Regional Anesthesia in the Patient with Preexisting Neurologic Dysfunction

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Patients with preexisting neurologic disease present a unique challenge to the anesthesiologist. The cause of postoperative neurologic deficits is difficult to evaluate, because neural injury may occur as a result of surgical trauma, tourniquet pressure, prolonged labor, improper patient positioning, or anesthetic technique. Progressive neurologic diseases such as multiple sclerosis may coincidentally worsen perioperatively, independent of the anesthetic method. The most conservative legal approach is to avoid regional anesthesia in these patients. However, high-risk patients, including those with significant cardiopulmonary disease, may benefit medically from regional anesthesia and analgesia. The decision to proceed with regional anesthesia in these patients should be made on a case-by-case basis. Meticulous regional anesthetic technique should be observed to minimize further neurologic injury.

Intracranial Tumors, Aneurysms, and Arteriovenous Malformations

Patients with preexisting intracranial masses and vascular lesions such as primary or metastatic brain tumors, saccular aneurysms, or arteriovenous malformations are at increased risk for neurologic compromise during spinal or epidural anesthesia. Alterations in intracranial pressure and mean arterial pressure associated with neuraxial block may result in subarachnoid hemorrhage, cerebral infarction, or cerebral herniation. Dural puncture is not recommended in patients with evidence of increased intracranial pressure such as cerebral edema, lateral shift of the midline structures, and obliteration of the fourth ventricle (Gower, 1987) since dural puncture causes an acute leakage of cerebrospinal fluid which decreases cerebrospinal fluid pressure and may produce cerebellar herniation. In patients with uncorrected vascular malformations, the decreased cerebrospinal fluid pressure increases the aneurysmal transmural pressure (mean arterial pressure-intracranial pressure) gradient and may result in subarachnoid hemorrhage.

Rupture of an occult arteriovenous malformation coincident with dural puncture during attempted epidural anesthesia has been reported (Wedel, 1983). Epidural and caudal anesthesia are also contraindicated in patients with increased intracranial pressure because of the risk of accidental dural puncture and because the intracranial pressure may be further increased by injection of local anesthetic solution into the epidural space. Patients with surgically repaired vascular malformations may undergo spinal or epidural anesthesia without increased risk of neurologic complications.

Epilepsy

Epilepsy is a recurrent seizure disorder that affects 0.5% to 1% of the population. Idiopathic epilepsy typically begins in childhood, but adult-onset seizure disorders represent intracranial pathologic conditions such as neoplasm, trauma, infection, or stroke. Seizure activity results from synchronous discharge of a group of neurons in the cerebral cortex. The neuronal hyperactivity may remain localized or may propagate to the thalamus and across to the contralateral hemisphere, resulting in generalized seizures. Epilepsy is treated with anticonvulsant medications; the choice of drug is determined primarily by the classification of the seizure disorder.

Central nervous system toxicity is a known complication of regional anesthesia. Most local anesthetic effects are believed to be dose-related, but a dichotomy of these effects on the brain is well documented. At low blood levels, local anesthetics are potent anticonvulsants, but at high levels, they act as convulsants (Sakabe, 1974; Usubiaga, 1966). Intravenous infusion of lidocaine at 4 to 6 mg/kg in human volunteers produced initial depression of the electroencephalogram, with a slowing down or a decrease in the amplitude of the alpha waves. Higher doses of lidocaine (7 to 9 mg/kg) induced tonic-clonic convulsions and spike waves. After convulsions ceased, no electrical activity was found for 10 to 20 seconds, raising the possibility of neuronal hypoxia secondary to convulsive activity (Usubiaga, 1966). However, a subsequent study reported lidocaine-induced seizures resulted in only small increases in cerebral blood flow and metabolism, unlike the seizures associated with epilepsy (Sakabe, 1974).

