Bronchoscopic Lung Volume Reduction

Michael J. Simoff, MD[a,*], Javier I. Diaz-Mendoza, MD[a], Ahmed Y. Khan, MD[b], Rabih I. Bechara, MD[c]

KEYWORDS

• Obstructive lung disease • Lung volume reduction • Bronchoscopic lung volume reduction

KEY POINTS

- The management of obstructive lung disease, particularly emphysematous lung disease, is aggressively being pursued.
- The patient populations that will experience the greatest benefit with lung volume reduction are those that would be the worst candidates for surgical intervention.
- Identifying a bronchoscopic approach that has a true impact on this patient population will be a major accomplishment in the management of patients with chronic obstructive pulmonary disease.
- Resurgence in work on the physiologic improvements in patients successfully treated with these techniques should identify better parameters that can be used in addition to quality-of-life scores to mark successful interventions.

INTRODUCTION

Over the past decade, since the publication of the original National Emphysema Treatment Trial (NETT) results in the *New England Journal of Medicine*,[1] the concept of a procedural intervention in patients with emphysema has grown. Chronic obstructive pulmonary disease (COPD) remains the third leading cause of death in the United States (Centers for Disease Control and Prevention National Center for Health Statistics, Deaths: Preliminary Data for 2008).[2] As such, the potential for an intervention that can help control morbidity and improve quality of life could have extensive application throughout the world.

The goal of surgery was the removal of 25% to 30% of the diseased lung. The reported 90-day mortality of 7.9% in the surgical group versus the 1.3% mortality in the medical control group was significant. There were also significant postoperative morbidities (air leak for longer than 7 days, prolonged hospitalization, readmission to the intensive care unit, and so forth) in the surgical group in comparison with the medical group. When subgroup analysis was completed, approximately 30% of surgical patients demonstrated clinically significant improvement in exercise capacity and quality-of-life scores.

These results were encouraging, but underscored by the fact that major surgical procedures needed for this intervention were being performed on very poor candidates. Minimally invasive techniques need to be created to allow the opportunity to provide the potential physiologic advantages to the patients that would be candidates for volume reduction surgery, but more importantly, to those patients with severe morbidities resulting from their emphysema, who are otherwise not surgical candidates and subsequently may receive the greatest benefits.

[a] Interventional Pulmonology, Pulmonary and Critical Care Medicine, Henry Ford Hospital, 2799 West Grand Boulevard, Detroit, MI 48202, USA; [b] Pulmonary and Critical Care Medicine, Emory University School of Medicine, 1365 Clifton Road, NE, Atlanta, GA 30322, USA; [c] Pulmonary and Critical Care, Cancer Treatment Centers of America/Southeastern, 600 Parkway North, Newnan, Atlanta, GA 30265; Georgia Regents University, Augusta, GA, USA

* Corresponding author.

E-mail address: MSimoff1@hfhs.org

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This article highlights the work currently ongoing in the area of bronchoscopic lung volume reduction. There are tools now clinically available in some locations throughout the world, but no standardized technique exists.

ENDOBRONCHIAL BLOCKERS

The initial attempts at bronchoscopic lung volume reduction were aimed at correcting loss of elastic recoil in emphysematous lung, by blocking those airways with the most severe airflow limitation.[3–5] This therapy was used for patients with heterogeneous emphysema. The blockage was to induce resorption atelectasis in the more distal lung segments, thereby allowing expansion of healthier lung with resultant improvement in overall elastic recoil. In addition, reductions of anatomic dead space would translate into a decrease in dynamic air trapping and, thus, improved exercise inspiratory capacity. In a manner similar to lung volume reduction surgery (LVRS), the reduction of hyperinflation would provide further benefits to optimizing chest-wall dimensions and the operating length of the diaphragm.

Early endobronchial blockers were composed of silicone (**Fig. 1**) vascular balloons filled with radiopaque contrast; however, custom-built stainless-steel stents with occlusive biocompatible sponges in the center were soon constructed.[5] Unfortunately, experience with this modality of bronchial lung volume reduction (BLVR) revealed that the benefit seen in improvement of dyspnea and exercise tolerance afforded by the blockers was overshadowed by postprocedural complications. Such problems included significant and numerous issues with migration of the blockers after implantation and subsequent postobstructive pneumonia caused by accumulation of distal secretions, which necessitated repeated bronchoscopies.[3–5]

Fig. 1. Watanabe spigot and example of an endobronchial blocker. (*Courtesy of* Michael Simoff, MD.)

Ultimately, further advancements for this route of BLVR were abandoned in favor of other modalities that sought to address the issues of drainage of distal secretions and migration of the implanted devices.

ONE-WAY ENDOBRONCHIAL VALVES

The experience with endobronchial blockers highlighted what the desired characteristics of an endobronchial device aimed to reduce lung volumes should be.[5] The ideal device should cause distal atelectasis in the target lung units, be able to be implanted via flexible bronchoscopy without risk for subsequent migration, be removable if required, and should allow drainage of distal secretions while blocking airflow into airways.[5]

The intended physiologic basis for this modality is similar to that of LVRS. Despite this, only a minority of patients achieve complete collapse of the selected area distal to the implanted valves.[6–11] In the majority of patients the valves divert airflow from the segments of lung with the most severe disease to airways with less airflow limitation, thereby attempting to reduce the amount of physiologic dead space and improve dynamic airflow trapping. The 1-way valve mechanisms seek to permit drainage of secretions distal to the valve in an attempt to reduce the incidence of postobstructive pneumonia.[6–11] Two types of valve have been developed with this goal. Their clinical efficacy at achieving the desired effects has been studied over the last 10 years.

Endobronchial Valve

The valve with the largest amount of data to date is the Zephyr endobronchial valve (EBV) (Pulmonx, Redwood City, CA), formerly known as the Emphasys Zephyr EBV. This device consists of a central silicone 1-way duckbill valve attached to a nitinol (nickel-titanium alloy) self-expanding retaining frame that is wrapped in a silicone seal (**Fig. 2**).[11] After selection of a single target lobe, the Zephyr valves are implanted unilaterally in a 3-step process. The valves are removable in the event of improper positioning or complications from the valve. The valve sits flush with the carina of the segmental bifurcation when correctly positioned (**Fig. 3**).[6–8,11]

After the initial pilot studies by Toma and colleagues[11] and Yim and colleagues[5] suggested efficacy and relative safety of the procedure, several smaller studies without control arms were conducted. These case series consistently were able to demonstrate improvements in subjective scores of dyspnea, but were unable to delineate a clear improvement in traditionally measured physiologic