and Guillain-Barré syndrome) might be used for respiratory monitoring of patients with botulism. Spirometry is an objective measure of respiratory muscle function that, along with physical examination, can help clinicians determine whether a patient needs intubation. For example, forced vital capacity (FVC) <20 mL/kg, maximum inspiratory pressure (i.e., negative inspiratory force) <30 cm H_2O, and maximum expiratory pressure <40 cm H_2O were each associated with the need for mechanical ventilation in Guillain-Barré syndrome patients (*59*).

Respiratory function also might be monitored using sniff nasal inspiratory pressure and the single breath count test. Sniff nasal inspiratory pressure testing, which evaluates diaphragm strength and inspiratory muscle function, involves occluding one nostril with a pressure-measuring device and inhaling sharply through the other nostril (*60*,*61*).Values greater than –70 cm H_2O (males) or –60 cm H_2O (females) might reflect the absence of clinically significant inspiratory muscle weakness; severe nasal congestion might cause falsely low values (*62*,*63*).The single breath count test involves taking a deep breath and then counting at a rate of two numbers per second for as long as possible while exhaling. A study of 31 patients with myasthenia gravis documented that the single breath count correlated with FVC, with each counted number equal to 116 mL of FVC; counting to ≥25 was proposed to correlate with normal respiratory muscle function (*64*). End-tidal carbon dioxide ($EtCO_2$) monitoring, which is noninvasive and available in many hospitals, is an optional modality for monitoring early respiratory failure. Rising partial pressure of CO_2 (pCO_2) or $EtCO_2$ strongly predicts the need for mechanical ventilation. Bulbar dysfunction is often a prominent feature of botulism and has been associated with the need for intubation and mechanical ventilation in patients with Guillain-Barré syndrome (*59*). Monitoring pulse oximetry and arterial blood gases might not be reliable early indicators of emerging respiratory failure in patients with botulism because hypoxia and hypercapnia might not develop until the later stages of respiratory failure, as documented in patients with other neuromuscular disorders in which gas diffusion is unimpaired, such as Guillain-Barré syndrome (*65*–*67*).

Autonomic Function Monitoring

Botulinum neurotoxins can impair the postganglionic release of acetylcholine in the parasympathetic nervous system, causing unopposed stimulation of the sympathetic system (*68*,*69*). Case reports and series have noted features of dysautonomia (e.g., dry mouth, urinary retention, constipation, and orthostatic hypotension) in patients with botulism, usually in cases caused by toxin type B (*70*–*73*). Similarly, autonomic dysfunction is commonly reported in Guillain-Barré syndrome patients, with cardiac manifestations of dysautonomia, including sinus tachycardia or bradycardia, cardiac dysrhythmias, blood pressure lability, abnormal hemodynamic responses to medications, and nonspecific electrocardiogram changes (*74*–*76*). These manifestations have prompted some experts to recommend close monitoring of pulse and blood pressure in patients with Guillain-Barré syndrome (*77*). Similar monitoring would therefore be reasonable for patients with botulism.

Recommendations

- Conduct frequent, serial neurologic examinations, with an emphasis on cranial nerve palsies, swallowing ability, respiratory status, and extremity strength.
- In settings of contingency and crisis standards of care, in which time is limited, focus examinations on signs and symptoms of early onset (Box 1). Consider brief, focused training in the emergency setting on the neurologic examination.
- When possible, have the same health care provider conduct the serial neurologic and other examinations.
- Adjust the frequency of neurologic and other examinations on the basis of signs and symptoms, with very frequent examinations for patients with rapid progression and for patients who have respiratory or bulbar symptoms but have not required intubation.
- Institute frequent, serial monitoring of respiratory and bulbar function. Serial measurements might be more helpful than a single measurement.
  - Focus the respiratory examination on respiratory rate, lung field auscultation, and work of breathing, including use of accessory muscles of respiration, nasal flaring, and paradoxical breathing (*78*).
    1. Obtain serial objective data through spirometry, $EtCO_2$ monitoring, blood gas analysis, or other tests. Patients with facial weakness might not achieve an adequate seal around the spirometer mouthpiece and so might require a mask device (*78*,*79*). If spirometry is not available, consider using the sniff nasal inspiratory pressure or the single breath count test.
    2. Consider respiratory status in the context of neurologic status because paralysis can alter signs typically associated with respiratory distress. For example, facial paralysis can produce a placid expression that can obscure distress from respiratory insufficiency and also prevent nasal flaring, and diaphragmatic paralysis can result in paradoxical abdominal movement in which the abdomen moves inward during inspiration (*80*).
  - Focus bulbar dysfunction examination on dysphagia, dysarthria, nasal voice, drooling, and impaired gag reflex (*78*). When feasible, consider assessing the patient's swallowing ability to help determine whether the patient can safely consume liquids or solids (*81*).