The initial state of central nervous system excitation elicited by local anesthetic agents is produced by a selective block of the inhibitory pathways in the cerebral cortex. Activity if the unopposed excitatory neurons leads to convulsions. Eventually, the inhibitory and excitatory pathways are blocked, resulting in generalized nervous system depression. The central nervous system toxicity of specific local anesthetic solutions is primarily related to anesthetic potency but it is also affected by rate of biotransformation and penetrability through the blood-brain barrier. The acid-base status of the patient also profoundly affects the central nervous system toxicity of local anesthetics. Hypercapnia and acidosis may decrease the convulsive threshold by 50%.

Many regional anesthetic techniques may be safely performed in patients with seizure disorders. Anesthetic management in the patient with epilepsy includes consideration of the cause and treatment of the seizure disorder as well as physiologic factors affecting local anesthetic central nervous system toxicity. Anticonvulsant medications should be identified. Measurement of serum anticonvulsant levels is useful to assess adequacy of treatment. Selection of a less potent and therefore less toxic local anesthetic is recommended. Local anesthetic blood levels should be minimized through the use of an appropriate dose and concentration of the local anesthetic, addition of vasoconstrictors, and slow and incremental injection (with frequent aspiration) through a short-bevel needle. A continuous catheter may be used if the regional anesthetic technique is associated with rapid uptake of local anesthetic solution, as with epidural or brachial plexus block.

The patient should be continuously monitored for early warning signs of local anesthetic systemic toxicity until the peak plasma concentration is achieved. Even small amounts of local anesthetics injected into the carotid, subclavian, or axillary arteries may result in seizures (Perkins, 1988). Administration of a benzodiazepine, thiopental, or propofol, increases the seizure threshold. However, if hypoventilation occurs from oversedation and results in hypercapnia and acidosis, it increases the likelihood of central nervous system side effects. Postoperative infusions must be carefully managed to avoid accumulation of local anesthetic. An opioid rather than a local anesthetic infusion may be a more prudent choice in these patients.

Chronic Disorders of Central and Peripheral Nerves

Patients with preexisting neurologic disorders of the central nervous system, such as multiple sclerosis or amyotrophic lateral sclerosis, and those with disorders of the peripheral nerves, such as lumbar radiculopathy, ancient poliomyelitis, and sensory-motor peripheral neuropathy, present potential management dilemmas for anesthesiologists. The presence of preexisting deficits, signifying chronic neural compromise, theoretically places these patients at increased risk for further neurologic injury. It is difficult to define the actual risk of neurologic complications in patients with preexisting neurologic disorders who receive regional anesthesia; no controlled studies have been performed, and accounts of complications have appeared in the literature as individual case reports. The decision to use regional anesthesia in these patients is determined on a case-by-case basis and involves understanding the pathophysiology of neurologic disorders, the mechanisms of neural injury associated with regional anesthesia, and the overall incidence of neurologic complications after regional techniques.

<u>Risk Factors for Regional Anesthesia-Related Nerve Injury</u>

Neurologic injury directly related to regional anesthesia may be caused by trauma, neurotoxicity, and ischemia. Direct needle- or catheter-induced trauma rarely results in permanent neurologic injury. The overall incidence of persistent paresthesias has been estimated at 0.08% after spinal anesthesia and at 2% after brachial plexus block (Philips, 1989; Selander, 1979). It has been suggested that paresthesia techniques may be associated with a higher incidence of neurologic injury after brachial plexus block, but there are no conclusive data supporting that claim (Selander, 1979).

Needle-bevel configuration may influence the frequency and severity of peripheral nerve damage during regional anesthesia. In an in vitro study, Selander and coworkers (Selander, 1977) demonstrated an increased frequency in perineural injury when a long-beveled need was used instead of a short-beveled needle. Rice and McMahon (Rice, 1992) assessed frequency and severity of neural trauma after nerve impalement by histologic and clinical methods and reported that injury produced by short-beveled needles was more severe, more

