CHAPTER

28

Anesthesia for Patients with Neurologic & Psychiatric Diseases

KEY CONCEPTS

1. Induction of anesthesia in patients receiving long-term levodopa therapy may result in either marked hypotension or hypertension.
2. In patients with multiple sclerosis, increases in body temperature cause exacerbation of symptoms.
3. The major risk of anesthesia in patients with autonomic dysfunction is severe hypotension, compromising cerebral and coronary blood flow.
4. Autonomic hyperreflexia should be expected in patients with lesions above T6 and can be precipitated by surgical manipulations.
5. The most important interaction between anesthetic agents and tricyclic antidepressants is an exaggerated response to both indirect-acting vasopressors and sympathetic stimulation.

Patients with vascular and nonvascular neurologic diseases and/or psychiatric disorders are frequently encountered by anesthesia staff. Anesthesiologists must have a basic understanding of the major neurologic and psychiatric disorders and their drug therapy. Failure to recognize potential adverse anesthetic interactions may result in avoidable perioperative morbidity.

Cerebrovascular Disease

Preoperative Considerations

Patients with diagnosed cerebrovascular disease typically have a history of transient ischemic attacks (TIAs) or stroke. Patients with TIAs undergoing surgery for other indications have an increased risk of perioperative stroke. Asymptomatic carotid bruits occur in up to 4% of patients older than age 40 years, but do not necessarily indicate significant carotid artery obstruction. Fewer than 10% of patients with completely asymptomatic bruits have hemodynamically significant carotid artery lesions. An asymptomatic carotid bruit may not increase the risk of stroke following surgery, but increases the likelihood of coexisting coronary artery disease. Moreover, the absence of a bruit does not exclude significant carotid obstruction.

The risk of perioperative stroke increases with patient age and varies with the type of surgery. The overall risk of stroke associated with surgery is low, but is greater in patients undergoing cardiovascular surgery. Rates of stroke after general anesthesia and surgery range from 0.08% to 0.4%. Even in patients with known cerebrovascular disease, the risk is only 0.4% to 3.3%. Patients at greatest risk of postoperative stroke are those undergoing open heart procedures for valvular disease, coronary artery disease with ascending aortic atherosclerosis, and diseases of the thoracic aorta. Stroke following open heart surgery is usually due to embolism of air, clots, or atheromatous debris. In

one study, 6.1% of patients experienced an adverse neurological outcome following cardiac surgery. Stroke following thoracic aortic surgery may be due to emboli or ischemia secondary to prolonged circulatory arrest or a clamp placed close to the origin of the carotid artery.

The pathophysiology of postoperative strokes following noncardiovascular surgery is less clear, but may involve severe sustained hypotension or hypertension. Hypotension with severe hypoperfusion can result in so-called "watershed" zone infarctions or thrombosis of cerebral arteries, whereas hypertension can result in intracerebral hemorrhage (hemorrhagic stroke). Sustained hypertension can disrupt the blood–brain barrier and promote cerebral edema. Widened pulse pressure (>80 mm Hg) can produce endothelial vessel injury, potentially resulting in cerebral hypoperfusion or embolism. Perioperative atrial fibrillation can likewise lead to atrial clot formation and cerebral embolism. The period of time during which anesthesia and surgery should best be avoided following a stroke has not been determined. Abnormalities in regional blood flow and metabolic rate usually resolve after 2 weeks, whereas alterations in CO_2 responsiveness and the blood–brain barrier may require more than 4 weeks. However, urgent surgery is performed for acute intracranial hemorrhage, symptomatic carotid disease, and cardiac sources of emboli.

Patients with TIAs have a history of transient (<24 h) impairment, and, by definition, no residual neurologic impairment. These attacks are thought to result from emboli of fibrin-platelet aggregates or atheromatous debris from plaques in extracranial vessels. Unilateral visual impairment, numbness or weakness of an extremity, or aphasia is suggestive of carotid disease, whereas bilateral visual impairment, dizziness, ataxia, dysarthria, bilateral weakness, or amnesia is suggestive of vertebral–basilar disease. Patients with TIAs have a 30% to 40% chance of developing a frank stroke within 5 years; 50% of these strokes occur within the first year. Patients with TIAs should not undergo any elective surgical procedure without an adequate medical evaluation that generally includes at least noninvasive (Doppler) flow and imaging studies. The presence of an ulcerative plaque of greater than 60% occlusion is generally an indication for carotid endarterectomy or endovascular intervention.

PREOPERATIVE MANAGEMENT

Preoperative assessment requires neurologic and cardiovascular evaluations. The type of stroke, the presence of neurologic deficits, and the extent of residual impairment should be determined. Thromboembolic strokes usually occur in patients with generalized atherosclerosis. Most patients are elderly and have comorbid conditions, such as hypertension, hyperlipidemia, and diabetes. Coexisting coronary artery disease and renal impairment are common. Following nonhemorrhagic strokes or TIAs, many patients are placed on long-term warfarin and/or antiplatelet therapy. Management of antiplatelet therapy and antithrombotic therapy should be reviewed by the anesthesia, primary care, and surgical teams to determine the risk/benefit of the discontinuation or maintenance of such therapy perioperatively. Other systemic diseases, such as diabetes, hypertension, coronary artery disease, heart failure, and chronic obstructive lung disease frequently manifest in the patient with cerebrovascular disease.

INTRAOPERATIVE MANAGEMENT

Patients may present for surgery following embolic, thrombotic, and hemorrhagic strokes.

Management of the patient following acute embolic stroke is directed toward the embolic source. Cardiac surgery is performed to remove atrial myxomas. Systemic emboli can also be produced from endocarditic vegetations, as well as from degenerated heart valves and intracardiac thrombus.

Patients with acute strokes secondary to carotid occlusive disease present for carotid endarterectomy and endovascular procedures. When an awake carotid endarterectomy is undertaken, the patient serves as a monitor of the adequacy of cerebral blood flow during application of vessel

clamps to facilitate the surgical repair. When general anesthesia is used electroencephalography, evoked potentials, carotid stump pressure, cerebral infrared spectroscopy, transcranial Doppler, and surgeon subjective sense of collateral back flow are all used to estimate the adequacy of cerebral oxygen delivery during cross clamp. When monitors or lack of appropriate patient response indicate hypoperfusion, the surgeon places a shunt to deliver blood to the brain around the cross-clamped vessel. Even with adequate cerebral blood flow, perioperative stroke can occur during carotid surgery secondary to emboli.

Management of patients following thrombotic or hemorrhagic stroke for nonneurological surgery must be individualized. Cerebral autoregulation of blood flow may fail, leaving flow directly dependent upon cerebral perfusion pressure (**Figure 28–1**). The penumbra of potentially salvageable neurologic tissue may therefore be very sensitive to injury from the effects of both hypotension and hypertension (**Figure 28–2**).

Patients taken to surgery following administration of thrombolytic therapy are at risk of cerebral hemorrhage, and tighter blood pressure control may be indicated to mitigate the possibility of cerebral bleeding.

