The complaint of weakness is common in emergency department (ED) patients and may be vague, subjective, and difficult to characterize. True loss of strength from a neurologic or muscle fiber lesion must be distinguished from other systemic conditions that result in fatigue, dyspnea, or imbalance because of inadequate substrate delivery to the nervous system or muscle unit. Such conditions may be described as weakness by the patient but are likely caused by cardiovascular, pulmonary, infectious, or metabolic processes. This chapter focuses on the evaluation of acute neuromuscular weakness; it may be focal or generalized and may originate in central or peripheral nerves, the neuromuscular junction (NMJ), or myofibers themselves. Other chapters provide more detail on peripheral nerve (Chapter 107) and neuromuscular disorders (Chapter 108).

Epidemiology

The epidemiology of weakness is closely linked to the epidemiology of other diseases and medical conditions. Although weakness can be a presenting problem at all ages, patients who are elderly or chronically ill are more likely to develop weakness. Advanced diabetes, cardiovascular and pulmonary diseases, chronic infectious diseases, and cancer may produce neuromuscular weakness through secondary effects on the brain and neuromuscular system. Brain, spinal cord, peripheral nerve, and neuromuscular causes of weakness are much less common than weakness that is secondary to other medical conditions.1

Pathophysiology

There are a number of physiologic considerations for the patient with diffuse weakness (Box 13-1).

Focal weakness confined to one area in the face or body (left, right, distal, or proximal) indicates a localized problem arising in the brain, spinal cord, peripheral nerve, or muscle.

Conditions that affect the upper motor neuron (UMN) produce signs that include spasticity to extension in the upper extremities, spasticity to flexion in the lower extremities, hyper-reflexia, pronator drift, Hoffmann’s sign, and Babinski’s sign (upgoing toes). UMN signs signify a lesion within the cerebral cortex or corticospinal tracts (CSTs) of the brainstem or spinal cord. Although these findings are not always detectable in the acute period, the presence of even one of them indicates pathology within the central nervous system.

Weakness caused by lower motor neuron (LMN) dysfunction is often accompanied by flaccidity, decreased reflexes, fasciculations, or muscle cramps. Lesions in the anterior horn of the spinal cord and its axonal extensions at the nerve root and peripheral nerve produce these findings.

Conditions that have only peripheral effects at the NMJ and muscle have preserved reflexes.

Differential Considerations

In the diffusely weak patient, first consideration is given to a systemic deficiency in substrate delivery to the nervous system or skeletal muscle unit. In patients with cardiac disease, myocardial ischemia can also be a source of generalized weakness.

History regarding circumstances at onset, progression, exacerbating or alleviating factors, and any fluctuations in severity may help the emergency physician discern if weakness is a result of cardiovascular disease, pulmonary insufficiency, the metabolic demands of a recent infection, or cancer. Review of systems can reveal orthopnea and symptoms of congestive heart failure in the fatigued patient with significant cardiac disease, chronic blood loss in the anemic patient, or incontinence in an elderly person with urosepsis.

Vital sign abnormalities, including tachycardia, tachypnea, fever, hypothermia, or hypotension, prompt immediate intervention and a search for a systemic cause of weakness. Cardiac, pulmonary, skin, and mucous membrane examinations may give the emergency physician a sense of the adequacy of the cardiovascular system in delivering substrate to brain and muscle. In such patients the neurologic examination should not demonstrate focal changes of the central or peripheral nervous system.

If by history, physical examination, and bedside ancillary testing the patient does not appear to have derangements in intravascular volume or cardiopulmonary function, metabolic abnormalities, or a source of infection, the investigation turns to a neural or primary muscular cause for weakness. Often these patients will have some asymmetrical finding on their neurologic examination. The critical and emergent diagnoses for neuromuscular weakness are listed in Table 13-1.

Diagnostic Algorithm

Deciphering loss of muscle power means following the pattern of a patient’s weakness from the myofiber back to a particular site within the central or peripheral nervous system (Fig. 13-1).
Unilateral Weakness: A Combination of Arm, Hand, or Leg but with Contralateral Facial Involvement

This pattern indicates a brainstem lesion. A careful cranial nerve (CN) examination can provide more clues. If the patient has contralateral facial findings, there will likely be ptosis (CN III or sympathetic fibers) or a facial droop with forehead involvement (CN VII nucleus). Signs of CN V, VI, VIII, IX, or XII dysfunction will help to localize to a particular level within the brainstem.4 Cerebellar findings or nystagmus may also be present on examination. Sensory disturbances can parallel the weakness, and some patients will report double vision, trouble swallowing, slurred speech, vertigo, or nausea and vomiting. The CST courses centrally through the brainstem, and extremity weakness with UMN signs in the involved limbs may accompany brainstem lesions. Depressed consciousness can also occur if the brainstem reticular activating system is involved. The two main underlying processes that cause unilateral extremity weakness with contralateral facial involvement are verteobasilar insufficiency and demyelinating diseases.