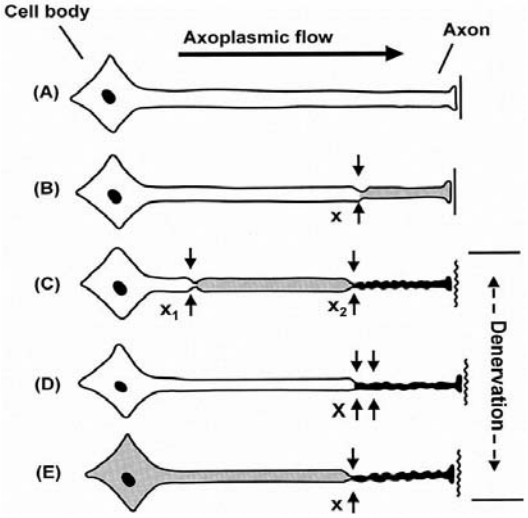
frequent, and recovered more slowly than those produced by long-beveled needles. Although no human studies have been performed to determine which of these in vitro studies accurately predicts clinical outcome, these studies illustrate the importance of minimizing direct needle trauma during regional techniques, especially in patients at increased risk for neurologic complications.

Neurologic deficits after regional anesthesia may be a direct result of local anesthetic toxicity. Clinical and laboratory findings indicate that anesthetic solutions are potentially neurotoxic (Schneider, 1993; Myers, 1989; Kalichman, 1992; Rigler, 1991; Drasner, 1993). It is generally agreed that local anesthetics administered in clinically appropriate doses and concentrations do not cause nerve damage (Selander, 1993). However, prolonged exposure ho high concentrations of local anesthetic solutions may result in permanent neurologic deficits. Patients with underlying nerve dysfunction may have a decreased requirement for local anesthetic and a decreased threshold for neurotoxicity (Kalichman, 1992). Indeed, Yee et al (Yee, 1997) demonstrated that the dose requirement for local anesthetics is decreased and potency increased in aged animals. This may have implications for the use of local anesthetics in an aging patient population.

Neural ischemia may occur as a result of systemic or local vascular insufficiency. Systemic hypotension with or without a spinal anesthetic may produce spinal cord ischemia in the watershed areas between radicular vessels, resulting in flaccid paralysis of the lower extremities (anterior spinal artery syndrome). The use of local anesthetic solutions containing epinephrine or phenylephrine theoretically may result in local ischemia, especially in patients with microvascular disease, but clinical data are lacking (Bromage, 1976, Myers, 1989). Furthermore, large clinical studies have failed to identify the use of vasopressors as a risk factor for neurologic injury. Most cases of presumed vasopressor induced neurologic deficits after spinal anesthesia have been single case reports, often with several other risk factors present (Kane, 1981).

The Neural Double Crush

Patients with a preexisting neurologic condition may be at increased risk for regional-anesthesia related nerve injury on the basis of the "double crush", which hypothesizes that nerve fibers which are already compromised are more vulnerable to injury at another site.



Neural lesions resulting in denervation. Axoplasmic flow is indicated by the density of shading. Complete loss of axoplasmic flow results in denervation (C–E). (A) Normal neuron. (B) Mild neuronal injury at a single site (x) is insufficient to cause denervation. (C) Mild neuronal injury at two separate sites (x_1 and x_2) may cause distal denervation. (D) Severe neuronal injury at a single site (X) may also cause distal denervation. (E) Diffuse underlying disease processes (toxic, metabolic, or ischemic) impair axonal flow throughout the neuron, and this predisposes the axon to distal denervation after a single minor neural insult at x.

All patients (n=360) who underwent ulnar nerve transposition at the Mayo Clinic from 1985 to 1999 were retrospectively studied to evaluate whether the performance of an axillary block in the presence of a preexisting (ulnar) neuropathy (Hebl, 2001). A general anesthetic was performed in 260 (72%) patients. The remaining 100 (28%) patients received an axillary block, including 64 patients in whom an ulnar paresthesia or nerve stimulator motor response was elicited at the time of block placement. Patient characteristics, the

severity of preoperative ulnar nerve dysfunction, and surgical variables were similar between groups. Anesthetic technique did not affect neurologic outcome (new or worsening pain, paresthesias, numbness, or motor weakness) immediately after surgery or at 2 or 6 wk after surgery. All six patients in the Axillary group who reported new or worsening neurologic symptoms after surgery had received bupivacaine in combination with either an ulnar paresthesia or motor response.

