inferiority of S-1 compared to infusional 5-FU in the first-line setting [6]. However, that trial did not limit the post-treatment, so the setting of PTX use in first- or second line mandatorily might show different results. The present study had started before the results of these two trials were disclosed. Consequently, it is important to check whether our results are in line with the data obtained in the JCOG9912 and the FLAGS trials. In our study, the OS, PFS, and RR for the 5-FU-containing and S-1-containing regimens were almost the same, without any significant differences, suggesting both oral and infusional fluorinated pyrimidine regimens have similar potency, a finding which would be confirmatory of the previous trials. In general, treatment with an oral agent would be more preferable both for the patients and for medical staff than a treatment requiring continuous intravenous infusion, with its risks of infection and thrombotic events.

In conclusion, our study did not show sufficient prolongation of survival with a concurrent strategy to proceed to a phase-III trial; however, the sequential arms showed survival comparable to that in the concurrent arms, with a lower incidence of neutropenia. In patients who are ineligible for CDDP, sequential treatment starting from S-1 and proceeding to PTX would be a good alternative strategy, considering the quality of life (QOL) and cost-benefits of an oral agent as first-line treatment.

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The Best Techniques for Performing Bronchoscopy

気管支鏡ベストテクニック

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Chapter 5

自家蛍光気管支鏡

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概要

気管支の微細な病変を発見する方法として自家蛍光気管支鏡（autofluorescence bronchoscopy: AFB）が開発された．青色波長領域の励起光を気管支の正常部に照射すると緑色波長領域の自家蛍光が発生するが，癌病巣ではこの波長の自家蛍光の強度は極端に低下している．自家蛍光を発する部位（正常部）と欠損部位（病変部）のコントラストを増幅することにより，通常の白色光では発見困難な微細な病変を発見するのが本検査法の原理である[1-3]．

AFB は気管支の早期癌や異型化生など，気管支病変の診断率を向上させるとともに[1-3]，病変の気管支粘膜上の浸潤範囲に関しても正確な評価が可能である[4]．また，喀痰細胞診で異常がある場合の病変の局在診断にも良い適応がある．AFB は特別な前処置も不要で，検査時間の延長も数分程度であるため，日常の気管支鏡検査の精度向上に有益であると考える．

中枢病変の質的診断には，AFB と超音波検査などを用いて包括的に行うことが推奨される．

略語

AFB：autofluorescence bronchoscopy，PDD：photodynamic diagnosis

重要ポイント

- 喀痰細胞診異常や中枢気管支の病変を疑う症例がよい適応である[2,3,5,6]．
- 自家蛍光が減弱している部位を生検する．微小な病変は自家蛍光画面でピンポイントに生検する．
- 出血は偽陽性の原因となるとともに，質の高い検査の妨げになる．適切な麻酔とともにスムースで丁寧な検査を心がける．
- 気管支鏡の技術不足を補うものではない．白色光での所見のとらえ方を熟知したうえで行うべきである．

目的

通常の気管支鏡で発見困難な気管支の早期病変の診断率を向上させる[2,3,5,6]．
気管支病変の粘膜上の浸潤範囲を正確に同定する[7]．

適応

中枢気管支に病変の存在が疑われる症例
喀痰細胞診断で異常が指摘された症例
中心型肺癌の治療方針決定など

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準備するもの

自家蛍光気管支鏡システム
通常の気管支鏡に必要な物品

MEMO 自家蛍光気管支鏡システムの違い

システムによる診断率の違いは検討されていないが，同等であろう．原理の違いを理解することにより，病的所見の解釈の参考とする．

AFI（auto-fluorescence imaging bronchovideoscope system；Olympus, Japan）

モノクロ CCD を用いたシステムで，自家蛍光画像として異なる 2 種類の反射光を合体した画像が得られる．ヘモグロビンの増加による自家蛍光の減弱と上皮の肥厚などによる自家蛍光の減弱が異なった色調で観察でき，その結果，癌は紫色に，炎症や出血は濃い緑色の色調に観察される[8]．

SAFE-3000（system of autofluorescence endoscopy-3000；HOYA-PENTAX, Japan）（図 1）

励起光源に半導体レーザーを用いて，超小型の高感度カラー CCD と，デジタル信号処理技術でフルフレーム，リアルタイムの自家蛍光動画像を表示できるようにしたシステムである．自家蛍光画像では正常部は緑色，癌や化生病変は黒色（cold spot）として観察される．白色光動画像と蛍光動画像を同時に 2 画面表示する Twin モード（図 2）や白色光と蛍光画像をデジタル画像処理により 1 枚の画像に合成した Mix モード（図 3）が使用可能である[3]．われわれは通常の検査も Twin モードを用いることが多いが，日常検査をより精密にすることが可能である．白色光と自家蛍光のモード切り替えの必要がないため検査時間が短縮するとともに，出血・炎症など自家蛍光単独では偽陽性と判断されるのを防ぐことができる．

手技

1）麻酔

AFB の検査対象となる患者は高喫煙者であることが多く，検査時に咳が強くなる傾向がある．気管支粘膜の出血や充血は検査の質を落とし，偽陽性の原因となるため，sedation を含め，十分な麻酔を検討する．

2）観察

（1）白色光検査

腫瘍の発生部位，粘膜上の浸潤範囲を把握する．特に腫瘍の末梢側が内視鏡の可視範囲にあるか否かが内視鏡的レーザー治療の適応を決定するため十分に観察する．また，粘膜上の腫瘍の長径と気管支壁への深達度はある程度比例するため[10,11]，浸潤範囲の正確な把握は深達度の推定のためにも必

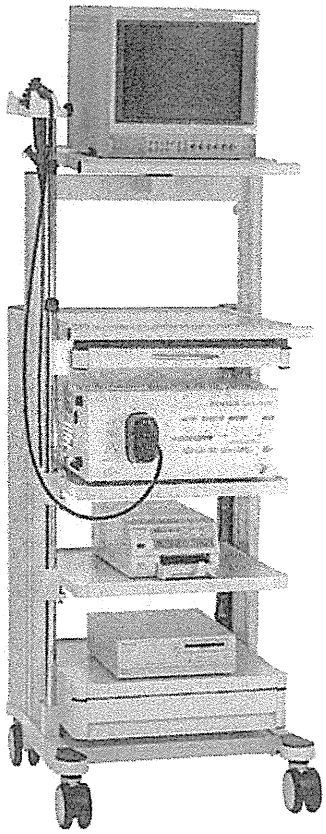

図 1　SAFE-3000 の外観

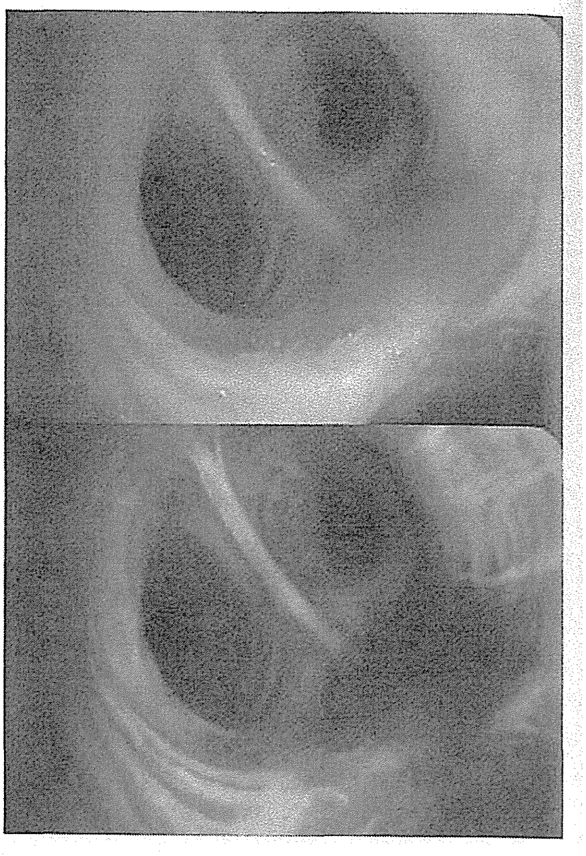

図 2　右 B^5 入口部の平坦型中心型早期肺癌
SAFE-3000 の Twin モード画像．白色光（上）と自家蛍光（下）が同時に観察できる．

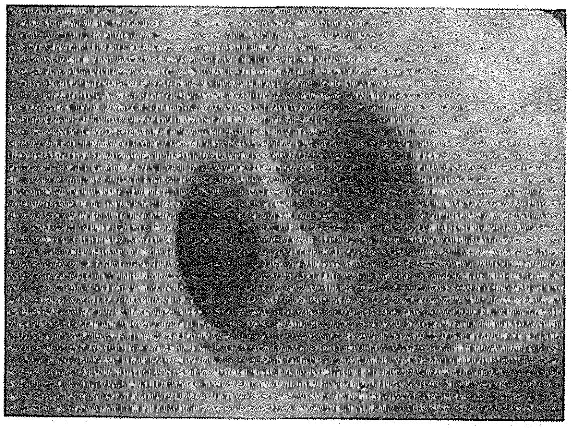

図 3　図 2 と同症例の Mix モード画像
白色光を観察中に自家蛍光の異常がある部位が明示される．

要である．気管支の分岐に発生した隆起性の病変は小さくても発見は容易であるが，平坦型の病変を発見するのは時として困難であるので，複数のスタッフでモニター観察を行うのが望ましい．

