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# Electromagnetic navigational bronchoscopic airway recanalization in patients with vanishing bronchus



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## ABSTRACT

**Background:** Stenosis is the most frequent airway complication after lung transplantation. When complete obstruction is diagnosed without possibility of recanalization, options are generally limited to either resection or retransplantation, both associated with increased morbidity and mortality. We describe our experience with a novel technique using electromagnetic navigational bronchoscopy (ENB) to recanalize the occluded airway after lung transplantation.

**Methods:** Patients who underwent lung transplantation between 2010 and 2016 with subsequent development of complete airway obstruction and failed conventional recanalization attempts were included in this study. All patients underwent attempted recanalization using ENB. Primary outcomes included success of the technique and long-term patency. Secondary outcomes included procedure-related complications.

**Results:** Four patients met inclusion criteria and underwent attempted recanalization using the ENB platform. Location of the obstruction was the bronchus intermedius in two patients, the lingular bronchus in one patient, and the left basilar bronchus in one patient. Mean length of stenosis was 8.8 mm. Three patients (75%) were successfully recanalized and all airways remain patent at 1, 48, and 66 mo. There were no procedure-related complications. The one patient who was unable to be recanalized successfully underwent bilobectomy and died 7 mo later.

**Conclusions:** ENB is a feasible method of airway recanalization in select patients with bronchial occlusion after lung transplantation. ENB recanalization spares lung parenchyma and avoids risks associated with surgical resection and retransplantation. This novel technique can be added to the armamentarium for thoracic surgeons who diagnose and treat this complicated problem.

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## Introduction

Postoperative airway complications are common after lung transplantation, affecting up to one-third of transplant recipients, and among these complications, airway stenosis is most common.<sup>1,2</sup> Not only are stenoses a frequent cause of reintervention but also progression to occlusion can be devastating, leading to worsening pulmonary function, infection, and even death.

The vulnerability of transplanted lungs to airway stenosis results from relative ischemia of the donor bronchus, with the bronchus intermedius (BI) being particularly prone to this event.<sup>3</sup> The bronchial arteries, which normally contribute significant blood flow to the airways,<sup>4</sup> are necessarily sacrificed during lung procurement and therefore, the donor bronchus relies exclusively on pulmonary arterial blood supply until neovascularization occurs.<sup>5</sup> Numerous factors increase the ischemic risk for transplanted lungs including lung ischemia reperfusion injury, postoperative infection, and extended periods of positive pressure ventilation.<sup>6,7</sup>

Vanishing bronchus syndrome is an infrequent, but extreme, form of airway stenosis and most often occurs in the BI distal to the bronchial anastomosis. Occurrence leads to occlusion of the airway and epithelialization; on bronchoscopic examination, the endoscopist encounters a blind end to the airway. This is often a devastating complication, with a median survival after diagnosis of only 25 mo.<sup>8</sup> Recanalization of the airway in this scenario is particularly challenging and often impossible, leaving the patient with only three options: 1) observation, accompanied by decreased pulmonary function and the risk of postobstructive pneumonia, 2) anatomic lung resection, which in the case of BI obstruction would necessitate bilobectomy, or 3) retransplantation. When surgical treatment is required, the risk of mortality increases significantly.<sup>9,10</sup>

Because of poor functional and long-term survival outcomes in patients with vanishing bronchus syndrome, our group has explored other methods to recanalize the completely obstructed airway in lung transplant recipients. Using experience with electromagnetic navigational bronchoscopy (ENB) on the superDimension (Medtronic, Minneapolis, MN) platform, we have expanded the use of this tool to recanalize the obstructed airway after lung transplant. We have found the ENB allows for three-dimensional guided angling of the needle, resulting in decreased risk of perforation or pleural violation. This platform also allows for accurate interventional deployment and recanalization when stenosis impairs visualization of distal airways with a standard bronchoscope. We present our institutional experience and associated patient outcomes with this novel use of ENB technology.

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## Materials and methods

### Patient selection

After receiving institutional board review exemption, we retrospectively reviewed the charts of patients who

underwent bilateral lung transplant who later presented with signs and symptoms of airway obstruction between 2010 and 2016. Patients who were found to have complete occlusion of a proximal (lobar) airway and failed recanalization by conventional means (i.e., bronchoscopy and dilation) were included in this study. Complete occlusion was defined by the visual appearance of epithelialization of the airway in question and inability to bronchoscopically access the airway with a needle or guidewire. Specific selection criteria were as follows: 1) patients must have had a diagnosis of an occluded central bronchus as evidenced by direct bronchoscopic examination by a thoracic surgeon, 2) computed tomography (CT) scan must have demonstrated the stenosis, a patent distal airway, and no significant atelectasis, 3) patients must have had a mappable distal airway target identified by the ENB software, and 4) patients must have been candidates for general anesthesia. In general, all patients at our institution who develop any degree of bronchial stenosis after lung transplant undergo up to weekly surveillance by standard bronchoscopy with dilation by a thoracic surgeon, as appropriate. The patients in this study developed progression to complete occlusion due to either rapid progression or failure to follow-up. Before undergoing the procedure, all patients underwent a standard consent process and had full knowledge of the potential risks, benefits, and complications of the procedure. Furthermore, they were all informed as to the unique combination of techniques used for this approach, and all alternatives were discussed and considered before electively proceeding.

### Technique

The bronchus anastomotic technique that was used in all patients in this study has been previously described.<sup>11</sup> Briefly, all airway anastomoses were performed with 4-0 polydioxanone suture with a running layer on the membranous airway and interrupted figure-of-eight sutures for the cartilaginous airway. The donor bronchus was trimmed to approximately one ring from the secondary carina and airway divisions are performed sharply without cautery. All patients diagnosed with post-transplant airway stenosis in this study underwent initial flexible and, in some cases, rigid bronchoscopic evaluation to evaluate the stenosis. When recanalization was not possible through standard dilation techniques or guide wire insertion and dilation, the initial procedure was terminated. Patients then underwent thin-slice chest CT using standard ENB protocol and formatting.<sup>12</sup> All patients were confirmed to have visible patent airways beyond the airway obstruction without atelectasis. The DICOM formatted images were then transferred to the iLogic software (Medtronic, Minneapolis, MN) for multiplanar reconstruction. The use of ENB, bronchography, and dilation are well-established tools at our institution. Their combined application to solve this difficult clinical problem were unique and as of yet, have not been previously described.

Each patient underwent a standard planning phase using the iLogic software with the “target lesion” set at the most proximal portion of the airway beyond the point of obstruction. The patients were then taken to the operating room and

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