Patients with intracerebral hemorrhage or traumatic brain injury undergo evacuation of hematoma and decompressive craniectomy. These patients usually require invasive arterial pressure monitoring to facilitate blood pressure management in settings where cerebral autoregulation is likely deranged (Figure 28–1). Hypertension is frequently treated with intravenous vasodilators and β-blockers. Subarachnoid hemorrhage is discussed in Chapter 27.

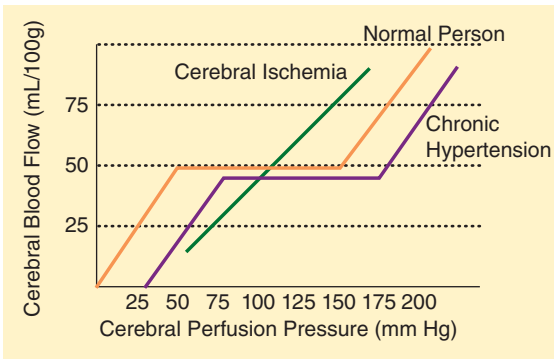

FIGURE 28–1 Cerebral autoregulation in a normal person, cerebral ischemia, and chronic hypertension. (Reproduced, with permission, from Shaikh S: Anesthesia consideration for the patient with acute ischemic stroke. Semin Cardiothorac Vasc Anesth 2010;14:62.)

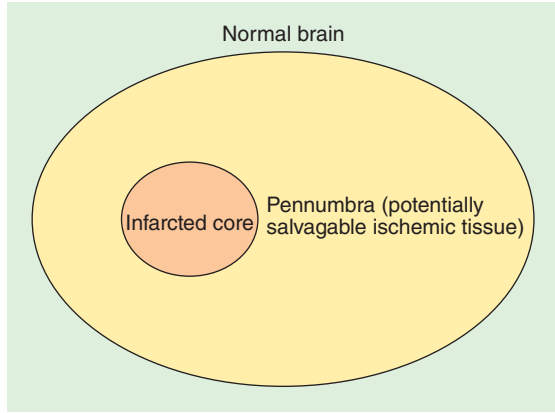

FIGURE 28–2 Penumbra. (Reproduced, with permission, from Shaikh S: Anesthesia consideration for the patient with acute ischemic stroke. Semin Cardiothorac Vasc Anesth 2010;14:62.)

INTRACRANIAL MASS LESIONS

Patients with intracranial mass lesions present to surgery with both malignant and nonmalignant lesions. Such patients frequently present to their primary care physicians with complaints of headache, vision disturbance, or seizures. Radiologic studies confirm the presence of a lesion, and initial treatment is aimed at decreasing cerebral edema with dexamethasone. Electrolytes should be reviewed perioperatively in all patients undergoing cranial surgery, as both hyponatremia and hypernatremia can develop secondary to cerebral salt wasting, inappropriate antidiuretic hormone secretion, or central diabetes insipidus (**Table 28–1**). Patients with altered mentation preoperatively may likewise be dehydrated. Hyperglycemia secondary to steroid use is frequently seen.

TABLE 28–1 Fluid and electrolyte disorders associated with intracranial pathology.

Condition	Serum Sodium Concentration	Plasma Volume	Serum Osmolality	Urine Sodium Concentration	Urine Osmolality	Treatment
SIADH	Low	Normal or increased	Low	High	High	Fluid restriction
CSWS	Low	Decreased	Normal or high	High	Normal or high	Isotonic or hypertonic saline
DI	High	Decreased	High	Normal	Low	Hypotonic saline + vasopressin

CSWS, cerebral salt wasting; DI, diabetes insipidus; SIADH, syndrome of inappropriate antidiuretic hormone secretion.
Reproduced, with permission, from Reddy U, Amin Y: Preoperative assessment of neurosurgical patients. Anaesth Intensive Care Med 2010;11:357.

Seizure Disorders

Preoperative Considerations

Seizures represent abnormal synchronized electrical activity in the brain. They may be a manifestation of an underlying central nervous system disease, a systemic disorder, or idiopathic. Potential underlying mechanisms are thought to include (1) loss of inhibitory activity, (2) enhanced release of excitatory amino acids, and (3) enhanced neuronal firing due to abnormal voltage-mediated Ca^{2+} currents. Up to 2% of the population may experience a seizure in their lifetime. Epilepsy is a disorder characterized by recurrent paroxysmal seizure activity. Healthy individuals who experience an isolated nonrecurrent seizure are not considered to have epilepsy.

Seizure activity may be localized to a specific area in the brain or may be generalized. Moreover, initially localized (focal) seizures can subsequently spread, becoming generalized. A simple classification scheme is presented in Table 28–2. Partial seizures (also called focal) are clinically manifested by motor, sensory, autonomic, or psychiatric symptoms, depending on the cortical area affected. Focal seizures associated with impairment in consciousness are termed "complex partial" (psychomotor or temporal lobe) seizures. Generalized seizures characteristically produce bilaterally symmetric electrical activity without local onset. They result with or without abnormal motor activity, loss of consciousness, or both. Generalized activity resulting in isolated, transient lapses in consciousness are called absence (petit mal) seizures. Other generalized seizures are usually classified according to the type of motor activity. Tonic–clonic (grand mal) seizures are most common and are characterized by a loss of consciousness followed by clonic and then tonic motor activity.

TABLE 28–2 Classification of seizures.

Partial (focal)
Simple
Complex
Secondarily generalized tonic–clonic
Generalized
Absence (petit mal)
Myoclonic
Clonic
Tonic
Tonic–clonic (grand mal)
Atonic

PREOPERATIVE MANAGEMENT

Anesthetic evaluation should focus primarily on the underlying disorder and secondarily on the seizures. One should determine the cause and type of seizure activity and the drugs with which the patient is being treated. Seizures in adults are most commonly due to structural brain lesions (head trauma, tumor, degeneration, or stroke) or metabolic abnormalities (uremia, hepatic failure, hypoglycemia, hypocalcemia, drug toxicity, or drug/alcohol withdrawal). Idiopathic seizures occur most often in children, but may persist into adulthood. Characterization of the type of seizure is important in detecting such activity

TABLE 28–3 Commonly used antiepileptic drugs, mechanisms of action and common side effects.