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MEMO 白色光の所見のとらえ方を習熟する

中心型早期肺癌はその形態により，平坦型，結節型，早期ポリープ型に分類される[9]．病変の長径の正確な把握は浸潤範囲の同定とともに深達度の推定のためにも必要である．長径が増すに従い，気管支壁への進展が進むとされる．腫瘍の深達度が気管支軟骨を超えない目安として，ポリープ型，結節型の腫瘍は 10 mm 以内，肥厚型の腫瘍は 15 mm 以内ともされる．平坦型では浸潤範囲が 10 mm 以下の症例は上皮内癌である可能性がきわめて高いと考えられている[10,11]．

(2) 自家蛍光検査

AFI では最初に白色光，続いて自家蛍光観察を行う．SAFE−3000 の場合は 2 画面同時表示機能を用いることが多い．

本診断法では組織が厚くなったり血流が増加しているために自家蛍光が減弱した部位を観察しており，腫瘍特有の変化を直接感知しているわけではない．したがって，炎症で血流が増加したり，粘膜が肥厚している場合も自家蛍光画像では“異常”として認識されることがあり注意を要する．白色光画像と対比することにより多くが判別可能であるが，不確かな場合は生検する．また，気管や主気管支など内径が大きい部位は励起光の強度が相対的に不足するため，画像が暗くなる傾向があることに注意する．

MEMO 自家蛍光

自家蛍光の大部分は粘膜下層に存在する collagen，flavin-adenine dinucleotide (FAD)，nicotinamide-adenine dinucleotide phosphate (NADP) などに由来するといわれている．癌病巣では発する自家蛍光の強度は極端に低下している．この原因は癌組織での代謝亢進による内因性蛍光物質の消費，病変部における粘膜組織の肥厚による自家蛍光のブロック，および血管新生で増加したヘモグロビンによる自家蛍光の吸収などによるものと考えられている．

3) 生検

白色光で異常が疑われる部位，自家蛍光が減弱している部位を生検する．AFB のみで発見されるような微小な病変は，白色光下に生検を行うと正確に目標から検体が採取されない恐れもあるので，自家蛍光画面でピンポイントに生検する．

MEMO AFB + EBUS で精密な診断を行う

AFB は気管支の表層のみの観察しかできないため，病変の深達度診断としてラジアル走査式超音波気管支鏡検査 (EBUS) を併用することが推奨される．広さと深さを正確に把握することにより適切な治療を選択しうる[12-15]．光線力学的治療 (PDT) の治療成績が近年向上している[16-19]のも新しい世代の腫瘍親和性物質の利用とともに，正確な診断により適応症例が適正に選別されていること，レーザーの照射すべき範囲が正しく把握されていることによる部分も大と考えている[2]．また，SAFE-3000 で PDT 治療直前に病変を観察すると，あらかじめ投与して

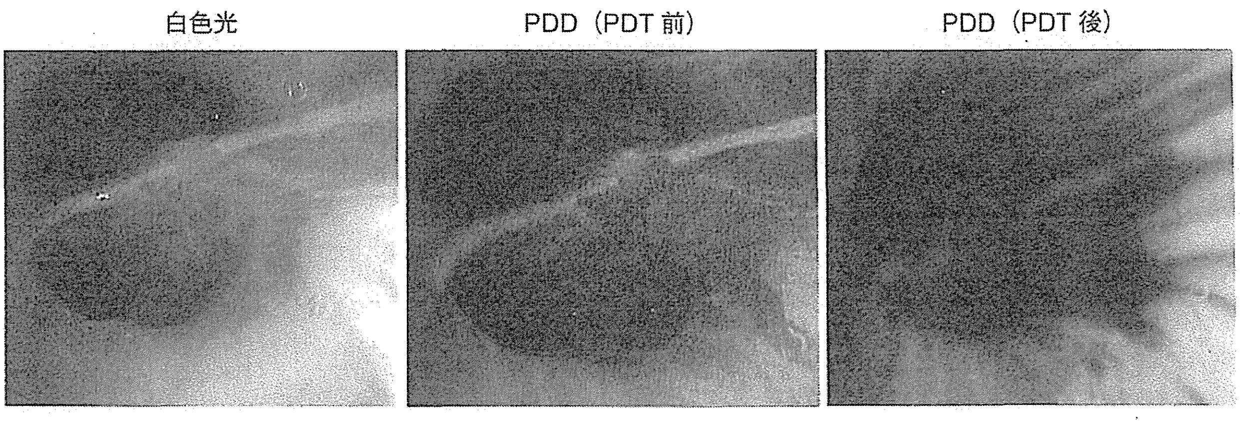

図 4　左 B^{1+2} の中心型早期肺癌

PDT 前は浸潤範囲に一致して赤色の蛍光が観察されるが，治療後は観察されない．十分な治療が行われた（腫瘍親和性物質とレーザーが十分な化学反応を起こした）と判断する．

おいた腫瘍親和性物質に特有な蛍光が浸潤部位から観察でき，治療すべき範囲が客観的に把握できる（光線力学的診断法 PDD：photodynamic diagnosis）．レーザー照射後，腫瘍親和性物質は化学反応を起こすため術前に観察された赤色蛍光は観察されなくなる（図 4）．これは十分な治療が行われた証拠であり，もし蛍光が観察されたなら治療不十分とみなし当該部位にはレーザー照射を追加する[19]．

合併症と対策

通常の気管支鏡と同等である．通常の検査と同様な対応を行う．しかし，検査対象が高喫煙者で呼吸機能が不良な症例が多いので，検査中のモニタリングやリスク管理に留意する必要がある．

