Lesson S01: Preanesthetic Assessment of the Patient for Major Back Surgery

Authored by: Elizabeth A.M. Frost MD, Clinical Professor of Anesthesia, Mount Sinai School of Medicine, New York, NY

A COURSE OF STUDY FOR AMA/PRA CATEGORY 1 CREDIT
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Needs assessment

In a survey of 801 anesthesiologists conducted by the Anesthesia Patient Safety Foundation, blindness due to anesthetic technique was viewed as “high priority” by 49% of the respondents and was ranked 11th highest among the total of 53 patient safety issues. Because the incidence of this complication appeared to be increasing, the American Society of Anesthesiologists established a registry in July 1999 to collect data in an attempt to identify risk factors. Although a single cause has not been specifically identified, much useful information has been gathered and the practicing anesthesiologist should be knowledgeable as to possible mechanisms, outcome statistics and preventive measures.

Objectives

At the end of the lesson, the reader will be able to:

1. Cite the incidence of postoperative visual problems.
2. Identify risk factors for postoperative visual problems.
4. Understand the difference between anterior and posterior ischemic optic neuropathy.
5. Realize the several procedures in which visual difficulties may occur.
6. Present an anesthetic plan for the patient who must undergo extensive back surgery.
7. Define central retinal artery occlusion.
8. Describe appropriate blood replacement after major loss.
9. Be aware of the responsibility of the anesthesiologist as to positioning and pressure point protection during surgery.
10. Describe appropriate postoperative consultation and care for the patient with visual loss.
Case Presentation

A 57 year old bus driver presented to the pain clinic with severe back pain. He had a history of multilevel laminectomies with minimal relief. Epidural steroid injections and analgesic drug and herbal therapies had also been ineffective. A repeat MRI at this time indicated severe spinal stenosis and osteophytes. A consultation with a neurosurgeon and an orthopedist resulted in a recommendation for repeat surgery with wide dissection and instrumentation. He gave a past history of heavy smoking with a recent decrease in his intake. He was diagnosed with hypertension and maintained on monopril, hydrochlorothiazide and diltiazem. Previous surgeries were without anesthetic complications. Laboratory tests were within normal limits except for a blood sugar level of 157mg/dl. He weighed 125kg and had a height of 5’10”. His blood pressure was recorded at 160/95. He required glasses for reading. He donated 2 units of autologous blood 10 and 3 days before surgery. Immediately before surgery, his Hb was 14.1g. At the preanesthetic assessment visit, the patient asked the anesthesiologist about potential risks associated with his procedure.

Introduction

Major back surgery is associated with long procedures which are often accompanied with considerable blood loss. Patient comorbidities, such as treated hypertension, often result in lowered blood pressure and decreased urine output. Appropriate fluid management and maintenance of a normoglycemic state is critical. Positioning problems exist, especially in the obese patient who may also have obstructive sleep apnea and pulmonary hypertension. The risk of postoperative visual loss is significant. Data compiled from recent studies has helped to identify specific risk factors for complications and can assist the anesthetist in understanding prevention and management of adverse outcomes of major back surgery.

Eye Injuries

The most common eye injury after surgery is corneal abrasion. Blindness is very rare. Early studies reported the incidence of postoperative visual loss (POVL) as approximately 1:61,000 cases (0.0016%). Since the publication of these reports, there has been increased awareness that visual loss is a devastating complication that can occur after many different types of surgery. More recent studies show a 0.11% risk associated with cardiac surgery and a 0.08% risk associated with spinal surgery.

The increase in the reported incidence is a result of many factors. With a greater focus on safety in anesthesia, more aggressive data collection and analysis is occurring and rare problems now receive greater attention. Also, with the increasing ability to perform more complex surgery, procedures are longer and often utilize hypotensive techniques which increase the risk of post-operative complications for older patients with comorbidities. With the increased use of autologous blood, patients may have reduced blood volumes prior to surgery resulting in intraoperative hypotension. Fear of malpractice litigation has also deterred anesthesiologists from presenting cases of such adverse outcomes and, as such, data compilation to define specific risk factors has been slowed. Recent reviews have identified common elements and defined better strategies for research on this topic.
American Society of Anesthesiologists Registry