Drug	Mechanism of Action	Major Side Effects	Comments
Phenytoin	Blocks voltage sensitive Na^+ channels	Dizziness, drowsiness, blurred vision, ataxia Fatigue Nausea and vomiting Constipation, abdominal pain, anorexia	Low therapeutic index Zero order kinetics Enzyme inducer Gingival hyperplasia Megaloblastic anaemia
Phenobarbital	Potentiates GABAergic inhibition AMPA receptor blockade	Sedation, dizziness, confusion, excitement	
Carbamazepine	Blocks voltage sensitive Na^+ channels	Allergic reactions	Introduced slowly
Oxycarbamazepine		Visual disturbance Enzyme induction Tetratogenic	Titrated to side effects
Valproic acid	Increases synthesis and release of GABA Reduces GHB Inhibits NMDA receptors	Sedation, tremor Weight gain Spina bifida Thrombocytopenia	Drug of choice in elderly Caution when combined with lamotrigine
Lamotrigine	Blocks voltage sensitive Na^+ channels	Allergic reactions	Non-sedative
Ethosuximide	Reduces low-threshold T-type Ca^{2+} currents in animals	Apathy, depression and drowsiness Nausea and vomiting	
Vigabatrine	Structural GABA analogue Irreversibly inhibits GABA-transaminase	Visual field defects	
Topiramate	Potentiates GABAergic inhibition	Allergic reactions Depression	Pulmonary embolism
Gabapentin	Unknown Reduces GABA	Somnolence, fatigue Ataxia	Used in intractable complex partial seizures

AMPA, α-amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid; GABA, γ-amino butyric acid; GHB, γ-hydroxybutyric acid; NMDA, *N*-methyl-D-aspartate.
Adapted, with permission, from Veenith T, Burnstein RM. Management of patients with neurological and psychiatric disorders. Surgery 2010;28:441.

perioperatively. Seizures—particularly grand mal seizures—are serious complicating factors in surgical patients and should be treated promptly to prevent musculoskeletal injury, hypoventilation, hypoxemia, and aspiration of gastrointestinal content. Even partial seizures can progress to grand mal seizures. If a seizure occurs, maintaining an open airway and adequate oxygenation are the first priorities. Intravenous propofol (50–100 mg), phenytoin (500–1000 mg slowly), or a benzodiazepine such as diazepam (5–10 mg) or midazolam (1–5 mg) can be used to terminate the seizure.

Most patients with seizure disorders receive antiepileptic drugs preoperatively (Table 28–3). Antiseizure medications should be continued throughout the perioperative period to maintain therapeutic levels.

INTRAOPERATIVE MANAGEMENT

In selecting anesthetic agents, drugs with epileptogenic potential should be avoided, most notably the general anesthetic enflurane (now of only historic

interest). Theoretically, ketamine and methohexital (in small doses) can precipitate seizure activity. Hypothetically, large doses of atracurium, cisatracurium, or meperidine may be relatively contraindicated because of the reported epileptogenic potential of their respective metabolites, laudanosine, and normeperidine. Hepatic microsomal enzyme induction should be expected from chronic antiseizure therapy. Enzyme induction may increase the dose requirement and frequency of intravenous anesthetics and nondepolarizing neuromuscular blockers (NMBs) and may increase the risk for hepatotoxicity from halothane.

Degenerative & Demyelinating Diseases

PARKINSON DISEASE

Preoperative Considerations

Parkinson disease (PD) is a common movement disorder that typically afflicts individuals aged 50–70 years; it has a prevalence of 3% in the United States and Canada. This neurodegenerative disease is characterized by bradykinesia, rigidity, postural instability, and resting (pill-rolling) tremor. Additional frequently occurring findings include facial masking, hypophonia, dysphagia, and gait disturbances. Increasing problems with freezing, rigidity, and tremor eventually result in physical incapacitation. Early in the course of the disease, intellectual function is usually preserved, but declines in intellectual function may be severe as the disease progresses. PD is caused by a progressive loss of dopamine in the nigrostriatum. The severity of loss of dopamine correlates with the severity of bradykinesia. Concurrent with the loss of dopamine, the activity of the gamma-aminobutyric acid (GABA) nuclei in the basal ganglia increases, leading to an inhibition of thalamic and brainstem nuclei. Thalamic inhibition, in turn, suppresses the motor system in the cortex, resulting in the characteristic signs and symptoms.

Medical treatment is directed at controlling the symptoms. A variety of drugs may be used for mild disease, including the anticholinergic agents trihexyphenidyl, benztropine, and ethopropazine; the irreversible monoamine oxidase (MAO) inhibitors selegiline and rasagiline; and the antiviral drug, amantadine. Moderate to severe disease is typically treated pharmacologically with dopaminergic agents, either levodopa (a precursor of dopamine) or a dopamine-receptor agonist. Levodopa, which is given with a decarboxylase inhibitor to retard the peripheral breakdown of the drug (thereby increasing its central delivery and decreasing the dose of levodopa that is required to control symptoms), is the most effective therapy and is used to treat moderate to severe symptoms. Catechol methyltransferase inhibitors are also used to prevent the decarboxylation of levodopa. Levodopa is available in either an immediate or sustained-release formulation, with durations of action of 2–4 hr and 3–6 hr, respectively. Side effects include nausea, vomiting, dyskinesias, sudden sleepiness, cardiac irritability, and orthostatic hypotension. Dopamine receptor agonists include both ergot derivatives (bromocriptine, cabergoline, lisuride, and apomorphine) and nonergot derivatives (pramipexole and ropinirole). The nonergot derivatives have been shown to be beneficial when used as monotherapy in early PD; all dopamine receptor agonists are effective when given as combination therapy with levodopa in the treatment of moderate to severe PD. Side effects are similar to those found with the use of levodopa alone, and, in addition, include headache, confusion, and hallucinations. Pulmonary and retroperitoneal fibrosis, pleural effusion and thickening, Raynaud syndrome, and erythromyalgia are more common side effects with the use of ergot derivatives than with nonergot derivatives.

The surgical treatment of PD includes both ablative procedures (thalamotomy and pallidotomy), as well as electrical stimulation of the ventral intermediate nucleus of the thalamus, the globus pallidus internus, or the subthalamic nucleus. Pallidotomy is effective for treating the dyskinesia (70% to 90%), as well as the tremor, rigidity, bradykinesia, and gait symptoms (30% to 50%) of the disorder. Thalamotomy is most effective in treating the contralateral tremor, but not for the other symptoms of the disease, and has been largely replaced

by the use of thalamic stimulation. The efficacy of deep brain stimulation of the thalamus is related to the effect on tremor; it has little to no effect on the other symptoms of PD. Subthalamic stimulation improves all of the primary symptoms of PD and decreases the amount of medication necessary for symptom relief. Bilateral stimulation has greater efficacy than unilateral stimulation. Some decrease in cognitive function may occur with this treatment, and, therefore, it should be used with caution in patients with cognitive impairment. The effects of globus pallidus internus stimulation are similar to those of pallidotomy with improvements in dyskinesia.

