Anesthesia consideration in neurological diseases

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Management of Anesthesia

Management of anesthesia during tumor resection procedures can be challenging, since patients may be of any age, and a variety of operative positioning issues may arise

❖ some procedures may be conducted with **electro-physiologic monitoring**, which may have implications for anesthetic drug choices and the use of muscle relaxants.

➢ Some procedures may even be performed **in awake patients** to facilitate resection of a mass located near an eloquent region of brain, such as the motor cortex.

1. Major goals during anesthesia include
maintaining adequate cerebral perfusion and oxygenation of normal brain,
(2) optimizing operative conditions to facilitate resection,
(3) ensuring rapid emergence from anesthesia at the conclusion of the procedure to facilitate neurologic assessment,
(4) accommodating intraoperative electro-physiologic monitoring if needed

Preoperative Management

Preoperative evaluation of a patient with an intracranial tumor is directed toward identifying the presence or absence of increased ICP.

Symptoms of increased ICP include

- nausea and vomiting,
- altered level of consciousness,
- decreased reactivity of the pupils to light,
- papilledema,
- bradycardia,
- Systemic hypertension,
- breathing disturbances.
- Evidence of midline shifts (>0.5 cm) on CT or MRI suggests the presence of increased ICP.

Patients with an intracranial pathologic process may be **extremely sensitive to the CNS depressant** effects of opioids and sedatives.

Drug-induced hypoventilation can lead to hypercarbia and further increase ICP. Likewise, drug-induced sedation can mask alterations in the level of consciousness that accompany intracranial hypertension.

On the other hand, preoperative sedation can **unmask subtle neurologic deficits** that may not usually be apparent. This is thought to result from increased sensitivity of injured neurons to the depressant effects of various anesthetic and sedative agents.

Considering all the potential adverse effects of preoperative medication, it is prudent to use premedication very sparingly, particularly if the patient is not being continually observed.

Preoperative administration of depressant drugs should be avoided in patients with diminished levels of consciousness.

In alert adult patients with intracranial tumors, benzodiazepines in small doses can provide anxiety relief without meaningfully affecting ventilation.

The decision to administer an anticholinergic drug or histamine 2 receptor antagonist is not influenced by the presence or absence of increased ICP.

Neurofibromatosis

Neurofibromatosis is due to an autosomal dominant mutation.
Both sexes are equally affected. Expressivity is variable, but penetrance of the trait is virtually 100%. The disorder is characterized by tumors that grow in the nervous system.

- There are three types of neurofibromatosis:
- NF1,
- NF2,
- schwannomatosis.

Each has distinctly different genetic mutations.
NF1 occurs in 1 of 3000–4000 persons. The diagnosis of NF1 is based on the National Institutes of Health criteria.
Patients must have at least two of the following:

- at least six café au lait spots
- two or more neurofibromas or one plexiform neuroma
- freckling in the axilla or inguinal areas
- at least two Lisch nodules (hamartomas of the iris)
- optic glioma
- osseous lesions such as sphenoid dysplasia or thinning of long bone cortex, with or without pseudarthrosis
- first-degree relative with NF1

In addition to abnormalities in the diagnostic criteria,
patients with NF1 may have

- macrocephaly,
- short stature,
- obstructive hydrocephalus,
- epilepsy,
- hypertension,
- Congenital heart defects,
- both learning and behavioral disorders.
- There is an increased incidence of cancer in patients with neurofibromatosis. Commonly associated cancers include neurofibrosarcoma, malignant schwannoma, Wilms tumor, rhabdomyosarcoma, and leukemia.
- There is an association between NF1 and MEN type IIb that consists of mucocutaneous tumors, medullary thyroid cancer, and pheochromocytoma.

Generally, neurofibromas are removed if they become

- symptomatic,
- painful,
- cancerous. T
- they may also be removed for cosmetic reasons.

NF2 is much rarer than NF1. It is diagnosed by the presence of at least one of the following:

- bilateral vestibular schwannomas
- family history of NF2 or unilateral vestibular schwannoma before age 30
- any two of glioma, meningioma, peripheral nerve schwannoma, or juvenile cataracts (Patients may undergo surgery for resection of tumors associated with this condition or removal of cataracts.)

Schwannomatosis is the rarest variant of neurofibromatosis. It consists of diffuse schwannomas but the absence of a schwannoma of the vestibular nerve.

Management of Anesthesia

Management of anesthesia in patients with neurofibromatosis includes consideration of the many clinical presentations of this disease.

- The possible presence of a **pheochromocytoma** should be considered during the preoperative evaluation.
- Signs of increased ICP may reflect expanding intracranial tumors
- Expanding laryngeal neurofibromas may jeopardize airway patency.
- Patients with neurofibromatosis and scoliosis are likely to have cervical spine defects that could influence positioning for direct laryngoscopy and the subsequent surgical procedure.
- Responses to muscle relaxants are variable.

These patients have been described as both sensitive and resistant to succinylcholine and sensitive to nondepolarizing muscle relaxants.

Neuraxial anesthesia should be avoided in patients with tumors involving the proximal peripheral nerves (i.e., tumors near the spine or within the spinal canal).

- In the absence of such tumors, epidural analgesia is an effective method for producing analgesia during labor and delivery.

Patients with Alzheimer's disease may come for a variety of surgical interventions that are common in the elderly population.

- Patients are often confused and sometimes uncooperative, which makes monitored anesthesia care or regional anesthesia challenging.
- There is **no one single anesthetic technique or drug** that is ideal in this group of patients. Shorter acting sedative-hypnotic drugs, anesthetics, and opioids are preferred, since they allow a more rapid return to baseline mental status.
- One should be aware of potential drug interactions, especially prolongation of the effect of succinylcholine and relative resistance to nondepolarizing muscle relaxants resulting from the use of cholinesterase inhibitors.

Parkinson's Disease

Parkinson's disease is a neurodegenerative disorder of unknown cause. Increasing age is the single most important risk factor in the development of this disease.

There is a characteristic loss of dopaminergic fibers normally present in the basal ganglia, and as a result, regional dopamine concentrations are depleted.

Dopamine is presumed to inhibit the rate of firing of the neurons that control the extrapyramidal motor system. Depletion of dopamine results in diminished

inhibition of these neurons and unopposed stimulation by acetylcholine.

The classic triad of major signs of Parkinson’s disease consists of

- skeletal muscle tremor,
- rigidity,
- akinesia.

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Skeletal muscle rigidity first appears in the proximal muscles of the neck. The earliest manifestations may be loss of arm swings when walking and absence of head rotation when turning the body.

There is facial immobility manifested by infrequent blinking and by a paucity of emotional expressions.

Tremors are characterized as rhythmic alternating flexion and extension of the thumbs and other digits (pill-rolling tremor).

Tremors are more prominent during rest and tend to disappear during voluntary movement.

Seborrhea, oily skin, diaphragmatic spasms, and oculogyric crises are frequent.

Dementia and depression are often present

Treatment of Parkinson's disease is designed to increase the concentration of dopamine in the basal ganglia or decrease the neuronal effects of acetylcholine.

Replacement therapy with the dopamine precursor levodopa combined with administration of a decarboxylase inhibitor such as carbidopa, which
prevents peripheral conversion of levodopa to dopamine and optimizes the amount of levodopa available to enter the CNS, is the standard medical treatment. Indeed, levodopa is the most effective treatment for Parkinson's disease, and early treatment with this drug prolongs life.

Levodopa is associated with a number of side effe
including

- dyskinesias and psychiatric disturbances.
- The increased myocardial contractility and heart rate seen in treated patients may reflect increased levels of circulating dopamine converted from levodopa.
- Orthostatic hypotension may be prominent in treated patients.
- Gastrointestinal side effects of levodopa therapy include nausea and vomiting, most likely caused by stimulation of the medullary chemoreceptor trigger zone.