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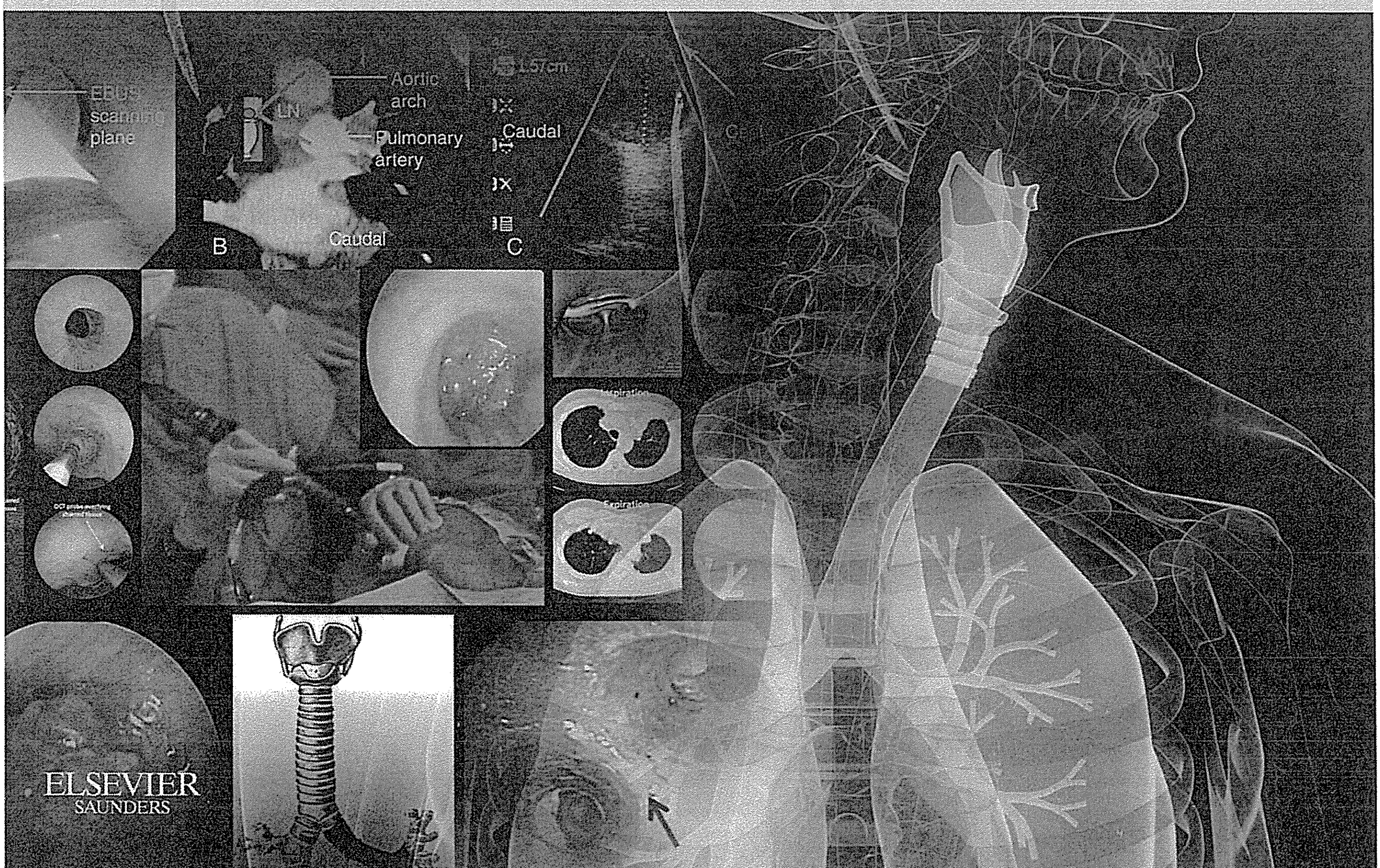
HENRI COLT · SEPTIMIU MURGU

BRONCHOSCOPY AND CENTRAL AIRWAY DISORDERS

A PATIENT-CENTERED APPROACH



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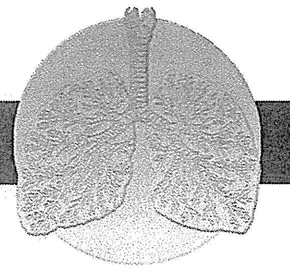

Rigid Bronchoscopic Tumor Debulking and Silicone Stent Insertion for Mixed Malignant Tracheal Obstruction Caused by Esophageal Carcinoma

This chapter emphasizes the following elements of the Four Box Approach: physical examination; complementary tests and functional status assessment; risk-benefit analyses and therapeutic alternatives; and techniques and instrumentation.

CASE DESCRIPTION

The patient is a 67-year-old male who presents with several weeks of progressive dysphagia, 25 lb weight loss, and dyspnea with activities of daily living. He recently developed intractable nausea and vomiting and was admitted to the hospital because of difficulty swallowing and choking. His medical history was unremarkable. He had a 40–pack-year history of tobacco smoking and a significant history of alcohol use. Head and neck examination revealed limited cervical range of motion and a two-fingerbreadth mouth opening. Lung examination showed a prolonged expiratory phase and bilateral rhonchi. Esophagogastroduodenoscopy (EGD) showed a mass protruding from the posterior mid-esophagus. After the EGD, his breathing became labored, prompting intubation with a No. 8 endotracheal tube and placement on mechanical ventilation. Bronchoscopy performed on mechanical ventilation revealed a 2 cm obstructing mass in the mid-trachea. Broad-spectrum antibiotics (levofloxacin and piperacillin/tazobactam) were initiated for presumed aspiration pneumonia, after which the patient was transferred to our tertiary care center.

Chest radiograph showed a soft tissue mass density projecting to the right of the trachea. Lung volumes appeared to be enlarged bilaterally (Figure 21-1). Laboratory markers revealed WBC 21.3, Hb 12, and Plt 164. Results from the esophageal mass biopsy showed squamous cell carcinoma. Ventilator settings included assist-control volume-control ventilation with a tidal volume of 500 mL, rate 16, PEEP 5, and FiO_2 0.5. At these settings, peak airway pressure was 60 cm H_2O and plateau pressure 28 cm H_2O. Weaning was attempted but failed. Rigid bronchoscopy was performed, revealing extrinsic compression and an exophytic endoluminal mass protruding from the posterior wall, completely occluding the mid-trachea (see Figure 21-1). The mass was 2 cm in length and was located 5 cm above the carina and 5 cm below the vocal cords. The endoluminal tumor was cored out using Nd:YAG laser for hemostasis. Airway patency was improved, but tracheal obstruction from extrinsic compression (>70%) remained significant. A 16 × 50 mm straight studded silicone stent was therefore placed in the mid-trachea, restoring airway patency satisfactorily. The patient was successfully extubated the next day (see Figure 21-1).

DISCUSSION POINTS

1. Describe three patient-related factors associated with difficult rigid bronchoscopic intubation.
2. Explain the rationale for stent insertion after tumor debulking in this patient.
3. List at least three strategies to prevent airway perforation and hemorrhage during rigid bronchoscopy.
4. Describe five ways to avoid complications of rigid bronchoscopy.

CASE RESOLUTION

Initial Evaluations

Physical Examination, Complementary Tests, and Functional Status Assessment

Advanced, unresectable esophageal cancer with airway invasion has a very poor prognosis (5 year survival rate <10%).[1] Patients with this disease have not only a limited life expectancy but also many potentially debilitating complications from the local effects of their tumors. These include dysphagia, dysphonia, dyspnea from airway involvement, chest pain, and, rarely, massive fatal hemorrhage from aortic erosion.[2,3] Airway involvement in the setting of esophageal carcinoma includes tissue invasion, infiltration, or the presence of an esophago-respiratory fistula (ERF).* Airway complications may be caused (1) by extrinsic compression on the airways by the tumor or by an esophageal stent and (2) by direct invasion by the tumor into the airways. These processes can result in severe airway narrowing or ERF. Among a large series of 372 patients seen over the 14 year study period, 74 (20%) were found to have airway involvement: 35 (47%) of these patients had an ERF; in the absence of ERF, airway involvement identified as invasion or

Juxtaposition, abutment, bulge, and *deviation* are terms used to describe extrinsic compression, which is not considered adequate evidence of true airway involvement.

