dures. Thus, the use of VSD or atrial septal defect occluder systems is also attractive for endoscopic treatment of other acquired fistulas. For example, we used an atrial septal defect occluder for successful closure of a biliodigestive fistula between the bulbus duodeni and common bile duct, which had induced ascending food impaction, cholangitis, and bile sludge formation (sump syndrome).

The treatment of chronic nonmalignant esophagorespiratory fistulas can be difficult. The self-expanding VSD occluder system described in this case might be useful in patients who are not surgical candidates.

ACKNOWLEDGMENT: We thank Sabine Nunius for translation of this article.

References

1 Lim KH, Lim YC, Liam CK, Wong CM-M. A 52-year-old woman with recurrent hemoptysis. Chest 2001; 119:955–957
2 Kim IS, Lee GH, Jang MK, et al. Bronchial fistula. Gastrointest Endosc 2004; 59:696–697
3 Cook RJ, Anderson LD Jr, Adler DG, et al. Oesophagorespiratory fistula [letter]. Gastrointest Endosc 2003; 58:255
4 Csikos M, Horvath O, Petri A, et al. Surgical treatment of acquired, benign oesophago-respiratory fistulas [in German]. Zentralbl Chir 2004; 129:104–107
5 May A, Ell C. Palliative treatment of malignant esophagorespiratory fistulas with Gianturco-Z stents: a prospective clinical trial and review of the literature on covered metal stents. Am J Gastroenterol 1998; 93:532–535
6 Ell C, May A. Self-expanding metal stents for palliation of stenosing tumors of the esophagus and cardia: a critical review. Endoscopy 1997; 29:392–398
7 Acosta JL, Battesby JS. Congenital tracheoesophageal fistula in the adult. Ann Thorac Surg 1974; 34:1751–1756
8 Azoulay D, Regnard JF, Magdeleinat P, et al. Congenital respiratory-oesophageal fistula in the adult: report on none cases and review of the literature. J Thorac Cardiovasc Surg 1992; 104:381–384
9 Ogunmola N, Wyllie R, McDowell K, et al. Endoscopic closure of oesophagobronchial fistula with fibrin glue. J Pediatr Gastroenterol Nutr 2004; 38:539–541
10 Thanopoulos BD, Tsaousis GS, Konstadopoulou GN, et al. Transcatheter closure of muscular ventricular septal defects with the Amplatzer ventricular septal defect occluder: initial clinical applications in children. J Am Coll Cardiol 1999; 33:1395–1399
11 Parsi A, Bruch L, Szurawitzki G, et al. Transcatheter closure of muscular ventricular septal defects in two patients after myocardial infarction. J Interv Cardiol 2001; 14:219–221

Management of Obstructing Pulmonary Broncholithiasis With Three-Dimensional Imaging and Holmium Laser Lithotripsy*

J. Scott Ferguson, MD, FCCP; Jonathan M. Rippentrop, MD; Bernard Fallon, MD; Alan F. Ross, MD; and Geoffrey McLennan, MD, PhD

Major airway obstruction due to broncholithiasis produces significant morbidity, and management is difficult. Many of the patients are elderly and are not good candidates for surgical removal. Bronchoscopic removal may be limited due to anatomic considerations, skill of the bronchoscopist, and exposure of the patient to additional procedural risks. Preprocedural planning with three-dimensional (3D) multidetector CT (MDCT) imaging enhances the bronchoscopist's knowledge of the relationships of the target lesions with critical structures, and improves the efficiency of the application of specific endobronchial therapies. Here we report our experience treating obstructing broncholithiasis in two patients utilizing pretreatment planning with 3D MDCT imaging, followed by bronchoscopically delivered holmium laser fragmentation of the stones.