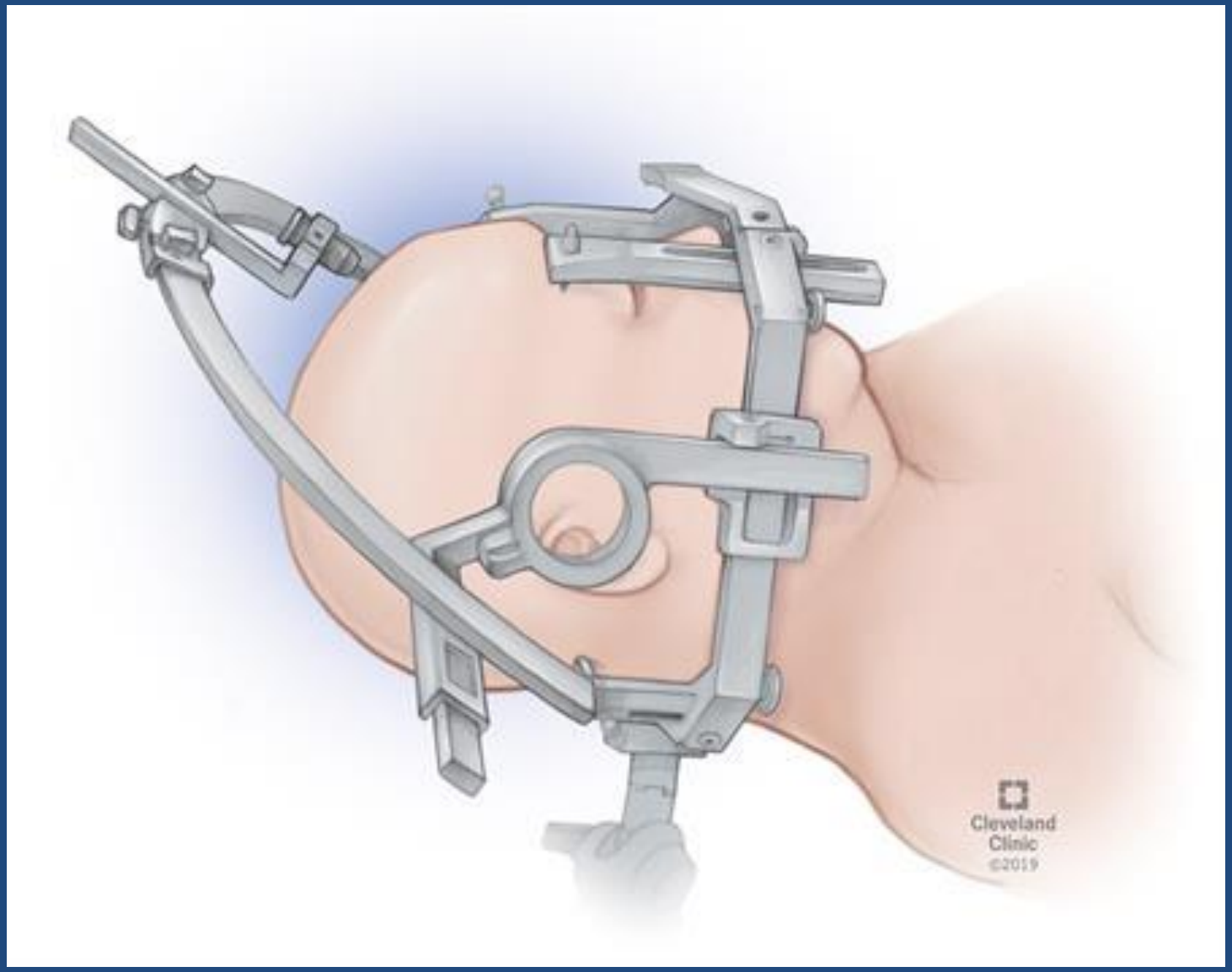
- **Amantadine**, an antiviral agent, is reported to help control the symptoms of Parkinson's disease. The mechanism for its effect is not fully understood.
- The type B monoamine oxidase inhibitors (MAOIs) **selegiline and rasagiline** can also help control the symptoms of Parkinson's disease by inhibiting catabolism of dopamine in the CNS. They have an advantage over nonspecific MAOIs because they are not associated with the occurrence of tyramine-related hypertensive crises.
- They do, however, have a significant reaction with meperidine.

- Surgical treatment of Parkinson’s disease is reserved for patients with disabling and medically refractory symptoms.
- Stimulation of the various nuclei within the basal ganglia via an implanted deep brain stimulating device can relieve or help control tremors.
- Fetal tissue transplantation for treatment of Parkinson’s disease is based on the demonstration that implanted embryonic dopaminergic neurons can survive in recipients. The effectiveness of this treatment is not currently known.

Deep brain stimulator placement is typically performed on an **awake patient**. However, in certain circumstances, such as in patients with developmental delay or those with severe claustrophobia, the procedure is performed under general anesthesia.

The procedure begins with placement of a rigid head frame, followed by MRI to allow for coordinate determination relative to fiduciary markers on the head frame.

The deep brain electrode is then advanced through a burr hole, often with microelectrode recordings taken while the electrode is being advanced, since specific nuclei differ in their spontaneous firing patterns. Following successful brain lead placement, a generator pack is implanted below the clavicle or in the abdomen. Of note, deep brain stimulation is currently also used for treatment of a variety of other disorders, such as essential tremor, dystonia, multiple sclerosis with a significant tremor, and some psychiatric disorders.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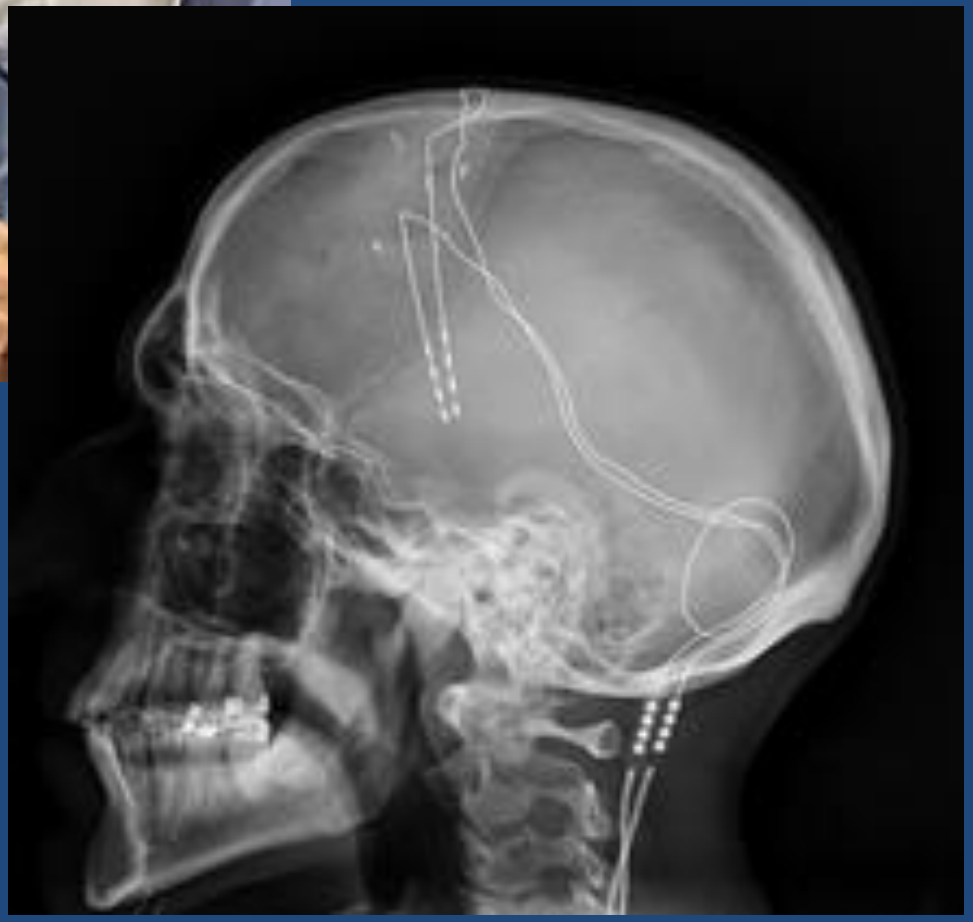


Management of Anesthesia

Management of anesthesia in patients with Parkinson’s disease requires an understanding of how this disease is treated.

- The elimination half-life of levodopa and the dopamine it produces is brief, so interruption of drug therapy for more than 6–12 hours can result in an abrupt loss of therapeutic effects.
- Abrupt drug withdrawal can also lead to skeletal muscle rigidity, which can interfere with ventilation.
- Therefore levodopa therapy, including the usual morning dose on the day of surgery, must be continued throughout the perioperative period.
- Oral levodopa can be administered approximately 20 minutes before induction of anesthesia, and the dose may be repeated

intraoperatively and postoperatively via an orogastric or nasogastric
tube as needed.

❖The possibility of hypotension and cardiac dysrhythmias must be considered,
and butyrophenones (e.g., droperidol, haloperidol) must be available to antagonize the effects of dopamine in the basal ganglia.

Acute dystonic reactions following administration of **alfentanil** might indicate an opioid induced decrease in **central dopaminergic transmission**.

- The use of ketamine is controversial because exaggerated sympathetic nervous system responses might be provoked, but ketamine has been administered safely to patients treated with levodopa.
- The choice of a muscle relaxant is not influenced by the presence of Parkinson's disease.

- Patients undergoing **deep brain stimulator implantation** may have been told by the surgeon to refrain from taking the usual morning dose of levodopa to facilitate the return of tremors and enhance sensitivity in detecting the efficacy of deep brain stimulation during the procedure.
- If that is the case, establishing IV access may prove challenging in an extremity with a significant tremor.
- Patients should receive minimal sedation during lead placement to prevent interference with microelectrode recordings and clinical assessment..

Since γ-aminobutyric acid (GABA) is a common neurotransmitter involved in the normal circuitry of the basal ganglia, anesthetic drugs with significant effects on GABA (e.g., propofol, benzodiazepines) can alter the characteristic microelectrode recordings of specific nuclei and should be avoided.

