Neuromuscular Disease Causing Acute Respiratory Failure

Sangeeta Mehta MD FRCPC

In the developed world, Guillain-Barré syndrome and myasthenia gravis account for the majority of cases of acute respiratory failure associated with neuromuscular disease. The 4 components that contribute to respiratory failure are upper-airway dysfunction, inspiratory-muscle weakness, expiratory-muscle weakness, and the pulmonary complications associated with these conditions. Careful observation and objective monitoring are essential to determine the appropriate timing of intubation and mechanical ventilation. Pulmonary function tests that can help predict the need for mechanical ventilation include vital capacity, peak inspiratory pressure, and peak expiratory pressure. The morbidity and mortality of patients who require mechanical ventilation are not insubstantial. This paper will review the mechanisms underlying acute respiratory failure, the clinical assessment of patients, the predictors of the need for mechanical ventilation, and the intensive-care-unit morbidity and mortality of patients with Guillain-Barré syndrome or myasthenia gravis. *Key words: neuromuscular disease, acute respiratory failure, myasthenia gravis, Guillain-Barré syndrome, endotracheal intubation, vital capacity, maximum inspiratory pressure, maximum expiratory pressure, complications, noninvasive positive-pressure ventilation.* [Respir Care 2006;51(9):1016–1021. © 2006 Daedalus Enterprises]

Introduction

Respiratory failure can complicate a number of acute neuromuscular conditions, including Guillain-Barré syndrome, myasthenia gravis, polymyositis, tetanus, botulism, organophosphate poisoning, and tick paralysis. In the de-

veloped world, Guillain-Barré syndrome and myasthenia gravis account for the majority of cases of respiratory failure associated with neuromuscular disease. As such, the majority of the published literature regarding acute respiratory failure due to neuromuscular disease describes those 2 populations. There are excellent reviews of this

Sangeeta Mehta MD FRCPC is affiliated with the Interdepartmental Division of Critical Care Medicine, and the Division of Respirology, Department of Medicine, Mount Sinai Hospital, University of Toronto, Toronto, Ontario, Canada.

Correspondence: Sangeeta Mehta MD FRCPC, Medical/Surgical Intensive Care Unit, Mount Sinai Hospital, 600 University Avenue, #18–216, Toronto, Ontario, M5G 1X5, Canada. E-mail: geeta.mehta@utoronto.ca.

topic.[1–4] This paper will review the mechanisms underlying acute respiratory failure, the clinical assessment of patients, the predictors of the need for mechanical ventilation (MV) and admission to the intensive care unit (ICU), and the morbidity and mortality of patients with Guillain-Barré syndrome or myasthenia gravis.

Mechanisms Underlying Acute Respiratory Failure

There are 4 components that may contribute to the occurrence of respiratory failure and the need for MV. First, upper-airway compromise due to weakness of the facial, oropharyngeal, and laryngeal muscles can interfere with swallowing and secretion clearance, placing the patient at risk for aspiration. In addition, weakness of those muscles may result in mechanical obstruction of the upper airway, particularly in the supine position. Second, weakness of the muscles of inspiration (the diaphragm, intercostals, and accessory muscles) results in inadequate lung expansion, with microatelectasis, leading to ventilation/perfusion mismatch, and consequent hypoxemia. Compensatory tachypnea, with small tidal volumes, exacerbates the atelectasis, which reduces the compliance of the respiratory system and increases the mechanical load on already weakened respiratory muscles. Third, expiratory-muscle weakness prevents adequate cough and secretion clearance, increasing the risk of aspiration and pneumonia. Finally, complications of the acute illness, such as pneumonia or pulmonary embolus, may further increase the ventilatory demands on an already failing respiratory system.

Clinical Assessment for Impending Respiratory Failure

Absolute criteria for intubation include impaired consciousness, respiratory or cardiac arrest, shock, arrhythmias, blood-gas alterations, and bulbar dysfunction with confirmed aspiration. The decision to intubate is much more challenging in those patients who do not meet absolute intubation criteria but whose weakness is gradually progressing. These patients need to be followed carefully and assessed regularly for the need for continuous monitoring and endotracheal intubation.

