Lesson 278: PreAnesthetic Assessment of the Parturient With Obstructive Hydrocephalus

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Needs statement

Controversy has arisen as to which anesthetic technique is preferred in the parturient with neurologic dysfunction, either active or latent. Questions have been raised as to whether good pain control during labor should be denied a patient with a history of hydrocephalus, established perhaps during childhood. Committee has identified the need to present and discuss topics for which a review of the literature and evaluation of evidence-based consensus are indicated.

Learning Objectives

At the end of this activity, the participant should be able to:

1. Summarize the anesthetic considerations in the management of a patient with obstructive hydrocephalus.
2. Differentiate between obstructive and nonobstructive hydrocephalus.
3. Define intracranial hypertension.
4. Review the physiology of cerebrospinal fluid.
5. Describe typical changes in neurophysiology that occur during pregnancy.
6. List the causes of obstructive hydrocephalus.
7. Present to the parturient the treatment options available for various types of obstructive hydrocephalus with different causes.
8. Explain how changes that normally occur during pregnancy affect the parturient with obstructive hydrocephalus.
9. Outline the effects on the fetus of alterations in maternal neurophysiology.
10. Identify the role of regional anesthesia in pregnant patients with hydrocephalus.

**Case History**

A 24-year-old woman, gravida 2 para 0010, with a history of Arnold-Chiari type 1 malformation and syringomyelia, presented for urgent primary cesarean delivery. Her case had been referred to the obstetric anesthesia high-risk clinic by the maternal–fetal medicine division at 7 months’ gestation to plan her anesthetic management.

As a 13-year-old, the patient had undergone a suboccipital craniotomy, laminectomy of the first cervical vertebra, duraplasty, and placement of a syringo-subarachnoid shunt—also termed a Chiari decompression. Three months later, the patient’s symptoms returned; she reported severe suboccipital headaches, gait disturbances, and sensory and motor deficits of the upper extremities. She immediately underwent emergency revision of the syringo-subarachnoid shunt and experienced dramatic improvement.

Since that time, the patient had been active with only occasional headaches. The rest of her medical history was negative with the exception of mild thoracolumbar scoliosis. She denied respiratory difficulties or exercise limitations. At the time of the anesthesia interview, she reported mild headaches unchanged by pregnancy. Physical examination findings, including the neurologic examination findings, were normal. The patient’s airway was class 2 with mild restriction in neck extension, the thyromental distance was 5 cm, and the interdental distance was adequate. Recent magnetic resonance imaging of the brain and cervical spine revealed a small syrinx of the cervical cord, with ample cerebrospinal fluid dorsal to the cerebellar tonsils, and no hydrocephalus.

As more women with preexisting neurologic disorders reach childbearing age, it becomes imperative to review and understand the risks and benefits associated with the anesthetic options for managing parturients through labor and delivery.\(^1\) Of particular concern to many anesthesiologists is the use of regional anesthesia in patients who may have preexisting neurologic deficits. Neuraxial anesthesia can provide many benefits to laboring patients, and it seems unreasonable to uniformly exclude all parturients with central nervous system (CNS) disorders as candidates for regional anesthesia—especially as rates of maternal morbidity and mortality associated with general anesthesia are significantly greater.\(^2\) Furthermore, recent studies have found that neuraxial anesthesia may not
necessarily pose a significantly increased risk for patients with neurologic disease. Nevertheless, regional anesthesia is associated with legitimate dangers in these patients, especially in those with increased intracranial pressure (ICP).

**Neurophysiology of the Parturient**

Normal ICP, which is between 5 and 15 mm Hg, represents a balance of brain tissue, blood, and cerebrospinal fluid (CSF) within a rigid container, the cranium (Table 1). Because the cranial space is limited, an increase in any one component within this rigid container must be offset by a displacement or decrease in one or both of the other components to prevent a rise in ICP—which can lead to brain ischemia caused by dangerous decreases in cerebral perfusion pressure.5,6

During pregnancy, the CSF volume increases along with total body water and cardiac output. However, the ICP remains normal until the patient experiences painful uterine contractions. During a normal pregnancy, alterations in physiologic parameters, such as an increase in alveolar ventilation resulting in hypocarbia, help maintain a normal ICP. However, if the parturient’s intracranial compliance is already decreased because of CNS pathology, the increase in intracerebral fluid, along with venous distention, can raise the ICP and cause the signs and symptoms of intracranial hypertension in a previously asymptomatic patient.