Sedative drugs such as opioids and **dexmedetomidine** are more satisfactory alternatives. Excessive sedation should be avoided not only to minimize difficulty obtaining neurologic assessments, but more importantly to avoid respiratory depression in a patient in whom there is little access to the airway because of the presence of a head frame.

- A variety of airway management devices (e.g., fiberoptic bronchoscope, laryngeal mask airway) should be readily available should airway compromise become an issue intraoperatively.

In patients having general anesthesia for lead implantation, microelectrode recordings cannot be used to facilitate placement of the lead, so choice of anesthetic drugs is not limited. During general anesthesia, lead localization is performed solely by stereotaxis to reach anatomic landmarks.

Lead placement can be a long procedure, so care should be taken to position the patient properly and comfortably. Proper padding should be placed at sites that may be prone to pressure injury.

The procedure is performed with the patient in the **sitting posi**tion, so there is a risk of air embolism.

Precordial Doppler monitoring can help identify air entrainment.

If venous air embolism and oxygen desaturation occur, the patient should not be encouraged to take a deep breath; this can lower intrathoracic pressure and cause entrainment of even more air.

Instead the surgeon should flood the field with saline and attempt to identify and treat the site of air entrainment.

In more severe cases the patient should be placed supine and hemodynamic support instituted as required.

Other potential complications of deep brain stimulator placement include hypertension, seizures, and bleeding

Hypertension should be treated to avoid increasing the risk of intracranial hemorrhage.

Seizures often spontaneously abate, but very small doses of a barbiturate, propofol, or a benzodiazepine may be required to terminate their activity despite the potentially suppressive effect of administration of these drugs on microelectrode recordings.

The effect of these drugs on ventilatory drive must also be appreciated and minimized.

A sudden alteration of consciousness could indicate intracranial hemorrhage. Hemorrhage would require aggressive management, such as emergent removal of the head frame, endotracheal intubation, and craniotomy after imaging.

Huntington's Disease

Huntington's disease is a degenerative disease of the CNS characterized by marked atrophy of the caudate nucleus and to a lesser degree the putamen and globus pallidus. Biochemical abnormalities include deficiencies of acetylcholine (and its synthesizing enzyme choline acetyltransferase) and GABA in the basal ganglia.

- Involvement of the pharyngeal muscles makes these patients susceptible to pulmonary aspiration as well as significant weight loss.
- The disease progresses over several years, and accompanying mental depression makes suicide a frequent cause of death.
- The duration of Huntington's disease from clinical onset to death averages 17 years.

Treatment

- . Haloperidol and other butyrophenones may be administered to control the chorea and emotional lability associated with the disease.
- Involuntary movements are best controlled by drugs that

1. interfere with the neurotransmitter effects of dopamine,
2. either by antagonizing dopamine (haloperidol, fluphenazine)
3. depleting dopamine stores (reserpine, tetrabenazine).

Experience in anesthesia management in patients with Huntington's chorea is too limited to allow recommendation of specific anesthetic drugs or techniques.

- Preoperative sedation using butyrophenones (e.g., droperidol, haloperidol) may be helpful in controlling choreiform movements.
- The increased likelihood of pulmonary aspiration must be considered.
- Use of nitrous oxide and volatile anesthetics is acceptable.
- Propofol and succinylcholine have been administered without adverse effects, but decreased plasma cholinesterase activity with prolonged responses to succinylcholine has been observed.
- It has been suggested that these patients may be sensitive to the effects of nondepolarizing muscle relaxants.

Torticollis

Torticollis (also called cervical dystonia) is thought to result from disturbances in basal ganglia function. The most common mode of presentation is spasmodic contraction of neck muscles, which may progress to involvement of limb and girdle muscles. Hypertrophy of the sternocleidomastoid muscles may be present. Spasm may involve the muscles of the vertebral column, leading to lordosis, scoliosis, and impaired ventilation.

Treatment may include injection of botulinum toxin.

Selective peripheral denervation of the affected cervical musculature is currently the favored surgical option to treat severe cervical dystonia. There are no known problems influencing the selection of anesthetic drugs for this procedure, but spasm of nuchal muscles can interfere with maintenance of a patent upper airway before institution of skeletal muscle paralysis.

Awake endotracheal intubation may be necessary if chronic skeletal muscle spasm has led to fixation of the cervical vertebrae.

Surgery may be performed with the patient in the sitting position. If so, anesthetic considerations related to use of the sitting position and the potential for venous air embolism will come into play.

The sudden appearance of torticollis after administration of anesthetic drugs has been reported. Administration of **diphenhydramine 25–50 mg IV** produces dramatic reversal of this drug-induced torticollis.

Management of Anesthesia

Management of anesthesia in patients with multiple sclerosis must consider the impact of surgical stress on the natural progression of the disease.

Regardless of the anesthetic technique or drugs selected for use during the perioperative period, it is possible that symptoms and signs of multiple sclerosis will be exacerbated postoperatively. This may be due to factors such as infection and fever. Any increase in body temperature, even as little as 1°C, can cause an exacerbation of multiple sclerosis.

It is possible that increased body temperature results in complete block of conduction in demyelinated nerves. The unpredictable cycle of clinical exacerbations and remissions inherent in multiple sclerosis might lead to erroneous conclusions that there are cause-and-effect relationships between disease severity and drugs or events occurring during the perioperative period.

The changing and unpredictable neurologic presentation of patients with multiple sclerosis during the perioperative period must be appreciated when regional anesthetic techniques are selected.
spinal anesthesia has been implicated in postoperative exacerbations of multiple sclerosis,
whereas there is currently no convincing evidence of exacerbations of the disease after epidural anesthesia or peripheral nerve block. The mechanism by which spinal anesthesia might differ in this regard from epidural anesthesia is unknown, but it might involve local anesthetic neurotoxicity. Specifically it is speculated that the demyelination associated with multiple sclerosis renders the spinal cord more susceptible to the neurotoxic effects of local anesthetics.
Epidural anesthesia may carry less risk than spinal anesthesia because the concentration of local anesthetics in the white matter of the spinal cord is lower than after spinal anesthesia. Nevertheless, both epidural anesthesia and spinal anesthesia have been used in parturient women with multiple sclerosis.

General anesthesia is the most frequently used technique in patients with multiple sclerosis. There are no unique interactions between multiple sclerosis and the drugs used to provide general anesthesia, and there is no evidence to support the use of one inhaled or injected anesthetic drug over another.

- In patients with motor weakness, use of succinylcholine can result in exaggerated potassium release and should be avoided.
- Prolonged responses to the paralyzing effects of nondepolarizing muscle relaxants would be consistent with co-existing skeletal muscle weakness and decreased skeletal muscle mass.
- However, resistance to the effects of nondepolarizing muscle relaxants has been observed, which perhaps reflects the proliferation of extra-junctional cholinergic receptors characteristic of upper motor neuron lesions.
- Corticosteroid supplementation during the perioperative period may be indicated in patients being treated long term with these drugs. Efforts must be made to recognize and prevent even a modest increase in body temperature, since this change may exacerbate symptoms. Periodic neurologic evaluation during the postoperative period is useful for detection of disease exacerbation.

Pharmacologic Treatment

Seizures are treated with antiepileptic drugs, starting with a single drug and achieving seizure control by increasing the dosage as necessary. Drug combinations may be considered when monotherapy fails. Changes in drug dosage are guided by clinical response (antiseizure effects vs. side effects) rather than by serum drug concentrations. Monitoring of serum drug levels is usually not necessary for patients who are experiencing adequate seizure control without evidence of toxicity.

Effective antiepileptic drugs appear to decrease neuronal excitability or enhance neuronal inhibition. Drugs effective

Management of Anesthesia

Management of anesthesia in patients with seizure disorders includes considering the impact of antiepileptic drugs on organ function and the effect of anesthetic drugs on seizures. Sedation produced by antiepileptic drugs may have additive effects with that produced by anesthetic drugs, and enzyme induction by antiepileptic drugs may alter the pharmacokinetics and pharmacodynamics of anesthetic drugs.

When selecting anesthetic induction and maintenance drugs, one must consider their effects on CNS electrical activity.

Methohexital administration can activate epileptic foci and has been recommended as a method for delineating these foci during electrocorticography in patients undergoing surgical treatment of epilepsy.
Alfentanil, ketamine, enflurane, isoflurane, and sevoflurane can cause epileptiform spike-and-wave EEG activity in patients without a history of seizures, but they are also known to suppress epileptiform and epileptic activity.
Seizures and opisthotonos have been observed in rare cases after propofol anesthesia, which suggests caution when administering this drug to patients with known seizure disorders.

In selection of muscle relaxants, the CNS-stimulating effects of laudanosine, a proconvulsant metabolite of atracurium and cisatracurium, may merit consideration.
Various antiepileptic drugs, specifically phenytoin and carbamazepine, shorten the duration of action of nondepolarizing muscle relaxants through both pharmacokinetic and pharmacodynamic means.