Anesthetic Considerations

Medications for PD should be continued perioperatively, including the morning of surgery. The half-life of levodopa is short. Abrupt withdrawal of levodopa can cause worsening of muscle rigidity and may interfere with ventilation. Phenothiazines, butyrophenones (droperidol), and metoclopramide can exacerbate symptoms as a consequence of their antidopaminergic activity and should be avoided. Anticholinergics (atropine) or antihistamines (diphenhydramine) may be used for acute exacerbation of symptoms. Diphenhydramine may be used for premedication and intraoperative sedation in patients with tremor. Induction of anesthesia in patients receiving long-term levodopa therapy may result in either marked hypotension or hypertension. Relative hypovolemia, catecholamine depletion, autonomic instability, and sensitization to catecholamines are probably contributory. Arterial blood pressure should be monitored carefully. Hypotension should be treated with small doses of a direct-acting vasopressor, such as phenylephrine, rather than ephedrine. The response to NMBs is generally normal, however, hyperkalemia may rarely follow succinylcholine. As mentioned previously, patients who fail medical treatment are candidates for surgical intervention—for example, an ablative therapy, such as a thalamotomy or pallidotomy or implantation of a deep brain stimulator of the subthalamic nucleus, the ventral intermediate nucleus, or the globus pallidus internus. Because general anesthesia alters the threshold for stimulation, correct placement of the electrodes can be affected. Awake craniotomy has been the norm for epilepsy surgery, and is being used increasingly for deep brain stimulation procedures. Two techniques are advocated—a true awake craniotomy with heavy sedation (dexmedetomidine is often used) and an approach in which the patient receives a general anesthetic, usually a total intravenous anesthetic with propofol and remifentanil and a laryngeal mask airway for control of the airway. Following appropriate surgical exposure, the intravenous infusions are discontinued, and the laryngeal mask airway is removed. The patient can be reanesthetized once the implantation of leads is complete.

ALZHEIMER DISEASE

Preoperative Considerations

Neurodegenerative diseases often lead to dementia. Along with a loss of gray matter, elderly patients have altered pharmacokinetic and pharmacodynamic responses to many drugs that are used to induce and maintain anesthesia or sedation. Alzheimer disease (AD) is the most common neurodegenerative disease, causing approximately 40% to 80% of all cases of dementia, with a prevalence of approximately 20% in patients older than age 80 years. The disease is characterized by a slow decline in intellectual function. Progressive impairment of memory, judgment, and decision-making and emotional lability are hallmarks of the disease. Late in the course of the disease, severe extrapyramidal signs, apraxias, and aphasia are often present. Although some degree of brain atrophy is normal with advancing age, patients with AD usually show marked cortical atrophy with ventricular enlargement; the pathological hallmarks of AD seen at necropsy include neurofibrillary tangles that contain the phosphorylated microtubular protein tau and neuritic plaques composed of the peptide β-amyloid.

Anesthetic Considerations

Anesthetic management of patients with moderate to severe AD is often complicated by disorientation and uncooperativeness. New onset of

temporary cognitive impairment is frequent in elderly patients and often persists for 1–3 days following surgery. Such patients require repeated reassurance and explanation. Legally incompetent patients cannot provide informed consent for anesthesia or surgery. Premedication is usually not given, and only small doses are used. Centrally acting anticholinergics, such as atropine and scopolamine, may contribute to postoperative confusion. Glycopyrrolate, which does not cross the blood–brain barrier, may be the preferred agent when an anticholinergic is required.

Laboratory studies have shown that anesthetic agents are increasingly associated with neuronal injury and cell death The outcome implications of general anesthesia in both the elderly and small children are currently the subject of much investigation and debate. Apoptotic neurodegeneration has been linked to the use of GABA receptor modulators and *N*-methyl-D-aspartic acid receptor antagonists, of which both mechanisms are used by common general anesthetics. Moreover, increased β-amyloid production is associated with both anesthetic exposure and AD. Consequently, there are concerns that anesthetic exposure may worsen dementia in the patient with AD; however, definitive conclusions regarding the risk of anesthetic toxicity in the patient with AD are not yet available.

MULTIPLE SCLEROSIS

Preoperative Considerations

Multiple sclerosis (MS) is characterized by reversible demyelination at random and multiple sites in the brain and spinal cord; chronic inflammation, however, eventually produces scarring (gliosis). The disease may be an autoimmune disorder that is initiated by a viral infection. It primarily affects patients between 20 and 40 years of age, with a 2:1 female predominance, and typically follows an unpredictable course of frequent attacks and remissions. With time, remissions become less complete, and the disease progresses to incapacitation; almost 50% of patients will require help with walking within 15 years of diagnosis. Clinical manifestations depend on the sites affected, but frequently include sensory disturbances (paresthesias), visual problems (optic neuritis and diplopia), and motor weakness. Symptoms develop over the course of days and remit over weeks to months. Early diagnosis of exacerbations can often be confirmed by analysis of cerebrospinal fluid and magnetic resonance imaging. Remyelination is limited and often fails to occur. Moreover, axonal loss can develop. Changes in neurological function seem to be related to changes in axonal conduction. Conduction can occur across demyelinated axons, but seems to be affected by multiple factors, particularly temperature. Increases in body temperature cause exacerbation of symptoms.

The treatment of MS may be primarily symptomatic or used in an attempt to arrest the disease process. Diazepam, dantrolene, or baclofen, and, in refractory cases, an intrathecal delivery system for baclofen are used to control spasticity; bethanechol and other anticholinergics are useful for urinary retention. Painful dysesthesia may respond to carbamazepine, phenytoin, or antidepressants. Glucocorticoids may decrease the severity and duration of acute attacks. Corticosteroid-resistant relapses may respond to five to seven courses of plasma exchange offered on alternate days. Interferon has also been used to treat MS. Immunosuppression with azathioprine or cyclophosphamide may also be attempted to halt disease progression. Mitoxantrone is used for relapsing and progressive MS. The systemic effects of these therapies on coagulation and immunologic and cardiac function should be reviewed preoperatively.

Anesthetic Considerations

The effect of stress, anesthesia, and surgery on the course of MS is controversial. Overall, the effect of anesthesia is unpredictable. Elective surgery should be avoided during relapse, regardless of the anesthetic technique employed. The preoperative consent record should document counseling of the patient to the effect that the stress of surgery and anesthesia might worsen the symptoms. Spinal anesthesia has been associated with exacerbation of the disease; however, the entire surgery/delivery/

anesthetic process may likewise lead to exacerbations. Peripheral nerve blocks are less of a concern because MS is a disease of the central nervous system; however, patients may also have peripheral neuropathies. Epidural and other regional techniques seem to have no adverse effect on the course of the disease. No specific interactions with general anesthetics are recognized. Patients with advanced disease may have a labile cardiovascular system due to autonomic dysfunction. In the setting of paresis or paralysis, succinylcholine should be avoided because of hyperkalemia. Regardless of the anesthetic technique employed, increases in body temperature should be avoided. Irrespective of anesthetic technique, patients may experience a worsening of symptoms perioperatively and should be counseled accordingly.

