Unilateral Lung Hyperinflation and Herniation as a Manifestation of Intrinsic PEEP*

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In a 64-year-old ventilated patient with severe chronic obstructive pulmonary disease and extensive unilateral pneumonia, intrinsic PEEP became recognized when the chest roentgenogram showed unilateral lung hyperinflation and herniation of a large bulla to the contralateral hemithorax. The use of an on-line suction catheter may have contributed to the development of intrinsic PEEP. Removal of the catheter resulted in roentgenographic and clinical improvement.

The occurrence of occult or "intrinsic" PEEP has been well documented. Patients with a prolonged expiratory time constant secondary to either increased airway resistance or a decreased elastic recoil are at high risk. Manifestations of intrinsic PEEP have ranged from overt hemodynamic compromise to unexplained hypoxemia, hypercarbia, tachycardia, and oliguria.

We describe an unusual roentgenographic and clinical manifestation of intrinsic PEEP. In this patient, intrinsic PEEP became recognized when the chest roentgenogram showed unilateral lung hyperinflation and herniation of a large bulla to the contralateral hemithorax. This resulted in the hemodynamic responses of tachycardia and hypotension.

CASE REPORT

A 64-year-old man with chronic obstructive pulmonary disease became febrile after remaining stable for five years on mechanical ventilation. Chest roentgenogram showed a right upper lobe infiltrate, a left upper lobe bulla, and generalized hyperinflation. Culture of endotracheal secretions revealed Pseudomonas aeruginosa. The patient was ventilated with an FIO2 of 28 percent, tidal volume of 800 ml, in assist/control mode. Delivered minute ventilation was 8 to 10 L/min and peak inspiratory pressure was 35 cm H2O. Despite appropriate antibiotic therapy, the infiltrate cavitated and progressed roentgenographically to involve the right lower lobe. Intrinsic PEEP, measured after transient occlusion of the expiratory ventilator tubing, was 10 cm H2O. An on-line suction catheter (TRACHCARE closed tracheal suction system, Ballard Med Products, Midvale, Utah) was added to the ventilator apparatus to facilitate suctioning. Routine chest roentgenograms on subsequent days revealed left lung hyperinflation with resultant herniation of the upper lobe bulla across the midline (Fig 1). Repeated measurements for intrinsic PEEP during this time were 20 cm H2O. In addition, his systolic blood pressure, which had been measured at 120 mm Hg, was reduced to 90 to 100 mm Hg. In response, his heart rate rose to approximately 120 beats per minute. Bronchoscopy showed no proximal endobronchial obstruction, but the chest roentgenogram immediately after the procedure showed partial resolution of the apparent lung herniation, which then recurred following reinstitution of mechanical ventilation. The on-line suction apparatus was removed and the patient was intermittently manually suctioned. Although little improvement in the patient's pneumonia was noted, subsequent chest roentgenograms demonstrated improvement in the left lung hyperinflation and a decrease in the size of the left upper lobe bullous lesion (Fig 2). Furthermore, the patient's blood pressure subsequently increased and heart rate decreased to their previous levels. Intrinsic PEEP was persistently measured at this point at approximately 10 cm H2O.

DISCUSSION

Routine chest roentgenograms in patients in the intensive care unit are inadequate for demonstrating the presence of PEEP, whether applied or intrinsic, as increased lung distention may be subtle and easily overlooked. However, in patients with air trapping due to severe obstructive airway disease who develop unilateral lung disease, the uninvolved lung may be relatively more compliant and thus more susceptible to the effects of intrinsic PEEP. Such an occurrence has, in fact, been reported previously with the use of applied PEEP in a patient with unilateral lung consolidation. Our patient demonstrates that intrinsic PEEP may also be unequally distributed in patients with asymmetric lung disease.

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FIGURE 1. Arrows show edge of left upper lobe bulla herniated across midline. Note contralateral shift of mediastinum.

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Unilateral Lung Hyperinflation and Herniation (Eveloff, Rounds, Braman)
Reduction of Peak Inspiratory Pressure Using High Frequency Jet Ventilation and Pressure Control Ventilation Following Pneumonecstasy*

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High peak inspiratory pressure (PIP) during mechanical ventilation is associated with increased risk of barotrauma. High frequency jet ventilation (HFJV) and pressure control ventilation (PCV) have been advocated for the reduction of PIP. The Food and Drug Administration has approved HFJV, respiratory frequency as high as 150 breaths per minute (bpm); however, bpm greater than 150 are still considered for experimental use. At less than 40 bpm, the point where HFJV is no longer considered to be high frequency, PCV is substituted which then becomes the mode of choice because of the ability to control ventilating pressures by setting the PIP. We present a case in which we used these two forms of ventilation for reducing the risk of stump blowout and barotrauma following pneumonectomy.

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| PIP | peak inspiratory pressure; HFJV=high frequency jet ventilation; PCV=pressure control ventilation; CMV=conventional mechanical ventilation; Vr,tidal volume |

H igh peak inspiratory pressures during conventional mechanical ventilation (CMV) are associated with increased risk of barotrauma. Avoidance of barotrauma is particularly important for a patient following pneumonectomy. The employment of ventilatory techniques that will reduce peak inspiratory pressure (PIP) while providing adequate oxygenation and CO₂ elimination is helpful in certain situations. Both high frequency jet ventilation (HFJV) and pressure control ventilation (PCV) reduce PIP while maintaining oxygenation and CO₂ elimination.

We describe a patient who underwent pneumonectomy for a destroyed right lung and chronic bronchopleural fistulas caused by pulmonary sporotrichosis. Both HFJV and PCV were successfully implemented to achieve a reduction in PIP.

CASE REPORT

A 46-year-old man was transferred to our medical center for further evaluation following diagnosis and partial treatment for pulmonary sporotrichosis. The patient had a recent history of a 36.3-kg weight loss, shortness of breath, night sweats, fever, productive cough, and occasional hemoptysis. A chest tube had been placed to drain a pyopneumothorax purulent fluid. He had a persistent air leak.

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REFERENCES

1. Pepe PE, Marini JJ. Occult positive end-expiratory pressure in mechanically ventilated patients with airflow obstruction. Am Rev Respir Dis 1982; 126:166-70

**FIGURE 2.** On-line suction catheter removal resulted in reduced intrinsic PEEP and reversal of left lung herniation and mediastinal shift.

After worsening of intrinsic PEEP was confirmed, our patient underwent bronchoscopy first to rule out proximal endobronchial obstruction and was then removed from the on-line suction apparatus. An immediate decrease in the intrinsic PEEP was demonstrated when the patient was intermittently removed from the ventilator for manual suctioning or for bronchoscopy. In response to this decrease in intrinsic PEEP, an improvement in the chest roentgenogram was noted.

This case therefore demonstrates that intrinsic PEEP may manifest roentgenographically in patients with unequal or asymmetric lung compliance. Chest roentgenograms should be reviewed carefully for evidence of progressive hyperinflation in patients at risk for intrinsic PEEP to avert potential hemodynamic complications or barotrauma. In addition, we postulate that the unilateral hyperinflation was worsened by the application of an on-line suction apparatus to the ventilator circuit. By obviating the need for removal of the patient from the ventilator for suctioning, it eliminated intermittent release of high intrathoracic volume caused by air trapping. Periodic interruption of mechanical ventilation may thus deflate the lungs and ameliorate the effects of intrinsic PEEP. On-line suction catheters should therefore be used with caution in such patients.