The American Society of Anesthesiologists (ASA) Committee on Professional Liability established the ASA Postoperative Visual Loss Registry in 1999 to collect detailed information on cases of POVL. The goal of the Registry was to identify intraoperative risk factors and patient characteristics associated with POVL by analyses of all cases received through anonymous case submission. Using models developed through the ASA Closed Claims Project, the Committee posted a form on the ASA web site (www.asaclosedclaims.org) with instructions for submitting an anonymous detailed case report. Completion of the reports required access to the medical record including preoperative records; intraoperative records, including anesthesia charts; and postoperative PACU and ophthalmologic examination records. The initial goal of collecting data on 100 cases was reached in 2005 with data analysis completed and reported in 2006. In 2005, the ASA appointed a task force of 12 members to develop a practice advisory for POVL associated with spine surgery.

Identification of Risk Factors

Early reviews of a few reported cases of POVL indicated multiple causes. Foreign bodies were found to have entered the eyes causing corneal abrasions. Excessive pressure on the orbits resulted in central retinal arterial or venous thrombosis. It was also discovered that some cases resolved completely while others did not most likely related to the area of the nerve damaged and the affected blood supply.

POVL from an ischemic event in the visual pathway is classified according to the site of injury:

1. **Ischemic injury** to the optic nerve is divided to *anterior ischemic optic neuropathy (AION)* and *posterior ischemic optic neuropathy (PION)*. In AION, optic disc swelling may be seen; in PION, fundal examination is initially normal with disc pallor later becoming apparent.

2. **Cortical blindness** results from emboli, shock, or cardiac arrest and is caused by damage to the occipital cortex. Blindness, normal fundal examination, and retention of light response are seen.

3. **Central retinal arterial occlusion** occurs after embolic or thrombotic events or is associated with excessive extraocular pressure. A characteristic “cherry red” spot is seen on the retina.

4. **Central retinal venous occlusion** is diagnosed by finding retinal hemorrhages in all 4 quadrants, cotton wool spots, and dilated tortuous retinal veins.

Posterior ischemic optic neuropathy (PION) is the most likely cause of POVL following long back surgery. It presents as an acute loss of vision which is likely caused by decreased oxygen delivery to the posterior part of the optic nerve which receives blood flow from the pial branches of the ophthalmic artery. Although AION and PION are manifestations of vascular insufficiency to the optic nerve, they represent two subtly different pathophysiologic entities because of differences in blood supplies.

Prone position and long surgery have been associated with POVL. Intraoperative hypotensive hypovolemia and perioperative anemia have also been identified as risk factors. Review of cases from the ASA Registry indicates that direct eye pressure is not likely to be a risk factor, but mild hypotension
sustained for hours may be partially causative. This is particularly apparent in patients with a preoperative diagnosis of hypertension.

To decrease the need for replacement with banked blood, crystalloid infusions are often administered. These infusions decrease hematocrit and create hemodilution. Early teaching suggested that blood replacement could be achieved with 3ml crystalloid per 1 ml blood loss. Fluid balance is critical in back surgery, as excess fluid gravitates rapidly to dependent positions and the prone position may result in marked postoperative facial swelling.

According to a recent study, central hypervolemia with hemodilution impairs cerebral autoregulation in humans, making blood flow dependent upon pressure. Increased ocular venous pressure may occur. Avoiding the Trendelenberg position and minimizing intravenous fluids are appropriate steps to avoid the complication. In the prone position, intraocular pressure increases and ocular perfusion pressure decreases.

Steps to control fluid balance may result in markedly decreased or urine output. A table frame - such as the Jackson frame - allows better accommodation of an increased girth which maintains renal perfusion and improves renal flow as renal perfusion pressure is maintained. Compartment syndrome within the abdomen (caused by fluid gravitating to the intestinal wall) is prevented. Abdominal pressure affects renal perfusion. By decreasing abdominal pressure, renal perfusion pressure is increased. Also, if intra-abdominal pressure is normalized, pressure in epidural veins is not increased and bleeding is lessened.

Anatomical variation in the blood supply to the optic nerve is undetectable to the anesthesiologist. This variation, combined with major shifts in fluid balance and blood pressure, is likely to significantly contribute to the occurrence of POVL.

The POVL Registry has identified some common findings.

1. In approximately 90% of cases, the cause of postoperative blindness was likely to be ischemic optic neuropathy. Central retinal artery occlusion was diagnosed in only 6% (n=3) of cases. (POVL is rarely due to pressure on the eyes).