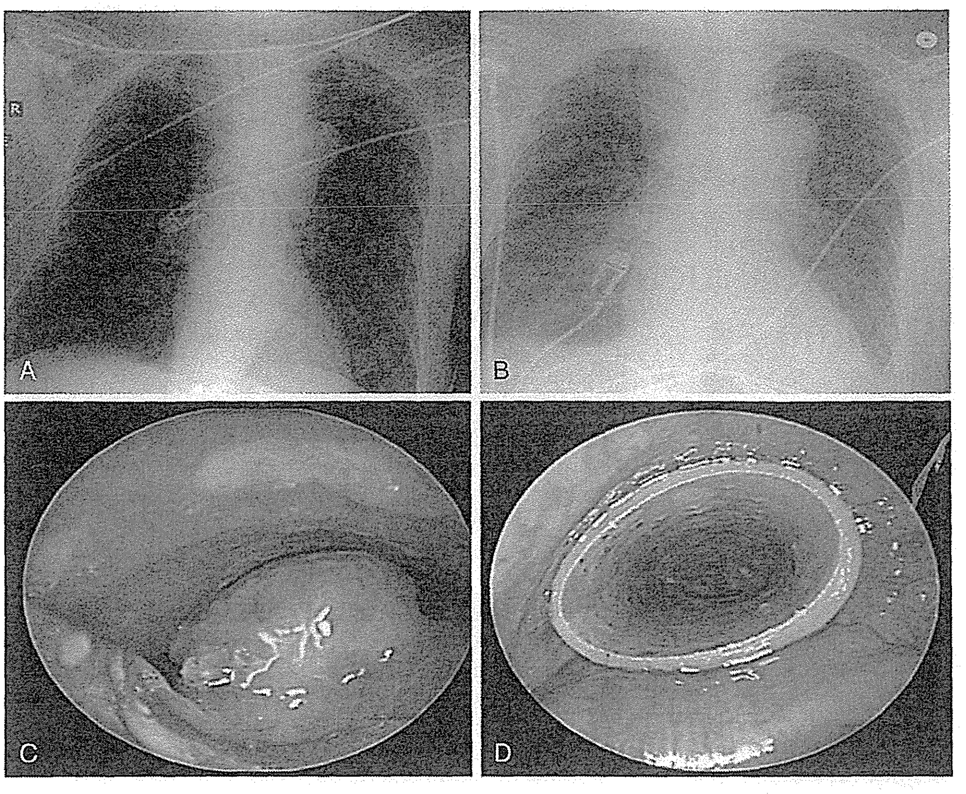

Figure 21-1 **A,** Chest x-ray (CXR) before the bronchoscopy showed a soft tissue mass density projecting to the right of the trachea, enlarged lung volumes bilaterally, and the endotracheal tube (ETT). **B,** The day after the rigid bronchoscopy, the ETT was removed, and air trapping had resolved. **C,** Rigid bronchoscopic view of the mixed airway obstruction, which consisted of exophytic endoluminal mass and extrinsic compression. **D,** Indwelling silicone stent after rigid bronchoscopy restored airway patency but is still partially compressed in the anteroposterior diameter.

infiltration was biopsy proven in 29 of 39 patients (74%).[4] Other investigators report airway involvement in 10.9% to 62% of cases.[4,5] Because of the proximity of the major airways to the upper two thirds of the esophagus in the thorax, major airway obstruction is also common. In fact, patients with esophageal tumors above the level of the main carina have a worse prognosis than those with lower tumors because of this anatomic relationship with the large airways.[6] Hence, up to 25% of patients with advanced esophageal cancer may require airway stent insertion to alleviate airway obstruction.[7-10] The mean duration of survival for patients requiring airway stent insertion for obstruction due to esophageal cancer reportedly ranges from only 35 to 121 days, with many patients dying at home or in hospice.[9]

Severe respiratory symptoms in these patients may occur because of ERF or severe airway narrowing. For tumors extending into the airway lumen, as is seen in our patient, primary goals of therapy include palliative relief of the malignant obstruction of the esophageal lumen and central airway. If present, attempts can be made to close fistulas between the esophagus and the central airway or, at the least, to alleviate or diminish risks of aspiration and inability to swallow. Recurrent aspiration pneumonia may be caused by dysphagia due to esophageal obstruction or by ERF and can lead to respiratory failure. Initial chest radiographs are often normal; in these cases, they are useful for excluding other causes of respiratory symptoms such as pneumonia, pneumothorax, and pleural effusion.[11] In our patient, for example, pneumonia was not evident on chest x-ray (CXR) nor was ERF on bronchoscopy. The critical airway obstruction was therefore the likely culprit for respiratory failure in view of notably high peak airway pressures and normal plateau pressures, which point to an airway resistance process. In the absence of evidence for bronchospasm, mucus plugging, or kinking of the endotracheal tube, the most plausible explanation for high peak airway pressures and respiratory failure in this patient was tracheal obstruction by the esophageal mass. This was probably worsened by the moderate sedation used for EGD.

On bronchoscopy, this patient's central airway obstruction was classified as mixed because it comprised an endoluminal component and extrinsic compression (Figure 21-2).[12] In addition to bronchoscopy, computed tomography (CT) provides a noninvasive means of confirming the presence and severity of suspected airway involvement and is valuable in assessing the length of a stenosis, especially when a bronchoscope may not be passable beyond the stenosis. Before bronchoscopy, CT may help to determine whether double stent insertion is necessary (Figure 21-3). In cases of suspected ERF, a barium swallow is usually performed.

Comorbidities

It is possible that our patient had hypoventilation post EGD, caused by sedation-induced reduction in minute ventilation in the setting of critical tracheal obstruction, or possibly by upper airway obstruction unmasked by sedatives. The redundant pharyngeal and laryngeal tissues, as seen in patients with obstructive sleep apnea (OSA), may further lose tonicity, contributing to the hypoventilation and hypoxemia induced by moderate sedation, which potentially leads to respiratory failure and endotracheal

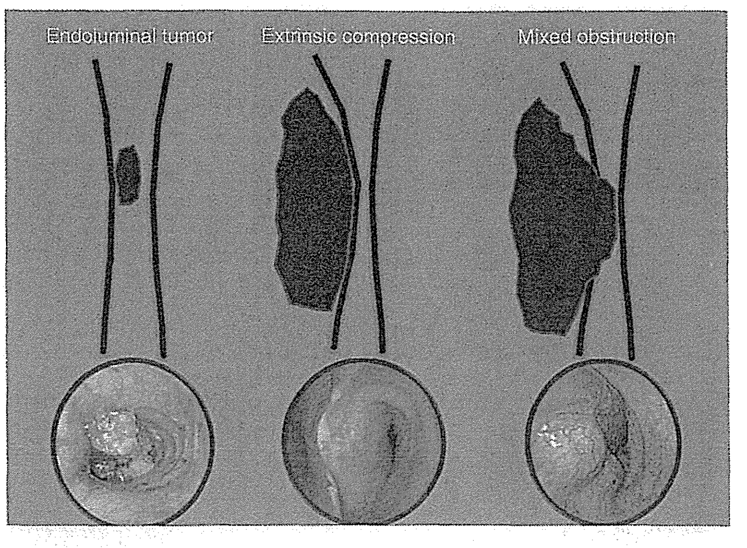

Figure 21-2 Central airway obstruction classification on the basis of mechanism. The bottom photos represent endoluminal papillomas *(left)*, extrinsic compression from the sarcoma *(center)*, and mixed extrinsic compression and endoluminal obstruction from the thyroid carcinoma *(right)*.

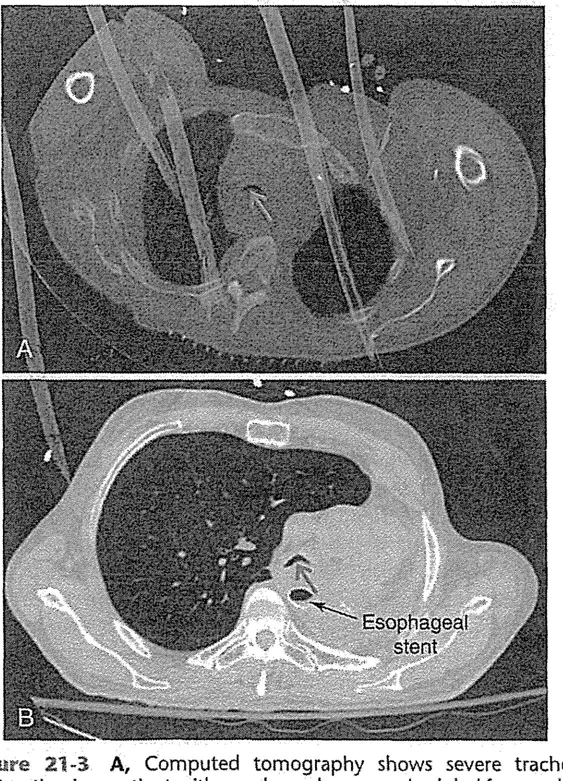

Figure 21-3 **A,** Computed tomography shows severe tracheal obstruction in a patient with esophageal cancer scheduled for esophageal stent placement. **B,** In a different patient with left pneumonectomy, the lower trachea and the right mainstem bronchus were severely narrowed post esophageal stent placement, resulting in respiratory failure.

intubation (see video on ExpertConsult.com) (Video V.21.1). Although not documented in his medical history, based on the bronchoscopic findings, we suspected OSA in our patient. This can also contribute to poor outcomes caused by perioperative complications. Indeed, evidence suggests that patients with OSA may have more postoperative hypoxemia, upper airway obstruction, cardiac arrhythmias, and myocardial infarction.[13] Results of observational studies show that most patients with OSA who are undergoing surgery have not been diagnosed before surgery. In a study of 2877 elective surgery patients, 24% were found to be at risk for having OSA, and 81% of these had not been diagnosed previously.[14] These data raise the question whether all patients undergoing surgery should be screened for OSA.

