Our patient was a 56-year-old woman who had a pseudoaneurysm of the right anterior basal pulmonary artery with normal pulmonary artery pressures and who had not received anticoagulant therapy.

The lower and middle lobe branches of the right pulmonary artery are injured in the majority of cases (93%). The right-sided preferential involvement coincides with the usual anatomical distribution of flow-directed catheters. Initial presentation may be hemoptysis, parenchymal consolidation, or a pulmonary nodule evidenced on a chest x-ray film. Hemoptysis may be immediate or may be delayed up to 72 h. Fifty percent of patients present within 24 h and 90% present within 3 days after placement of the pulmonary artery catheter. The nodule, on a chest x-ray film, may have sharp margins, which correspond in size to the pseudoaneurysm. Two thirds of these cases with consolidation may evolve into a mass or nodular lesion. This may represent intra-alveolar hemorrhage which then resolves to reveal the underlying pseudoaneurysm.

Treatment options for pulmonary artery pseudoaneurysms include positive end-expiratory pressure, an emergency thoracotomy for pulmonary artery ligation, segmentectomy, or lobectomy. Positive end-expiratory pressure, while theoretically decreasing hemorrhage by increasing airway pressure, has little reported success. Emergency transcatheter embolization is a safe and cost-efficient treatment which may be performed on an emergency basis with the patient under local anesthesia.

To our knowledge, transcatheter embolization as treatment for pulmonary artery pseudoaneurysms has received little attention in the medical literature and has been reported only in six patients to date. Of these patients, only one was treated on an emergency basis following development of hemoptysis during Swan-Ganz catheter placement. The other five patients were managed conservatively, but they all presented later with recurrent hemoptysis or pulmonary nodule on a chest x-ray film or both. Review of the medical literature shows a time interval between the initial episode of hemoptysis and embolization varying between 56 h to 7 months. This delay may expose the patient to considerable risk of subsequent rupture and fatal hemorrhage. We, in agreement with Jondeau et al., strongly favor immediate embolization as the best therapeutic approach to avoid risk of significant mortality (50%). Considering the low morbidity associated with embolization of pulmonary arteriovenous malformations which is oftentimes more complicated than pulmonary arterial embolization for pseudoaneurysm, the risk of significant morbidity associated with embolization of a single pulmonary artery with pseudoaneurysm is negligible.

Our case is intriguing in that conventional magnification cut film pulmonary angiography failed prospectively to reveal the pseudoaneurysm, whereas digital angiography easily revealed the lesion. The slight obliquity of the digital study may have contributed to the lesion's conspicuity in the arterial phase, but the lesion was particularly more visible on the parenchymal and venous phases of the digital study when there were no superimposed vessels to obscure the lesion. This was clearly due to the superior contrast resolution of digital subtraction.

In summary, we feel that digital subtraction angiography under these circumstances is an indispensable complement to cut film studies for the detection of pulmonary artery injury. We feel that immediate transcatheter embolization of catheter-induced pulmonary artery pseudoaneurysm is a safe, minimally invasive, fast, and cost-effective alternative to surgical treatment.

**References**


**Management of Bronchopleural Fistula with a Variable-Resistance Valve and a Single Ventilator**

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Independent lung ventilation with two ventilators is sometimes used in the management of bronchopleu-
ral fistula (BPF). We describe a patient in whom gas flow through a large BPF was initially reduced, and subsequently eliminated, during differential lung ventilation using a single ventilator and a variable-resistance valve attached to one lumen of a bifurcated endotracheal tube.