Autoregulation also plays an important role in CNS physiology, allowing the cerebral blood flow (CBF) to remain constant between mean arterial pressures of 50 and 150 mm Hg. Autoregulation is achieved by the relaxation and constriction of cerebral arterioles in response to perfusion pressure. In addition to autoregulation, chemical mediators play a significant role in maintaining and manipulating the CBF (Table 2) by altering cerebral vascular resistance. The mechanisms of autoregulation are similar whether the patient is pregnant or not; however, maintaining optimal CBF by hypoventilation and alterations in the mean arterial pressure can adversely affect the fetus.

<table>
<thead>
<tr>
<th><strong>Table 1. Normal Cerebral Hemodynamics</strong>5</th>
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<tbody>
<tr>
<td>CSF production: 0.3 mL/min (400-500 mL/d)</td>
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<tr>
<td>CSF volume: 150 mL</td>
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<tr>
<td>ICP: 5-15 mm Hg</td>
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<tr>
<td>CBV: 15% of cardiac output</td>
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<td>CBF: 40-50 mL/100 g per minute</td>
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<td>CPP=CPP/CVR</td>
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<td>CPP=MAP–ICP</td>
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<tr>
<th><strong>Table 2. Important Modulators of Cerebral Blood Flow</strong>9</th>
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<tr>
<td>Adenosine</td>
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<tr>
<td>Autoregulation</td>
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<tr>
<td>Carbon dioxide</td>
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<td>Endothelin</td>
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Intracranial Hypertension and Obstructive Hydrocephalus

Intracranial hypertension is defined as an ICP greater than 15 mm Hg. A variety of disease states can increase the ICP. The signs and symptoms associated with an increasing ICP are uniform and depend on the severity of intracranial hypertension, rather than the specific disease state causing the pressure increase. The initial manifestations of an elevated ICP are nonspecific, such as headache, nausea, and vomiting. As the CSF pressure continues to rise, the neurologic status of the patient rapidly deteriorates, with the development of visual disturbances, seizures, cranial nerve deficits, loss of consciousness, coma, herniation, and death.5,6

In obstructive hydrocephalus, the ICP is increased because of an obstruction of the ventricular pathway through which the CSF flows. CSF is produced in the ventricles, where it circulates continuously before being absorbed into the blood. When passage of the CSF is blocked, fluid accumulates inside the ventricles (Table 3).6

Table 3. Types of Hydrocephalus and Effects on Intracranial Pressure6

- Hydrocephalus (“water in the brain”): an abnormal accumulation of CSF in the brain.
- Obstructive hydrocephalus (noncommunicating hydrocephalus): caused by obstruction in the ventricular system, preventing flow of CSF to the subarachnoid space. ICP increases.
- Nonobstructive hydrocephalus (communicating hydrocephalus): caused by overproduction or malabsorption of CSF. Normal communication between the fourth ventricle and subarachnoid space is maintained. ICP increases.
- Normal-pressure hydrocephalus: ventricles of the brain are enlarged, but CSF pressure is not increased, and there is no demonstrable block to the outflow of CSF. ICP remains normal.
- Idiopathic intracranial hypertension (pseudotumor cerebri): syndrome characterized by elevated CSF pressure and normal CSF composition, with no identifiable cause such as hydrocephalus or mass lesion. Herniation is not a risk in such cases because of uniform brain swelling and normal position of the cerebellar tonsils. ICP increases.