Support System

The patient had been married for 47 years and had no children. He had no living will and no advance health care directives. His wishes were not known.

Patient Preferences and Expectations

The prognosis was discussed with the patient's wife. By investing in patient-centered conversations with family members, health care providers can better meet the needs of families and patients during a medical crisis such as respiratory failure or admission to the intensive care unit.[15] His wife hoped he could be weaned from the ventilator, so she could speak with him about his wishes.

Procedural Strategies

Indications

The primary goal was to restore airway patency to facilitate extubation and change the level of care. Interventional bronchoscopic procedures have been reported to facilitate weaning from mechanical ventilation.[16] Relevant to this patient's condition, in a study of 11 inoperable patients with esophageal carcinoma and airway involvement treated with a combination of rigid bronchoscopy, neodymium-doped yttrium aluminum garnet (Nd:YAG) laser resection, and silicone stent placement, authors noted that 4 patients who required mechanical ventilation for respiratory failure were successfully weaned from mechanical ventilation after the procedure.[9] Overall, airway stent insertion is considered a palliative intervention for airway complications in patients with unresectable esophageal cancer.[9] Airway stents are effective for treating airway narrowing from both extrinsic compression and direct tumor invasion and have been shown to be useful in the treatment of ERF, if present.[4,17,18] The choice of stent depends on the clinician, the place of practice, financial or health care social policy circumstances, institutional biases, and equipment availability, as well as the particular needs of the individual patient. Clinician factors include personal training, familiarity with rigid and flexible bronchoscopy, and personal preference. Institution-related factors include costs (self-expanding metallic stents [SEMS] are generally more expensive), availability of operating theaters and anesthesiologists for emergency rigid bronchoscopy, and stent availability. In terms of patient factors, one might consider the fitness of the patient for general anesthesia, the risk of provoking complete airway occlusion outside of an operating theater while performing flexible bronchoscopy, and any foreseeable chance that a stent may need to be adjusted or replaced subsequently.[11]

Contraindications

Owing to illness severity, high anesthesia risk, or surgical refusal, patients with advanced esophageal carcinoma may not be candidates for minimally invasive airway procedures, in which case comfort care and placement of a feeding tube, if warranted, may be offered. Except for the high likelihood of OSA, our patient had no obvious pulmonary or cardiac comorbidities that could have increased the risk for perioperative myocardial infarction. Nor did evidence reveal renal or hepatic dysfunction, which, in cases of interventional bronchoscopy under general anesthesia, could make perioperative fluid management difficult and increase risks for bleeding.

Expected Results

Stent insertion in the involved airway of esophageal cancer has been shown to improve the life quality and outcomes of patients with advanced esophageal cancer.[4] In the largest case series to date, 66 airway stents (65 studded silicone stents and 1 Wallstent metal stent) were inserted in 51 patients with airway involvement from esophageal carcinoma. Forty stents were inserted in the trachea, 16 in the left main bronchus, and 10 in the right main bronchus. In 47 patients (92%), improvement in respiratory symptoms was significant. The mean survival was 107.7 days.[8]

Although some might say that bronchoscopic stent insertion is an unwarranted and potentially costly therapeutic alternative with patients with ultimately and rapidly fatal disease, we contend that stent insertion is a palliative intervention that always warrants consideration, not only because it results in greater comfort, even over the short term, but also because it improves quality of life, might allow withdrawal from mechanical ventilation so that patients can communicate more fully with their loved ones, and may result in a reduction in level of care or more rapid discharge from the intensive care or hospital setting. In the Netherlands, where euthanasia is a legal alternative to certain palliative therapies for patients with advanced cancer, 7 out of 12 patients with esophageal cancer who elected to have airway stents inserted were judged by their family physicians to have received "worthwhile" palliation in terms of quality of life during the terminal phase of their disease, despite their relatively short remaining survival time.[19]

Team Experience

In high esophageal tumors and in locally invasive tumors with evidence of ERF, a shared interdisciplinary care approach between gastroenterology and pulmonary teams is recommended.[20] The type of airway stent selected may depend on the level of team experience and training in the technique of rigid bronchoscopy.[21] Bronchoscopic resectional techniques such as laser, electrocautery, cryotherapy, argon plasma coagulation (APC), and photodynamic therapy (PDT), in addition to metal or silicone stent insertion, were available at our institution. Therefore in our case, the choice of treatment was guided by (1) a need for immediate improvement in airway patency to facilitate extubation, (2) a need to maintain airway patency in view of extrinsic compression, and (3) a desire for a stent that could be removed or changed easily in case of changes in clinical illness. Thus we elected to perform our procedure using a resection technique such as Nd:YAG laser for possible hemostasis and photocoagulation of tumor in conjunction with coring out, and to insert a silicone rather than a covered metal stent because of its greater expansile force.[22,23]

Therapeutic Alternatives for Restoring Airway Patency

Alternative therapeutic modalities include insertion of SEMS, radiation therapy, chemotherapy, surgical intervention (esophageal bypass, diversion, and attempted resection), and comfort measures. This patient was not considered a candidate for surgical intervention given his advanced disease, poor functional status, and respiratory failure. Less invasive palliative interventions considered included other palliative bronchoscopic options such as mechanical debridement, dilation, laser ablation, electrocautery, cryotherapy, photodynamic therapy, and brachytherapy alone.[24] Without stent insertion, however, restoration of airway patency may not be immediate or long-lasting. In addition, any remaining extrinsic compression after debulking would require stent placement to maintain patency.

1. *Covered self-expandable metallic stents (SEMS)* have been used to relieve the airway obstruction and seal ERFs to avoid aspiration symptoms.[10,17] Insertion of SEMS in mechanically ventilated patients could be performed via rigid bronchoscopy under general anesthesia (Figure 21-4) or via flexible bronchoscopy under fluoroscopic guidance.[25] Some patients are not suitable for rigid bronchoscopy with a general anesthetic because of the severity of their illness, comorbidities, or refusal to undergo intervention. Fluoroscopy requires special facilities that may not be available in every intensive care unit (ICU). In the absence of ready availability of an operating room, and for those operators not versed in the techniques of rigid bronchoscopy,[21] this procedure can, however, be performed while the patient is on the ventilator in the ICU. Because a significant part of the obstruction was caused by

