Quality Improvement

We did not believe that an earlier bronchoscopy could have altered the outcome in our patient because, after all, he had no diagnosis before the time of his initial hospitalization. The high incidence of airway involvement by esophageal cancer and the difficulty in predicting it accurately with clinical data or other staging procedures, however, argue for the routine use of bronchoscopy in patients with known tumor located at or above the level of the tracheal bifurcation. Excluding airway invasion is warranted, especially in patients with esophageal tumors longer than 8 cm, or in those for whom CT findings suggest airway invasion. A multivariate logistic regression model indicated, for example, that suspect CT findings (odds ratio, 4.4) and maximal tumor length greater than 8 cm (odds ratio, 3.7) were associated independently with airway invasion.[41] Although esophageal ultrasound and CT are considered the best means of assessing the local extent of esophageal cancer, bronchoscopy is best to identify invasion of the cancer into the airways. If patients have previously undergone chemoradiotherapy, interpreting bronchoscopic findings is more difficult than at baseline; the positive predictive value of macroscopic abnormalities without microscopic proof of cancer is low, and even with extensive sampling for histology and cytology, the false-negative rate is 9.4%.[42]

DISCUSSION POINTS

1. Describe three patient-related factors associated with difficult rigid bronchoscopic intubation.
   - *Anatomy factors:* In addition to the Mallampati score,* one should evaluate for obesity, short or thick neck, face or neck trauma, teeth integrity, dentures, large tongue, and micrognathia or macrognathia.
   - *Evaluate the 3-3-2 rule because successful laryngoscopy is predicated by relative normal anatomy:* three fingers in the mouth opening; three fingers from the front of the chin to the hyoid, and two fingers from the hyoid to the thyroid cartilage.
   - *Evaluate neck mobility:* This is reduced in neck trauma, cervical spine arthritis, osteoporosis, bone metastases, ankylosing spondylitis, and burns, as well as post neck surgery.
2. Explain the rationale for stent insertion after tumor debulking in this patient.

   In patients with CAO, stents are placed for extrinsic compression and combined extrinsic and intrinsic obstruction, and in patients with intrinsic obstruction, they are placed when more than 50% of the lumen is obstructed after debulking or when involvement and instability of the airway wall (malacia) are significant.[43]

   The physiologic rationale for the "50%" cutoff rests on several facts:
   - In a simulation study of tracheal stenosis, the effect of glottic narrowing was of the same order as that of 50% constriction; therefore in theory, an airway narrowing of 50% or less may not significantly affect airflow.[44]
   - A significant pressure increase (which correlates with the work of breathing and dyspnea) was observed well beyond 70% narrowing in a characteristic pattern that was similar for 15 and 30 L/min flows; at 50% narrowing, an increase in pressure was seen only at 30 L/min.[44]
   - These data may provide physiologic justification for the practice of increasing the size of the airway lumen to less than 50% narrowing when treating tracheal obstruction (by stent insertion if necessary).
3. List at least three strategies to prevent airway perforation and hemorrhage during rigid bronchoscopy.
   - To prevent airway perforation during laser treatment, the operator should:
     - Avoid aiming the laser directly into the airway wall.
     - Aim parallel to the wall.
     - Use appropriate settings depending on the goal (vaporization or coagulation).
     - Use laser sparingly, before mechanical dilation and resection.
     - Always find the correct axis and identify airway anatomy distal to the stenosis.
   - To prevent hemorrhage, the bronchoscopist should:
     - Correct coagulopathy.
     - Perform devascularization (deep coagulation) by observing tissue blanching using laser at low power density and before vaporization of tissues.
     - Use the suction catheter frequently to remove debris, blood, and secretions and to palpate necrosing tissues.
     - Be knowledgeable of regional vascular anatomy.
4. Describe five ways to avoid complications of rigid bronchoscopy.
   - Protect the eyes (see Figure 21-6).
     - Place tape over eyelids.
     - Avoid laser-induced eye injury by using protective eye shielding.
     - Keep the bronchoscopist's fingers and palm off the eyes of the patient during the procedure.
   - Protect the teeth.
     - Avoid breaking the teeth or lacerating the gums by carefully inserting the rigid bronchoscope and using a mouth guard or gauze to protect the teeth, lips, and gums (see Figure 21-6).
   - Protect the neck.
     - Intubate through the corner of the mouth rather than at midline to avoid hyperextension, especially in a patient with known limited cervical range of motion.

*The Mallampati rule states that there is a relationship between what is seen on direct peroral pharyngeal visualization and what is seen with laryngoscopy. To perform a Mallampati evaluation, with the patient seated, have the patient extend his neck, open his mouth fully, protrude his tongue, and say "ah." Visualize the airway, looking for the tongue, soft and hard palate, uvula, and tonsillar pillars. In patients with a Mallampati score of 1, the entire posterior pharynx is easily visualized; with a 4, no posterior structures can be seen. Patients with a higher Mallampati grade tend to have poorer visualization during direct laryngoscopy. The examination can be approximated in supine and comatose patients using a tongue blade.

