Successful Weaning after Five Years of Mechanical Ventilation

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Patients with upper cervical spinal cord lesions frequently require prolonged mechanical ventilatory support, especially if one or both phrenic nerves are affected. The problem may be compounded by disuse atrophy or discoordination of functioning muscles when the work of breathing is replaced by mechanical ventilation of the patient's lungs for prolonged periods. The following case report describes the methods used for the successful discontinuance of mechanical ventilation of a quadriplegic patient whose respiration was supported mechanically for five years.

REPORT OF A CASE

A 59-year-old man had suffered a neck injury while diving at 11 years of age. He had become quadriparetic for two hours, but regained normal neurologic function in spite of a fractured odontoid process. At the age of 52 years he had noticed the slow, but progressive, onset of right hemiparesis and paresthesias of both arms. Myelograms revealed narrowing of the cervical spinal canal, and a C1–C3 spinal fusion was performed. Postoperatively, the patient was totally quadriplegic, and fluoroscopy revealed no diaphragmatic motion. Neurologic findings were consistent with a C3–C4 spinal cord lesion, but no other central nervous system abnormality was present. A tracheostomy was performed, and respirations were mechanically controlled,§ with an FI_{O_2} of 0.21. A Bird Pneumoband and external chest respirator were used on several occasions, but they failed to prevent the development of hypoxemia and hypercarbia.

On March 5, 1969, the patient was transferred to the Hines, Illinois, VA Hospital Respiratory Rehabilitation Service, where an attempt was made to wean him from mechanical ventilation. Initial studies revealed Pa_{O_2} 81 torr, Pa_{CO_2} 19 torr, bicarbonate 19 mEq/l, and total pulmonary and chest compliance of 0.089 l/cm H_2O. Attempts to reduce minute ventilation and abruptly increase Pa_{CO_2} to 30 torr resulted in extreme anxiety, in spite of an adequate Pa_{O_2}. When this was done over a period of three weeks, however, Pa_{CO_2} and bicarbonate increased to normal levels without discomfort. The patient was placed on an Emerson rocking bed,¶ and with additional assistance from a Bird Pneumoband, he tolerated two to three hours without assistance from a mechanical ventilator.

Seven months later, he returned to his home, with a rocking bed, an air compressor, a Pneumoband, and a Bird respirator. With respirations controlled by the Bird respirator, he did well until February 1970, when he developed pneumonia in the right lower lobe and was readmitted to the Gainesville VA Hospital. He remained hospitalized for three months, during which time pulmonary compliance increased with therapy from 0.020 to 0.080 l/cm H_2O. Because of the varying compliance the patient was placed on an Emerson Post-Operative¶ ventilator which delivered 1.2 liters of room air 15 times/min. Following discharge to his home, he did well for three years, requiring only one hospital admission secondary to a local power failure, during which he used a hospital emergency generator.

The patient was brought to the Gainesville VA Hospital on June 24, 1973, for an attempt to wean him from his ventilator. Physical examination on admission revealed that he was obese, but in no acute distress; respirations were mechanically controlled. The patient was quadriplegic, with a C3–C4 sensory level. He had no apparent diaphragmatic movement, an inspiratory force of −4 torr, a vital capacity of 50 ml, and a spontaneous tidal volume of 50 ml. Auscultation of the chest revealed rhonchi and basilar inspiratory rales. The rest of the physical examination was unremarkable. A roentgenogram of the chest was interpreted as normal, with the exception of poor inspiratory effort. Complete blood count, serum electrolyte values and protein electrophoresis were all within normal limits. Initial arterial blood analysis revealed *p*H 7.42, P_{O_2} 68 torr, and P_{CO_2} 33 torr. V_D/V_T was 0.51, with a ventilator tidal volume of 950 ml.

Attempts at spontaneous ventilation caused extreme anxiety within one minute. The patient was given diazepam, 10 mg, orally four times a day, and sodium bicarbonate, 650 mg, orally, four times a day; respiration was controlled with an Emerson Volume-Controlled¶ ventilator, modified to pro-

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§ Mark VIII Ventilator, Bird Corporation, Palm Springs, California.

¶ J. H. Emerson Company, Cambridge, Massachusetts.

vide intermittent mandatory ventilation (IMV**) set to deliver room air with a tidal volume of 950 ml 10 times/min. The next day the ventilator rate was changed to deliver 8 breaths/min, and the patient soon attempted to breathe spontaneously one time between each mandatory ventilation. Each morning inspiratory force, vital capacity, tidal volume, pH_a, Pa_{CO_2}, and Pa_{O_2} were measured, and the ventilator IMV rate was decreased by 2 breaths/min.

Initially, the patient's efforts at spontaneous ventilation were futile, but within 24 hours his vital capacity was 200 ml. Gradual reductions in the ventilator IMV rate were accompanied by an increase in spontaneous minute ventilation. After five days the patient required no mechanical ventilation.

On the sixth day the tracheostomy was plugged. Ten days after the start of therapy, vital capacity was 1,100 ml, inspiratory force −20 torr, tidal volume 350 ml, respiratory rate 15 breaths/min, pH_a 7.44, Pa_{O_2} 61 torr, Pa_{CO_2} 36 torr, V_D/V_T 0.55, and fluoroscopy demonstrated a 4 cm excursion of each diaphragm. The patient was transferred to his home, where he did well and was without the need for mechanical respiratory support for approximately 2 months.

Following a mild upper respiratory infection his wife began placing him on continuous intermittent positive-pressure breathing at night only. She reports that seven months following weaning he is able to tolerate having his tracheostomy tube plugged during the day and regularly takes trips from his house by automobile. In addition, tracheal aspiration is performed approximately four times daily.

Discussion

Inability to maintain adequate alveolar ventilation will prevent successful weaning from mechanical ventilation. The initial failure of this patient to support spontaneous respiration was probably secondary to paresis of his diaphragm and paralysis of his intercostal muscles. Anxiety played an important role in this failure, and on many occasions trials of spontaneous ventilation breathing from a T-tube were aborted, in spite of adequate arterial blood-gas values. With time, the prolonged hyperventilation which he demanded for comfort led to chronic respiratory alkalosis with metabolic compensation.[1,2] Thus, he became "air hungry" at Pa_{CO_2} levels in excess of 32 torr, and his impaired ventilatory musculature was probably incapable of maintaining the needed alveolar minute ventilation without early fatigue.[3] Sodium bicarbonate was given orally to offset the compensatory metabolic acidosis in an attempt to reduce respiratory drive. The patient's total minute ventilation was reduced by 49 per cent to a level which he could more easily maintain with spontaneous respiration.

On June 29, the patient's vital capacity was repeatedly less than his spontaneous tidal volume. This was due to extreme discoordination of his ventilatory efforts.[4] IMV has been shown to increase respiratory muscle coordination in some patients who have had difficulty in being weaned from mechanical ventilation.[5] Within ten days after the start of therapy, the patient's vital capacity was more than three times his spontaneous tidal volume, and his respiratory effort appeared to be well coordinated.

Traditional weaning methods caused apprehension and led to an uncoordinated and ineffective spontaneous ventilatory pattern. Although the long-term success of this therapy is purely speculative, we believe that IMV allows a gradual return to spontaneous ventilation.

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** IMV is a form of mechanical ventilation which allows unassisted spontaneous respiration to occur, but which provides periodic, mechanical hyperinflations to the patient's lungs at a preset rate.