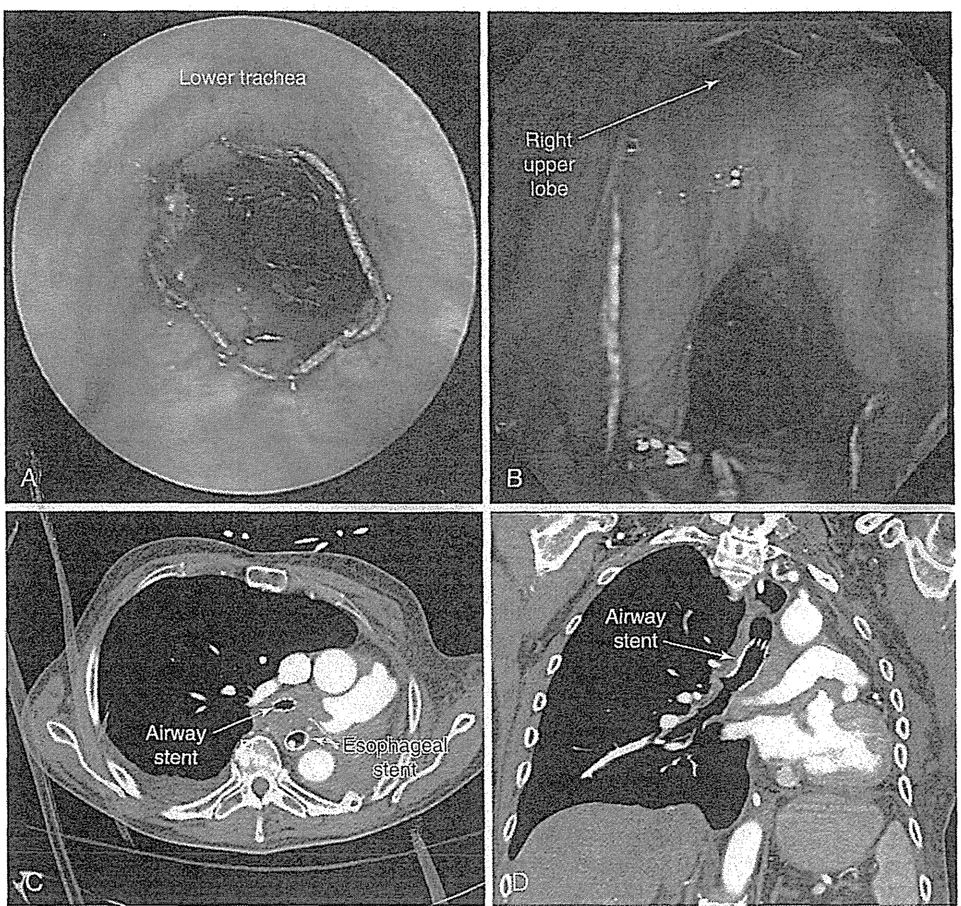

Figure 21-4 **A,** Partially covered 14 × 40 mm Ultraflex stent placed in the lower trachea and the right mainstem bronchus in a patient with respiratory failure post esophageal stent placement. **B,** The distal aspect of the stent is just above the right upper lobe takeoff, thus allowing ventilation to the right upper lobe bronchus. **C,** Axial computed tomography (CT) view post stent placement shows a patent but still compressed airway. **D,** Coronal CT view reveals the exact location of the stent with its distal aspect above the right upper lobe takeoff.

malignant extrinsic compression in our patient, stent insertion could have restored airway patency with or without minimal flexible bronchoscopic debulking of the mass using electrocautery or APC. A technique for placing these stents without fluoroscopy includes the following steps: The bronchoscope is inserted into the mouth through a bite block alongside the endotracheal tube (ETT) and is advanced into the space between the tracheal wall and the endotracheal tube; the scope is then positioned proximal to the lesion; a guidewire is inserted through the bronchoscope and is passed alongside the lesion, after which the bronchoscope is withdrawn, leaving the guidewire in place. The scope is reinserted into the ETT to confirm guidewire location. A stent delivery catheter is advanced over the guidewire, and the stent is deployed under bronchoscopic visualization. The delivery catheter and the guidewire are withdrawn together, with the stent left in position (Figure 21-5). If necessary, the stent can be repositioned by grasping its proximal loop with a flexible alligator forceps **(see video on ExpertConsult.com)** (Video V.21.2).

2. *Definitive chemo-radiotherapy* has been proposed for patients with esophageal cancer and airway invasion with or without ERF. Radiation therapy is effective in palliating dysphagia in 34% to 48% of patients with inoperable esophageal cancer.[26] Concurrent chemotherapy with radiotherapy affords even greater benefit in terms of survival and loco-regional control,[1] although it is associated with significant treatment-related morbidity and mortality. Anecdotal evidence suggests a clinical complete response with induction chemotherapy followed by consolidation with concurrent chemo-radiotherapy—an approach that may reduce the morbidity of upfront radiation.[27] Progression to ERF, however, has been reported with radiotherapy; in one case series, the incidence was approximately 10% (9 of 85 patients).[28] This palliative intervention was not considered a first step in our patient given his poor performance status and the presence of respiratory failure.
3. *Double stent insertion* can effectively palliate both dyspnea and dysphagia. Several reports have described the use of "double" stenting of the esophagus and the airway. Results in terms of immediate relief of respiratory and swallowing symptoms appear to be excellent. Esophageal stents, however, are known to compress the adjacent airway, precipitating or exacerbating airway narrowing (see Figure 21-3).[7,29] Acute airway obstruction

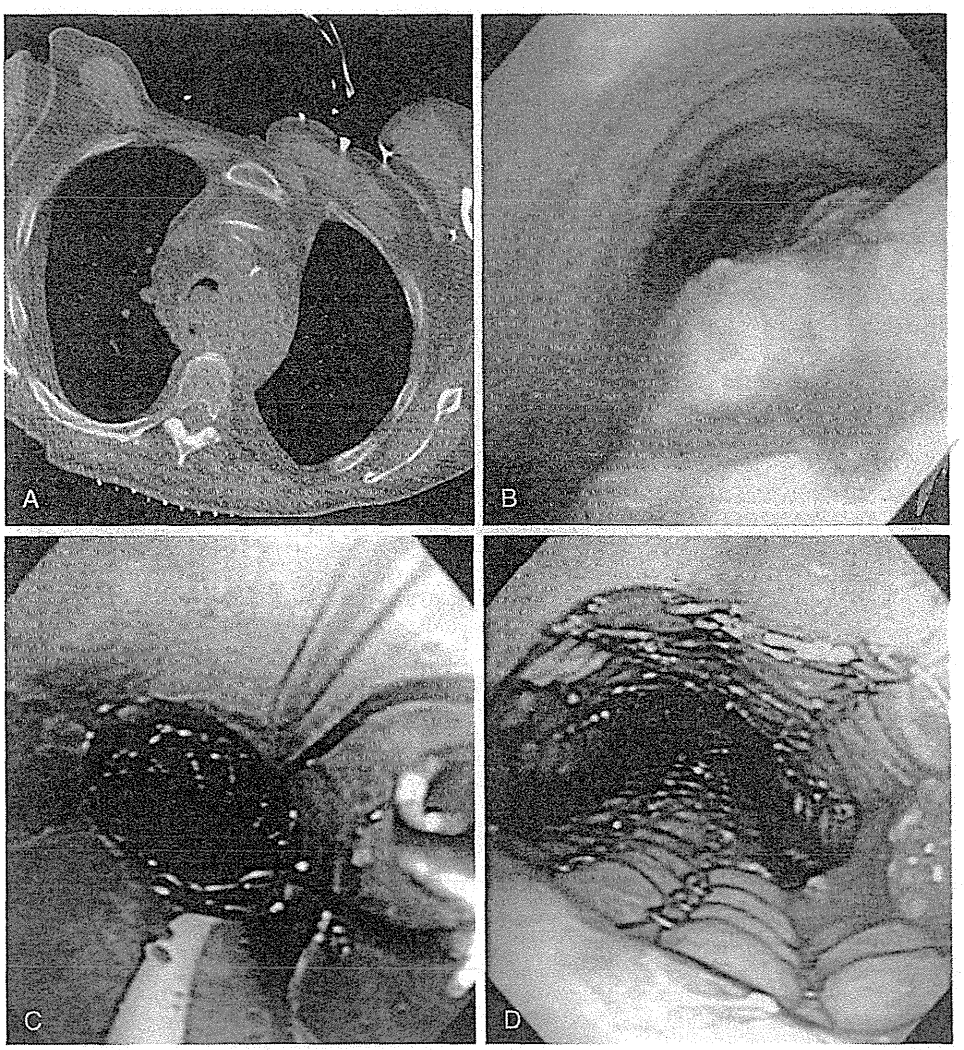

Figure 21-5 **A,** Computed tomography (axial view) from a different patient with esophageal cancer, respiratory failure, and tracheal obstruction. **B,** Flexible bronchoscopy shows the mixed pattern of obstruction with extrinsic compression and exophytic endoluminal tumor. **C,** The self-expandable metallic stent is adjusted by pulling the proximal loop using a grasping forceps through the flexible bronchoscope introduced through the No. 8 endotracheal tube. **D,** Final view of the stent expanded in the trachea, restoring airway patency and allowing removal of mechanical ventilation.

accompanied by stridor, respiratory failure, and death has been reported after placement of esophageal stents in the proximal one third of the esophagus.[7,30] Double stenting of the esophagus and the airway has been described to manage this complication,[7,8,17] particularly when malignancy obstructs the lumina of the esophagus and the tracheobronchial tree. The incidence of airway obstruction following esophageal stent insertion ranges from about 1% to 10%.[9] Airway stent insertion effectively restores airway patency in this setting.[7] Airway stent insertion should always be considered when the esophagus requires stent placement, and certainly respiratory compromise accompanying or following esophageal stent insertion should raise the possibility of airway obstruction by the stent itself. A multidisciplinary approach including an initial airway evaluation for patients being considered for esophageal stent insertion improves prognosis and decreases airway complications related to the esophageal stent.[31] The double stenting procedure is not without complications, however. When double stenting is used in combined esophago-airway lesions, massive bleeding is reported in up to 27%.[32] Double stenting is associated with ERF in up to 18% to 38% of patients with esophageal cancer,[29,32] although it is unclear whether fistulas occur as a direct result of stent-related erosion of altered neoplastic infiltration or airway and esophageal mucosa, or if they are a natural result of disease progression.

