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Independent Lung Ventilation Using High-frequency Ventilation in the Management of a Bronchopleural Fistula

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High-frequency ventilation has been evaluated in several studies of airway disruption.[1–6] In adults, the major use of this pattern of ventilation has been in patients in respiratory failure with bronchopleural fistulae.[1–3] Independent lung ventilation using a double-lumen endotracheal tube has been used in patients with unilateral lung disease to optimize the ventilation of each lung.[7–9] This technique is most useful when there is severe disease in one lung and the other is nearly normal.

We describe a patient who developed a large bronchopleural fistula following resection of an infected descending aortic graft that was managed using a technique of ventilation combining high-frequency ventilation with independent lung ventilation using a double-lumen endotracheal tube. High-frequency ventilation was applied to the lung with extensive airway disruption, and the other lung received conventional positive pressure ventilation for 10 days.

CASE REPORT

A 59-yr-old man was hospitalized because of an infected graft of his descending aorta. He had a history of valvular heart disease necessitating replacement of his aortic and mitral valves, as well as a type B aneurysm of the descending aorta, which had been replaced with a Dacron graft 2 yr prior to admission. Prior to surgery, he had signs of the development of a mycotic aneurysm of the graft. He had persistent back pain, bacteremia, empyema, and mild renal insufficiency. He was taken to surgery where a #37 left-sided double-lumen endotracheal tube (MallincKrodt #95892) was placed, and the infected graft was removed *via* a left thoracotomy. The graft was adherent to lung throughout its course. A right axillo-femoral bypass graft was inserted for perfusion of the abdomen and lower extremities. At the completion of the vascular procedure, the left lung was ventilated with the right; however, a massive leak of air was present from all along the surface. The air leak was so large that the dependent right lung could not be ventilated if positive pressure was applied to both lungs simultaneously. The right lung was, therefore, ventilated with intermittent positive pressure ventilation and the left lung left to continuous positive airway pressure (CPAP) for completion of surgery and return to the ICU. In the ICU, each lung was ventilated independently using two conventional positive pressure ventilators using a low tidal volume and rate on the left lung and a more conventional tidal volume and rate on the right (table 1). His major problems were a low arterial oxygen tension and a large air leak. Interventions that were attempted but were unsuccessful in improving oxygenation included right lateral decubitus position, end-expiratory pressure to the right lung, and then continuous positive airway pressure to the left lung.[10] Prolonged periods in the right lateral decubitus position were not possible because of the axillo-femoral artery graft. On the first postoperative day, there was a persistent air leak from the left pleural tubes despite low tidal volume ventilation and a large intrapulmonary right-to-left shunt manifest by a low Pa_{O_2}/FI_{O_2} ratio. The patient was thought to have a lung contusion, involvement of the lung with the mycotic aneurysm, and a large air leak. Chest x-ray revealed diffuse infiltration of the left lung and a relatively normal-appearing right lung. The left lung was then ventilated with a ServoVentilator (Siemens 900C) set at 100 breaths/min delivering a tidal volume of approximately 30 ml to the left lung. Over the next several hours, there was a marked improvement in his Pa_{O_2}/FI_{O_2} ratio and no change in cardiac output (table 1). Arterial carbon dioxide tensions were always maintained within the normal range (35–44 mmHg). Ventilation was continued in this manner until the 10th postoperative day, at which time he had no further air leak both with high frequency ventilation and when conventional mechanical ventilation (V_T–13 ml/kg) was applied to both lungs. His double-lumen tube was removed and replaced with an 8.0-mm nasotracheal tube. Fiberoptic bronchoscopy was performed and no tracheal or endobronchial damage was seen. He required mechanical ventilatory support for another 20 days and was extubated on the 30th postoperative day. Over that time, there was gradual resolution of the left lung infiltrate. There was no evidence of superinfection of the left lung. He left the ICU 42 days after surgery; however, he died on postoperative day 61 of recurrent sepsis and renal failure.

DISCUSSION

We combined the concepts of asynchronous independent lung ventilation and high-frequency ventilation in the postoperative management of this patient with a large bronchopleural fistula. This application of high-frequency ventilation has been previously described for the anesthetic management of a patient with a bronchopleural fistula.[11] In our case, we used this form of support for 10 days. The double-lumen endotracheal tube allowed the patient to receive a large minute ventilation delivered to the better right lung with moderate elevations in airway pressure, while providing ventilation to the leaky lung with significantly lower airway pressures. The air leak persisted until day 7, and after 10 days of therapy conventional mechanical ventilation was resumed without recurrence of the air leak.