AMYOTROPHIC LATERAL SCLEROSIS

Motor neuron disease is another common neurodegenerative disease, with amyotrophic lateral sclerosis (ALS) being the most prevalent. The cause of ALS is unknown, although small numbers of patients with the familial form of the disease have a defect in the superoxide dismutase-1 gene. ALS is a rapidly progressive disorder of both upper and lower motor neurons. Clinically, patients present in the fifth or sixth decade of life with muscular weakness, atrophy, fasciculation, and spasticity. The disease may initially be asymmetric, but over the course of 2–3 years becomes generalized, involving all skeletal and bulbar muscles. Progressive respiratory muscle weakness makes the patient susceptible to aspiration and eventually leads to death from ventilatory failure. Although the heart is unaffected, autonomic dysfunction can be seen. There is no specific treatment for ALS.

The primary emphasis in management is judicious respiratory care. As with other patients with lower motor neuron disease, succinylcholine is contraindicated because of the risk of hyperkalemia. Adequacy of ventilation should be carefully assessed both intraoperatively and postoperatively; an awake extubation is desirable. Difficulty in weaning patients from mechanical ventilation postoperatively is not uncommon in patients with moderate to advanced disease.

GUILLAIN–BARRÉ SYNDROME

Guillain–Barré syndrome (GBS), a relatively common disorder affecting one to four individuals per 100,000 population, is characterized by a sudden onset of ascending motor paralysis, areflexia, and variable paresthesias. Subtypes of GBS include acute inflammatory demyelinating polyneuropathy (about 75% of cases), acute motor axonal neuropathy (with antibodies against gangliosides), and acute motor sensory axonal neuropathy. Bulbar involvement, including respiratory muscle paralysis, is a frequent complication. Pathologically, the disease seems to be an immunologic reaction against the myelin sheath of peripheral nerves, particularly lower motor neurons. In most instances, the syndrome seems to follow viral respiratory or gastrointestinal infections; the disorder can also present as a paraneoplastic syndrome associated with Hodgkin's disease or as a complication of human immunodeficiency virus infection. Some patients respond to plasmapheresis. The prognosis is relatively good, with most patients recovering completely; unfortunately, however, approximately 10% of patients die of complications, and another 10% are left with long-term neurologic sequelae.

Anesthetic management is complicated by lability of the autonomic nervous system in addition to concerns about respiratory insufficiency. Exaggerated hypotensive and hypertensive responses during anesthesia may be seen. As with other lower motor neuron disorders, succinylcholine should not be used because of the risk of hyperkalemia. The use of regional anesthesia in these patients remains controversial, as it might worsen symptoms. As with all decisions, the risks and benefits of regional versus general anesthesia must be weighed on an individual basis. As damaged nerves are more susceptible to a second injury (the "double crush" effect), performance of neuraxial techniques in patients with preexistent neurologic dysfunction should be carefully considered.

AUTONOMIC DYSFUNCTION

Preoperative Considerations

Autonomic dysfunction, or dysautonomia, may be due to generalized or segmental disorders of the central or peripheral nervous system. Symptoms can be generalized, segmental, or focal. These disorders may be congenital, familial, or acquired. Common manifestations include impotence; bladder and gastrointestinal dysfunction; abnormal regulation of body fluids; decreased sweating, lacrimation, and salivation; and orthostatic hypotension. The latter can be the most serious manifestation of the disorder.

Acquired autonomic dysfunction can be isolated (pure autonomic failure), part of a more generalized degenerative process (Shy–Drager syndrome, PD, olivopontocerebellar atrophy), part of a segmental neurological process (MS, syringomyelia, reflex sympathetic dystrophy, or spinal cord injury), or a manifestation of disorders affecting peripheral nerves (GBS, diabetes, chronic alcoholism, amyloidosis, or porphyria).

Congenital or familial dysautonomia occurs most frequently in Ashkenazi Jewish children and is usually referred to as Riley–Day syndrome. Autonomic dysfunction is prominent and is associated with generalized diminished sensation and emotional lability. Moreover, patients are predisposed to dysautonomic crises triggered by stress and characterized by marked hypertension, tachycardia, abdominal pain, diaphoresis, and vomiting. Intravenous diazepam is effective in resolving such episodes. Hereditary dysautonomia associated with a deficiency of dopamine β-hydroxylase is described. Administration of α-dihydroxyphenylserine improves symptoms in these patients.

Anesthetic Considerations

3 The major risk of anesthesia in patients with autonomic dysfunction is severe hypotension, compromising cerebral and coronary blood flow. Marked hypertension can be equally deleterious. Most patients are chronically hypovolemic. The vasodilatory effects of spinal and epidural anesthesia are poorly tolerated. Similarly, the vasodilatory and cardiac depressant effects of most general anesthetic agents combined with positive airway pressure can be equally problematic. Continuous intraarterial blood pressure monitoring is useful. Hypotension should be treated with fluids and direct-acting vasopressors (in preference to indirect-acting agents). Enhanced sensitivity to vasopressors due to denervation sensitivity may be observed. Blood loss also is usually poorly tolerated. Body temperature should be monitored closely. Patients with anhidrosis are particularly susceptible to hyperpyrexia.

SYRINGOMYELIA

Syringomyelia results in progressive cavitation of the spinal cord. In many cases, obstruction of cerebrospinal fluid outflow from the fourth ventricle seems to be contributory. Many patients have craniovertebral abnormalities, particularly the Arnold–Chiari malformation. Increased pressure in the central canal of the spinal cord produces enlargement or diverticulation to the point of cavitation. Syringomyelia typically affects the cervical spine, producing sensory and motor deficits in the upper extremities, and, frequently, thoracic scoliosis. Extension upward into the medulla (syringobulbia) leads to cranial nerve deficits. Syringo-peritoneal shunting and other decompressive procedures have variable success in arresting the disease.

Anesthetic evaluation should focus on defining existing neurologic deficits and any pulmonary impairment due to scoliosis. Autonomic instability should be expected in patients with extensive lesions. Succinylcholine should be avoided when muscle wasting is present because of the risk of hyperkalemia. Adequacy of ventilation and reversal of nondepolarizing NMBs should be achieved prior to extubation. Neuraxial techniques in the setting of elevated intracranial pressure are contraindicated. Case reports of epidural anesthetics having been performed for labor analgesia in patients with Arnold Chiari malformations, with and without syringomyelia, can be found in the literature. Risks of cerebral herniation, worsening

nerve injury, and infection must be weighed against potential benefits.

Spinal Cord Injury

Preoperative Considerations

Most spinal cord injuries are traumatic and may arise from partial or complete transection. The majority of injuries are due to fracture and dislocation of the vertebral column. The mechanism is usually either compression and flexion at the thoracic spine or extension at the cervical spine. Clinical manifestations depend on the level of the injury. Injuries above C3–5 (diaphragmatic innervation) require patients to receive ventilatory support to stay alive. Transections above T1 result in quadriplegia, whereas those above L4 result in paraplegia. The most common sites of injury are C5–6 and T12–L1. Acute spinal cord transection produces loss of sensation, flaccid paralysis, and loss of spinal reflexes below the level of injury. These findings characterize a period of spinal shock that typically lasts 1–3 weeks.