Topiramate may be the cause of unexplained metabolic acidosis, given its ability to inhibit carbonic anhydrase.
It seems reasonable to avoid administering potentially epileptogenic drugs to patients with epilepsy.

Instead, thiobarbiturates, opioids, and benzodiazepines are preferred.
Isoflurane, desflurane, and sevoflurane seem to be acceptable choices in patients with seizure disorders. Regardless of the anesthetic drugs used, it is important to maintain treatment with the preoperative antiepileptic drugs throughout the perioperative period.
During intraoperative electrocorticography, monitoring is
aimed at identifying interictal epileptiform activity, the characteristic patterns of electrical activity that occur in the time
between seizures. Many anesthetic agents, such as benzodiazepines,
volatile anesthetics, and anesthetic doses of barbiturates
and propofol, can significantly suppress epileptiform activity,
which renders electrocorticographic monitoring difficult or
impossible.

During the monitoring period, anesthesia should be managed with agents such as opioids, nitrous oxide, droperidol, diphenhydramine, and possibly dexmedetomidine.
If epileptiform activity remains suppressed or is inadequate for analysis, high-dose short-acting opioids (e.g., alfentanil 50 µg/ kg as an IV bolus), or small IV boluses of methohexital (0.3 mg/kg) or etomidate (0.05–0.1 mg/kg) can serve to enhance epileptiform activity.
Careful attention to maintaining muscle paralysis during this part of the procedure is important.
During the preoperative discussion, the patient should be made aware that anesthetic techniques used to improve the quality of electrophysiologic recordings may also increase the risk of awareness during anesthesia.

Despite general anesthesia and muscle relaxation, patients may still exhibit seizure activity. This may manifest as

- unexplained abrupt changes in heart rate
- blood pressure
- with or without overt clonic movement,

depending on the degree of muscle paralysis.

- Increases in carbon dioxide production from increased brain and muscle metabolism will be reflected in an increased end-tidal carbon dioxide concentration and may result in patient respiratory efforts.
- Seizures can be terminated by administration of a barbiturate, propofol, or a benzodiazepine that is titrated to seizure cessation. Seizures can also be rapidly terminated by direct application of cold saline to the brain surface. This is a very useful technique in procedures performed in awake patients, because it avoids the use of drugs that could potentially produce somnolence, hypoventilation, airway obstruction, or apnea.

SUMMARY OF PROCEDURE

Position	Supine
Incision	Anterolateral neck; occasionally, if "patching" arteriotomy, may have to harvest portion of greater saphenous vein from leg.
Special instrumentation	Magnification loupes; vascular instruments ± shunt (Bard, Javid, Pruitt-Inahara)
Unique considerations	Techniques for monitoring cerebral perfusion: EEG-spectral analysis or raw EEG, somatosensory evoked potentials (SEPs), back-bleeding, internal carotid artery stump pressure (> 50 mm Hg), or transcranial Doppler. Full anticoagulation with heparin (typically 100 U/kg iv) during arterial occlusion ± reversal with protamine (typically 0.5 mg/kg iv) 10 min after repair and reopening of carotid arteries. Maintaining ↑ BP during internal carotid artery occlusion (MAP 90–110). Use of neuroprotective agents just before internal carotid artery occlusion (e.g., iv STP 2–3 mg/kg or propofol 1–2 mg/kg as necessary to produce EEG burst-suppression).
Antibiotics	Cefazolin (1–2 g iv q 6 h)
Surgical time	~3 h
Closing considerations	Avoid ↑ BP or ↓ BP (typical MAP 80–100); meticulous hemostasis.
EBL	50–150 mL
Postop care	Control of BP (MAP 80–100 mm Hg); start aspirin on postop d 1; ICU or other monitored bed × 6–24 h.
Mortality	0.3–1.1% (if combined CABG/CEA: up to 17.7%)
Morbidity	Postop MI: 0.5–4% Cranial nerve injury: Up to 39% (typically 8%) • recurrent/superior laryngeal nerve (hoarseness) • hypoglossal nerve (tongue deviates to side of injury) • mandibular br. of facial nerve (lower lip weakness) Cerebral hyperperfusion syndrome (if postop BP not well controlled) Intraop MI: 1–2% Postop bleeding: 1.7–2.7% Wound infection: Rare
Pain score	3

NEUROLOGIC DISEASE

The preoperative history in a patient with neurologic disease should focus on

- ❖ recent exacerbations,
- ❖ prior investigations, and therapy (both current and prior).

The basic neurologic examination should evaluate

- ➢ mental status,
- ➢ speech,
- ➢ cranial nerves,
- ➢ gait,
- ➢ motor function,
- ➢ sensory function

This baseline determination also allows for comparison of any new postoperative deficits

Cerebrovascular Disease

The major clinical manifestation of CVD is acute stroke with more than 10 million new strokes per year worldwide.

In addition, about 6.5 million individuals die annually from stroke, making it the second leading cause of death globally.

The two main categories of stroke are

- Hemorrhagic stroke
- ischemic stroke.

❖ Hemorrhagic stroke is largely related to either intracerebral hemorrhage or subarachnoid hemorrhage.

❖ Common causes of intracerebral hemorrhage include

- ❖ hypertension,
- ❖ trauma,
- ❖ coagulopathies,
- ❖ illicit drug use (i.e., amphetamines, cocaine),
- ❖ arteriovenous malformations (AVMs).

❖ Causes of subarachnoid hemorrhage are bleeding from aneurysms and AVMs

- **Ischemic stroke** may be related to thrombosis of an artery through several different mechanisms (e.g., atherosclerosis, arterial dissection), embolism (e.g., related to atrial fibrillation), or systemic hypoperfusion (e.g., cardiac arrest).
- The other major manifestation of CVD is **a TIA**, which is a transient episode of neurologic dysfunction caused by focal ischemia in the brain, spinal cord, or retina, but without infarction.358

CVD has important perioperative implications.
It is a risk factor for postoperative complications, including

- ✓ cardiac events
- ✓ Stroke
- ✓ death

- the risks of postoperative cardiac complications and recurrent stroke are particularly increased when elective non-cardiac surgery is performed **within 9 months** after a prior stroke.
- when surgical aortic valve replacement is performed within 3 months after a prior stroke.
- Importantly, **if emergency surgery** needs to be performed after a stroke, it may **be preferable to not delay surgery**. Specifically, while the risks of postoperative cardiovascular complication are very high when emergency surgery is performed within 2 weeks after an ischemic stroke,
- these risks were reduced when surgery proceeded within 72 hours after the stroke.361
- This temporal pattern may be explained by progressively worsening cerebral autoregulation during the first 5 days after an ischemic stroke (which then recovers over the next 3 months)

The preoperative evaluation should focus on

- ❖ the timing,
- ❖ presentation,
- ❖ etiology,
- ❖ treatment of prior strokes or TIAs.

➢ It is important to document the etiology in order to distinguish carotid stenosis (i.e., atherosclerosis) from cardioembolic disease.

- Causes of cardiac emboli include stasis (i.e., atrial fibrillation, severe cardiomyopathy, ventricular aneurysm), thrombogenic (i.e., valvular heart disease, prosthetic heart valve), and paradoxical venous source (e.g., patent foramen ovale).

- The physical examination should include
- a brief neurologic exam to identify any preexisting deficits,
- auscultation for carotid bruits,
- a precordial assessment to assess for murmurs or extra heart sounds.

- Depending on the underlying basis for CVD
- (i.e., atherosclerosis, atrial fibrillation), patients may be on long-term therapy with aspirin,

P2Y12 inhibitors (e.g., clopidogrel),

P2Y12 INHIBITORS

Clopidogrel (Plavix®)
Prasugrel (Effient®)
Ticagrelor (Brilinta®)
Ticlopidine (Ticlid®)

- vitamin K antagonists,

Warfarin (Coumadin)
Coumatetralyl.
Phenprocoumon.
Acenocoumarol.
Dicoumarol.
Tioclomarol.
Brodifacoum.

- DOACs.
- Direct oral anticoagulants (DOACs)—dabigatran (Pradaxa), rivaroxaban (Xarelto), apixaban (Eliquis), edoxaban (Savaysa), and betrixaban (Bevyxxa) are anticoagulation pharmacotherapy used for **the prevention of thrombosis** in several cardiovascular contexts.