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TABLE 1. Ventilation Data Following Surgery

	Postoperative Day												
	0	1	2	3	4	5	6	7	8	9	10	20	30
Tidal volume (ml) (L/R)	200/800	30/800	30/800	30/800	20/800	20/800	20/800	10/800	10/800	10/800	1000	1000	300
Rate (breaths/min) (L/R)	5/16	100/16	100/13	100/11	120/11	120/11	120/11	120/11	120/8	120/6	10	8	28
Peak inspiratory pressure (cm H_2O) (L/R)	45/47	27/44	29/42	29/48	24/44	26/42	20/30	20/30	21/34	22/30	40	37	—
Positive end-expiratory pressure (cm H_2O) (L/R)	5/5	7.5/5	7.5/5	7.5/5	7.5/5	7.5/5	7.5/5	7.5/5	7.5/5	7.5/5	10	5	—
Pa_{O_2}/FI_{O_2}	65	152	182	160	154	161	274	242	230	240	267	300	391
Cardiac output (l/min)	4.0	6.5	7.0	6.0	5.6	5.5	6.0	5.1	NA	NA	NA	NA	NA
Air leak	+	+	−	+	−	−	−	−	−	−	−	−	−

L/R = Left lung/Right lung; Pa_{O_2}/FI_{O_2} = ratio of arterial oxygen tension (Pa_{O_2}) to fraction of inspired oxygen (FI_{O_2}) (Normal value >400)

Double-lumen endotracheal tubes have been used to provide independent lung ventilation in cases of unilateral lung disease where there was rapid resolution of the underlying pathophysiology.[8,9,12–14] Independent lung ventilation allows for titration of end-expiratory pressure and tidal volume in each lung.[8,9,12] Earlier uses of independent lung ventilation attempted to synchronize the ventilation of each lung to inflate at the same time; however, this is not necessary because asynchronous ventilation does not appear to be harmful to cardiovascular function.[13,14] No previous reports described use of the double lumen endotracheal tube for more than 36 h.[8,9,12–14] Careful attention was paid to the inflation of the tracheal and bronchial balloons. This meant daily measurement of cuff pressures and the use of a minimal leak technique to use the lowest possible cuff pressure. Tracheal suctioning was possible with this type of intubation.

While some studies have demonstrated a benefit in treating bronchopleural fistulae with high frequency ventilation,[1–6] a recent study by Albelda *et al.* demonstrated a variable response to high-frequency ventilation when leak flow was measured.[15] This seems to be especially true when the air leak is associated with a bilateral lung injury pattern. In a recent study by Bishop *et al.*, air leak increased and Pa_{O_2}/FI_{O_2} ratio fell during high-frequency ventilation.[16] Five of the seven patients they studied had the adult respiratory distress syndrome and poor compliance of both lungs. Our patient had unilateral lung disease with a bronchopleural fistula in the diseased lung. The double-lumen endotracheal tube allowed us to apply high-frequency ventilation only to the diseased lung using low mean and peak airway pressures. The fact that the other lung was relatively normal meant that conventional ventilation could be used and aided in the normalization of blood gas exchange. While we did not attempt to quantitate the air leak, the leak was so severe at the time of surgery that conventional ventilation was not possible. The leak gradually disappeared to visual observation over the first 24 h of the start of high-frequency ventilation.

The Siemens 900C ventilator can operate at rates up to 120 breaths/minute without special modification, and was very effective in delivering high-frequency ventilation. The result was a gradual elimination of the air leak with maintenance of normal carbon dioxide elimination and improvement in arterial oxygenation. Cardiac output was not reduced. The technique allowed us to provide adequate ventilatory support, as well as a selective reduction in airway pressure in the diseased lung. The technique may be of use in the management of other patients with large bronchopleural fistulae with respiratory failure who require postoperative ventilatory support. Double-lumen endotracheal tubes can be used for prolonged ventilatory support outside the operating room.

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Epidural Abscess following Epidural Catheterization in a Chronic Pain Patient: A Diagnostic Dilemma

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Reviews addressing the epidemiology of epidural abscess conclude that infection of the epidural space is an extremely rare condition accounting for, on average, about 1 in 50,000 hospital admissions.[1] Reported cases suggest that most epidural infections result from trauma, surgical procedures, intravenous drug use, or hematogenous spread of infection from elsewhere in the body, rather than as a result of epidural analgesia.[2–4]

Clinical recognition of either acute or chronic epidural abscess can be extremely difficult. In patients with underlying painful disorders in whom continuous epidural analgesia or anesthesia is used for evaluative or therapeutic purposes, this diagnostic dilemma may be compounded. We report a case of a patient who developed an epidural abscess after continuous epidural catheterization for management of a long-standing thoracic neuralgic pain syndrome.

CASE REPORT

A 35-yr-old woman was referred to our Pain Management Center for evaluation and treatment of left-sided parascapular pain of 7 months duration. This pain problem followed an episode of acute bronchitis and had been unresponsive to treatment with non-steroidal anti-inflammatory agents, tricyclic antidepressants, transcutaneous nerve stimulation, massage and ultrasound, and intercostal nerve blocks. The patient was taking up to ten Percocet® tablets a day and was organizing her life around the acquisition of analgesics for pain relief.

Her pain was described as sharp and burning with intermittent stabbing sensations in a circumscribed area from the lateral border of the left scapula to the ipsilateral posterior axillary line. It was described as severe and debilitating, keeping her from enjoying an active life and interfering with her work as a realtor. She consumed alcohol moderately, smoked one to two packs of cigarettes a day, frequently used over-the-counter soporifics in order to fall asleep at night, and consumed approximately 12–14 cups of caffeinated beverages each day.

Physical examination was remarkable for a tearful and agitated affect and an area of reproducible dysesthesia in a wedge-like distribution from the left scapular border to the ipsilateral posterior axillary

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