CSF, cerebrospinal fluid; ICP, intracranial pressure

A definitive diagnosis is made with imaging studies. It is important to know the exact cause of obstructive hydrocephalus in order to decide treatment. In mild cases caused by a temporary obstruction, patients can be managed conservatively with observation. If the obstruction is due to an operable tumor, a cyst, or an arteriovenous malformation, surgery is usually the best option. When the obstruction cannot be removed and symptoms progressively worsen, CSF flow is diverted to prevent fluid accumulation, either by placing a shunt or performing an endoscopic third ventriculostomy.1,6,7,10
Anesthetic Management

The key to managing the parturient with obstructive hydrocephalus is communication. To ensure the best care and present the patient with all reasonable anesthetic options during the course of labor and delivery, the anesthesiologist must have access to a detailed history of the course of the neurologic illness. Initially, the obstetric and neurosurgical teams must decide if surgery can be delayed until after delivery in a parturient with an operable condition. If the decision is made to allow the patient to deliver before surgery, the obstetrician decides whether the delivery will be vaginal or surgical.6,8

In most instances, a cesarean delivery is indicated only for obstetric reasons because no increase in maternal or fetal morbidity or mortality is observed after vaginal deliveries. Avoiding wide fluctuations in blood pressure and situations that can increase the ICP is key to patient management. Because the ICP increases significantly with painful contractions, most obstetricians agree that a shortened second stage of labor is preferred. This can be accomplished with the use of forceps or vacuum delivery.8,10

Whichever course is chosen, the obstetric anesthesiologist should be consulted before the due date to plan for a safe delivery. The dilemma is that general anesthesia in certain neurosurgical patients may be riskier than regional anesthesia. Pregnant women near term are at significantly increased risk for failed or difficult intubation and aspiration compared with the general surgical population. The classic rapid-sequence approach employed in pregnant patients requiring general anesthesia is at odds with the slow, smooth induction required to maintain stable cerebral hemodynamics in patients with decreased intracranial compliance.2,8

Neuraxial anesthesia has become the anesthesia of choice in the management of labor and delivery among both practitioners and patients. Still, many anesthesiologists are hesitant to use regional techniques in patients with preexisting CNS disorders. Many cite medicolegal concerns, but most worry about aggravating or worsening a preexisting neurologic condition. No substantive evidence is available to validate this concern, according to a 2006 study by Hebl et al, who note that “... CNS disorders cannot be considered an absolute contraindication for neuraxial blockade.”3 However, in patients with increased ICP, regional anesthesia is not without hazards. Several studies have shown that the ICP increases transiently with epidural injection. In patients whose intracranial compliance is already compromised, such an increase in ICP may not be tolerated and may lead to deterioration in neurologic status.11-13

The main concern when a neuraxial blockade is being considered for a patient with increased ICP is herniation. A pressure gradient is created when the lumbar CSF is drained rapidly, and herniation can occur in patients with intracranial hypertension or a space-occupying lesion. In one report, a healthy parturient requested and received epidural analgesia for labor. During the procedure, the dura was accidentally punctured. The epidural injection was repeated at a different interspace, and a normal spontaneous vaginal delivery ensued. However, 11 hours after the accidental dural puncture, the patient’s neurologic status deteriorated. Computed tomography revealed a large tumor and tentorial herniation. The patient had an occult tumor and a herniation had developed, possibly due to the accidental dural puncture when the epidural needle was placed.13

Nevertheless, many case reports have appeared of patients with intracranial pathology who have been successfully managed with regional anesthesia. A recent study based on the UK registry of high-risk obstetric patients found no single correct way to manage women with neurologic disease but determined that careful anesthetic and obstetric planning resulted in good outcomes for both mother
and baby. Regional blocks in women with neurologic disease did not cause a deterioration of their condition.\(^4\)

In stable patients in whom a shunt has been placed and who exhibit no signs of intracranial hypertension, neuraxial blockade is not contraindicated and may help prevent the rise in ICP observed during contractions and second-stage pushing. A theoretical concern in patients with a shunt is inadequate analgesia if some of the local anesthetic escapes into the peritoneum.\(^2,8,10\)