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Key words: bronchopleural fistula; independent lung ventilation; mechanical ventilation

Abbreviations: BPF = bronchopleural fistula; ILV = independent lung ventilation

Bronchopleural fistula (BPF) is a well-known complication of lung resection.1 In patients receiving mechanical ventilation, BPF may result in adverse effects such as incomplete expansion of the affected lung, inability to maintain positive end-expiratory pressure, hypoxemia, and respiratory acidosis due to inadequate minute ventilation.1,2 Independent lung ventilation (ILV) with two ventilators has been used in the management of BPF in cases in which the loss of tidal volume is sufficiently severe to result in refractory hypoxemia and hypercarbia.2 Previously we have shown in an animal model that a variable-resistance valve in conjunction with a bifurcated endotracheal tube may be used in the management of BPF for ILV with a single ventilator.3 The valve is constructed of lightweight plastic and has a metal volume knob adjuster with a metal plunger which is used to progressively occlude a central channel (Fig 1). Thus, the valve provides variable resistance to airflow and, when attached to one lumen of a double-lumen endotracheal tube, it can be used to adjust the amount of tidal volume delivered to a single lung, which can therefore influence the resultant peak pressure in that lung. We now describe a patient with postoperative BPF in whom ILV was achieved with the use of a variable-resistance valve and a single ventilator.

Case Report

A 52-year-old man with severe COPD and recurrent spontaneous pneumothoraces underwent thoracoscopic bullectomy of the right lung. The patient had severe diffuse bullous disease and, following bullectomy, two chest tubes were placed to evacuate air from the right pleural space. During the postoperative period, he developed a large air leak from both chest tubes which was of sufficient magnitude that ventilation and oxygenation became compromised. The patient’s arterial blood gas levels rapidly deteriorated and he subsequently required a full thoracotomy in order to seal a large number of leaking sites in his visceral pleura. Prior to closing the chest, the surgeon determined that inflation pressures above 20 cm H2O resulted in air leaks at multiple sites, but air leaks were not present at a lower inflation pressure. Consequently, ILV was attempted via a double-lumen endotracheal tube (Sheridan Catheter Corp; Argyle, NY) in order to avoid higher inflation pressures in the right lung. The patient was placed on two mechanical ventilators (Puritan-Bennett 7200A; Carlsbad, Calif), operating in an asynchronous fashion, with the following settings (patient weight, 46 kg): right lung—pressure control ventilation (1.15 ratio), 15 cm H2O; rate, 15 breaths/min; positive end-expiratory pressure, 5 cm H2O; FiO2, 0.5 (and a resultant exhaled tidal volume of approximately 100 mL); left lung—pressure control ventilation (1.15 ratio), 25 cm H2O; rate, 15 breaths/min; FiO2, 0.5 (and a resultant exhaled tidal volume of approximately 300 mL).

On these settings, there continued to be a significant air leak from both chest tubes. The patient’s arterial blood gas levels 1 h following thoracotomy were: pH, 7.29; PaCO2, 45 mm Hg; PaO2, 80 mm Hg. The amount of suction applied to the chest tubes was decreased in order to decrease the transpulmonary pressure, but there was no significant improvement in the air leak with these maneuvers.

On the 2nd hospital day, a continuous air leak was present from both chest tubes. Pressure control ventilation (now at 19 cm H2O to the right lung and 26 cm H2O to the left) resulted in exhaled tidal volumes of approximately 50 to 80 mL from the right lung and approximately 300 mL from the left. Arterial blood gas levels showed a pH of 7.29; PaCO2, 54 mm Hg; and PaO2, 61 mm Hg (FiO2, 0.5). At this point, a variable-resistance valve was inserted online in the endotracheal tube lumen to the right lung and, through a Y-connector, the entire system was connected to a single ventilator (Puritan-Bennett 7200A) in order to provide synchronized ILV and, yet, prevent excessive pressures in the lung with the BPF. The details of this technique have previously been described.3 The patient was placed on assist-control with a rate of 15 breaths/min, set tidal volume, 400 mL; peak flow, 60 L/min; FiO2, 0.5. The airway pressure and volume were controlled by opening the valve (from 100% occlusion) and titrating the degree of occlusion to obtain the desired airway pressures and tidal volumes distal to the valve (measured between the valve and the endotracheal tube). As the valve was progressively occluded, resulting in a decrease in peak airway pressure in the right lung, the airway pressure in the left lung increased by an average of 4 to 9 cm H2O. On these settings, the results were as follows: right lung—average exhaled tidal volume was 80 mL, and peak airway pressure was 16 cm H2O; left lung: average exhaled tidal volume was 500 mL, and peak airway pressure was 30 cm H2O. The ventilator tubing (Respi-Flex Ventilator Circuits) compliance averaged 3.3 mL/cm H2O. The air leak from the apical chest tube ceased entirely. The leak from the posterior chest tube decreased and was now only present during inspiration. Arterial blood gas levels 1 h following initiation of these settings were pH, 7.33; PaCO2, 45 mm Hg; PaO2, 63...