(CHEST 2006; 130:909–912)

Key words: airway obstruction; bronchoscopy; lasers; lithiasis; lithotripsy; lymph nodes

Abbreviations: 2D = two dimensional; 3D = three dimensional; Ho-YAG = holmium-yttrium aluminum garnet; MDCT = multidetector CT

Major airway obstruction due to broncholithiasis, although uncommon, produces significant morbidity and is difficult to treat using the surgical and bronchoscopic methods available. Removal of broncholiths via bronchoscopy is often extremely difficult due to embedding of the stone into surrounding structures, large size, or difficulty with crushing the stone using bronchoscopic forceps.[1] Surgical interventions are often required; however, many patients are poor surgical candidates, and removal of the stone may require lobectomy or pneumonectomy.[2] For these reasons, we have sought alternatives to traditional surgical and bronchoscopic approaches.

The Nd-YAG and holmium-yttrium aluminum garnet (Ho-YAG) lasers are possible alternatives to surgery and mechanical crushing.[3,4] However, these modalities are associated with rare but important complications,[5] some of which may be lessened by the use of advanced imaging

*From the Departments of Internal Medicine (Drs. Ferguson and McLennan), Urology (Drs. Rippentrop and Fallon), and Anesthesia (Dr. Ross), University of Iowa, Iowa City, IA.
Drs. Ferguson and Rippentrop participated equally in the preparation of this article.
This work was performed at the University of Iowa.
Drs. Ferguson and Rippentrop, Fallon, and Ross have no conflicts of interest to declare. Dr. McLennan is part owner of VIDA Diagnostics (Iowa City, IA), which is a company that develops three-dimensional software imaging solutions.
Manuscript received October 11, 2005; revision accepted February 21, 2006.

Correspondence to: J. Scott Ferguson, MD, FCCP, Department of Internal Medicine, Division of Pulmonary, Critical Care, and Occupational Medicine, 200 Hawkins Dr, C-33 GH, Iowa City, IA 52242-1089; e-mail: john-s-ferguson@uiowa.edu.
DOI: 10.1378/chest.130.3.909

techniques used to improve the operator's knowledge of the anatomy, which aids in preprocedural planning.

Preprocedural planning with three-dimensional (3D) multidetector CT (MDCT) imaging enhances the bronchoscopist's knowledge of the relationships of the target lesions with critical structures, and improves the efficiency of the application of specific endobronchial therapies. We report two cases of obstructive broncholiths managed via bronchoscopic Ho-YAG laser lithotripsy after planning with 3D reconstruction of the airway utilizing MDCT.

Case Reports

Patient 1

An 84-year-old, diabetic woman with end-stage renal disease, chronic lymphocytic leukemia, and significant osteoporosis and kyphosis was evaluated for a history of recurrent right middle and lower lobe Pseudomonas pneumonia. Chest radiographs demonstrated an endobronchial lesion in the bronchus intermedius with postobstructive changes of the right middle and lower lobes. Chest MDCT with 3D reconstruction[6] revealed the broncholith to be adherent to, if not eroding into the bronchial wall and immediately juxtaposed to the right pulmonary artery; however, the distal airways appeared patent (Fig 1).

Flexible bronchoscopy revealed a broncholith that appeared to obstruct the bronchus intermedius and partially obstructed the lumen to the right upper lobe. The patient was taken to the operating room, where attempts to retrieve the stone with forceps and fragment the stone with an Nd-YAG laser probe (0.5 s and 20 W) were not successful. The stone did not appear to be affected by Nd-YAG after repeated applications of energy. A Ho-YAG laser (365-μm and 1,000-μm fibers; 0.6 to 1.0 J; 8 to 12 pulses per second) was introduced via the flexible bronchoscope, and laser energy was applied to the stone through the fiber in the working channel. With each application, a cloud of fine dust was observed, indicating that the stone was disintegrating from the laser energy. A plane of resection was planned along the medial wall of the bronchus intermedius, and eventually large fragments of the stone could be removed. The former site of obstruction was seen to be widely patent, although the stone was still impacted into the medial wall of the bronchus intermedius. Copious thick mucus was aspirated from both the lower and middle lobes. The patient was extubated at the conclusion of the procedure. Postoperatively, defervescence was noted and chest radiographs demonstrated resolution of the obstruction on day 2.