In 5 case studies published by Riffaud et al in 2006, pregnant women with newly diagnosed obstructive hydrocephalus or shunt malfunction were treated with endoscopic third ventriculostomy. In all cases, symptoms of increased ICP resolved, and the women had normal cesarean or vaginal deliveries near term. Four of the women received a spinal anesthetic with no adverse effects; one patient had general anesthesia for cesarean delivery and also did well.\(^7\) The consensus is that for patients with a functioning shunt system, the risk for tentorial herniation with neuraxial blockade is remote. In patients with a lumboperitoneal shunt, shunt position should be determined before the epidural catheter is placed so that the shunt is not disrupted. The anesthetic requirement may appear to be increased if the drug is washed out by the shunt. Strict aseptic technique and prophylaxis with broad-spectrum antibiotics may help reduce shunt infection. As seen in numerous cases, when obstructive hydrocephalus is adequately managed with endoscopic third ventriculostomy or placement of a shunt and no sign of increased ICP is present, a regional anesthetic poses little risk and offers many advantages.\(^2,8,10\)

Other case reports describe similar findings. Obstructive hydrocephalus and increased ICP are often observed in patients with an Arnold-Chiari malformation. The parturient who has undergone surgical decompression and exhibits no signs of intracranial hypertension can be managed successfully with neuraxial blockade. A spinal or epidural technique can be employed. There are concerns that a large, rapidly injected bolus of epidural anesthetic causes a transient increase in ICP; if dural puncture occurs, a significant alteration in cerebrospinal dynamics may cause morbidity.\(^11,12,14\)

Although the evidence overwhelmingly supports using a regional technique in the laboring parturient with stable CNS pathology, the same case cannot be made for patients presenting with a large intracranial mass or progressively worsening intracranial compliance. General anesthesia continues to be the choice for managing a parturient with symptomatic intracranial hypertension due to obstructive hydrocephalus who requires an emergency cesarean delivery. Theoretically, the risk for herniation is considered to be exceedingly small when a small-gauge needle is used to administer a neuraxial block, and sporadic cases have been reported in which a spinal technique was used in patients with a CNS tumor who required surgical delivery. However, most practitioners believe that because of the very real risk for herniation and a disastrous outcome, the use of regional anesthesia is unjustified in such cases.

Thus, a parturient who has a lesion that occupies a large space or another condition that manifests with an acute increase in ICP will most likely receive general anesthesia. Because of concerns about aspiration, a difficult airway, and failed intubation, a rapid-sequence induction of anesthesia is preferred. In patients with neuropathologic disorders, a rapid-sequence technique is recommended; attenuation of the hypertensive response to laryngoscopy and intubation must be ensured by the administration of labetalol and/or lidocaine.
The placement of an arterial catheter is essential because it allows continuous blood pressure readings and early intervention. Succinylcholine is not contraindicated because in most studies, any mild increase in ICP is not clinically significant. Rocuronium (0.6 mg/kg) is a suitable alternative to succinylcholine for rapid-sequence induction; good intubating conditions are achieved within 80 seconds, and the duration of action is 33 minutes. Larger doses of rocuronium (0.9-1.2 mg/kg) result in an onset of paralysis similar to that seen with succinylcholine, at the expense of a prolonged duration of action.

Agents that are commonly used to manage fluctuations in blood pressure should be readily available. Labetalol and nicardipine have been successfully used to block hypertensive responses to laryngoscopy and intubation and do not adversely affect the fetus.