Subjective assessment of patients is combined with pulmonary function testing to guide the decision about endotracheal intubation (Table 1). Warning signs in patients with Guillain-Barré syndrome or myasthenia gravis include increasing generalized weakness, dysphagia, dysphonia, exertional or at-rest dyspnea, and inability to handle secretions. At-rest dyspnea is a more sensitive marker of impending respiratory failure than is exertional dyspnea. On subjective assessment, the following signs may be useful for predicting the need for observation in a mon-

Table 1. Signs and Symptoms of Respiratory Failure and the Need for Endotracheal Intubation

General Warning Signs
    Increasing generalized weakness
    Dysphagia
    Dysphonia
    Dyspnea on exertion and at rest

Subjective Assessment
    Rapid shallow breathing
    Tachycardia
    Weak cough
    Staccato speech
    Accessory muscle use
    Abdominal paradox
    Orthopnea
    Weakness of trapezius and neck muscles
    Single-breath count
    Cough after swallowing

Objective Assessment
    Vital capacity < 15 mL/kg, vital capacity < 1 L, or 50% drop in vital capacity
    Maximum inspiratory pressure > -30 cm H_2O
    Maximum expiratory pressure < 40 cm H_2O
    Nocturnal desaturation

itored setting: rapid shallow breathing, tachycardia, accessory-muscle use, abdominal paradox, orthopnea, and cough after swallowing, which indicates aspiration. Palpation of accessory-muscle activity may be more sensitive than observation. Weakness of the trapezius and neck muscles parallels diaphragmatic weakness. Another informative sign is staccato speech (the need to pause between words while speaking). The single-breath-count test is performed by having the patient count out loud after a maximal inspiration. Individuals with normal respiratory function can reach 50, whereas a single-breath count of < 15 correlates with severe impairment of vital capacity (VC). Other factors that may be helpful in clinical decision making include the rate of respiratory deterioration and patient comfort.

Objective variables that are simple to measure and should be followed at regular intervals are VC, maximum inspiratory pressure (P_{Imax}) and maximum expiratory pressure (P_{Emax}). A normal VC is 60–70 mL/kg. VC < 30 mL/kg is associated with a weak cough and atelectasis, and VC of 15 mL/kg or 1 L is generally accepted as an absolute criterion for intubation. P_{Imax} reflects the strength of the inspiratory muscles, primarily the diaphragm but also the external intercostal and accessory muscles. P_{Emax} reflects the strength of the expiratory muscles (internal intercostals and abdominal muscles) and correlates with cough strength and secretion clearance. VC, P_{Imax}, and P_{Emax} may be spuriously low if there is inadequate mouth closure due to

facial palsy. Patients with diaphragmatic weakness may have nocturnal oxygen desaturation, as the rib-cage contribution to respiration is normally reduced during sleep.

In normal adults, VC drops $< 10\%$ in the supine position, compared with upright VC,[5] and greater changes reflect diaphragmatic weakness. Fromageot and colleagues evaluated the seated-versus-supine difference in lung volumes in the assessment of diaphragmatic weakness in 24 patients with neuromuscular disorders.[6] These patients had measurements of VC and mouth pressure generated during a maximal static P_{Imax} in both the seated and supine positions. The fall in supine VC was greater in the 15 patients who had paradoxical diaphragmatic motion than in the 9 patients who did not. The specificity and sensitivity of a $> 25\%$ supine fall in VC for the diagnosis of diaphragmatic weakness, compared with transdiaphragmatic pressure (P_{di}) during maximal sniff > -30 cm H_2O, were 90% and 79%, respectively. Stepwise multiple regression analysis of maximal-sniff P_{di} showed that both the supine fall in VC and P_{Imax} were associated with diaphragmatic weakness ($r^2 = 0.66$, p < 0.0001).

The decision to intubate these patients should be made earlier rather than later, to avoid emergency intubation or cardiorespiratory arrest. In practice, the decision is based on subjective assessment of the patient for clinical signs of respiratory-muscle fatigue, combined with frequent measurements of VC, P_{Imax}, and P_{Emax}.

Predictors of the Need for Mechanical Ventilation

It is crucial to identify early those patients who will develop progressive respiratory failure and will require MV, to avoid the consequences of urgent intubation. In one study, 48% of patients were intubated between 6:00 PM and 8:00 AM, and 16% required urgent intubation for cardiorespiratory arrest or severe respiratory distress.[7] Consequently, many investigators have attempted to identify predictors of respiratory failure and the need for endotracheal intubation.