Unilateral Weakness: A Combination of Arm, Hand, or Leg without Facial Involvement

Before a patient is placed in this category, a careful examination of facial symmetry is required to determine that subtle facial droop or effacement of the nasolabial fold is not present. If there is truly no facial involvement, the source of extremity weakness without facial involvement is most likely to be a result of one of the following processes:

- A lesion in the medial, contralateral, cerebral homonculus (over the area where the lower extremity is represented)
- A discrete internal capsule or brainstem lesion involving only the corticospinal rather than the corticobulbar tracts
- Brown-Séquard hemi cord syndrome if the patient also has contralateral hemibody pain and temperature sensory disturbances below the level of motor weakness

Unilateral Weakness: One Limb Only (Monomelic Weakness, Monoparesis, or Monoplegia)

Isolated weakness of one extremity is most commonly caused by a spinal cord or peripheral nerve lesion. Examination for UMN signs in the affected limb will help to uncover rare monomelic presentations of central nervous system lesions. If UMN signs such as hyper-reflexia or spasticity are present, a careful evaluation is performed for facial weakness or involvement of the contralateral or involvement of the contralateral or other ipsilateral limb as indicative of a central process. If weakness is in the entirety of one lower limb, one should ensure that the patient does not have a contralateral pinprick level indicative of Brown-Séquard hemi cord syndrome. Monomelic weakness is often the result of a radiculopathy, plexopathy, peripheral neuropathy, or NMJ disorder. See Table 13-1 for emergent and critical peripheral nervous system diagnoses.

The examination for monomelic weakness presentations includes detailed strength testing and determination if weakness localizes to one ventral nerve root myotome or one particular peripheral nerve within the limb. Reflexes with a peripheral nerve disorder will be diminished, not hyperactive. Although radiculopathies can occasionally be purely motor, most peripheral lesions have some sensory component to their presentation; therefore a careful sensory examination in the distribution of dorsal nerve root dermatomes and peripheral nerves is essential. See Box 13-2 for a list of nonemergent causes of peripheral neuropathy.

If suspicion is low for a UMN source of isolated extremity weakness, reflexes are intact, and there are no sensory deficits to suggest...
a nerve or root problem, then NMJ disorders are considered. In such cases the weakness is often mild, fluctuating, and worse later in the day. It usually involves the proximal arm or leg muscles, wrist extensors, finger extensors, or ankle dorsiflexors. NMJ disorder–induced weakness with only monomelic symptoms will be an uncommon diagnosis in the ED (see Chapter 108). In elderly patients and others with significant cardiac risk factors, myocardial ischemia is considered if arm sensory symptoms or arm weakness that does not demonstrate measurable loss of motor power is reported.

**Bilateral Weakness: Lower Extremities Only** (Paraparesis or Paraplegia)

The first consideration with this presentation pattern is a spinal cord lesion. If this is the case, UMN signs *may* be absent in the
Bilateral extremity weakness may occur in patients with GBS that has ascended from the lower extremity peripheral nerve myelin sheaths to the upper extremities. In this case the lower limbs are usually weaker than the upper limbs.

Bilateral Weakness: Proximal Portions of Extremities Only

Provided that there are no UMN signs and no sensory deficits, this pattern points to a myofiber disorder.7 Patients may report general fatigue or trouble raising the arms above the head, climbing stairs, or rising from a chair. The common acute and progressive causes of proximal muscular weakness are inflammatory diseases such as polymyositis or dermatomyositis, or necrosis as in rhabdomyolysis from HMG-CoA reductase inhibitors. Muscles are commonly but not always tender to palpation. Myositis patients can also have dysarthria and dysphagia from weakness of the pharyngeal muscles. Airway protective mechanisms may eventually be compromised.

Chronic or recurrent myofiber pathology includes abnormalities to anchoring proteins supporting fibrils to the cytoskeleton and cell membrane (muscular dystrophies), dysfunctional ion channels responsible for depolarization of the muscle fiber cell (channelopathies such as hyperkalemic and hypokalemic periodic paralysis), or an impaired ability to use carbohydrate and lipid energy sources (metabolic myopathies and mitochondrial myopathies). The presentation of these varied conditions ranges from insidious and progressive to sudden onset and episodic. Occasionally, a patient with an NMJ disorder will demonstrate proximal extremity or neck muscle weakness mimicking myofiber disease.

Bilateral Weakness: Distal Portions of Extremities Only

This pattern is almost always caused by a peripheral neuropathy (see Box 13-2). Patients will have weakness and poor coordination with fine movements of their feet or hands. If this type of distal weakness is present in both lower extremities only, the patient will most likely have a chronic peripheral neuropathy or an acute demyelinating neuropathy (GBS). The patient will have some sensory disturbance over the feet as well. Examination for perianal sensory deficits or issues with fecal or urine continence will help to exclude the compressive polyradiculopathy of cauda equina syndrome as a cause of bilateral distal extremity weakness. If only the fingers and hands are involved, evaluation for central cord syndrome is performed. Bilateral lower cervical radiculopathies or symmetrical polyneuropathies are possible but much less likely.