After a patient has been intubated successfully, the administration of general anesthesia facilitates the control of cerebral hemodynamics. In the parturient with decreased intracranial compliance, critical events that can lead to a rapid deterioration in neurologic status include laryngoscopy, intubation, and emergence from anesthesia. In several case studies, excellent results were achieved when patients were given a nerve block before induction. A multimodal approach to pain management, including bilateral ilioinguinal and iliohypogastric nerve blocks, can lead to a successful emergence with minimal fluctuation in hemodynamics.6,8,12,15

In the intubated patient, techniques such as hyperventilation and titration of blood pressure allow cerebral perfusion to be optimized without an increase in ICP. However, it must be kept in mind that these treatment modalities may adversely affect maternal–fetal physiology. Using hyperventilation to control the ICP may not be as effective in the pregnant patient because pregnancy induces a compensated respiratory alkalosis. Further decreases in PaCO2 will not lessen cerebral blood flow as it might in a patient who is not pregnant. In addition, maternal alkalosis adversely affects the fetus by decreasing fetal blood flow and the placental transfer of oxygen to the fetal circulation. Diuretics cross the placenta and can adversely affect the fetus. Loop diuretics may be safer than osmotic diuretics, but both types should be used with caution and in low doses. Because the fetal circulation depends on maternal hemodynamic stability, maternal blood pressure should be manipulated cautiously with fetal monitoring.8,12

Management of the Case Presented

A conference call was initiated with the neurosurgeon. Because the patient’s shunt was operational and she had minimal symptoms, it was agreed that epidural anesthesia would be the safest. Epidural anesthesia with bupivacaine 0.5% would deliver a gradual onset of sensory block, avoiding the rapid-onset sympathectomy with associated hypotension that is frequently encountered with spinal anesthesia. The avoidance of general anesthesia prevented potential airway difficulties and hemodynamic responses to laryngoscopy and intubation. Because strict control of hemodynamics was essential, the preoperative placement of a radial arterial line was planned.

At 39 weeks’ gestation, the patient was admitted for primary cesarean delivery. Fetal tachyarrhythmia was detected. On maternal examination, no interval changes were noted from her preanesthetic interview at 28 weeks’ gestation. Prophylactically, 2 g of ampicillin and 80 mg of gentamycin were administered intravenously to prevent shunt infection. In addition, 30 mL of sodium bicitrate was given orally.
After her arrival in the operating room, a right radial arterial cannula was inserted, and she received 1,000 mL of lactated Ringer’s solution intravenously for intravascular volume expansion. Monitoring consisted of electrocardiography, pulse oximetry, and continuous measurement of the arterial blood pressure. Preprocedural ultrasonography was used to lessen the possibility of an accidental dural puncture during epidural placement by identifying the midline, interspace, and actual depth of the epidural space.

The loss-of-resistance technique was used to insert a closed-end, 19-gauge, multiple-orifice epidural catheter in a deflexed position, and this was secured at 10 cm at skin. The patient was then placed in the supine position with a left lateral tilt. Supplemental oxygen (3 L) was delivered via nasal cannula. An external fetal heart rate monitor was applied before activation of the epidural anesthesia. Following the administration of a test dose of 3 mL of lidocaine 2% with epinephrine 1:200,000 through the indwelling epidural catheter, the patient received incremental doses of bupivacaine 0.5% (3 mL every 5 minutes; total, 15 mL). Fentanyl (100 mcg) had been added to the mixture.

Throughout the induction of epidural anesthesia, the patient’s blood pressure ranged from 120/70 to 112/62 mm Hg; the fetal heart rate remained between 120 and 160 beats/min. Forty minutes after the initial bolus of epidural medication, a bilateral sensory level was evident at T4, and surgery commenced. A low-flap transverse uterine incision was made, and a healthy baby girl was delivered (Apgar scores, 9/9). Uterine tone was achieved by the slow administration of oxytocin at 30 U/L. Hysterotomy closure was performed in situ rather than by exteriorization to prevent nausea, vomiting, and pain—as well as associated changes in the ICP. After hemostasis had been achieved, the abdomen was closed.

The patient remained comfortable and awake throughout the procedure. She was hemodynamically stable without vasopressors. Postoperative analgesia consisted of 5 mg of epidural morphine administered slowly at the end of the case. The epidural catheter was removed in the operating room. Total intake consisted of 2,000 mL of lactated Ringer’s solution. Estimated blood loss was 800 mL; urine output was 350 mL. She was transferred to the recovery room, where she was monitored for 8 hours. No postoperative complications developed, and the patient was discharged home on postoperative day 4.