Lawn and colleagues retrospectively reviewed their experience with 114 consecutive patients with severe Guillain-Barré syndrome admitted to intensive care, to identify clinical and respiratory features associated with progression to respiratory failure.[7] The clinical and electrophysiologic features of 60 patients receiving MV were compared with 54 patients who did not receive MV. Progression to MV was highly likely to occur in those patients with rapid disease progression, bulbar dysfunction, bilateral facial weakness, or dysautonomia. Factors associated with progression to respiratory failure included VC < 20 mL/kg, $P_{Imax} > -30$ cm H_2O, $P_{Emax} < 40$ cm H_2O, or a reduction of $> 30\%$ in VC, P_{Imax}, or P_{Emax}. Bulbar dysfunction, characterized by dysarthria, dysphagia, or impaired gag reflex, and VC < 20 mL/kg, were the strongest predictors

of the need for MV, with odds ratios (ORs) of 17.5 and 15.0, respectively. The use of these data (the "20/30/40 rule") may allow early identification of patients at risk for respiratory failure and provoke the institution of preemptive measures such as admission to the ICU.

Sharshar and colleagues reviewed the data from 722 patients enrolled in 2 multicenter randomized clinical trials evaluating plasma exchange in patients with Guillain-Barré syndrome.[8] Forty-three percent of the patients required intubation and MV. Multivariate analyses identified 6 predictors of MV: time from onset to admission of < 7 days (OR 2.51), inability to cough (OR 9.09), inability to stand (OR 2.53), inability to lift the elbows (OR 2.99) or head (OR 4.34), and liver-enzyme increases (OR 2.09). In the 196 (27%) patients whose VC was measured, time from onset to admission of < 7 days (OR 5.00), inability to lift the head (OR 5.00), and VC $< 60\%$ of predicted (OR 2.86) predicted the need for intubation and MV. MV was required in $> 85\%$ of patients with at least 4 predictors from the first multivariate model, and in 85% of patients with all 3 predictors from the second multivariate model. The investigators concluded that patients with at least one of these predictors should be monitored in an ICU.

Sundar and colleagues compared clinical and electrodiagnostic data between 28 ventilated and 18 nonventilated patients with Guillain-Barré syndrome.[9] Compared with the nonventilated patients, the MV patients were more likely to have autonomic dysfunction, and bulbar weakness, and had more rapid progression to peak weakness (33 h vs 6 d). Although the data were not sufficient for statistical analysis, the presence of markedly attenuated compound muscle action potentials, inexcitable motor nerves, and denervation changes on electromyography were more common in the ventilated group. All 5 patients who died had required MV.

In a small prospective study of 10 patients with Guillain-Barré syndrome, in which VC was measured serially, the investigators found that a 50% reduction in VC from admission, or a reduction in VC below 1 L, predicted the need for MV in 36 h and 18 h, respectively.[10] In contrast, Rieder and colleagues found that serial VC was a poor predictor of the need for MV in 5 patients with 10 exacerbations of myasthenia gravis.[11] They hypothesized that this was due to the erratic nature of myasthenia gravis, with fluctuations in VC.

In conclusion, the course of patients with severe Guillain-Barré syndrome can, to some extent, be predicted using clinical information and simple bedside tests of respiratory function. These data may be helpful in decision making regarding admission to the ICU and preparation for early elective intubation. Given the dearth of studies on acute respiratory failure in patients with myasthenia gravis, as well as the fluctuating nature of the weakness, it is

more difficult to identify predictors of the need for MV. However, in practice, the predictors of the need for MV in patients with Guillain-Barré syndrome may be clinically generalizable to other neuromuscular conditions.

Noninvasive Positive-Pressure Ventilation

Noninvasive positive-pressure ventilation (NPPV) is clearly inappropriate in patients with acute respiratory failure unless upper-airway function is well preserved. In addition, NPPV may not be appropriate in patients with Guillain-Barré syndrome if a long duration of MV is anticipated. Thus, the use of NPPV in patients with Guillain-Barré syndrome or myasthenia gravis has not been extensively evaluated; there have been only 2 small published studies.[12,13]

Vianello and colleagues applied NPPV to 14 patients with acute hypercapnic respiratory failure due to Duchenne muscular dystrophy, amyotrophic lateral sclerosis, congenital muscular dystrophy, congenital myopathy, and motor-sensory neuropathy.[12] Patients were included if they had dyspnea, lethargy, hypercapnia, and acute respiratory acidosis; they were excluded if they were unable to swallow. NPPV-treated patients were matched with 14 historical control patients who received conventional MV. Of the 14 NPPV-treated patients, two were intubated for inability to swallow, and seven underwent a cricothyroid mini-tracheostomy for secretion clearance. Treatment failure was more common in the control group ($n = 11$, death or failure to wean from MV), compared with the NPPV group ($n = 4$, death or need for intubation) ($p = 0.021$). Mortality and ICU stay were also significantly lower in the NPPV group. Although these results appear to favor the use of NPPV in these patients, several factors limit firm conclusions, including the retrospective study design. In addition, the patients in the 2 groups may not be comparable, as VC was higher in the NPPV group than in the control group at baseline (1.1 L vs 0.6 L). Finally, the use of a mini-tracheostomy in half of the NPPV-treated patients contradicts the "noninvasive spirit" of NPPV.