Over the course of the next few weeks, spinal reflexes gradually return, together with muscle spasms and signs of sympathetic overactivity. Injury in the low thoracic or lumbar spine may result in cauda equina (conus medullaris) syndrome. The latter usually consists of incomplete injury to nerve roots rather than the spinal cord.

Overactivity of the sympathetic nervous system is common with transections at T5 or above, but is unusual with injuries below T10. Interruption of normal descending inhibitory impulses in the cord results in autonomic hyperreflexia. Cutaneous or visceral stimulation below the level of injury can induce intense autonomic reflexes: sympathetic discharge produces hypertension and vasoconstriction below the transection and a baroreceptor-mediated reflex bradycardia and vasodilation above the transection. Cardiac arrhythmias are common.

Emergent surgical management is undertaken whenever there is reversible compression of the spinal cord due to dislocation of a vertebral body or bony fragment. Operative treatment is also indicated for spinal instability to prevent further injury.

Anesthetic Considerations

A. Acute Transection

Anesthetic management depends on the age of the injury. In the early care of acute injuries, the emphasis should be on preventing further spinal cord damage during patient movement, airway manipulation, and positioning. High-dose corticosteroid therapy (methylprednisolone) can be used for the first 24 hr following injury to improve neurologic outcome. Airway management of the patient with unstable cervical spine is discussed in Chapter 19. Patients with high transections often have impaired airway reflexes and are further predisposed to hypoxemia because of a decrease in functional residual capacity and atelectasis. Spinal shock can lead to hypotension and bradycardia prior to any anesthetic administration. Direct arterial pressure monitoring is helpful. An intravenous fluid bolus and the use of ketamine for anesthesia may help to prevent further decreases in blood pressure; vasopressors may also be required. Succinylcholine can be used safely in the first 24 hr, but should not be used thereafter because of the risk of hyperkalemia. The latter can occur within the first week following injury and is due to excessive release of potassium secondary to the proliferation of acetylcholine receptors outside of the neuromuscular synaptic cleft.

B. Chronic Transection

Anesthetic management of patients with nonacute transections is complicated by the possibility of autonomic hyperreflexia and the risk of hyperkalemia. Autonomic hyperreflexia should be expected in patients with lesions above T6 and can be precipitated by surgical manipulations. **Regional anesthesia and deep general anesthesia are effective in preventing hyperreflexia**. Many clinicians, however, are reluctant to administer spinal and epidural anesthesia in these patients because of the difficulties encountered in determining anesthetic level, exaggerated hypotension, and technical problems resulting from deformities. Severe hypertension can result in pulmonary edema, myocardial ischemia, or cerebral hemorrhage and should be treated promptly. Direct arterial vasodilators should

be readily available. Nondepolarizing muscle relaxants may be used. Body temperature should be monitored carefully, particularly in patients with transections above T1, because chronic vasodilation and loss of normal reflex cutaneous vasoconstriction predispose to hypothermia.

Encephalitis

Various forms of encephalitis can present secondary to infectious or autoimmune mechanisms. Patients with encephalitis are managed with the normal care given any patient with potentially increased intracranial pressure at risk of cerebral hypoperfusion.

Psychiatric Disorders

DEPRESSION

Depression is a very common mood disorder characterized by sadness and pessimism. Its cause is multifactorial, but pharmacological treatment is based on the presumption that its manifestations are due to a brain deficiency of dopamine, norepinephrine, and serotonin or altered receptor activities. Up to 50% of patients with major depression hypersecrete cortisol and have abnormal circadian secretion. Current pharmacological therapy utilizes drugs that increase brain levels of these neurotransmitters: tricyclic antidepressants, selective serotonin reuptake inhibitors (SSRIs), MAO inhibitors, and atypical antidepressants. The mechanisms of action of these drugs result in some potentially serious anesthetic interactions. Electroconvulsive therapy (ECT) is increasingly used for refractory severe cases and may be continued prophylactically after the patient's mood recovers. The use of general anesthesia for ECT is largely responsible for its safety and widespread acceptance.

Tricyclic Antidepressants

Tricyclic antidepressants may be used for the treatment of depression and chronic pain syndromes. All tricyclic antidepressants work at nerve synapses by blocking neuronal reuptake of catecholamines, serotonin, or both. Desipramine and nortriptyline are used because they are less sedating and tend to have fewer side effects. Other agents are generally more sedating and include amitriptyline imipramine, protriptyline, amoxapine, doxepin, and trimipramine. Clomipramine is used in the treatment of obsessive–compulsive disorders. Most tricyclic antidepressants also have significant anticholinergic (antimuscarinic) actions: dry mouth, blurred vision, prolonged gastric emptying, and urinary retention. Quinidine-like cardiac effects include tachycardia, T-wave flattening or inversion, and prolongation of the PR, QRS, and QT intervals. Amitriptyline has the most marked anticholinergic effects, whereas doxepin has the fewest cardiac effects.

St. John's wort is being used with increased frequency as an over-the-counter therapy for depression. Because it induces hepatic enzymes, blood levels of other drugs may decrease, sometimes with serious complications. During the preoperative evaluation, the use of all over-the-counter medications should be reviewed.

Antidepressant drugs are generally continued perioperatively. Increased anesthetic requirements, presumably from enhanced brain catecholamine activity, have been reported with these agents. Potentiation of centrally acting anticholinergic agents (atropine and scopolamine) may increase the likelihood of postoperative confusion and delirium.

5 The most important interaction between anesthetic agents and tricyclic antidepressants is an exaggerated response to both indirect-acting vasopressors and sympathetic stimulation. Pancuronium, ketamine, meperidine, and epinephrine-containing local anesthetic solutions should be avoided. Chronic therapy with tricyclic antidepressants is reported to deplete cardiac catecholamines, theoretically potentiating the cardiac depressant effects of anesthetics. If hypotension occurs, small doses of a direct-acting vasopressor should be used instead of an indirect-acting agent. Amitriptyline's anticholinergic action may occasionally contribute to postoperative delirium.

Monoamine Oxidase Inhibitors

MAO inhibitors block the oxidative deamination of naturally occurring amines. At least two MAO isoenzymes (types A and B) with differential substrate

selectivities have been identified. MAO-A is selective for serotonin, dopamine, and norepinephrine, whereas MAO-B is selective for dopamine and phenylethylamine. Nonselective MAO inhibitors include phenelzine isocarboxazid, and tranylcypromine. Selective MAO-B inhibitors are useful in the treatment of PD. Additionally, unlike older nonreversible MAO inhibitors, reversible, MAO-A inhibitors have been developed. Side effects include orthostatic hypotension, agitation, tremor, seizures, muscle spasms, urinary retention, paresthesias, and jaundice. The most serious sequela is a hypertensive crisis that occurs following ingestion of tyramine-containing foods (cheeses and red wines), because tyramine is used to generate norepinephrine.