Pneumothorax may occur in 3% to 4% of esophageal cancer patients receiving airway stents.[8] Patients with previous radiotherapy to the stented area may be especially vulnerable to airway damage.[33] In patients with respiratory symptoms, we prefer to place airway and esophageal stents in stages, inserting the airway stent first. In patients without respiratory symptoms, palliation of the esophageal obstruction takes precedence, and an airway stent is inserted only in case of development or suspicion of airway compromise. Of course, in a patient with an esophageal tumor above the level of the tracheal bifurcation, it is advisable to exclude tracheal stenosis before esophageal stent insertion even if the patient is not dyspneic. Although bronchoscopic inspection of the airway before insertion of an esophageal stent is routine practice in many centers, it is not clear from the literature whether this procedure is absolutely cost-effective. An alternative is to insert an airway stent preventively before esophageal stent placement if significant airway compromise is present on CT scan or bronchoscopic evaluation.[34] Otherwise, airway compromise after esophageal stent insertion can be effectively palliated by airway stents. Colt et al.[7] performed bronchoscopy in 39 patients requiring esophageal stents for esophageal cancer. Airway stents were required in 10 of these patients (26%) because of airway obstruction. Placement of the esophageal prosthesis contributed significantly to airway compromise in 4 of these patients (10% overall). In our patient, we elected to proceed with conversations regarding esophageal stent insertion only after airway patency had been safely established and the patient had been successfully extubated.

4. *Supportive care measures* include intravenous hydration, feeding tubes, antibiotics, analgesics, and comfort care, including medication for sedation and pain control.

Cost-Effectiveness

No formal cost-effectiveness evaluations of these various modalities have yet been published. Emergent bronchoscopic interventions in the setting of central airway obstruction (CAO) favorably affect health care utilization in patients with acute respiratory distress from CAO who require ICU hospitalization.[16] Successful withdrawal from mechanical ventilation and substantial level of care changes from ICU hospitalization to the medical ward in more than 50% of patients, whether for initiation of systemic therapy or for initiation of comfort/supportive care, suggest that consideration should be given to emergent bronchoscopic intervention in cases of CAO resulting in ICU admission. Early intervention probably is justified from both a clinical and an economic standpoint. If mechanical ventilation cannot be discontinued, the long-term prognosis is dismal, and conversations addressing supportive care, including transfer to hospice, should be initiated.

With regard to the placement of metallic stents, bronchoscopic removal, when indicated, has been shown to be associated with significant complications, health care resource utilization, and costs. Their use therefore should be restricted to patients with advanced malignant airway disease with a short life expectancy, in which case long-term complications requiring stent removal are unlikely to occur.[35]

Informed Consent

No learning barriers were identified in our patient, and the patient's wife had good insight into her husband's disease. Expectations were realistic. After she had been advised regarding all of the alternatives, the wife elected to proceed with rigid bronchoscopy under general anesthesia. She was informed of our potential inability to restore airway patency, and she was informed of the risks for bleeding, airway perforation, worsening respiratory failure, prolonged mechanical ventilation, and death.

Techniques and Results

Anesthesia and Perioperative Care

In patients with OSA, the effects of general anesthesia, neuromuscular agents (when used), narcotics, and sedatives may enhance pharyngeal muscle relaxation and depress the arousal response. This results in more frequent and longer apneas postoperatively.[13] Nasal continuous positive airway pressure (CPAP) after extubation may improve outcomes, but only limited data suggest possible benefit.[13]

At our institution, we perform procedures with patients under general anesthesia, usually achieved by intravenous propofol and, when necessary, remifentanil. Neuromuscular blocking drugs are not used because we aim to keep patients breathing spontaneously throughout the procedure. Ideally, the depth of anesthesia should allow spontaneous breathing while preventing excessive body movement in response to rigid bronchoscopy stimulation.[36] We routinely use a local anesthetic, such as 1%, 2%, or 4% lidocaine, sprayed directly to the larynx before insertion of the rigid bronchoscope to prevent laryngospasm, to reduce patient discomfort leading to coughing and bucking during the procedure, and to help avoid throat soreness afterward.

Instrumentation

Selection of a particular stent for an individual patient is often based on the operator's preference and previous experience with a particular stent, evolution in stent technology, and the local availability of various stents. In addition to the geometry (extent, morphology, severity) of the tumor, knowledge of the mechanical properties of the stent is helpful in selecting the appropriate stent.[37] We therefore consider the biomechanical properties of various stents before insertion because the expansile force (physical strength) and ability to withhold angulation (buckling) vary widely among different types. The important attribute of a stent in a case of extrinsic compression is its expansile force because this determines whether the stent is likely to expand fully. However, in a distorted, curved airway, the buckling radius becomes important as well because this determines whether the stent can conform to an acutely angulated tumor and yet remain functional. Stents may differ greatly in their elasticity and resistance to angulation. Available information on this topic for airway stents is unfortunately very limited.* For example, Ultraflex stents (Boston Scientific, Natick, Mass) were shown to withstand angulation, but their expansile force is not very great, and a studded silicone stent

*For esophageal stents, on the other hand, methods of measurement under experimental conditions simulating actual stent implantation have been developed, and the test results for various types of metal stents are available (*ASAIO J.* 2001 Nov-Dec;47:646-650).

(Dumon stent, Novatech, Cedex, France) has the opposite behavior.[22,23] In this regard, a recent study evaluating the role of therapeutic bronchoscopy for malignant CAO showed that the stent used most commonly in the trachea and the right mainstem bronchi (relatively straight airways) was the Dumon stent, and the one used most commonly in the left mainstem bronchus (curved, tapered airway; often distorted in the setting of malignancy) was the Ultraflex stent, likely because of its better ability to withhold angulation.[38] In this study, patients with esophageal carcinoma involving the airway most often required only stent placement without laser-assisted debulking, probably because the main problem was extrinsic compression.[38]

Anatomic Dangers and Other Risks

Limited neck mobility as noted in this patient potentially increased the risk for difficult rigid intubation. Therefore, an endotracheal tube had to be readily available to allow prompt intubation of the patient in case rigid bronchoscopy could not be performed (especially once anesthesia induction had occurred). In this patient with significant tumor involvement, risks for airway perforation, hypoxemia, bleeding, and procedure-related death were present.

Results and Procedure-Related Complications

Because of the limited neck mobility, we chose to insert the rigid scope via the corner of the mouth (Figure 21-6). We used a large-diameter tube (13 mm) to facilitate placement of a large stent. The ETT was removed under direct visualization, and the bronchoscope was inserted through the larynx as the endotracheal tube was being removed **(see video on ExpertConsult.com)** (Video V.21.3). We avoided laser resection of tumor to avoid necrosis and rupture of the posterior membrane of the trachea, which might precipitate ERF formation. Partial resection and coring out of the tumor within the airway were achieved using the beveled edge of the rigid bronchoscope; once tissues were partially removed, significant extrinsic compression remained and extended for 3 cm **(see video on ExpertConsult.com)** (Video V.21.4). This began at 5 cm below the vocal cords and extended to an area 2.5 cm above the carina. Flexible bronchoscopy was performed through the rigid tube to remove blood and secretions from the airway. Hemostasis was achieved by using an Nd:YAG laser at 30 W, with 1 second pulse photocoagulation, using a total of 935 joules. We chose to insert a Dumon silicone stent (16 mm × 50 mm) because its advantages include ease of adjustment in cases of migration, as well as protection against tumor invasion. Its main disadvantage is the need for rigid bronchoscopy and general anesthesia, which may be poorly tolerated in malnourished patients or in those with concurrent cardiopulmonary disease. Compared with flexible bronchoscopy, however, rigid bronchoscopy affords superior airway control and the ability to safely ventilate patients during the procedure.