- Both vitamin K antagonists and DOACs should be temporarily discontinued before surgery (see section on “Atrial Fibrillation”).
- Similarly, P2Y12 inhibitor therapy should be interrupted before surgery, with the possible exception of cases with very recent coronary stent implantation (see section on “Coronary Stents”).
- Continuing aspirin peri-operatively does not prevent cardiovascular complications,136 but leads to an increased risk of major bleeding (a risk factor for perioperative stroke).132

- Nonetheless, selective continuation of aspirin can be considered in patients with high-risk atherosclerotic CVD or recent stroke (i.e., previous 9 months).
- In other cases, aspirin should be temporarily held 72 hours before surgery.
- In addition, concomitant CVD should be carefully considered in any decision to initiate new β-adrenergic blocker therapy in a patient awaiting non-cardiac surgery.
- Although β-blockade does decrease perioperative cardiac risk, it also significantly increases the risk for acute postoperative stroke.132,133

Asymptomatic Carotid Bruit

The presence of a carotid bruit significantly increases the likelihood of a significant lesion (i.e., 70%-99% stenosis) in both symptomatic or asymptomatic patients.26

Thus,

a newly discovered carotid bruit should prompt a careful search for any evidence of prior strokes or TIA, especially if the planned surgical procedure involves **neck manipulation**.

At-risk individuals include those with risk factors for CVD (e.g.,

- hypertension,
- smoker,
- diabetes mellitus,
- hyperlipidemia,
- IHD,
- PAD),
- as well as patients with prior head and neck radiation exposure.

Asymptomatic Carotid Bruit

The anesthesiologist should specifically inquire about
amaurosis fugax ,
dysphagia,
dysarthria,
other symptoms of cerebrovascular insufficiency.
Carotid Doppler ultrasound studies are simple, effective tools to evaluate suspicious carotid bruits.
Significant abnormalities on Doppler studies may entail a referral to a neurologist or vascular surgeon.
The risk of stroke in patients who have truly asymptomatic bruits is 1% to 2% per year,
with most strokes preceded by transient symptoms.
No evidence indicates that truly asymptomatic bruits increase the risk of *perioperative* stroke.

Seizure Disorder

The **seizure type** (e.g., grand mal, absence) and specific symptoms (e.g., staring, focal findings) are important to document in the preoperative evaluation.

For example, absence (previously petit mal) seizures may be particularly difficult to recognize after surgery because they lack generalized motor signs.

Hence, typical symptoms, such as staring and obtundation, may be misinterpreted as residual anesthetic effects in the postoperative period.

It is important to determine the etiology of the seizure disorder because of possible associated morbidities, which include brain tumors, aneurysms, AVMs, classic epilepsy, drug toxicity, electrolyte disorders, infections, CVD, sickle cell disease, and SLE.

The anesthesiologist should document the anticonvulsant dosing regimen and adequacy of seizure control.

Routine measurement of serum drug levels of anticonvulsants is not indicated unless there are concerns about drug toxicity or ongoing breakthrough seizures. Indeed, patients with good control of seizures may have levels outside the therapeutic range. Drug levels are highly influenced by when the blood draw occurs relative to the timing of drug administration.

Anti-seizure medications multiple side effects

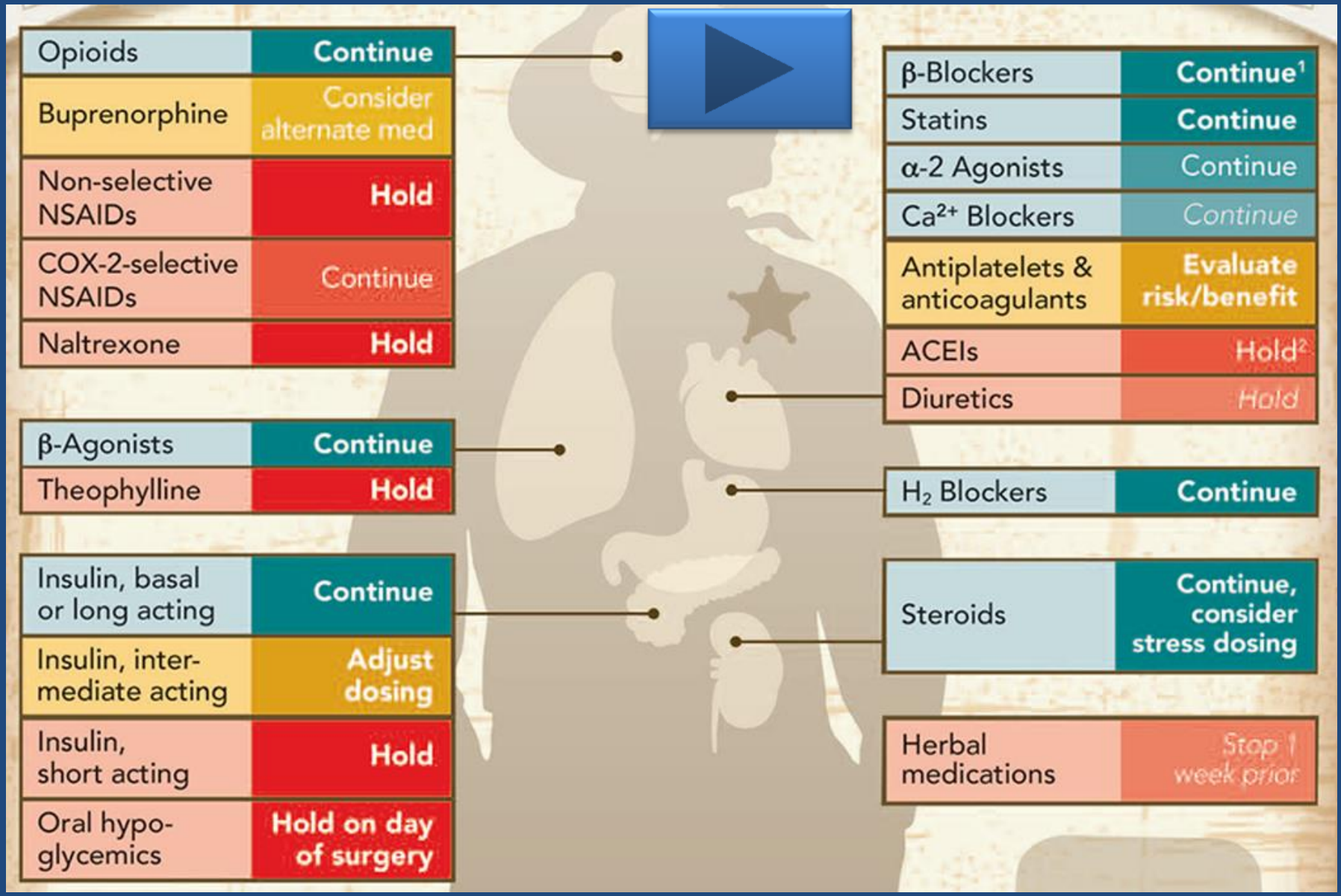
- bone marrow suppression,
- macrocytic anemia,
- leucopenia,
- hyponatremia),

➢ testing may be needed based on suspected abnormalities.

The most commonly ordered tests are CBC and electrolyte concentrations.

❖ All anticonvulsant s should be continued perioperatively.

✓ **poorly controlled or new-onset seizures should be evaluated by a neurologist before any non-emergent surgery**.


Opioids
Continue
Buprenorphine
Consider alternate med
Non-selective NSAIDs
Hold
COX-2-selective NSAIDs
Continue
Naltrexone
Hold
β-Agonists
Continue
Theophylline
Hold
Insulin, basal or long acting
Continue
Insulin, inter-mediate acting
Adjust dosing
Insulin, short acting
Hold
Oral hypo-glycemics
Hold on day of surgery
β-Blockers
Continue[1]
Statins
Continue
α-2 Agonists
Continue
Ca2+ Blockers
Continue
Antiplatelets & anticoagulants
Evaluate risk/benefit
ACEIs
Hold[2]
Diuretics
Hold
H2 Blockers
Continue
Steroids
Continue, consider stress dosing
Herbal medications
Stop 1 week prior

Multiple Sclerosis

✓ Multiple sclerosis is believed to be an inflammatory immune disorder with two general clinical patterns: exacerbating remitting and chronic progressive.

❖ **Symptoms** can include
- ataxia,
- motor weakness,
- sensory deficits,
- autonomic dysfunction,
- emotional lability,
- bladder or bowel dysfunction,
- and visual disturbances.

Exacerbations of multiple sclerosis can be triggered by stress, infections, pregnancy, and elevated temperatures.

Various **treatments** have been tried, including
- corticosteroids,
- immunosuppressants,
- Monoclonal antibodies,
- plasmapheresis,
- benzodiazepines,
- ➢ baclofen.

The preoperative evaluation should document the

- History
- and pattern of disease, especially
- symptoms and
- physical deficits affecting the respiratory system (including oxygen saturation).
- Medications,
- previous triggers,
- and preexisting neurologic deficits should be documented.

- Testing is generally directed toward
  - associated disturbances (e.g., chest radiography and CBC if pulmonary infection is suspected)
  - any medication side effects. For example, azathioprine can suppress bone marrow or affect liver function, cyclophosphamide may cause electrolyte abnormalities, and corticosteroids can cause hyperglycemia.