Although laboratory studies have identified multiple risk factors for the development of neurologic injury after regional anesthesia, clinical studies have not been performed to verify the results. Even less information is available for the variables affecting neurologic damage in patients with preexisting neurologic disease. However, several disorders of the central and peripheral nerves require further mention.

Multiple Sclerosis

Multiple sclerosis is a degenerative disease of the central nervous system, characterized by multiple sites of demyelination in the brain and spinal cord. The peripheral nerves are not involved the course of the disease consists of exacerbations and remissions of symptoms, and the unpredictability in the patient's changing neurologic status must be appreciated when selecting an anesthetic technique. Stress, surgery, and fatigue have been implicated in the exacerbation of multiple sclerosis. Epidural and, more often, spinal anesthesia have been implicated in the relapse of multiple sclerosis, although the evidence is not strong (Crawford, 1981). The mechanism by which spinal anesthesia may exacerbate multiple sclerosis is presumed to be direct local anesthetic toxicity. Epidural anesthesia has been recommended over spinal anesthesia because the concentration of local anesthetic in the white matter of the spinal cord is one-fourth the level after epidural administration (Warren, 1982). A dilute solution of local anesthetic with spinal or epidural anesthesia is also advised. Because multiple sclerosis is a disorder of the central nervous system, peripheral nerve blocks do not affect neurologic function and are considered appropriate anesthetic techniques.

The largest series of neuraxial anesthesia in the patient with a preexisting CNS condition involved 139 patients (Hebl, 2005). Post-polio syndrome and multiple sclerosis were the most common CNS disorders.

Central Nervous System Diagnoses

Neurologic Diagnosis	Number of Patients (N)*	Percentage (%)
Post-Poliomyelitis	79	56.4
Multiple sclerosis	35	25
Traumatic spinal cord injury	13	9.3
Amyotrophic lateral sclerosis	5	3.6
Guillain-Barré syndrome	3	2.1
Meningomyelocele	2	1.5
Cauda equina syndrome	1	0.7
Huntington's chorea	1	0.7
Neurosyphilis with paraplegia	1	0.7

*One patient had a diagnosis of both multiple sclerosis and prior poliomyelitis.
From Hebl et al. Reg Anesth Pain Med 2005;29A66.

Twenty-five (18%) patients had a co-existing radiculopathy, peripheral sensorimotor neuropathy, or spinal stenosis. Gender distribution was 86 (62%) males and 53 (38%) females. Mean patient age was 60±17 yrs. CNS diagnoses were present a mean of 23±23 yrs. The majority of patients had sensorimotor deficits at the

time of block placement. There were no patients with new or worsening postoperative neurologic deficits when compared to preoperative findings (0.0%; 95%CI 0.0%-0.3%).

Diabetes Mellitus

A substantial proportion of diabetic patients report clinical symptoms of a peripheral neuropathy. However, a subclinical peripheral neuropathy may be present before the onset of pain, paresthesia, or sensory loss and may remain undetected without electrophysiologic testing for slowing of nerve conduction velocity. The presence of underlying nerve dysfunction suggests that patients with diabetes may have a decreased requirement for local anesthetic. The diabetes-associated microangiopathy of nerve blood vessels decreases the rate at which local anesthetic uptake occurs from the site of administration, resulting in prolonged exposure to local anesthetic solutions. The combination of these two mechanisms may cause nerve injury with an otherwise save dose of local anesthetic in diabetic patients.

In a study examining the effect of local anesthetics on nerve conduction block and injury in diabetic rats, Kalichman and Calcutt (Kalichman, 1992) reported that the local anesthetic requirement is decreased and the risk of local anesthetic-induced nerve injury is increased in diabetic. These findings support the suggestions that diabetic patients may require less local anesthetic to produce anesthesia and that a reduction in dose may be necessary to prevent neural injury by doses considered safe in non-diabetic patients. Likewise, Singelyn et al (Singelyn, 2004) reviewed block difficulty, success rate and neurologic complications in a series of 1342 patients undergoing popliteal fossa block using a nerve stimulator approach. The 371 patients with a diagnosis of diabetes mellitus required more needle passes to obtain a satisfactory motor response but also noted a higher success rate. There were no neurologic complications in any patient.