The practice of discontinuing MAO inhibitors at least 2 weeks prior to elective surgery is not recommended. Phenelzine can decrease plasma cholinesterase activity and prolong the duration of succinylcholine. Opioids should generally be used with caution in patients receiving MAO inhibitors, as rare but serious reactions to opioids have been reported. Most serious reactions are associated with meperidine, resulting in hyperthermia, seizures, and coma. Meperidine should not be administered to patients receiving MAO inhibitors. As with tricyclic antidepressants, exaggerated responses to vasopressors and sympathetic stimulation should be expected. If a vasopressor is necessary, a direct-acting agent in small doses should be employed. Drugs that enhance sympathetic activity, such as ketamine, pancuronium, and epinephrine (in local anesthetic solutions), should be avoided.

Atypical Antidepressants and Selective Serotonin Reuptake Inhibitors

SSRIs include fluoxetine, sertraline, and paroxetine, which some clinicians consider first-line agents of choice for depression. A surprisingly large fraction of patients undergoing elective surgery will be receiving one of these agents. These agents have little or no anticholinergic activity and do not generally affect cardiac conduction. Their principal side effects are headache, agitation, and insomnia. Other agents include the norepinephrine/dopamine reuptake inhibitors, the serotonin/norepinephrine reuptake inhibitors, selective serotonin reuptake enhancers, and norepinephrine-dopamine disinhibitors. Patients taking St. John's wort are at increased risk of serotonin syndrome, as are those taking drugs with similar effects (eg, MAO inhibitors, meperidine). Serotonin syndrome manifestations include agitation, hypertension, hyperthermia, tremor, acidosis, and autonomic instability. Treatment is supportive, along with the administration of a 5-HT antagonist (eg, cyprohepatadine).

BIPOLAR DISEASE

Mania is a mood disorder characterized by elation, hyperactivity, and flight of ideas. Manic episodes may alternate with depression in patients with a bipolar (formerly manic–depressive) disorder. Mania is thought to be related to excessive norepinephrine activity in the brain. Lithium which interferes with Na^+ ion transport with effects on many signaling pathways in the brain affecting neurotransmitter release, and lamotrigine, which inhibits sodium channels and modulates release of excitatory amino acids, are the drugs of choice for treating acute manic episodes and preventing their recurrence, as well as suppressing episodes of depression. Concomitant administration of an antipsychotic (haloperidol) or a benzodiazepine (lorazepam) is usually necessary during acute mania. Alternative treatments include valproic acid, carbamazepine, and aripiprazole as well as ECT.

The mechanism of action of lithium is poorly understood. It has a narrow therapeutic range, with a desirable blood concentration between 0.8 and 1.0 mEq/L. Side effects include reversible T-wave changes, mild leukocytosis, and, on rare occasions, hypothyroidism or a vasopressin-resistant diabetes insipidus-like syndrome. Toxic blood concentrations produce confusion, sedation, muscle weakness, tremor, and slurred speech. Still higher concentrations result in widening of the QRS complex, atrioventricular block, hypotension, and seizures.

Although lithium is reported to decrease minimum alveolar concentration and prolong the duration of some NMBs, clinically these effects seem to be minor. Nonetheless, this is yet another reason why neuromuscular function should be monitored when NMBs are used. Blood levels should be checked perioperatively. Sodium depletion (secondary to

loop or thiazide diuretics) decreases renal excretion of lithium and can lead to lithium toxicity. Fluid restriction and overdiuresis should be avoided. Lithium dilution cardiac output measurements are contraindicated in patients on lithium therapy.

SCHIZOPHRENIA

Patients with schizophrenia display disordered thinking, withdrawal, paranoid delusions, and auditory hallucinations. This disorder is thought to be related to an excess of dopaminergic activity in the brain.

The most commonly used antipsychotics include phenothiazines, thioxanthenes, phenylbutylpiperadines, dihydroindolones, dibenzapines, benzisoxazoles, and butyrophenones. There are numerous trade names for these drugs. Older antipsychotic medications had strong dopamine antagonistic effects, leading to extrapyramidal side effects (eg, muscle rigidity and progression to tardive dyskinesia). Other agents have less dopamine antagonism and occupy the D2 dopamine receptor to a lesser degree, thereby reducing extrapyramidal effects. The antipsychotic effect of these agents seems to be due to dopamine antagonist activity. Most are sedating and mildly anxiolytic. Mild α-adrenergic blockade and anticholinergic activity are also observed. Side effects include orthostatic hypotension, acute dystonic reactions, and parkinsonism-like manifestations. Risperidone and clozapine have little extrapyramidal activity, but the latter is associated with a significant incidence of granulocytopenia. T-wave flattening, ST segment depression, and prolongation of the PR and QT intervals may be seen, increasing the risk of les torsades des pointes.

Continuing antipsychotic medication perioperatively is desirable. Reduced anesthetic requirements may be observed in some patients, and some patients may experience perioperative hypotension.

NEUROLEPTIC MALIGNANT SYNDROME

Neuroleptic malignant syndrome is a rare complication of antipsychotic therapy that may occur hours or weeks after drug administration. Meperidine and metoclopramide can also precipitate the disorder. The mechanism is related to dopamine blockade in the basal ganglia and hypothalamus and impairment of thermoregulation. In its most severe form, the presentation is similar to that of malignant hyperthermia. Muscle rigidity, hyperthermia, rhabdomyolysis, autonomic instability, and altered consciousness are seen. Creatine kinase levels are often high. The mortality rate approaches 20% to 30%, with deaths occurring primarily as a result of renal failure or arrhythmias. Treatment with dantrolene seems to be effective; bromocriptine, a dopamine agonist, may also be effective. Differential diagnoses include malignant hyperthermia and serotonin syndrome.

SUBSTANCE ABUSE

Behavioral disorders from abuse of psychotropic (mind-altering) substances may involve a socially acceptable drug (alcohol), a medically prescribed drug (eg, diazepam), or an illegal substance (eg, cocaine). Characteristically, with chronic abuse, patients develop tolerance to the drug and varying degrees of psychological and physical dependence. Physical dependence is most often seen with opioids, barbiturates, alcohol, and benzodiazepines. Life-threatening complications primarily due to sympathetic overactivity can develop during abstention.

Knowledge of a patient's substance abuse preoperatively may prevent adverse drug interactions, predict tolerance to anesthetic agents, and facilitate the recognition of drug withdrawal. The history of substance abuse may be volunteered by the patient (usually only on direct questioning) or deliberately hidden.

Anesthetic requirements for substance abusers vary, depending on whether the drug exposure is acute or chronic (see **Table 28–4**). Elective procedures should be postponed for acutely intoxicated patients and those with signs of withdrawal. When surgery is deemed necessary in patients with physical dependence, perioperative doses of the abused substance should be provided, or specific agents should be given to prevent withdrawal. In the case of opioid dependence, any opioid can be used, whereas for alcohol, a benzodiazepine is usually substituted due to the reluctance of hospital pharmacies to dispense

TABLE 28–4 Effect of acute and chronic substance abuse on anesthetic requirements.[1]

Substance	Acute	Chronic
Opioids	↓	↑
Barbiturates	↓	↑
Alcohol	↓	↑
Marijuana	↓	0
Benzodiazepines	↓	↑
Amphetamines	↑[2]	↓
Cocaine	↑[2]	0
Phencyclidine	↓	?