2. The incidence of POVL dramatically increased when the patient was in the prone position from 5 to 9 hours. The prone position places patients at risk. The Committee cautioned that the Registry did not have sufficient denominator data (i.e., all cases in the prone position) and therefore conclusions regarding risk and duration of the prone position are not definitive.

3. Younger age does not appear to be protective. Many patients were under 60 years of age. The frequent occurrence in younger, healthier individuals suggests that intraoperative physiologic variables such as edema formation and venous congestion in the prone position, as well as physiologic variation in ocular arterial structure and hemodynamics, may be important etiologic factors.

4. Measurement of intraocular pressure (IOP) over time in the prone position indicates about 100% increase over 6 hours. IOP increases uniformly from a baseline of 20+/−7mmHg to 29+/−9mmHg in the initial prone position to 41+/−10mmHg at the end of surgery. Given this increase
in IOP, decreased mean arterial blood pressure could markedly reduce ocular perfusion pressure. Other authors have cited high blood sugar levels postoperatively and suggest that glycemic control during the perioperative period is essential to neuronal survival.

5. In all cases of POVL in the Registry, there was considerable blood loss with replacement utilizing large volumes of crystalloid solutions.

Several factors not considered by the Registry. This included rate of blood loss and time to replacement; urine output; levels of glucose; and blood pressure control, especially in known hypertensive patients with well controlled blood pressure levels. However, the available evidence indicated that certain patients are at risk of developing POVL. The combination of several of the following factors should be considered as potentially problematic.

1. Repeat spinal surgery and the prone position are significant risk factors. Chronic pain patients having gone through prior surgeries are likely candidates for long procedures requiring extensive instrumentation. Such procedures evoke considerable blood loss. Patients often pre-donate blood and present with a reduction in their hematocrit preoperatively.

2. Disc disease is often associated with smoking, obesity and sedentary lifestyle. In fact, obesity was identified in many of the Registry patients. Hypoxia and/or bronchospastic disease may occur during anesthesia.

3. Hypertensive patients are often unstable intraoperatively. Given the decrease of IOP associated with the prone position, ocular perfusion pressure may be seriously decreased if any period of hypotension occurs or is prolonged.

4. Diabetes and increased perioperative glucose levels have been associated with poor neurologic outcome. Hypoxic or ischemic tissue is unable to metabolize sugar through normal pathways and the size of infarcted area is increased. Patients undergoing spinal surgery are often treated prophylactically with steroids to decrease edema formation, which further increases blood glucose levels. Stress also contributes to hyperglycemia. Recent studies have emphasized the need for tight perioperative glycemic control.

5. Hemodilution and pre-donation therapy may result in anemia. Earlier guidelines for care of young trauma victims suggested that blood could be replaced with crystalloid in the amount of 3ml crystalloid per 1ml blood loss. Crystalloids stay in the circulation for about an hour before leaking to other tissues. In the prone position, especially if there is a degree of Trendelenberg tilt, fluid will gravitate to dependent soft tissues in the face and around the eyes causing edema and increasing venous pressure. Excess fluid also fills the intestinal wall thereby increasing intra-abdominal pressure, decreasing renal output (which may in turn be treated by increased fluid boluses), and increasing bleeding from epidural venous plexuses. Current guidelines advocate replacement of blood as necessary to maintain adequate oxygen delivery. Excessive crystalloid replacement may contribute to POVL\textsuperscript{13} and cause the development of a compartment syndrome within the eye.
Perianesthetic Management

The anesthesiologist must consider all aspects of the management of a patient for complex spinal surgery starting with the preanesthetic interview. The patient should be clearly advised that there is a risk for POVL.

Perioperative measures and precautions should be taken:

1. Preanesthetic assessment should investigate any history of vascular disease or diabetes and ensure that the patient is in optimal condition. A history of previous visual problems should be sought and documented.

2. The patient’s body must be well protected. There should be no abdominal compression and the eyes should be padded and observed frequently. One report indicated that the use of goggles may not prevent excessive pressure and retinal occlusion.\[^{14}\] A notation at regular intervals must be made in the patient’s record. Use of a Jackson frame may be indicated.

3. The head must be positioned at or above the level of the heart. If a Wilson frame is used, flexing the spine frame allows the legs to be lowered, thus improving gravitational blood flow away from the operative site. It is important that the supports of the Wilson frame be adjusted to ensure that the abdomen is free.