Rabinstein and Wijdicks retrospectively reviewed their experience with NPPV in 9 patients with 11 episodes of acute respiratory failure due to myasthenic crisis.[13] NPPV prevented intubation in 7 of 11 trials, and it was used for up to 15 days. These authors emphasized that bulbar weakness was present in 4 episodes in which NPPV successfully prevented intubation. Mean NPPV pressures were 13/5 cm H_2O, with an inspiratory-pressure range of 10–16 cm H_2O, and an expiratory-pressure range of 4–6 cm H_2O; however, NPPV success was not related to the pressures applied. The only predictor of NPPV failure was a $P_{aCO_2} > 50$ mm Hg at baseline. Standard pulmonary function tests such as VC, P_{Imax}, and P_{Emax} did not predict NPPV failure, nor did the presence of secretions. Hence,

these authors concluded that NPPV is a useful modality in patients with myasthenic crisis, but NPPV should not be used in patients with hypercapnic respiratory failure.

At present there is insufficient data to recommend the use of NPPV in patients with neuromuscular disease presenting with acute respiratory failure. If NPPV is used, patients need to be carefully selected and treated in a monitored environment.

Intubation and Mechanical Ventilation

Between 25% and 50% of Guillain-Barré syndrome patients,[4,14] and 15–27% of myasthenia gravis patients, require intubation and MV.[15,16] The median duration of MV is 18–29 days in Guillain-Barré syndrome.[4] In patients with myasthenia gravis, the median duration of MV was 14 days in one study, with 25% extubated by day 7, 50% by day 13, and 75% by 31 days.[17]

In patients with Guillain-Barré syndrome, intubation may be associated with excessive complications due to dysautonomia. These include blood-pressure shifts, bradycardia, profound hypotension with sedatives, and fatal hyperkalemia with the use of succinylcholine, due to the heightened chemosensitivity of denervated muscle. These potential complications further support the need to prospectively identify patients in imminent need of intubation, to avoid emergency intubation. An intubation strategy that includes topical anesthesia, small doses of short-acting benzodiazepines, atropine if needed, avoidance of depolarizing neuromuscular blockers, and fiberoptic intubation may prevent some of these complications.

Given the wide range of durations of MV, predictive factors for prolonged intubation would be extremely helpful in guiding the timing of tracheostomy. In patients with acute respiratory failure due to myasthenia gravis, Thomas and colleagues identified 3 factors predictive of prolonged ventilation: pre-intubation $HCO_3^- > 30$ mEq/L ($p < 0.001$), peak VC on days 1–6 after intubation < 25 mL/kg ($p = 0.001$), and age > 50 y ($p = 0.01$).[17] The likelihood of intubation beyond 2 weeks if a patient had one, two, or three of these risk factors was 25%, 46%, and 88%, respectively.

Lawn and Wijdicks recommend the use of a pulmonary-function score, which is the sum of the VC, P_{Imax}, and P_{Emax}, to predict prolonged ventilation and the need for tracheostomy.[18] In 37 ventilated Guillain-Barré syndrome patients, the day-12 pulmonary-function score was higher than the day-1 pulmonary-function score (pulmonary-function ratio > 1) in all 10 patients ventilated for < 3 weeks. The pulmonary-function ratio was < 1 in 19 of 27 patients ventilated > 3 weeks, with a sensitivity of 70% and a specificity of 100%. A pulmonary-function ratio < 1 indicates worsening strength of the inspiratory and expiratory muscles, compared with intubation.