**Summary**

In the parturient with neuropathology, the anesthetic technique should revolve around maintaining cerebral hemodynamics without adversely affecting maternal–fetal physiology. Whether a regional or general anesthetic is planned, monitoring of the neurologic status is essential, along with having the facility and equipment to manage increased ICP. If an epidural technique is chosen, the most experienced anesthesiologist should place the epidural to minimize the risk for dural puncture with a large needle. Medication should be administered slowly in small increments to achieve an adequate level with minimal hemodynamic fluctuation and increases in ICP.

In epidural anesthesia, a gradual onset is important to avoid hemodynamic alterations due to sympathetic blockade and a sudden expansion of epidural space, which will increase CSF pressures. In those patients who are better managed with general anesthesia, close attention must be given to airway management and maintaining hemodynamic stability to prevent sudden increases in ICP. A strategy for a smooth induction of and emergence from anesthesia, as well as multimodal pain control, will further ensure stable pressures and prevent neurologic instability.
Postoperative management requires avoiding situations that may cause the ICP to increase, such as coughing and vomiting. The neurologic status must be monitored diligently, and early signs of neurologic decline should be addressed immediately. Optimal management of the high-risk obstetric patient requires close communication among the obstetrician, anesthesiologist, and other services involved in her care.

Dr. Elizabeth A.M. Frost, who is the editor of this continuing medical education series, is clinical professor of anesthesiology at The Mount Sinai School of Medicine in New York City. She is the author of Clinical Anesthesia in Neurosurgery (Butterworth-Heinemann, Boston) and numerous articles. Dr. Frost is past president of the Anesthesia History Association and former editor of the journal of the New York State Society of Anesthesiologists, Sphere. She is also editor of the book series based on this CME program, Preanesthetic Assessment, Volumes 1 through 3 (Birkhäuser, Boston) and 4 through 6 (McMahon Publishing, New York City).
References


Post-test

1. The following parameters are all increased during a normal pregnancy, except:
   a. production of cerebrospinal fluid (CSF)
   b. intracranial pressure (ICP)
   c. cardiac output
   d. alveolar ventilation

2. Increased ICP is seen with which of the following:
   a. normal-pressure hydrocephalus
   b. hyperventilation
   c. painful contractions
   d. hypotension

3. Which of the following is a true statement regarding maternal alkalosis?
   a. It decreases fetal blood flow.
   b. It does not affect fetal circulation.
   c. It increases fetal blood flow.
   d. It increases the amount of oxygen transferred to the fetus.

4. Chemical mediators of cerebral blood flow include all of the following, except:
   a. nitric oxide
   b. adenosine
   c. carbon dioxide
   d. autoregulation

5. Which of the following is true regarding rates of maternal morbidity and mortality?
   a. Both are greater with regional anesthesia than with general anesthesia.
   b. Rates are the same regardless of anesthetic technique.
   c. Both have significantly decreased with the use of neuraxial anesthesia.
   d. Both have significantly increased with the use of neuraxial anesthesia.
6. Hydrocephalus is likely to be present in all of the following disease states, except:
   a. tumors of the central nervous system
   b. Arnold-Chiari malformations
   c. arachnoid cysts
   d. idiopathic intracranial hypertension

7. An epidural injection:
   a. transiently increases ICP
   b. decreases ICP
   c. has no effect on ICP
   d. causes hypertension

8. The following risks are associated with general anesthesia in the parturient, except:
   a. aspiration
   b. failed intubation
   c. increased ICP
   d. aseptic meningitis

9. Regional anesthesia is contraindicated in patients with:
   a. obstructive hydrocephalus
   b. signs of impending herniation
   c. functioning shunts
   d. idiopathic intracranial hypertension

10. The anesthetic method of choice in the parturient with obstructive hydrocephalus:
    a. is general anesthesia
    b. is spinal analgesia
    c. is an epidural blockade
    d. The type of anesthesia must be decided on a case-by-case basis.