4. Invasive monitoring allows accurate assessment of blood pressure and blood sugar levels. Elevated blood sugar levels should be treated.

5. Blood pressure should be maintained at normal levels for the patient.

6. Fluid balance should be maintained. Measurement of fluid input and output must be maintained and placement of a Foley catheter is necessary. Hemodilution should be minimized.

7. Infusion of colloid is an alternative to multiple liters of crystalloid.

8. Urinary output should be maintained at about 1ml/kg/hour, using small doses of furosemide (5-8mg), if necessary, rather than resorting to large fluid challenges, especially in otherwise healthy individuals.

9. Blood replacement should be timely. With stable patients, blood replacement often occurs at the end of the case, following a rationale that it is preferable for the patient to lose less of the high hemoglobin replacement blood. Blood should be replaced early, especially if the patient has pre-donated, or is maintained on beta adrenergic blocking drugs. Although base line and periodic hematocrit levels are customarily measured, red blood cell transfusions should not be dictated by a single hemoglobin “trigger” value, as these measurements are often erroneous. It is important to consider that shortly after pre-donation, the hemoglobin level may be abnormally low.

10. Normoglycemia should be maintained with a target blood sugar level around 120mg/dl.
11. Operative time should be kept as short as possible. Staging a procedure is an alternative.

12. Accurate charting and recording of as much intraoperative information as possible is essential. The use of electronic record keeping is advised. Although some have argued that intraoperative fluctuations in blood pressure are common and inconsequential, such aberrations might have legal consequences. If a blood pressure is recorded as severely depressed for hours without remedy, then the anesthesiologist will experience difficulties defending an adverse outcome.

13. Follow up of the patient through the Postoperative Care Unit with documentation is important. POVL may not be realized for several hours after emergence from anesthesia, especially if the eyes are swollen shut, or if the patient does not have access to reading or distance glasses. A patient may not be able to communicate a problem if intubated. Attempts to assess vision should be made and recorded as soon as possible. If facial swelling is apparent, the patient should be placed in reverse Trendelenberg position. Diuretics should be given to increase urinary output and promote fluid shifts from the tissues. Blood should be replaced to restore hemoglobin to preoperative levels. Normoglycemia and hemodynamic and respiratory stability should be maintained. Appropriate consults should be obtained.

While adherence to these recommendations will decrease the risk of POVL, there remain areas for further research. For example, although studies have confirmed that intraocular pressure increases approximately 100% in the prone position during prolonged operations, this measurement alone does not predict patients who will develop POVL. In a study of 23 cases, all of whom showed some increase in intraocular pressure, only one patient, who had only moderate increases in pressure, developed POVL. Placing the head in Mayfield tongs does not prevent intraocular pressure increase or POVL. It has been suggested that anatomic abnormalities that cannot be recognized preoperatively by the anesthesiologist may be a causative factor, especially when combined with some of the other factors identified.

Other Evidence

Development of an animal model that might confirm the association of risk factors and the development of POVL has been difficult. A porcine model presented in one recent study might be relevant. Compensatory mechanisms for pig cerebral blood flow will maintain stable oxygen delivery during periods of hypotension or anemia. However, optic nerve compensatory mechanisms were unable to maintain flow and preserve oxygen delivery. This indicates that the optic nerve in the pig is more susceptible to physiologic derangements than is the pig’s brain. The ophthalmic vasculature provides a conduit between extracranial and intracranial vessels in both pigs and humans. In the prone position, the porcine model produced only about 20% increase in intraocular pressure from baseline as compared to a 100% increase demonstrated in humans. The explanation for this finding may be that supplemental venous channels in the porcine neck prevent venous congestion during prone surgery. Other human studies have confirmed a “steal” phenomenon where blood flow from the ophthalmic vasculature is shunted away in favor of cerebral blood supply when cerebral oxygen delivery is inadequate.
**Management of the Case**

After induction of general endotracheal anesthesia, the patient was placed in a prone position on a Wilson frame. The head was slightly below the level of the heart. An arterial line was placed.