[1]↓, decreases; ↑, increases; 0, no effect; ?, unknown.
[2]Associated with marked sympathetic stimulation.

alcohol-containing beverages to patients. Alcoholic patients should receive B vitamin/folate supplementation to prevent Korsakoff's syndrome. Tolerance to most anesthetic agents is often seen, but is not always predictable. For general anesthesia, a technique primarily relying on a volatile inhalation agent may be preferable so that anesthetic depth can be readily adjusted according to individual need. Awareness monitoring should be likewise considered. Opioids with mixed agonist–antagonist activity should be avoided in opioid-dependent patients because such agents can precipitate acute withdrawal. Clonidine is a useful adjuvant in the treatment of postoperative withdrawal syndromes.

Patients routinely present acutely intoxicated for emergency surgery following trauma related to substance abuse. Patients have often consumed more than one class of intoxicating agent. Acute cocaine intoxication may produce hypertension secondary to the increase in central neurotransmitters, such as norepinephrine and dopamine. Hypertension and arrhythmias can occur perioperatively. Chronic abusers deplete their sympathomimetic neurotransmitters, potentially developing hypotension. Amphetamine abusers have similar anesthetic concerns, as amphetamines also affect the sympathetic nervous system.

Patients on chronic prescribed opioid therapy, or those taking medications illicitly, have substantially increased opioid postoperative requirements. Multimodal approaches to pain control are useful perioperatively, and patients should be started on maintenance methadone as soon as possible.

Consultation with pain management and addiction specialists is often indicated.

CASE DISCUSSION

Anesthesia for Electroconvulsive Therapy

A 64-year-old man with depression refractory to drug therapy is scheduled for electroconvulsive therapy (ECT).

How is ECT administered?

The electroconvulsive shock is applied to one or both cerebral hemispheres to induce a seizure. Variables include stimulus pattern, amplitude, and duration. The goal is to produce a therapeutic generalized seizure 30–60 sec in duration. Electrical stimuli are usually administered until a therapeutic seizure is induced. A good therapeutic effect is generally not achieved until a total of 400–700 seizure seconds have been induced. Because only one treatment is given per day, patients are usually scheduled for a series of treatments, generally two or three a week. Progressive memory loss often occurs with an increasing number of treatments, particularly when electrodes are applied bilaterally.

Why is anesthesia necessary?

When the efficacy of ECT was discovered, enthusiasm was tempered in the medical community because drugs were not used to control the violent seizures caused by the procedure, thus engendering a relatively high incidence of musculoskeletal injuries. Moreover, when an NMB was used alone, patients sometimes recalled being paralyzed and awake just prior to the shock. The routine use of general anesthesia to ensure amnesia and neuromuscular blockade to prevent injuries has renewed interest in ECT. The current mortality rate for ECT is estimated to be one death per 10,000 treatments.

What are the physiological effects of ECT-induced seizures?

Seizure activity is characteristically associated with an initial parasympathetic discharge followed by a more sustained sympathetic discharge. The initial phase is characterized by bradycardia and increased secretions. Marked bradycardia (<30 beats/min) and even transient asystole (up to 6 s) are occasionally seen. The hypertension and tachycardia that follow are typically sustained for several minutes. Transient autonomic imbalance can produce arrhythmias and T-wave abnormalities on the electrocardiogram. Cerebral blood flow and ICP, intragastric pressure, and intraocular pressure all transiently increase.

Are there any contraindications to ECT?

Contraindications are a recent myocardial infarction (usually <3 months), a recent stroke (usually <1 month), an intracranial mass, or increased ICP from any cause. More relative contraindications include angina, poorly controlled heart failure, significant pulmonary disease, bone fractures, severe osteoporosis, pregnancy, glaucoma, and retinal detachment.

What are the important considerations in selecting anesthetic agents?

Amnesia is required only for the brief period (1–5 min) from when the NMB is given to when a therapeutic seizure has been successfully induced. The seizure itself usually results in a brief period of anterograde amnesia, somnolence, and often confusion. Consequently, only a short-acting induction agent is necessary. Moreover, because most induction agents (barbiturates, etomidate, benzodiazepines, and propofol) have anticonvulsant properties, small doses must be used. Seizure threshold is increased and **seizure duration** is decreased by all of these agents.

Following adequate preoxygenation, methohexital, 0.5–1 mg/kg, is most commonly employed. Propofol, 1–1.5 mg/kg, may be used, but higher doses reduce seizure duration. Benzodiazepines raise the seizure threshold and decrease duration. Ketamine increases seizure duration, but is generally not used because it also increases the incidence of delayed awakening, nausea, and ataxia and is also associated with hallucinations during emergence. Use of etomidate also prolongs recovery. Short-acting opioids, such as alfentanil, are not given alone because they do not consistently produce amnesia. However, alfentanil (10–25 mg/kg) can be a useful adjunct when very small doses of methohexital (10–20 mg) are required in patients with a high seizure threshold. In very small doses, methohexital may actually enhance seizure activity. Increases in seizure threshold are often observed with each subsequent ECT.

Neuromuscular blockade is required from the time of electrical stimulation until the end of the seizure. A short-acting agent, such as succinylcholine (0.25–0.5 mg/kg), is most often selected. Controlled mask ventilation, using a self-inflating bag device or an anesthesia circle system, is required until spontaneous respirations resume.

Can seizure duration be increased without increasing the electrical stimulus?

Hyperventilation can increase seizure duration and is routinely employed in some centers. Intravenous caffeine, 125–250 mg (given slowly), has also been reported to increase seizure duration.

What monitors should be used during ECT?

Monitoring should be similar to what is appropriate with the use of any other general anesthetic. Seizure activity is sometimes monitored by an unprocessed electroencephalogram. It can also be monitored in an isolated limb: a tourniquet is inflated around one arm prior to injection of succinylcholine, preventing entry of the NMB and allowing observation of convulsive motor activity in that arm.

How can the adverse hemodynamic effects of the seizure be controlled in patients with limited cardiovascular reserve?

Exaggerated parasympathetic effects should be treated with atropine. In fact, premedication with glycopyrrolate is desirable both to prevent the profuse secretions associated with seizures and to attenuate bradycardia. Nitroglycerin, nifedipine, and α- and β-adrenergic blockers have all been employed successfully to control sympathetic

manifestations. High doses of β-adrenergic blockers (esmolol, 200 mg), however, are reported to decrease seizure duration.

What if the patient has a pacemaker?

Patients with pacemakers may safely undergo electroconvulsive treatments, but a magnet should be readily available to convert the pacemaker to a fixed mode, if necessary.

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