- Patients with stable minor disease require no special testing.
- **Related medications should be continued on the day of surgery.**
- No clear association has been shown between the type of anesthetic or a specific anesthetic drug and disease exacerbations.
- Nonetheless, regional anesthesia may offer theoretical advantages for patients with respiratory compromise or cognitive dysfunction.
- No spinal anesthesia

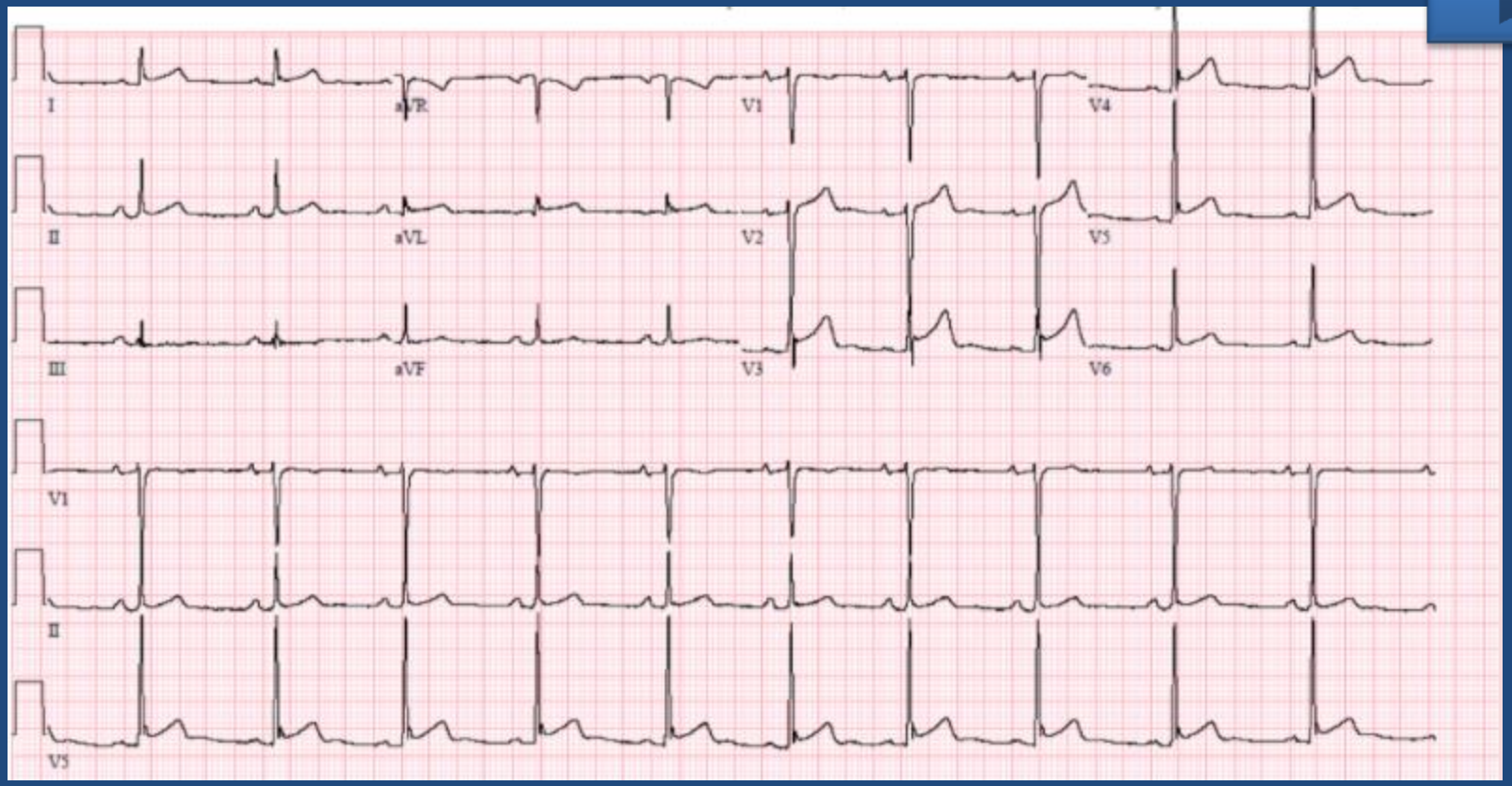
Aneurysms and Arteriovenous Malformations

Aneurysms and AVMs can occur in the cerebral and spinal vascular beds. These lesions may be intact, ruptured, symptomatic, or incidental asymptomatic findings.

- Associated risk factors include
  - polycystic kidney disease,
  - fibromuscular dysplasia,
  - type IV Ehlers-Danlos syndrome
  - a family history.
- Some AVMs become large enough to exert a mass effect.
- The risk of aneurysmal bleeding, and possibly AVM bleeding, increases during pregnancy.
- Most patients have minimal symptoms before a rupture.
- A rupture can result in altered mental status, syncope, increased intracranial pressure, inappropriate antidiuretic hormone (ADH) secretion, and hemodynamic changes (i.e., bradycardia, tachycardia, ectopic beats).

- Typical testing includes an
- ECG
- blood sampling to measure electrolyte, glucose, and creatinine concentrations.
- Chest radiography,
- echocardiography,
- neurologic imaging (e.g., computed tomography scan) are also often needed.

- Importantly, the ECG changes seen following a rupture, which often include ST-segment and T-wave changes, mimic those seen with myocardial ischemia.
- In addition, troponin concentrations are often elevated, while echocardiography may reveal significant cardiac dysfunction with depressed contractility and wall motion abnormalities.
- Although the bleeding may be primarily responsible for these cardiovascular changes, concomitant IHD or preexisting cardiomyopathy should also be considered.
- Measures aimed at controlling increased intracranial pressure, arterial blood pressure, and blood glucose are important.



ECG prior to the surgery showing ST segment elevation in leads V3-V6.

Parkinson Disease

Parkinson disease is a degenerative disorder of the basal ganglia characterized by **failure of dopamine secretion** and diminished inhibition of the extrapyramidal motor system.

Patients typically have diminution of spontaneous movements,
rigidity (cogwheel rigidity is classic),
resting tremor,
masked facies,
difficulty speaking,
difficulty walking,
depression,
and dementia.

Autonomic dysfunction (including orthostatic hypotension), excessive salivation, and impaired thermoregulation may also occur.

Patients are at risk of pulmonary complications from

- Difficulty swallowing,
- altered mental status,
- increased aspiration risk,
- and ventilatory muscle dysfunction.

Pharmacologic treatments include l

- Levodopa,
- dopamine agonists (e.g., bromocriptine, pramipexole, ropinirole, rotigotine),
- monoamine oxidase type B inhibitors (e.g., selegiline, rasagiline, safinamide),
- anticholinergic agents (e.g., trihexyphenidyl, benztropine),
- amantadine,
- catechol-O-methyl transferase inhibitors (tolcapone, entacapone).

Levodopa can cause dyskinesias (i.e., dystonic and myoclonic involuntary movements).

Some individuals also undergo implantation of deep brain stimulators to manage their symptoms.

Preoperative evaluation should assess the

- pulmonary system,
- signs of dysphagia,
- and degree of disability.

clinician managing the device.

Evidence of significant pulmonary symptoms or possible infection
Requires

- chest radiography,
- pulmonary consultation,
- possible delay of the procedure for improvement.

- **All associated medications should be continued.**

❖ Abrupt withdrawal of levodopa may exacerbate symptoms (especially dysphagia and chest wall rigidity) or precipitate neuroleptic malignant syndrome.

The latter disorder is characterized by

- ❑ autonomic instability,
- ❑ altered mental status,
- ❑ rigidity,
- ❑ fever.

- Some medications encountered in the perioperative setting, such as
- metoclopramide
- phenothiazines, may exacerbate symptoms of Parkinson disease by interfering with dopamine.

Individuals with deep brain stimulators require deactivation of the devices before any procedures in which electrocautery will be used.

The specific device should be identified, along with the severity of disease symptoms when the device is turned off.

Perioperative management of the device ideally should be coordinated with the surgeon and the

Myasthenia gravis

Myasthenia gravis is an autoimmune disorder of skeletal muscle neuromuscular junctions that is caused by antibodies against nicotinic acetylcholine receptors.

The disease is characterized by skeletal muscle weakness that worsens with activity and improves with rest.

Cardiac and smooth muscle function is unaffected.

Weakness is exacerbated by

- stress,
- infections,
- hypokalemia,
- medications (e.g., aminoglycosides, propranolol, ciprofloxacin, clindamycin),
- surgery.

A classification system for severity of myasthenia gravis is presented in Box

BOX 31.13 Osserman Classification System for Myasthenia Gravis Clinical Classification System

Class I: Ocular myasthenia
Class IIA: Mild generalized myasthenia with slow progression: no crises, responsive to drugs
Class IIB: Moderately severe generalized myasthenia: severe skeletal and bulbar involvement but no crises; drug response less than satisfactory
Class III: Acute fulminating myasthenia: rapid progression of severe symptoms, with respiratory crises and poor drug response
Class IV: Late severe myasthenia, same as III but progression over 2 years from class I to II

Data from Osserman KE, Genkins G. Studies in myasthenia gravis: review of a twenty-year experience in over 1200 patients. *Mt Sinai J Med.* 1971;38:497–537.