Patient 2

A 78-year-old man with a 6-month history of shortness of breath, cough, and recurrent left-sided pneumonia despite long-term administration of antibiotics was evaluated using chest CT, which demonstrated a broncholith in the left mainstem bronchus. A planning MDCT scan with virtual endoscopy was performed, demonstrating an abnormal course of the left main bronchus that contained a large broncholith in close proximity to the pulmonary artery (Fig 2). The patient underwent flexible bronchoscopy under general anesthesia demonstrating near-total occlusion of the left main bronchus by a large broncholith. The Ho-YAG laser (200-μm, 365-μm, 1,000-μm fibers; 0.6 to 1.2 J; 8 to 15 pulses per second) was applied via the flexible bronchoscope. Much of the stone was vaporized during lithotripsy, and a plane within the stone was treated causing the stone to split into two large fragments. The two fragments of stone were removed with N-circle and Dormia baskets, leaving one piece of stone embedded in the bronchial wall intact, thus avoiding potential bleeding

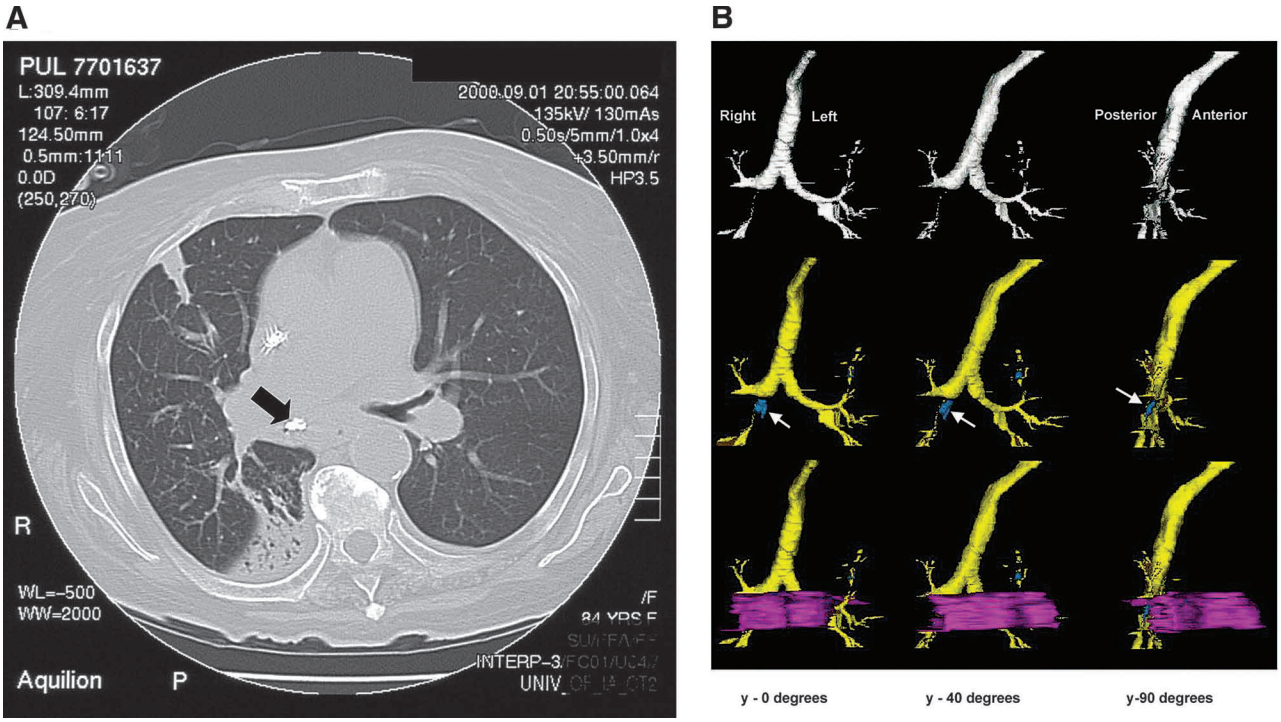

Figure 1. *Left*, *A*: Patient 1. MDCT demonstrating obstructing broncholith (arrow) and resulting pneumonia. *Right*, *B*: 3D reconstruction demonstrating trachea and bronchial tree (white or yellow), pulmonary artery (magenta), and juxtaposed broncholith (blue).