Blood loss was estimated at 4,500ml, replaced with 10 liters lactated Ringer’s solution, 2 units of colloid, 2 units of autologous blood, 1,750ml cell saver blood, 1 unit of banked blood and 1 liter of normal saline. Urine output was 350ml. Vital signs were maintained throughout the procedure, with the blood pressure in the range of 130/80 to 95/70. The final Hemoglobin was 9.6g. Blood sugar was measured on 3 occasions and the highest value was 186mg/dl. The patient awoke promptly at the conclusion of surgery. His face was noted to be very swollen. In the PACU, he complained that his vision was blurred even when he pushed his eyes open and put his glasses on. He could see the clock on the wall. The orthopedic surgeon was called and he, in turn, called the anesthesiologist, questioning excessive pressure on the eyes, hypotension or anemia as possible causes. The anesthesiologist reviewed all documentation and determined that the Hemoglobin never fell below 7gm and the mean arterial blood pressure was never below 60-70.

**Conclusion**

Weak perfusion of the optic nerve may result from the amount and rate of blood loss combined with a prone position and long surgery. Other causes of visual difficulties such as corneal abrasions or excessive residual eye ointment should be excluded.

The combination of red painful eyes and visual loss may also be due to acute angle glaucoma, which has been described after many types of non-ocular surgery. A patient may not have reported a history of eye disease but chronic back pain patients are usually over 50 years putting them at risk for this disorder. Headache can often accompany visual loss.

In its early stages, PION may be reversible and aggressive treatment is essential. Some authors have recommended visual testing postoperatively for rapid early detection of ION. Simple tests such as pupil reactivity or gross visual field testing may not be adequate. An ophthalmologic consult should be requested immediately, especially when there is clear indication of vision loss.

Immediate therapy should be directed at improving ocular perfusion pressure to restore and improve circulation in the short posterior ciliary arteries. Head up position, mannitol, acetazolamide, furosemide and/or topical timolol may be used to lower intraocular pressure.

Hypovolemia, hypotension and anemia should be promptly corrected. Use of pressors that act by peripheral vasoconstriction is not indicated. Steroids have been used although no large studies have proven their efficacy (except in cases of AION due to arteritis). Moreover, any increase in glucose levels may further damage neural tissue. In patients with a history of glaucoma, the pressure should be measured and appropriately controlled. In most instances, resolution or at least improvement is to be expected.

In cases of POVL, the anesthesiologist should contact the risk management department of the hospital, be aware of all consultations and communicate with colleagues, the patient and family.
Further information

www.asahq.org

References:

7. Posner KL. Committee on professional liability forms a new registry to investigate postoperative blindness. ASA News! 1999;63:25
POST-TEST

1. The most common eye injury after general anesthesia is
   a. Posterior ischemic optic neuropathy
   b. Corneal abrasion
   c. Chemical injury
   d. Conjunctivitis

2. The ASA Postoperative Visual Loss Registry
   a. has already received enough data to make definitive statements
   b. planned to investigate at least 100 cases
   c. reviews only closed claims of complete blindness
   d. requires minimal reporting only

3. Blood supply to the posterior part of the optic nerve is:
   a. mainly via the retinal artery
   b. overabundant
   c. from pial branches of the ophthalmic artery
   d. derived from anastomosis between the internal carotid and anterior cerebral arteries

4. Animal studies to investigate POVL:
   a. have not been done yet
   b. indicate that oxygen delivery to the optic nerve may be compromised during hypotension and anemia
   c. cannot mimic the human situation
   d. none of the above

5. Risk factors for posterior ischemic optic neuropathy are least likely to include:
   a. prolonged surgery
   b. prone position
   c. pressure on the eyes
   d. all of the above

6. Treatment of postoperative visual loss:
   a. is not necessary as there will be no improvement
   b. should be aggressive
   c. requires neosynephrine infusion to increase the blood pressure
   d. is not necessary as the patient will get better after a few days
7. **Examination of the optic disc in patients with POVL:**
   a. shows disc swelling early in AION
   b. is always normal
   c. shows disc atrophy immediately in PION
   d. is never possible because the eyelids are swollen shut

8. **Intraocular pressure in the prone position:**
   a. does not increase
   b. stays constant over time
   c. may double
   d. is unlikely to be a factor in the development of POVL

9. **Recommendations for the management of patient undergoing repeat spinal surgery include:**
   a. Avoid Trendelenberg position
   b. Replace blood as it is lost
   c. Restrict crystalloid replacement
   d. All of the above

10. **Physical characteristics identified by the ASA POVL Registry include:**
    a. Obesity
    b. Younger and older age groups
    c. Smoking history
    d. All of the above