The relative thickness of the stent wall tends to lower the maximum achievable luminal diameter. After stent insertion, the rigid scope was removed, and the patient was intubated with a No. 7 endotracheal tube positioned so that its distal aspect was within the stent itself. No intraoperative or postoperative complications were reported. During rigid bronchoscopy with stent insertion, the airway walls can be traumatized or perforated by instrumentation during stent placement and by pressure exerted onto the walls by the stent itself. Complications such as hemorrhage, fistula formation, pneumothorax, pneumomediastinum, or infection cannot always be avoided. Expected delayed adverse events post silicone stent insertion include migration, obstruction by mucus, and granulation. Migration rates for silicone airway stents placed in esophageal cancer patients are reportedly 8% to 12%.[11] With migration, not only does the stenotic region again become obstructed, but the solid walls of a displaced silicone stent may potentially block off a bronchial orifice. To prevent mucus plugging after stent insertion, we routinely begin chest physiotherapy as soon as the patient can tolerate it, usually later on the day of stent insertion. Inhaled air is moisturized by means of steam inhalation or nebulized saline, and mucolytics can be given occasionally. Pneumonia, which may result from sputum plugging, has been reported in 4% of esophageal cancer patients after airway stent insertion.[8] Granulation tissue overgrowth can be very rapid and can cause

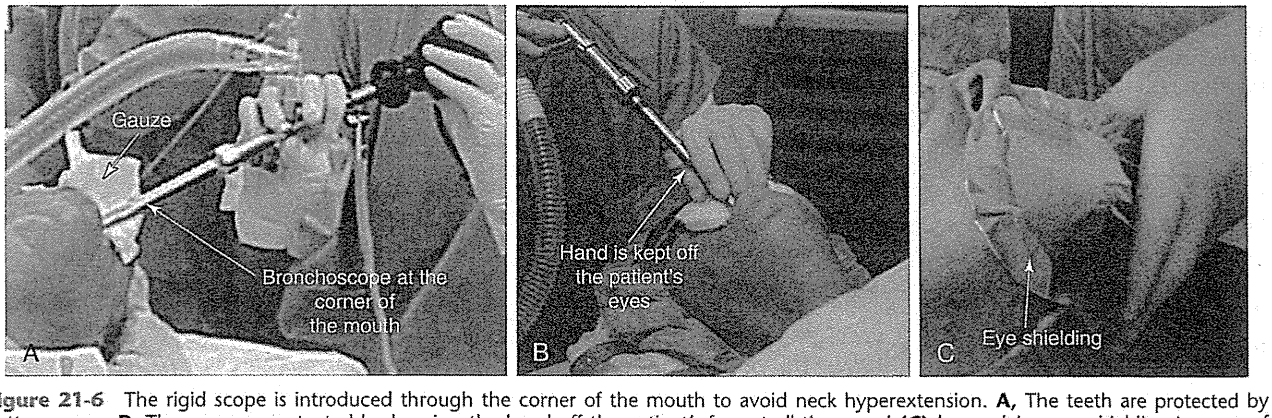

Figure 21-6 The rigid scope is introduced through the corner of the mouth to avoid neck hyperextension. **A,** The teeth are protected by cotton gauze. **B,** The eyes are protected by keeping the hand off the patient's face at all times and **(C)** by applying eye shielding in cases of laser use.

significant obstruction of either or both ends of an airway stent within days or weeks. Excessive pressure from too large a stent or friction of a loose stent rubbing against the airway wall might also enhance granulation tissue formation.[39]

Long-Term Management

Outcome Assessment

The underlying disease, the location of the obstructing lesion, the nature of the lesion (extrinsic, intraluminal, or mixed), and the treatment modality are independent predictors of survival in patients with CAO who undergo therapeutic bronchoscopy.[38] In one study, for instance, the median survival for esophageal carcinoma was 2.5 months versus 5.5 months for lung cancer; the median survival for patients with tracheal and bilateral mainstem bronchial stenosis was 1.6 months versus 4.7 and 4.8 months for patients with left- and right-sided obstruction, respectively. Patients with mixed obstruction had a median survival of 2.3 months versus 5.7 months for patients with purely intraluminal disease.[38] Patients treated with laser and stent had a median survival of 3 months versus 2.7 months for stent only and 10.7 months for laser only treatment. These data do not necessarily imply that one treatment modality is better than another but may simply reflect the nature and severity of the airway obstruction. For example, patients who needed only laser therapy had less severe airway obstruction (e.g., intrinsic exophytic obstructive lesion) and lesions amenable to this modality alone.[38]

Referral

Upon discussion in our multidisciplinary chest conference (cardiothoracic surgery, oncology, critical care, and medical and radiation oncology), a referral to oncology was recommended. Hospice evaluation and home nursing care were also recommended.

Follow-up Tests and Procedures

After stent insertion, a follow-up CXR was performed to confirm its location (see Figure 21-1). Surveillance bronchoscopy is warranted in those patients suspected of having stent-related adverse effects. Secretions, migration, tumor progression, fistula formation, and pneumothorax usually are detected by follow-up bronchoscopy or on chest imaging studies. Complications usually are detected by the onset of new respiratory symptoms and do not necessitate systematic flexible bronchoscopy. Preventive measures such as aerosol therapy, respiratory physiotherapy, and clinical visits[8] are advocated. If patients undergo radiation treatment, bronchoscopy can reveal radiation-induced changes and can help the clinician determine the need for a prolonged indwelling airway stent. In the vast majority of cases of advanced esophageal carcinoma, airway stents are, in fact, permanent once placed. Although this probably reflects the short survival of this group of patients, given the potential for stent-related complications, arguments for removing airway stents in cases of subsequent tumor-specific therapy are valid here, as well as in cases of remission of the airway stenosis.[40] We provided the family with a stent alert card. This document includes the patient's name; indication for stent insertion; type, location, and size of stent inserted; and contact information, as well as instructions for both patients and physicians in case of stent-related complications (Figure 21-7).

The patient was successfully extubated the day after the procedure. He then was transferred back to the referring hospital and was discharged home. Six weeks later, however, he was hospitalized with malnutrition, muscle weakness, and respiratory failure. His airway stent was patent. After a few days of hydration, nutrition, and resting on a ventilator, he was successfully extubated and this time was discharged to home hospice care.

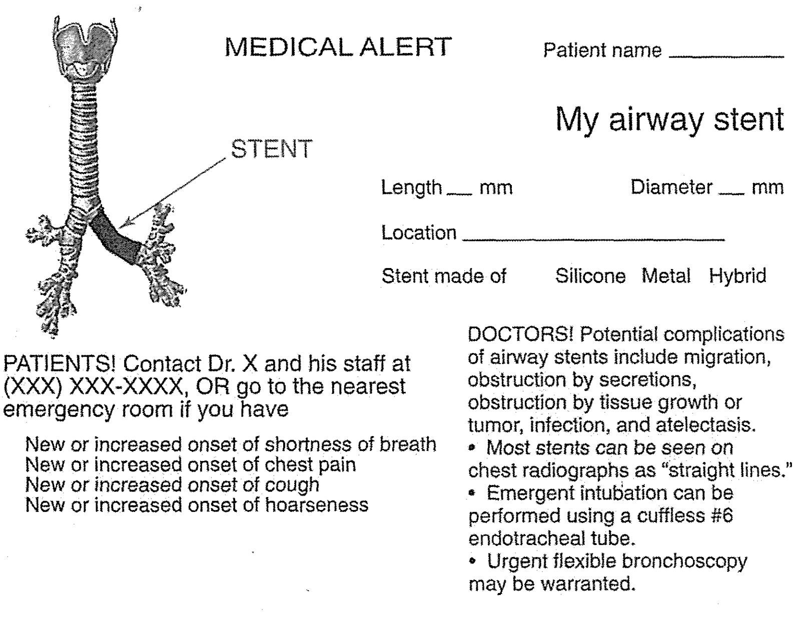

Figure 21-7 The stent alert card provides information both for patients and for physicians who may encounter patients with airway stents. They are informed that even though the stents are not radiopaque, one can identify them on the chest x-ray (CXR) as straight lines. Also, if intubation is necessary, we advise bronchoscopic intubation using a cuffless No. 6 endotracheal tube (ETT) to avoid stent dislodgment or mucosal trauma.