Patients with myasthenia gravis commonly have other autoimmune diseases, such as

- rheumatoid arthritis,
- polymyositis,
- thyroid disorders.

- Ocular symptoms (i.e., diplopia, ptosis) are almost always present; often, they are the presenting complaint or sole complaint.
- Cranial nerve and bulbar involvement are common, with an associated aspiration risk related to pharyngeal and laryngeal muscle weakness.
- Affected individuals may have **thymic hyperplasia** and tumors. Since the thymus is located in the anterior mediastinum, thymic enlargement has potential implications for anesthesia care (see section on “Mediastinal Masses”).

- Patients are usually treated with
  - thymectomy,
  - acetylcholinesterase inhibitors (e.g., pyridostigmine, neostigmine),
  - immunosuppressants (corticosteroids, azathioprine, mycophenolate, cyclosporine),
  - plasmapheresis, and
  - intravenous immunoglobulins.
- Worsening symptoms may reflect worsening disease (i.e., myasthenic crisis) or excessive acetylcholinesterase inhibitor treatment (i.e., cholinergic crisis).
- A short-acting anticholinesterase (edrophonium) can help distinguish the two states, since only a myasthenic crisis improves with more anticholinesterase.
- Plasmapheresis and intravenous immunoglobulins have been used to treat myasthenic crises and prepare patients for surgery, but still require several days to weeks to produce improvement.

❖ All medications (with associated doses) should be documented and continued perioperatively.

❖ These drugs may also have implications themselves. For example, patients taking azathioprine require a CBC and liver function tests because of drug-induced bone marrow suppression and liver dysfunction.

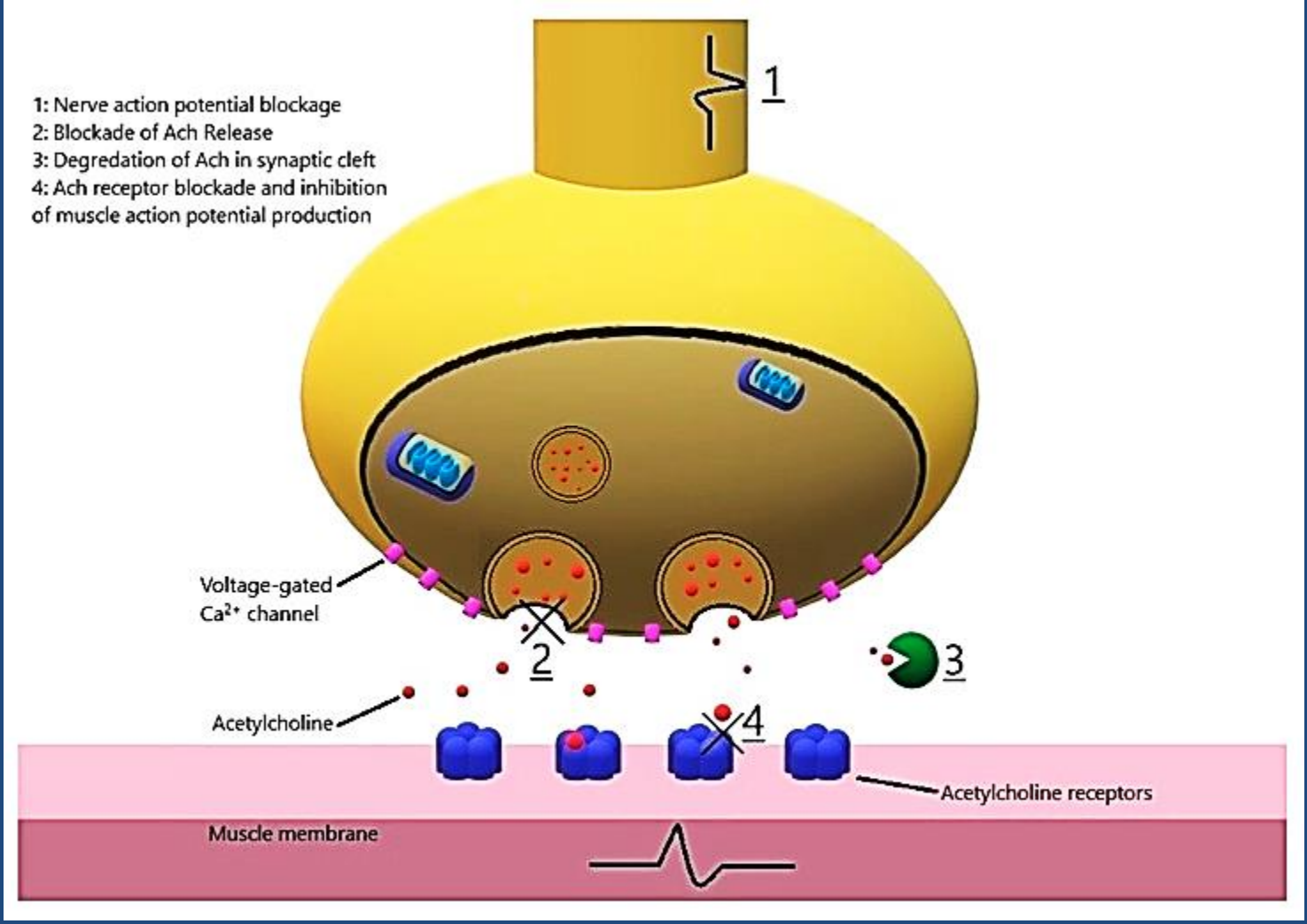
- Patients treated with corticosteroids need measurement of blood glucose concentration, as well as possible perioperative corticosteroid supplementation.
- Since ventilatory function can be compromised, preoperative PFTs may also be indicated for selected patients, particularly those suspected of having severely affected ventilatory function.
- PFTs may be particularly helpful if patients are being considered for ambulatory surgery, especially in freestanding surgical centers.

Drugs that can exacerbate myasthenic symptoms should also be avoided.

Medications reported to cause exacerbations of myasthenia gravis include the following:

•Antibiotics - Macrolides, fluoroquinolones, aminoglycosides, tetracycline, and chloroquine.

•Antidysrhythmic agents - Beta blockers, calcium channel blockers, quinidine, lidocaine, procainamide, and trimethaphan.


1: Nerve action potential blockage
2: Blockade of Ach Release
3: Degredation of Ach in synaptic cleft
4: Ach receptor blockade and inhibition of muscle action potential production
1
Voltage-gated
Ca2+ channel
2
3
Acetylcholine
4
Acetylcholine receptors
Muscle membrane

Drug	Mechanism	ADR Probability	Comments
Macrolides	Impair neuromuscular transmission, possibly at presynaptic level	Definite	Avoid in MG patients if there is another alternative, otherwise closely monitor
Fluoroquinolones	Impair neuromuscular transmission, pre and postsynaptic levels	Probable	Avoid in MG patients if there is another alternative, otherwise closely monitor
Aminoglycosides	Impair neuromuscular transmission, pre and postsynaptic levels	Definite	Avoid in MG patients if there is another alternative, otherwise closely monitor
Penicillins	Unclear, impaired neuromuscular transmission in an animal model	Probable	Can be used in MG patients as MG exacerbation is rare
β-adrenergic blockers	Unclear effect on neuromuscular transmission	Possible	Can be used in stable MG patients, monitor closely, especially early after starting.
L type Calcium channel blockers	Unclear effect on neuromuscular transmission	Possible	Can be used in stable MG patients, monitor closely, especially early after starting.
Class Ia antiarrhythmics	Impair neuromuscular transmission, pre and postsynaptic levels	Definite	Avoid in MG patients if there is another alternative, otherwise closely monitor
Magnesium	Presynaptic (blocks release of ACh) and postsynaptic	Definite	Caution and close monitoring are advised in magnesium replacement (specially parenteral) in MG patients
Neuromuscular blockers and inhalation anesthetics	Postsynaptic neuromuscular block	Definite	Nondepolarizing NMBs and inhalation anesthetics better be avoided; if used, observe close postop monitoring, consider using acetylcholinesterase inhibitor and sugammadex
Antipsychotics	Impair neuromuscular transmission at presynaptic and postsynaptic levels	Possible	Can be used in MG patients as MG exacerbation is rarely reported
	Presynaptic: reduction in ACh		Can be used in MG patients as

Lambert-Eaton syndrome is similar to myasthenia gravis, with muscle weakness including oculobulbar involvement and dysautonomia.

It is caused by **antibodies against voltage-gated calcium channels** that result in decreased acetylcholine release. It is not associated with thymic abnormalities, but commonly occurs with malignant diseases, especially small cell lung cancer and gastrointestinal tumors.

The other distinguishing feature of this disorder is that the muscle weakness classically improves with activity and is worse after inactivity.

In addition to acetylcholinesterase inhibitors, typical treatments include 3,4-diaminopyridine, which is a selective potassium channel blocker.

Preoperative evaluation and management are similar to those for myasthenia gravis. All related medications should be continued perioperatively.