Atelectasis and/or pneumonia can complicate the ICU course of intubated patients with neuromuscular disease and contribute to increased morbidity and mortality. Varelas and colleagues implemented an aggressive respiratory-care program that included the use of suctioning, intermittent positive-pressure breathing or bronchodilator treatments, sighs, and chest physiotherapy.[19] The frequency and intensity of each of these interventions depended on the presence of atelectasis or pneumonia. The use of this program in 18 myasthenia gravis patients with 24 episodes of respiratory failure that required MV resulted in less atelectasis and pneumonia, and shorter duration of MV and ICU stay than a previously published series.[17]

Weaning and Extubation

In patients with respiratory failure due to neuromuscular disease, the decision to extubate can be a challenging one, and no studies have specifically addressed weaning and extubation in this patient population. In general, patients should have adequate cough, few secretions, and should tolerate a low level of pressure support for a prolonged period without signs of fatigue. In patients with myasthenia gravis, whose respiratory-muscle strength may fluctuate, Rieder and colleagues required VC stability of > 10 mL/kg for > 4 h and tolerance of T-piece breathing for > 4 h prior to extubation.[11]

To evaluate whether improvement in diaphragmatic strength correlates with weaning from ventilator support, Borel and colleagues measured P_{di}, maximum P_{di}, tidal volume, and inspiratory time fraction during 74 spontaneous breathing trials in 9 patients who were successfully extubated.[20] Although P_{di}, maximum P_{di}, and tidal volume improved significantly during MV, the P_{di} and maximum P_{di} values remained low, even after successful weaning. Improvement in maximum P_{di} was the best predictor of recovery (r = 0.48, p < 0.001). P_{Imax} correlated with maximum P_{di} (r = 0.48, p < 0.005), but FVC did not. Finally, the tension-time index rarely exceeded the expected fatigue threshold of 0.15, despite the patients' inability to sustain spontaneous ventilation. Thus, although the patients demonstrated diaphragmatic weakness, the tension-time index of the diaphragm did not confirm diaphragmatic fatigue.

Given the fluctuating course in patients with myasthenia gravis, extubation failure may be common. Rabinstein and Mueller-Kronast retrospectively reviewed 26 episodes of MV in 20 patients with myasthenic crisis, to determine which clinical variables predict unsuccessful extubation.[21] There were 7 episodes of extubation failure (prevalence rate 27%), with a median time to reintubation of 36 hours. Older age (p = 0.05), atelectasis (p < 0.01), and pneumonia (p = 0.02) were significantly associated with extubation failure. Compared with successfully extubated pa-

tients, those who failed extubation had longer ICU stay (median 28 d vs 7 d, p < 0.01) and hospital stay (median 40 d vs 12 d, p < 0.01). Importantly, pre-extubation blood-gas values and pulmonary function tests did not correlate with extubation failure.

ICU Morbidity and Mortality

In patients with prolonged MV and ICU stay, complications include infections, aspiration, atelectasis, thromboembolic disease, contractures, and decubitus ulcers. ICU mortality is generally related to the occurrence of these complications. In one series of 114 patients with Guillain-Barré syndrome, major morbidity, predominantly pulmonary, occurred in 60% of patients.[22] Respiratory complications such as pneumonia and tracheobronchitis occurred in 50%, and bacteremia in 20%. Complications were uncommon if ICU stay was < 3 weeks. In another series, 15 of 38 patients receiving MV for Guillain-Barré syndrome developed ventilator-associated pneumonia.[23] Among 95 patients ventilated for myasthenic crisis, 30% developed ventilator-associated pneumonia.[15]

ICU mortality is generally low, but is higher in patients who require MV. In a large cohort of 320 ventilated and nonventilated patients admitted for Guillain-Barré syndrome, 4% died, most commonly due to ventilator-associated pneumonia.[24] Patients who died were older (p = 0.006) and more likely to have underlying pulmonary disease (p = 0.004). Cheng et al observed a 12% mortality rate in 25 patients ventilated for Guillain-Barré syndrome; the cause of death was septic shock in all 3 cases.[25] In another study, the mortality rate was 20% among Guillain-Barré syndrome patients who required MV.[26] In 2 series of patients with myasthenic crisis, the overall mortality rates were 4%[17] and 8%.[15]

Although recovery from Guillain-Barré syndrome may be prolonged, most survivors regain independent functioning. Cheng and colleagues retrospectively reviewed their experience with 77 patients with Guillain-Barré syndrome to evaluate long-term recovery in patients who required MV.[25] At 1 year after ICU discharge, 16 of 25 ventilated patients had a good outcome and could walk unassisted. Those patients who had low maximal inspiratory and expiratory pressures (< 14.5 cm H_2O) at the time of intubation, and those who developed ICU complications had worse functional status at 1 year. Fletcher et al also found that ventilated patients with Guillain-Barré syndrome who survived did well, with 79% eventually regaining independent ambulation.[26] Older age (OR 1.99, p = 0.004) and delayed transfer to a tertiary-care center (OR 19.8, p = 0.002) were independently predictive of poor outcome on multivariate analysis.