- If the patient cannot be intubated with the rigid bronchoscope, the patient should be intubated with the flexible bronchoscope using an ETT. A resectional technique can then be used in conjunction with expandable metal stent insertion.
- Protect the larynx.
  - Provide sufficient medication during induction so that muscles are relaxed and alignment of the mouth, larynx, and trachea is possible.
  - Decrease risk for laryngospasm by providing sufficient laryngotracheal analgesia with lidocaine.
- Protect the cardiovascular and respiratory systems.
  - Avoid hypoxemia.
  - Avoid complete airway collapse by keeping the patient spontaneously breathing.
  - Avoid vomiting and reflux by inserting a nasogastric tube in selected instances (e.g., patients with known aspiration history or gastroesophageal reflux disease [GERD]).

Expert Commentary

provided by Norihiko Ikeda, MD, PhD

As a thoracic surgeon, I would like to focus on issues pertaining to procedural strategies as they apply to this patient. In my analysis of the case using the four-box approach, I will focus on indications and results, team experience, and risk-benefit/alternative therapeutic modalities.

From indications, contraindications, and expected results perspectives, we know that two main types of airway stents are in use today: silicone stents and expandable metallic stents. The Dumon-type studded stent, a silicone tube, is well established, especially for the treatment of stenosis caused by intraluminal growth of tumors. Expandable metallic airway stents are used most often in patients with airway stenosis caused by extramural compression. Silicone and expandable metallic stents have different indications and advantages, which should be considered when the interventional bronchoscopist (whether a pulmonologist or a thoracic surgeon) selects the most appropriate stent for the lesion.

We speculate that the management of mixed malignant tracheal obstruction caused by esophageal cancer may be different depending on whether the case has already been treated by chemotherapy or radiotherapy, or both. For treatment-naive cases, similar to the present case, tumor debulking using rigid bronchoscopy followed by silicone stent insertion should be standard practice. If the tumor responds to chemotherapy or radiotherapy, and increased airway patency is obtained, the silicone stent could be removed. Similar tracheal stenosis occurs in patients with esophageal cancer who have been treated previously, in which case the insertion of an expandable covered metal or hybrid stent is recommended. Particularly in such cases of previous treatment, as the tracheal stenosis tends to get worse because of persistent tumor growth, it is possible that the silicone stent will not maintain airway patency.

Cases of esophago-respiratory fistula (ERF) are good indications for metallic (or covered expandable metal and hybrid) stent insertion to the airway because stent insertion into the esophagus can be problematic. Frequently, the esophageal stent causes external compression to the airway, which worsens the airway stenosis. The effect of an esophageal stent on the airway should be predicted by preoperative CT scanning. I personally am not happy with the results of double stent insertion because ERF frequently occurs as the result of poor local blood circulation. Once ERF occurs, the patient seldom takes nourishment orally even if the esophageal stent is inserted successfully. We consider that for these reasons, esophageal stenting is not a complete solution for ERF.

Regarding the issue of operator and team experience and expertise, we need experienced anesthetists to enable us to perform interventions for severe airway stenosis. In patients with severe airway stenosis, obstruction by hemorrhage, secretion, and edema occur easily; therefore certain measures should be taken for the operation, and various precautions are required during the perioperative period. For example, anesthesia usually is maintained with propofol (2.0 to 4.0 mg/kg/hr) and fentanyl citrate (0.1 to 0.2 mg/body weight) for therapeutic rigid bronchoscopy.[45] In select cases of severe tracheal stenosis, it is our custom to ensure percutaneous cardiopulmonary support (PCPS) via the femoral artery and vein before induction of anesthesia. Figure 21-3 shows a patient who has had a left pneumonectomy. In such cases, pulmonary reserve is limited, and the shift of the trachea may hinder insertion of rigid bronchoscopy. This is an example in which we find preparation by PCPS extremely helpful, especially if less-experienced operators are performing the procedure.