Facial Weakness without Extremity Involvement

This will appear in one of two forms, as follows:

1. Unilateral facial droop. If the weakness is a result of a CN VII problem, unilateral weakness in the upper and lower half of the face should be present on examination. Causes for an isolated CN VII neuropathy are Bell's palsy, mastoiditis, and parotitis. The examination must confirm that there is no extremity involvement and that other CNs, cerebellar testing results, and visual fields are normal. This will ensure that a brainstem lesion is not causing the weakness.

2. Facial weakness not limited to CN VII and the muscle of expression, but including some combination of ptosis, binocular diplopia, dysarthria, or dysphagia. This can be caused by a brainstem lesion, multiple cranial neuropathies, or an NMJ problem. If there are no cerebellar findings, visual field deficits, sensory
disturbances, or extremity UMN signs, posterior cerebral circulation and brainstem disorders are less likely, and an NMJ disorder is more likely. Dysfunction of one or more ocular, facial, or pharyngeal muscles will be the most common presentation for NMJ pathology. The history may indicate that the facial weakness is acute and progressive (botulism) or chronic and fluctuating (myasthenia gravis). Signs of these diseases can be determined by examining extraocular motion, facial expression, and soft palate rise. Generalized fatigue is often reported, and neck, extremity, and respiratory muscle weakness caused by involvement of these neuromuscular units may be present on examination.

Patients with an abnormality of the presynaptic release of acetylcholine (botulism, Eaton-Lambert syndrome, organophosphate poisoning) can have autonomic ganglia involvement and hence abnormal pupillary response to light, dry mouth, fluctuations in heart rate and blood pressure, anhidrosis, or gastrointestinal and bladder dysmotility.

Facial weakness from cranial polyneuropathy manifests with more than one CN deficit not localizing to a brainstem level and without any other long tract signs. Such patients may have a variant of GBS or irritation of multiple CNs after they have exited the brainstem and pierced through inflamed meninges or malignant skull base metastases.

PIVOTAL FINDINGS

1. Patients with tachypnea or shallow respirations should be considered at higher risk for respiratory failure from diaphragmatic, intercostal, and accessory muscle fatigue. Consideration should be given to quantify respiratory effort with pulmonary function tests and/or intervene with positive pressure ventilation.

2. In any patient with sudden onset of focal weakness, a vascular cause (either occlusion or hemorrhage) is strongly considered until proven otherwise by an adequate imaging study.

3. The presence of a severe headache with unilateral weakness, or midline back pain with lower extremity weakness, alerts the emergency physician to a compressive space-occupying lesion.

4. Patients with UMN signs have weakness that localizes to the spinal cord CST or above and are considered to have an emergent problem. They may be at risk for progression to sympathetic autonomic failure or obtundation from enlarging space-occupying spinal or cerebral lesions, respectively.

5. The presence of anorectal or bladder insufficiency without another explanation suggests a UMN or cauda equina lesion.

6. Laboratory tests are most useful in excluding non-neuromuscular causes of weakness (electrocardiogram [ECG], hemoglobin, glucose, electrolytes, troponin, lactate, urinalysis). Two exceptions are creatinine kinase level in inflammatory myositis and potassium level in channelopathies.

EMPIRICAL MANAGEMENT

The ED management of neuromuscular weakness is based on the underlying cause; however, basic emergency tenets are followed for all patients.

1. Neck and pharyngeal muscle weakness may herald a risk for aspiration or insufficiency of the diaphragm with paradoxical abdominal wall motion. Signs of inadequate hypopharyngeal muscle control or respiratory muscle fatigue should prompt protection of the airway and/or positive pressure ventilation.

2. During rapid sequence intubation (RSI), succinylcholine is avoided in suspected cases of progressive denervation of muscle. Nondepolarizing neuromuscular blocking agents such as rocuronium or vecuronium are used in this situation.

3. New quadriparesis or quadriplegia and hypotension without another cause is assumed to be caused by failure of autonomic sympathetic fibers in the cervical spinal cord. Consider a volume load and pressor support in addition to emergent imaging of this area.

4. Although new weakness localizing to the spinal cord or above calls for immediate imaging, weakness from the spinal roots down does not always necessitate imaging in the ED.

5. Patients with suspected GBS need pulmonary function testing in addition to admission to a critical care setting for further management.

6. An infectious or metabolic trigger is sought in patients with myasthenic crisis. If the patient is currently on acetylcholinesterase inhibitors, consideration should be given to a cholinergic crisis.

7. Be aware of medications that may worsen weakness in patients with NMJ disease (e.g., aminoglycosides, quinolones, beta-blockers).

8. Rhabdomyolysis is treated with aggressive fluid resuscitation and intervention directed at the primary cause, if known.

DISPOSITION

Patients with mild LMN or myofiber weakness of benign origin may be discharged with close follow-up, provided the condition is not believed to be rapidly progressing.

Those with more severe or progressive LMN or myofiber weakness and any patient with new UMN weakness should be admitted for further testing. Patients requiring positive pressure ventilation for respiratory muscle fatigue or blood pressure support for sympathetic failure should receive an intensive care unit level of care.

The references for this chapter can be found online by accessing the accompanying Expert Consult website.
References