ICU morbidity and mortality are not insubstantial in patients with neuromuscular disease. As with all ICU pa-

tients, attention to preventive measures and early diagnosis and treatment are essential to minimize the ICU complications, and potentially to reduce mortality.

Summary

Acute respiratory failure is the most feared complication in patients with Guillain-Barré syndrome or myasthenia gravis. The decision to intubate these patients should be made earlier rather than later, to avoid emergency intubation or cardiorespiratory arrest. Regular assessment for clinical signs of respiratory-muscle fatigue and objective monitoring of VC, P_{Imax}, and P_{Emax} are essential to determine the appropriate timing of intubation and mechanical ventilation. The morbidity and mortality of patients who require mechanical ventilation are not insubstantial. Once they are intubated, attention to prevention of complications and prompt treatment of complications such as ventilator-associated pneumonia may improve patient outcome.

REFERENCES

1. Rabinstein AA. Update on respiratory management of critically ill neurologic patients. Curr Neurol Neurosci Rep 2005;5(6):476–482.
2. Bella I, Chad DA. Neuromuscular disorders and acute respiratory failure. Neurol Clin 1998;16(2):391–417.
3. Yavagal DR, Mayer SA. Respiratory complications of rapidly progressive neuromuscular syndromes: Guillain-Barré syndrome and myasthenia gravis. Semin Respir Crit Care Med 2002;23(3):221–229.
4. Orlikowski D, Prigent H, Sharshar T, Lofaso F, Raphael JC. Respiratory dysfunction in Guillain-Barré Syndrome. Neurocrit Care 2004;1(4):415–422.
5. Vilke GM, Chan TC, Neuman T, Clausen JL. Spirometry in normal subjects in sitting, prone, and supine positions. Respir Care 2000;45(4):407–410.
6. Fromageot C, Lofaso F, Annane D, Falaize L, Lejaille M, Clair B, et al. Supine fall in lung volumes in the assessment of diaphragmatic weakness in neuromuscular disorders. Arch Phys Med Rehabil 2001;82(1):123–128.
7. Lawn ND, Fletcher DD, Henderson RD, Wolter TD, Wijdicks EF. Anticipating mechanical ventilation in Guillain-Barré syndrome. Arch Neurol 2001;58(6):893–898.
8. Sharshar T, Chevret S, Bourdain F, Raphael JC; French Cooperative Group on Plasma Exchange in Guillain-Barré Syndrome. Early predictors of mechanical ventilation in Guillain-Barré syndrome. Crit Care Med 2003;31(1):278–283.
9. Sundar U, Abraham E, Gharat A, Yeolekar ME, Trivedi T, Dwivedi N. Neuromuscular respiratory failure in Guillain-Barré Syndrome: evaluation of clinical and electrodiagnostic predictors. J Assoc Physicians India 2005 Sept;53:764–768.
10. Chevrolet JC, Deleamont P. Repeated vital capacity measurements as predictive parameters for mechanical ventilation need and weaning success in the Guillain-Barré syndrome. Am Rev Respir Dis 1991;144(4):814–818.
11. Rieder P, Louis M, Jolliet P, Chevrolet JC. The repeated measurement of vital capacity is a poor predictor of the need for mechanical ventilation in myasthenia gravis. Intensive Care Med 1995;21(8):663–668.
12. Vianello A, Bevilacqua M, Arcaro G, Gallan F, Serra E. Non-invasive ventilatory approach to treatment of acute respiratory failure in neuromuscular disorders: a comparison with endotracheal intubation. Intensive Care Med 2000;26(4):384–390.
13. Rabinstein A, Wijdicks EF. BiPAP in acute respiratory failure due to myasthenic crisis may prevent intubation. Neurology 2002;59(10):1647–1649.
14. Ropper AH. The Guillain-Barré syndrome. N Engl J Med 1992;326(17):1130–1136.
15. Murthy JM, Meena AK, Chowdary GV, Naryanan JT. Myasthenic crisis: clinical features, complications and mortality. Neurol India 2005;53(1):37–40; discussion 40.
16. Marinelli WA, Leatherman JW. Neuromuscular disorders in the intensive care unit. Crit Care Clin 2002;18(4):915–929.
17. Thomas CE, Mayer SA, Gungor Y, Swarup R, Webster EA, Chang I, et al. Myasthenic crisis: clinical features, mortality, complications, and risk factors for prolonged intubation. Neurology 1997;48(5):1253–1260.
18. Lawn ND, Wijdicks EF. Post-intubation pulmonary function test in Guillain-Barré syndrome. Muscle Nerve 2000;23(4):613–616.
19. Varelas PN, Chua HC, Natterman J, Barmadia L, Zimmerman P, Yahia A, et al. Ventilatory care in myasthenia gravis crisis: assessing the baseline adverse event rate. Crit Care Med 2002;30(12):2663–2668.
20. Borel CO, Tilford C, Nichols DG, Hanley DF, Traystman RJ. Diaphragmatic performance during recovery from acute ventilatory failure in Guillain-Barré syndrome and myasthenia gravis. Chest 1991;99(2):444–451.
21. Rabinstein AA, Mueller-Kronast N. Risk of extubation failure in patients with myasthenic crisis. Neurocrit Care 2005;3(3):213–215.
22. Henderson RD, Lawn ND, Fletcher DD, McClelland RL, Wijdicks EF. The morbidity of Guillain-Barré syndrome admitted to the intensive care unit. Neurology 2003;60(1):17–21.
23. Ropper AH, Kehne SM. Guillain-Barré syndrome: management of respiratory failure. Neurology 1985;35(11):1662–1665.
24. Lawn ND, Wijdicks EF. Fatal Guillain-Barré syndrome. Neurology 1999;52(3):635–638.
25. Cheng BC, Chang WN, Chang CS, Tsai NW, Chang CJ, Hung PL, et al. Predictive factors and long-term outcome of respiratory failure after Guillain-Barré syndrome. Am J Med Sci 2004;327(6):336–340.
26. Fletcher DD, Lawn ND, Wolter TD, Wijdicks EF. Long-term outcome in patients with Guillain-Barré syndrome requiring mechanical ventilation. Neurology 2000;54(12):2311–2315.