A recent retrospective review of 567 patients with a sensorimotor neuropathy or diabetic polyneuropathy who underwent neuraxial block evaluated the risk of neurologic complications. All patients had a single neurologic diagnosis; there were no coexisting spinal canal or CNS disorder (Hebl, 2005). The majority of patients had sensorimotor deficits at the time of surgery. Two (0.4%; 95%CI 0.1%-1.3%) patients experienced new or worsening postoperative neurologic deficits when compared to preoperative findings. This frequency is consistent with previous investigations examining non-diabetic patients. The investigators concluded that neuraxial blockade does not appear to increase the risk of neurologic complications among patients with diabetic sensorimotor or polyneuropathy.

Epidural and Spinal Anesthesia after Major Spinal Surgery

Previous spinal surgery has been considered to represent a relative contraindication to the use of regional anesthesia. Many of these patients experience chronic back pain and are reluctant to undergo epidural or spinal anesthesia, fearing exacerbation of their preexisting back complaints. Several postoperative anatomic changes make needle or catheter placement more difficult and complicated after major spinal surgery. In a study 105 of 48 patients with chronic low back pain after spinal fusion, eight showed significant spinal stenosis on computed tomographic scans and required surgical decompression (Laasonen, 1989). The ligamentum flava may be injured during surgery, resulting in adhesions within or obliteration of the epidural space. The spread of epidural local anesthetic may be affected by adhesions, producing an incomplete or ‘patchy’ block. Obliteration of the epidural space may increase the incidence of dural puncture and make subsequent placement of an epidural blood patch difficult. Needle placement in an area of the spine that has undergone bone grafting and posterior fusion is not possible with midline or lateral approaches; needle insertion can be accomplished at unfused segments only.

The guidelines for epidural anesthesia after spinal surgery are unclear. Daley and colleagues (Daley, 1990) reviewed the charts of 18 patients with previous Harrington rod instrumentation who underwent 21 attempts at epidural anesthesia for obstetric analgesia. Continuous lumbar epidural anesthesia was successfully established in 20 of 21 attempts, but only 10 procedures were performed easily on the first attempt. The remaining 11 patients required larger amounts of local anesthetics or complained of a patchy block or both. There was no correlation between the level of surgery and the easy of insertion or the quality of epidural

anesthesia. There were no side effects except for low back pain in two patients with multiple attempts at catheter placement.

Crosby and Halpern (Crosby, 1989) studied nine parturients with previous Harrington rod instrumentation who underwent epidural anesthesia for analgesia during labor and delivery. Five of the nine catheters were successfully placed on the first attempt. Four of the nine procedures were complicated and involved multiple attempts before successful insertion, traumatic catheter placement requiring a second insertion, in adequate epidural analgesia with subsequent dural puncture on a repeated attempt, or an inability to locate the epidural space despite attempts at two levels. Seven of the nine patients obtained satisfactory analgesia. There were no adverse sequelae related to the epidural insertion.

Hubbert (Hubert, 1985) described attempted epidural anesthesia in 17 patients with Harrington rod instrumentation. Four of five patients with fusions terminating above the interspace between L-3 and L-4 had successful epidural placement. However, in 12 patients with fusions extending to the interspace between L-5 and S-1, six attempts were unsuccessful, five patients required multiple attempts, and one patient had a dural puncture after multiple attempts before success at epidural placement. A false loss of resistance was reported to have occurred frequently.

Thus, historically it was concluded that epidural anesthesia may be successfully performed in patients who have had previous spinal surgery, but successful catheter placement may be possible on the first attempt in only 50% of patients, even by an experienced anesthesiologist. Although adequate epidural anesthesia is eventually produced in 40% to 95% of patients, there appears to be a higher incidence of traumatic needle placement, unintentional dural puncture, and unsuccessful epidural needle or catheter placement, especially if spinal fusion extends to between L-5 and S-1.