Figure 1. Schematic of variable-resistance valve.
mm Hg (FlO2, 0.5). Within 3 hs, no further deterioration occurred. On the same settings, the arterial blood gas levels showed the following; pH, 7.28; Pco2, 42 mm Hg; Po2, 60 mm Hg (FlO2, 0.5). The patient was maintained on a single ventilator with a bifurcated endotracheal tube and the variable-resistance valve in place for the next 3 days, during which time the air leak via the BPF slowly decreased and ultimately resolved. He was then reintubated with a standard single-lumen endotracheal tube and maintained on the ventilator until he clinically improved.

**DISCUSSION**

The management of severe unilateral lung disease often is difficult because of the different physical characteristics of the two lungs. In these cases, the majority of the ventilator-delivered tidal volume enters the lung with the higher compliance and, as a result, insufficiently ventilates the contralateral lung, thus leading to worsening gas exchange or barotrauma.4 Patients with a large bronchopleural fistula may have the majority of the tidal volume delivered to the diseased lung and, subsequently, may lose a significant amount of volume via the air leak. In this situation, the nondiseased lung is insufficiently ventilated, and oxygenation and ventilation may be difficult to maintain.1,5 When the mechanical properties of the two lungs are different, synchronized,4,5 or asynchronous,6 ILV with two ventilators, or one ventilator with 2 separate breathing circuits,7,8 is occasionally attempted. Differential lung ventilation with two ventilators requires more extensive monitoring and is more labor-intensive. Concerns have been raised regarding impairments in venous return and oxygenation with the use of asynchronous dual ventilation in unilateral lung disease.6 Although synchronous ILV was not found to have an advantage over asynchronous ventilation in a dog model of unilateral acid-induced lung injury,9 it is unclear whether ventilator synchrony is important in the management of BPF.

We have designed and constructed a variable-resistance valve which has been tested in an animal model of BPF to demonstrate its efficacy in allowing differential lung ventilation, in a synchronized fashion, with the use of one ventilator. With a double-lumen endotracheal tube, the valve provides variable resistance to the lumen of the tube to one lung and, thus, controls the volume and airway pressure to that lung. We found that it effectively diverts a certain percentage of the ventilator-delivered tidal volume to the lung which is predominantly responsible for gas exchange, decreases the airway pressures to the injured lung, and, hence, decreases the air leak through an experimental BPF.2 The technique is comparatively simple and requires a less complex breathing circuit, as it allows for modification of tidal volumes, pressures, and flow rates by regulating a single valve to an optimal point between 0 and 100% occlusion. Other advantages of this method include a reduction in cost and improved ease of ventilator management because only one ventilator is used instead of two.

In this patient, BPF was successfully managed with differential lung ventilation using a variable-resistance valve in conjunction with a double-lumen endotracheal tube and a single ventilator. With the valve in place, the differential tidal volumes, flows, and pressures in each lung nearly matched the same parameters that were obtained when two ventilators were used. Therefore, the use of a variable-resistance valve and a single ventilator can be considered an alternative technique for the management of BPF. Further studies are needed in order to determine the efficacy of this technique in other forms of unilateral lung disease which require ILV.

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**Nonsustained Polymorphous Ventricular Tachycardia During Amiodarone Therapy for Atrial Fibrillation Complicating Cardiomyopathy**

**Management With Intravenous Magnesium Sulfate**

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A case is presented in which amiodarone was administered to suppress paroxysmal atrial fibrillation in a

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