Discussion

Hess: At this conference we've heard a lot about the use of the In-Exsufflator [CoughAssist In-Exsufflator, JH Emerson, Cambridge, Massachusetts] with a mask, but we can also use it with intubated patients. If they're tracheostomized, we sometimes use it quite aggressively, and with benefit.

Mehta: I don't have experience using the In-Exsufflator with intubated patients: only in nonintubated patients. Do you find it adds additional benefit to suctioning? Or just avoidance of suctioning?

Hess: Both. We don't do a lot of chest physiotherapy. We probably

favor the In-Exsufflator over traditional chest physiotherapy. We use it in conjunction with suctioning. Often the re
spiratory therapist will attach it with the in-line suction catheter attached to the tracheostomy tube or the endotracheal tube. They put the In-Exsufflator on the automatic mode, cycle it through 6 to 8 cycles, and as the mucus comes up the tube, they clear it with the suction catheter.

Mehta: One concern I have about that in patients who are intubated, and may have a degree of acute lung injury, is further atelectasis and hypoxemia. There is evidence that suctioning, or even disconnecting the ventilator system, is associated with a decrease in FRC [functional residual capacity] and an increase in hypoxemia and atelectasis, which can take quite a while to resolve.

Hess: I agree with that if the patient has acute lung injury or ARDS [acute respiratory distress syndrome], but that is usually not the case in patients with neuromuscular disease. When we use the In-Exsufflator to clear mucus, their oxygen saturation may get better.

Deem: How do you determine when to extubate these people? You said the literature suggests that we should use longer periods of spontaneous ventilation. Do you think that's really warranted? Are there any data that suggest that the criteria we apply to the average patient in the ICU shouldn't be applied here? What's your practice? Do you do these prolonged T-piece trials?

Mehta: Yes. Not 12–24 hours, but longer than with the average patient. Our usual spontaneous breathing trial is 1 hour, with pressure support of 5 cm H_2O and a PEEP [positive end-expiratory pressure] of zero, but I don't think that's adequate in these patients, particularly the myasthenia patients, so I use longer trials, and I measure

all those variables I talked about. If the patient can tolerate several hours of a spontaneous breathing trial, I think they're likely to do well.

We did a study in which we looked at pre-extubation variables during T-piece breathing, with CPAP [continuous positive airway pressure] of 5 cm H_2O and pressure support of 5 cm H_2O.[1] We found that the tidal volume during CPAP or PSV overestimated the post-extubation tidal volume. That evidence may support the use of T-piece trials, particularly in this patient population.