A more recent investigation examined the overall success and neurologic complication rates among 937 patients with spinal stenosis or lumbar disc disease undergoing neuraxial block between 1988 and 2000 (Hebl, 2005). Of these, 210(22%) patients had a co-existing peripheral neuropathy in addition to their spinal cord pathology. Gender distribution was 619(66%) males and 318(34%) females. Mean patient age was 67±14 yrs. Neurologic diagnoses were present a mean of 5±6 yrs; 335 (51%) patients had active symptoms at the time of block. In addition, 207 (22%) patients had a history of prior spinal surgery before undergoing neuraxial block, although the majority were simple laminectomies or discectomies.

Outcomes of Neuraxial Blockade in Patients with Spinal Stenosis of Lumbar Disc Disease

	Patients without prior spine surgery (n=730)		Patients with prior spine surgery (N=207)	
Block Efficacy	n	(%)	N	(%)
Satisfactory	709	(97.1)	202	(97.6)
Unilateral	0	(0.0)	1	(0.5)
Segmental	9	(1.2)	0	(0.0)
No block	12	(1.6)	4	(1.9)
Technical Complications				
Unable to locate epidural or intrathecal space	6	(0.8)	0	(0.0)
Traumatic (bloody)	19	(2.6)	8	(3.9)
Paresthesia	37	(5.1)	9	(4.4)
“High” spinal	1	(0.1)	0	(0.0)
Unable to advance catheter (epidural)	14	(4.9)	3	(4.1)
Accidental dural puncture (epidural)	8	(2.8)	2	(2.7)
Neurologic complications	7	(1.0)	3	(1.4)

From Hebl et al Reg Anesth Pain Med 2005;29:A89

Success rates did not differ between patients who had previous surgery and those who had undergone a spine procedure. Ten (1.1%; 95%CI 0.5%-2.0%) patients experienced new or progressive neurologic deficits when compared to preoperative findings. Although the majority of the deficits were related to surgical trauma or tourniquet ischemia, the neuraxial block was the primary etiology in four patients.

The preliminary nature of these data warrants care in their interpretation. However, overall, patients with spinal stenosis or lumbar disc disease may undergo successful neuraxial block without a significant increase in neurologic complications. Importantly, this includes patients who have undergone prior (minor) spine surgery.

Anesthestic Management of Neurologic Disease

Progressive neurologic disease is considered by some to be a relative contraindication to regional anesthesia because of the difficulty in determining the cause of new neurologic deficits that appear perioperatively. There are no controlled clinical studies identifying regional anesthesia as a significant factor for increased risk of neurologic injury; only anecdotal reports are available. The medicolegal issue, however, remains, and if regional anesthesia is indicated for other preexisting medical conditions or by patient request, the patient should be informed of the risk of neurologic complications, including coincidental progression of preoperative deficits, associated with anesthesia and surgery. This discussion, along with preoperative neurologic status should be fully documented in the patient's record.

Patients with preoperative neurologic deficits may undergo further nerve damage more readily from needle or catheter placement, local anesthetic systemic toxicity, and vasopressor-induced neural ischemia. Although the use of paresthesia techniques is not contraindicated, care should be taken to minimize needle trauma and intraneuronal injection. Dilute local anesthetic solutions should be used when feasible to decrease the risk of local anesthetic systemic toxicity.

The use of epinephrine-containing solutions is controversial. The potential risk of vasopressor-induced nerve ischemia must be weighed against the advantages of predicting local anesthetic intravascular injections, improved quality of block, and decreased blood levels of local anesthetics. Because epinephrine also prolongs and block and therefore neural exposure to local anesthetics, the appropriate concentration and dose of local anesthetic solutions must be considered. Patients with microvascular disease in combination with an underlying peripheral neuropathy, such as those with diabetes, may be most sensitive to the vasoconstrictive effects of epinephrine.

Efforts should also be made to decrease neural injury in the operating room through careful patient positioning. Postoperatively, these patients must be followed closely to detect potentially treatable sources of neurologic injury, including constrictive dressings, improperly applied casts, and increased pressure on neurologically vulnerable sites. New neurologic deficits should be evaluated promptly by a neurologist to document formally the patient's evolving neurologic status, arrange further testing, and provide long-term follow-up.

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