With regard to risk-benefit analysis and therapeutic alternatives, it is true that a standard method of operation would consist of tumor debulking and silicone stent insertion under rigid bronchoscopy in cases such as that described. This is probably the most effective way to improve the caliber of the severely restricted airway diameter. Patients can receive chemotherapy and radiotherapy after performance status and respiratory condition improve.[46] However, we should explain ERF may develop as an effect of the treatment. Fistula formation prompted by the treatment itself will probably adversely affect the patient's quality of life and survival. Therefore alternatives should be considered and possibly offered to the patient during or before the informed consent process. An expandable metallic stent may be inserted by using a rigid bronchoscope or a flexible bronchoscope. When the flexible bronchoscope is used, intubation with an endotracheal tube is necessary in patients with poor respiratory condition. Advantages of intubation include the ability to maintain sufficient ventilation; the ability to control airway bleeding by compressing the bleeding area or tumor with the inflated cuff of the endotracheal tube; and the possibility for unilateral intubation to protect the contralateral airway in case of massive bleeding. To

provide a safeguard against any surprises that might be found during intervention, I insist on performing an inspection flexible bronchoscopy before proceeding with therapeutic procedures, especially if deviation of the proximal airway is suspected on chest x-ray or CT. Doing so allows me to prepare equipment and my team for any otherwise unexpected events, thereby enhancing patient safety and building team confidence.