Muscular Dystrophies and Myopathies

Muscular dystrophies and myopathies are inherited disorders that affect the neuromuscular junction. They share many similarities but do have a few differences.

The hallmark of these disorders is progressive skeletal muscle weakness that commonly leads to respiratory failure. No effective therapy is available.

Many individuals have associated cardiomyopathies and possible association with malignant hyperthermia.

Duchenne and Becker muscular dystrophies are X-linked recessive disorders that occur primarily in males. Affected individuals have elevated creatine phosphokinase levels, often preceding the onset of symptoms. Male patients with a family history of either Duchenne or Becker muscular dystrophy should be considered at risk (even when they have not been formally tested), and they require precautions similar to those in patients with diagnosed disease. Cardiomyopathy and respiratory failure are the usual causes of death.

Female carriers of the abnormal gene may have dilated cardiomyopathy despite having no other manifestations of the disease.

The preoperative evaluation should focus on

- the cardiovascular (e.g., palpitations, dyspnea, chest pain, syncope, orthopnea, dependent edema)
- pulmonary (e.g., aspiration, pneumonia) systems.

Potentially helpful
additional preoperative tests include

- ECGs,
- PFTs,
- echocardiography.

Facioscapulohumeral muscular dystrophy
(also known as faciohumeroscapular or Landouzy-Dejerine muscular dystrophy) is an autosomal dominant disorder that affects both sexes and causes a slow, progressive weakness of muscles in the shoulders and face.

- **Cardiomyopathy occurs much less frequently** than in other dystrophies,
- but arrhythmias have been reported.
- Limb-girdle dystrophies

have a variable genetic inheritance pattern and primarily affect the muscles of the shoulders and pelvis.

❖ **Conduction abnormalities** are present in some patients, although frank cardiomyopathies are less frequent.

The preoperative

evaluation is largely similar to that described previously for Duchenne muscular dystrophy.

Myotonia was historically thought to predispose patients to **malignant hyperthermia**, however, current evidence indicates that they are not at increased risk.365
Nonetheless,
succinylcholine should still be avoided in these patients because it may cause diffuse muscle contraction.

Symptomatic
treatments for myotonic contractions include
corticosteroids,
quinine, and procainamide; otherwise,
these diseases have no cure.

These treatments should be continued perioperatively.

The preoperative evaluation focuses on the cardiopulmonary system, with special emphasis on evaluating for
pulmonary infection,
heart failure,
syncope,
conduction abnormalities,
valvular abnormalities.

Preoperative testing includes an
ECG,
Echocardiogram (except for myotonia congenita),
and chest radiograph (if symptoms of pulmonary disease are present).
Evidence of
a conduction abnormality on ECG should trigger a cardiology consultation.

Myotonia is not inhibited by regional anesthesia, but local anesthetic infiltration into muscle may provide symptomatic relief.

Central Nervous System Tumors
Pituitary tumors are classified as
functioning (associated with endocrine abnormalities)
versus nonfunctioning,
as well as benign (adenomas are the most common pituitary lesion) versus malignant.
The tumor can have **mass effects that lead to** associated symptoms, such as
headaches,
visual field defects,
and increased intracranial pressure
(with resulting gait disturbances, vomiting, cranial nerve deficits, bladder incontinence, bowel incontinence).

Other symptoms may be related to

pituitary insufficiency (e.g., hypoadrenalism, hypothyroidism, infertility) or

overactivity.

Manifestations of pituitary overactivity include
Cushing syndrome from ACTH-secreting tumors;
Acromegaly from growth hormone secretion;
hyperthyroidism from TSH production;
gynecomastia, lactation, and sex hormone-related changes from prolactin and gonadotropin (follicle stimulating and luteinizing hormones) secretion.

These hormones are all produced by the anterior lobe of the pituitary and are controlled by a feedback loop from the hypothalamus. The posterior pituitary stores and secretes vasopressin and oxytocin, which are synthesized in the hypothalamus.

Acromegaly results in enlargement of connective tissue, bone, and visceral organs.
Affected individuals have an enlarged jaw (i.e., macrognathia), nose, feet, hands, pharyngeal tissue, and laryngeal tissue (including macroglossia and enlarged epiglottis).
Affected individuals have **increased risks of sleep apnea** (both central and obstructive), **neuropathies (from nerve entrapment**), hypertension, diastolic dysfunction, cardiac valvular abnormalities. IHD, heart failure, diabetes mellitus, hypothyroidism, and difficult airway management (i.e., mask ventilation, laryngoscopy, intubation) may also occur.

The preoperative
evaluation should document any chest pain, dyspnea, snoring, numbness, polydipsia, headaches, and visual disturbances.
The physical examination focuses on
blood pressure,
airway examination,
murmurs,
neurologic findings,
peripheral edema.
It is important to plan for possible difficult airway management and inform the patient about the possible use of awake fiberoptic intubation.

Preoperative testing may include

- an ECG and
- blood sampling for electrolyte concentration, glucose concentration, and thyroid function tests.

TSH increases production of thyroid hormones (T3 and T4) by the thyroid gland (see section on “Thyroid Disease”).
Prolactin- and gonadotropin-secreting tumors have little impact on anesthetic management, but their symptoms may alert clinicians to an undiagnosed pituitary tumor.

Posterior pituitary tumors result in failure to secrete vasopressin or ADH, which regulates renal water excretion. A deficiency results in **diabetes insipidus**, which is characterized
by excessive urine output from a failure to reabsorb water. Unless treated with DDAVP, these patients may develop hypernatremia and volume depletion. The anesthesiologist should therefore carefully evaluate patients' intravascular volume status and conduct blood sampling for electrolyte concentrations and creatinine concentrations.

Patients with pituitary tumors, pituitary apoplexy (hemorrhage into pituitary, which is associated with hypertension, trauma, or pregnancy), or previous pituitary tumor resection may require hormone replacement therapy (i.e., corticosteroids, thyroid replacement, DDAVP).

These medications must not be interrupted during the perioperative period. The adequacy of replacement therapy can be determined based on the clinical evaluation, as well as blood sampling for electrolyte concentrations, creatinine concentrations, and thyroid function tests.

Special Issues in Preoperative Evaluation

PSEUDOCHOLINESTERASE DEFICIENCY

A personal or family history of pseudocholinesterase, or butyrylcholinesterase, deficiency should be identified preoperatively (see Chapter 35). Pseudocholinesterase, which is found in the plasma, liver, pancreas, heart, and brain, is distinct from acetylcholinesterase, which is found in erythrocytes.

- Patients with an "allergy to succinylcholine" should be suspected of having either this disorder or malignant hyperthermia. Previous anesthetic records may help clarify an uncertain history. Additionally, inquiring whether the patient was intubated postoperatively, gravely ill, or in need of intensive care may be helpful.

Pseudocholinesterase activity may be permanently reduced because of abnormal genotypes, or transiently altered because of disease, drugs, pregnancy, or infancy. In patients with a history suggestive of pseudocholinesterase deficiency, recommended testing includes plasma cholinesterase activity, dibucaine number, and fluoride number.

Plasma cholinesterase activity is a quantitative measure of enzyme activity, whereas the dibucaine number and fluoride number are qualitative measures.

Plasma cholinesterase activity should not be confused with acetylcholinesterase activity, which is an assessment of erythrocyte cholinesterase.

The dibucaine number represents the percentage inhibition of the enzyme by the local anesthetic dibucaine,

the fluoride number represents the percentage inhibition by fluoride.

Normal individuals—who are homozygous for the wild-type gene—have a dibucaine number of 80 because their plasma cholinesterase is 80% inhibited by dibucaine.

Individuals who are homozygous for the atypical genes have a dibucaine number of 20 (corresponding to 20% inhibition) and can be paralyzed for 4 to 8 hours after receiving succinylcholine.

In heterozygous individuals who have a dibucaine number of 60 (corresponding to 60% inhibition), the duration of action of succinylcholine is prolonged by 50% to 100%.

The combination of dibucaine number and plasma cholinesterase activity therefore differentiates genetic from acquired causes of prolonged apnea after succinylcholine administration.

Patients with known or suspected pseudocholinesterase deficiency should be encouraged to obtain proper medical alert identification.

Additionally, they should be educated that the enzyme also metabolizes ester-linked local anesthetics.

MALIGNANT HYPERTHERMIA

A known history or suggestive history (e.g., hyperthermia or rigidity during anesthesia) of malignant hyperthermia in a patient or family member must be clearly documented in the preoperative assessment. This information must also be communicated to the surgeon and eventual anesthesia provider—especially to ensure that appropriate arrangements are made preoperatively (see Chapter 35). Individuals who are genetically predisposed to malignant hyperthermia are asymptomatic until they are exposed to triggering agents. Certain neuromuscular diseases are also associated with elevated risks of malignant hyperthermia, including some muscular dystrophies (i.e., Duchenne, Becker, myotonic), King-Denborough syndrome, central core disease, periodic paralysis, osteogenesis imperfecta, myelomeningocele, and strabismus.