REFERENCE

1. Mehta S, Nelson DL, Klinger JR, Buczko GB, Levy MM. Prediction of post-extubation work of breathing. Crit Care Med 2000; 28(5):1341–1346.

Hill: I see the spontaneous breathing trial as something that tells us that the patient can ventilate. But what I worry about before I extubate a patient like this is their ability to expectorate. Inadequate secretion clearance is often what gets them into trouble. Are they going to be able to protect the airway? Are they going to be able to handle their secretions?

Manthous[1] looked at expiratory function as a predictor of extubation success. He uses the "white card test"; if the patient can spit on a white card and leave a mark, that's good. He looked at expiratory pressure and flow, and all of these things correlate. I'm very concerned about these indices in these patients. Is there anything in the literature to suggest that these measures might be useful in these patients?

REFERENCE

1. Salam A, Tilluckdharry L, Amoateng-Adjepong Y, Manthous CA. Neurologic status, cough, secretions and extubation outcomes. Intensive Care Med 2004;30(7): 1334–1339.

Mehta: Not in this particular population. We're definitely limited. And I think we have to use everything out

there that's been published in other populations, with even greater caution. And you're right; in general, they can ventilate. Their ability to ventilate probably recovers more quickly than their ability to clear secretions. And we use that white-card test. We also sort of quantitate their daily secretions by counting the nurse's documentation of secretions. But I think there's nothing in the literature about this population.

Deem: I agree with your concern about secretions. I think that probably is the major issue. However, if we're too conservative in our requirements for extubation, then we end up with patients who are intubated too long, and they develop more complications, which has been shown in neurosurgical patients.[1]

What about patients who are diagnosed with Guillain-Barré or even myasthenia during their hospital course? They present with something else, and then it turns out that they have Guillain-Barré. Did you come across any literature about that? It's alluded to in the polyneuropathy literature, but I don't know if that's a common problem or just something that pops up every now and then.

REFERENCE

1. Coplin WM, Pierson DJ, Cooley KD, Newell DW, Rubenfeld GD. Implications of extubation delay in brain-injured patients meeting standard weaning criteria. Am J Respir Crit Care Med 2000;161(5):1530–1536.

Mehta: No, I didn't find anything.

Lechtzin: How frequently should we monitor vital capacity or maximum inspiratory pressure when trying to evaluate if a patient needs to be intubated? It's been my experience that the neurologists want us to be much more aggressive than I ordinarily would be, and they want vital capacities checked at least every 4 hours, and sometimes even more frequently than that.

Mehta: When there are suggestions, it is every 4 to 6 hours, but less frequently, obviously, if they present with very high vital capacities. If they start to deteriorate, more frequently, and, of course, if they start to deteriorate in a monitored setting.

Upinder Dhand: I was impressed by the fact that patients with myasthenia gravis did better on noninvasive ventilation than did those with Guillain-Barré syndrome. The likely reason, I think, is that with noninvasive ventilation their muscles were rested. Patients with myasthenia gravis have fatigable weakness, so muscle rest probably starts their process of recovery, as compared to Guillain-Barré syndrome, which, because of demyelination, is going to take time.

Secondly, since the mid-1990s, plasmapheresis and intravenous immunoglobulin have become standard modes of treatment, I think the need for tracheostomy has gone down quite a lot in these patients, particularly the myasthenia gravis patients, who can improve with plasmapheresis within a matter of days, and so they don't need tracheostomy. The only myasthenia gravis patients in whom it becomes a problem are those who are already advanced and they have a fixed baseline weakness.

Regarding patients with Guillain-Barré syndrome: when their forced vital capacity is still at, say, 30 mL/kg, could noninvasive ventilation, such as BiPAP, at that time help prevent them from going on to full mechanical ventilation?

Mehta: It's a good question. I think it lies in the balance between the relief they have with noninvasive ventilation and whether they will tolerate it. Because, obviously, with a vital capacity of 30 mL/kg they don't really require noninvasive ventilation, as they shouldn't have a lot of atelectasis, gas-exchange abnormalities, or respiratory distress. So the question is whether they will tolerate it. Also, if they have any degree of bulbar dysfunction, the efficacy may be reduced because of inability to fit the mask, and potentially an increased risk of aspiration. Nick, do you have any comments about that?

Hill: No, I think you hit it on the head.

Iron lungs in poliomyelitis ward
Latter-Day Saints Hospital
Salt Lake City, Utah, 1949
Courtesy National Library of Medicine