JAMA 253:2373-2377, 1985.
[72]Taylor G, Larson CP, Prestwich R: Unexpected cardiac arrest during anesthesia and surgery. An environmental study. JAMA 236:2758-2760, 1976.
[73]Bolander FMF: Deaths associated with anesthesia. Br J Anaesth 47:36-40, 1975.
[74]Harrison GG: Death attributable to anesthesia. Br J Anaesth 50:1041-1046, 1978.
[75]Davis DA: An analysis of anesthetic mishaps from medical liability claims. Int Anesthesiol Clin 22:31-42, 1984.
[76]Hermens JM, Bennett MJ, Hirshman CA: Anesthesia for laser surgery. Anesth Analg 62:218, 1983.
[77]Wegrzynowicz ES, Jensen NF, Pearson KS, et al: Airway fire during jet ventilation for laser excision of vocal cord papillomata. Anesthesiology 76:468-469, 1992.
[78]Wilton N: Pediatric difficult airways. *In* Norton ML, Brown ACD (eds): Atlas of the Difficult Airway. Philadelphia, WB Saunders, 1992, pp 164.

[79]Benjamin B: Congenital disorders. *In* Cummings CW, Fredrickson JM, Harker LA, et al. (eds): Otolaryngolology-Head and Neck Surgery. St. Louis, C.V. Mosby, 1986, pp 1916-1917.
[80]Bastian RW: Benign mucosal disorders, saccular disorders, and neoplasms. *In* Cummings CW, Fredrickson JM, Harker LA, et al (eds): Otolaryngolology-Head and Neck Surgery. St. Louis, C.V. Mosby, 1986, pp 1983-1984.
[81]Donlan JV: Anesthesia and eye, ear, nose and throat surgery. *In* Miller RD (ed): Anesthesia. New York, Churchill Livingstone, 1990, pp 2015.
[82]Crockett DM, Scamman FL, McCabe BF, et al: Venturi jet ventilation for micro laryngoscopy: technique, complications, pitfalls. Laryngoscope 97:1326-1330, 1987.
[83]McGoldrick KE, Ho MD: Endoscopy procedures and laser surgery of the airway. *In* McGoldrick K (ed): Anesthesia for Ophthalmic and Otolaryngologic Surgery. Philadelphia, WB Saunders, 1992, pp 39.
[84]Babinski M, Smith RB, Klain M: High frequency jet ventilation for laryngoscopy. Anesthesiology 1980; 52:178-180.
[85]Eng UB, Eriksson I, Sjostrand U: High frequency positive pressure ventilation (HFPPV): A review based upon its use during bronchoscopy and for laryngoscopy and microlaryngeal surgery under general anesthesia. Anesth Analg 1980; 59:594.
[86]Gettinger A, Glass DD: High-frequency positive pressure ventilation. *In* Carlon GC, Howland WS (eds): High Frequency Ventilation in Intensive Care and During Surgery. New York, Marcel Dekker, 1985, pp 63-75
[87]Kolton M: A review of high frequency oscillation. Can Anaesth Soc J 1984, 31:416.
[88]Donlan JV: Anesthesia and eye, ear, nose and throat surgery. *In* Miller RD (ed): Anesthesia. New York, Churchill Livingstone, 1990, pp 2016.
[89]Guild SR: A hitherto unrecognized structure, the glomus jugulare in man. Anat Rec 1941; 79 (suppl 2):28.
[90]Ghani GA, Yung Fong S, Per-Lee JH: Glomus jugulare tumors-origin, pathology, and anesthetic considerations. Anesth Analg 62:686-691, 1983.
[91]Brown JS: Glomus jugulare tumors. Methods and difficulties of diagnosis and surgical treatment. Laryngoscope 77:26-67, 1967.
[92]Pratilis V, Pratile MG: Anesthetic management of pheochromocytoma. Can Anaesth Soc J 26:253-259, 1979.
[93]Jackson CG, Gulya AF, Knox GW, Glasscock ME, Pensak ML, Poe DS, Johnson GD: A Paraneoplastic Syndrome Associated with Glomus Tumors of the Skull Base? Early Observations. Otolaryngol Head Neck Surg 100:583-7, 1989.
[94]Bedger RC, Chang JL: A jet-stylet endotracheal catheter for difficult airway management. Anesthesiology 66:221-223, 1987.
[95](Goskowicz R, Gaughan S, Benumof JL, et al: It is not necessary to remove a jet stylet in order to determine tracheal tube location. J Clin Anesth, in press.)
[96](Wheeler S, Fontenot R, Gaughan S, Benumof JL: Use of fiberoptic bronchoscope as a jet stylet. Anesthesiology Review, in press.)