REFERENCES

1. Herskovic A, Martz K, Al-Sarraf M, et al. Combined chemotherapy and radiotherapy compared to radiotherapy alone in patients with cancer of the esophagus. *N Engl J Med.* 1992;326:1593-1598.
2. Nelson DB, Axelrad AM, Fleischer DE, et al. Silicone-covered Wallstent prototypes for palliation of malignant esophageal obstruction and digestive-respiratory fistulas. *Gastrointest Endosc.* 1997;45:31-37.
3. Cheng SL, Wang HC, Lee YC, et al. The role of bronchoscopic assessment in esophageal cancer—clinical and survival analysis in 153 patients. *J Formos Med Assoc.* 2005;104:168-173.
4. Alexander EP, Trachiotis GD, Lipman TO, et al. Evolving management and outcome of esophageal cancer with airway involvement. *Ann Thorac Surg.* 2001;71:1640-1644.
5. Altorki NK, Migliore M, Skinner DB. Esophageal carcinoma with airway invasion. *Chest.* 1994;106:742-745.
6. Kato H, Tachimori Y, Watanabe H, et al. Thoracic esophageal carcinoma above the carina: a more formidable adversary? *J Surg Oncol.* 1997;65:28-33.
7. Colt HG, Meric B, Dumon JF. Double stents for carcinoma of the esophagus invading the tracheo-bronchial tree. *Gastrointest Endosc.* 1992;38:485-489.
8. Belleguic C, Lena H, Briens E, et al. Tracheobronchial stenting in patients with esophageal cancer involving the central airways. *Endoscopy.* 1999;31:232-236.
9. Chan KP, Eng P, Hsu AA, et al. Rigid bronchoscopy and stenting for esophageal cancer causing airway obstruction. *Chest.* 2002;122:1069-1072.
10. Takamori S, Fujita H, Hayashi A, et al. Expandable metallic stents for tracheobronchial stenoses in esophageal cancer. *Ann Thorac Surg.* 1996;62:844-847.
11. Sihoe AD, Wan IY, Yim AP. Airway stenting for unresectable esophageal cancer. *Surg Oncol.* 2004;13:17-25.
12. Murgu SD, Colt HG. Interventional bronchoscopy from bench to bedside: new techniques for central and peripheral airway obstruction. *Clin Chest Med.* 2010;31:101-115.
13. Gupta RM, Parvizi J, Hanssen AD, et al. Postoperative complications in patients with obstructive sleep apnea syndrome undergoing hip or knee replacement: a case-control study. *Mayo Clin Proc.* 2001;76:897-905.
14. Finkel KJ, Searleman AC, Tymkew H, et al. Prevalence of undiagnosed obstructive sleep apnea among adult surgical patients in an academic medical center. *Sleep Med.* 2009;10:753-758.
15. Leon AM, Knapp S. Involving family systems in critical care nursing: challenges and opportunities. *Dimens Crit Care Nurs.* 2008;27:255-262.
16. Colt HG, Harrell JH. Therapeutic rigid bronchoscopy allows level of care changes in patients with acute respiratory failure from central airways obstruction. *Chest.* 1997;112:202-206.
17. Freitag L, Tekolf E, Steveling H, et al. Management of malignant esophagotracheal fistulas with airway stenting and double stenting. *Chest.* 1996;110:1155-1160.
18. Sihoe AD, Wan IY, Yim AP. Airway stenting for unresectable esophageal cancer. *Surg Oncol.* 2004;13:17-25.
19. Vonk-Noordegraaf A, Postmus PE, Sutedja TG. Tracheobronchial stenting in the terminal care of cancer patients with central airways obstruction. *Chest.* 2001;120:1811-1814.
20. Gottlieb J, Wedemeyer J. Endoscopic palliation of esophageal and bronchial carcinomas. *Internist (Berl).* 2010;51:237-245.
21. Colt H, Prakash U, Offord K. Bronchoscopy in North America: survey by the American Association for Bronchology, 1999. *J Bronchol.* 2000;7:8-25.
22. Freitag L, Eicker K, Donovan TJ, et al. Mechanical properties of airway stents. *J Bronchol.* 1995;2:270-278.
23. Hautmann H, Rieger J, Huber RM, et al. Elastic deformation properties of implanted endobronchial wire stents in benign and malignant bronchial disease: a radiographic in vivo evaluation. *Cardiovasc Intervent Radiol.* 1999;22:103-108.
24. Stephens KE Jr, Wood DE. Bronchoscopic management of central airway obstruction. *J Thorac Cardiovasc Surg.* 2000;119:289-295.
25. Lee KE, Shin JH, Song HY, et al. Management of airway involvement of oesophageal cancer using covered retrievable nitinol stents. *Clin Radiol.* 2009;64:133-141.
26. Petrovich Z, Langholz B, Formenti S, et al. Management of carcinoma of the esophagus: the role of radiotherapy. *Am J Clin Oncol.* 1991;14:80-86.
27. Ku GY, Goodman KA, Rusch VW, et al. Successful treatment of esophageal cancer with airway invasion with induction chemotherapy and concurrent chemoradiotherapy. *J Thorac Oncol.* 2009;4:432-434.
28. Lewinsky BS, Annes GP, Mann SG, et al. Carcinoma of the esophagus. *Radiol Clin Biol.* 1975;44:192-196.
29. Nomori H, Horio H, Imazu Y, et al. Double stenting for esophageal and tracheobronchial stenoses. *Ann Thorac Surg.* 2000;70:1803-1807.
30. Dasgupta A, Jain P, Sandur S, et al. Airway complications of esophageal self-expandable metallic stent. *Gastrointest Endosc.* 1998;47:532-535.
31. Paganin F, Schouler L, Cuissard L, et al. Airway and esophageal stenting in patients with advanced esophageal cancer and pulmonary involvement. *PLoS One.* 2008;3:e3101.
32. Yamamoto R, Tada H, Kishi A, et al. Double stent for malignant combined esophago-airway lesions. *Jpn J Thorac Cardiovasc Surg.* 2002;50:1-5.
33. Yorozu A, Dokiya T, Ogita M, et al. Complications of esophageal stenting after radiotherapy and brachytherapy. *Jpn J Clin Radiol.* 1997;42:1579-1585.
34. Neuhaus H. The use of stents in the management of malignant esophageal strictures. *Gastrointest Endosc Clin North Am.* 1998;8:503-519.
35. Alazemi S, Lunn W, Majid A et al. Outcomes, health-care resources use, and costs of endoscopic removal of metallic airway stents. *Chest.* 2010;138:350-356.
36. Wong AYC, Lawmin JC, Irwin MG. Anaesthetic management of a patient with low tracheal obstruction requiring placement of a T-Y stent. *Anaesth Intensive Care.* 2000;28:196-198.
37. Chan AC, Shin FG, Lam YH, et al. A comparison study on physical properties of self-expandable esophageal metal stents. *Gastrointest Endosc.* 1999;49:462-465.
38. Chhajed PN, Somandin S, Baty F, et al. Therapeutic bronchoscopy for malignant airway stenoses: choice of modality and survival. *J Cancer Res Ther.* 2010;6:204-209.
39. Cotran RS, Kumar V, Robbins SL. *Robbins Pathologic Basis of Disease.* 4th ed. Philadelphia, Pa: WB Saunders; 1989:73-76.
40. Witt C, Dinges S, Schmidt B, et al. Temporary tracheobronchial stenting in malignant stenoses. *Eur J Cancer.* 1997;33:204-208.
41. Riedel M, Stein HJ, Mounyam L, et al. Predictors of tracheobronchial invasion of suprabifurcal oesophageal cancer. *Respiration.* 2000;67:630-637.
42. Riedel M, Stein HJ, Mounyam L, et al. Influence of simultaneous neoadjuvant radiotherapy and chemotherapy on bronchoscopic findings and lung function in patients with locally advanced proximal esophageal cancer. *Am J Respir Crit Care Med.* 2000;162:1741-1746.
43. Bolliger CT. Multimodalities treatment of advanced pulmonary malignancies. In: *Interventional Bronchoscopy: Progress in Respiratory Research.* Vol 30. Basel, Switzerland: S. Karger AG; 2000.
44. Brouns M, Jayaraju ST, Lacor C, et al. Tracheal stenosis: a flow dynamics study. *J Appl Physiol.* 2007;102:1178-1184.
45. Furukawa K, Ishida J, Yamaguchi G, et al. The role of airway stent placement in the management of tracheobronchial stenosis caused by inoperable advanced lung cancer *Surg Today.* 2010;40:315-320.
46. Saji H, Furukawa K, Tsutsui H, et al. Outcomes of airway stenting for advanced lung cancer with central airway obstruction. *Interact Cardiovasc Thorac Surg.* 2010;11:425-428.