www.apsf.org

NEWSLETTER

The Official Journal of the Anesthesia Patient Safety Foundation

Volume 22, No. 2, 25-40 | Circulation 81,489 | Summer 2007

Beach Chair Position May Decrease Cerebral Perfusion

Catastrophic Outcomes Have Occurred

by David J. Cullen, MD, and Robert R. Kirby, MD

Case Presentation

A 47-year-old, healthy female underwent general anesthesia for shoulder arthroscopy. Preoperative blood pressure (BP) was 125/83 mmHg. After premedication with 50 mg of meperidine, 40 mg hydroxyzine, and 0.2 mg glycopyrrolate intramuscularly, anesthesia was induced with 200 mg propofol, 100 mg succinylcholine, and 30 mg lidocaine. Because she was hypertensive, just prior to induction, 50 mg of labetalol was given intravenously. Anesthesia was maintained with 2% isoflurane, 60% nitrous oxide, and oxygen. The patient was placed in the "barbershop" position for the surgery. Twenty minutes into the case, blood pressure decreased to 100/60 mmHg and then remained in the 80-90 mmHg systolic range for the remainder of the case. Oxygen saturation was 100% and end tidal CO_2 values were in the 30s throughout the case. Upon arrival in the post-anesthesia care unit (PACU), her blood pressure was 113/60 mmHg but she did not awaken. Naloxone 0.1 mg was given intravenously, but she remained unresponsive and did not move her extremities. Another 0.1 mg of naloxone was given 35 min after arrival in the PACU followed by 3 more doses of naloxone and 2 doses of physostigmine. During this time, her trachea remained intubated and she was well oxygenated. Neurologic evaluation suggested a diencephalic syndrome, possibly brain infarction. She was unresponsive to voice commands or painful stimuli, and reflexes were decreased bilaterally. A computer axial tomography (CAT) scan of the head was normal initially, but 5 days later suggested brain swelling and obliteration of the cistern. Magnetic resonance imaging (MRI) 1 week later showed changes in both cerebral hemispheres suggesting cortical infarcts, involvement of the anterior and medial temporal lobe bilaterally, no significant edema, and no significant herniation. At no time was there any evidence of an intracranial bleed. After 2 weeks, her Glasgow coma scale was 3; her fundi were clear and crisp. She had corneal reflexes, a positive gag, and negative doll's eyes; she was hyperreflexive with increased tone and was unresponsive to noxious stimuli in all 4 extremities. She is expected to remain in a persistent vegetative state.

Considerations When Using the Beach Chair Position

The beach chair (barbershop) position was developed in the 1980s for orthopedic shoulder arthroscopy procedures. Patients are sat up at angles varying from 30-90° above the horizontal plane with appropriate padding and with the head secured in a headrest. Injuries to the brachial plexus are reduced compared to the lateral decubitus position, and the surgeon has excellent access to the shoulder. The position helps the surgeon because the weight of the arm distracts the shoulder joint while avoiding distortion of the intra-articular anatomy.

However, significant changes can develop when patients are moved to the upright position. Mean arterial pressure (MAP), central venous pressure (CVP), pulmonary artery occlusion pressure (PAOP), stroke volume, cardiac output, and PaO_2 all decrease while the alveolar-arterial oxygen gradient (PAO_2-PaO_2), pulmonary vascular resistance, and total peripheral resistance increase. Under nonanesthetized conditions, these effects are compensated for by an increase in systemic vascular resistance by up to 50-80%. However, this autonomic response is blocked by vasodilating anesthetics, which further exacerbate and compromise cardiac output. Blood pressure remains unchanged or increases slightly in nonanesthetized patients in the sitting position but decreases in the anesthetized state. Cerebral perfusion pressure (CPP) decreases by approximately 15% in the sitting position in non-anesthetized patients and could further decrease under anesthesia because of vasodilation and impaired venous return. Venous return from the cerebral circulation is usually increased by inspiratory subatmospheric pressure during spontaneous ventilation, but this mechanism is nullified by positive pressure ventilation. Obstruction of the internal jugular veins in the sitting position may also impede cerebral venous drainage, especially with unfavorable positions of the head and neck, such as flexion of the head. Pohl and Cullen reported a series of cases in 2005 that documented blood pressure decreases ranging from 28-42%; consequently, hypotension was thought to be a likely cause of ischemic brain injury. Given the potential for peripheral vasodilatation and myocardial depression that can occur in patients who are anesthetized with potent intravenous and inhalational drugs, the effects of the upright position and anesthesia synergize.

Cerebral autoregulation has been thought to maintain cerebral blood flow (CBF) constant between MAP of 50-150 mmHg. However, it must be remembered that in poorly controlled hypertensive patients, autoregulation of CBF is shifted to the right, requiring higher CPP/MAP to ensure adequate cerebral perfusion. In recent years, Drummond and others have emphasized that the quoted value of 50 mmHg for the lower limit of autoregulation (LLA) should be modified upward to reflect a range of values from 70-93 mmHg with a mean value of 80 ± 8 mmHg rather than the specific number of 50 mmHg. Some orthopedic surgeons request deliberate hypotension for shoulder surgery. With the acquiescence of the anesthesiologist or the nurse anesthetist, deliberate hypotension to mean arterial pressures of 50-60 mmHg eliminates any margin for error in case blood pressure falls further. In addition, neither the surgeon nor the anesthesiologist nor the CRNA typically seems to consider the added effect of the beach chair position on cerebral perfusion.

See "Perfusion," Page 27

Inside:

Consider Correction for Cuff Location

"Perfusion," From Page 25

In the upright position, MAP at the brain is very different when compared to the site at which the BP is actually measured, usually the arm. Unfortunately this difference may be overlooked. In the supine position, BP measured in the arm and BP perfusing the brain are essentially the same. However, if the patient is upright in the beachchair position, BP will be less in the brain than at the heart or arm. The BP difference will be equal to the hydrostatic pressure gradient between the heart/arm and the brain. For example, suppose the BP at the heart/arm is 120/80 mmHg, (MAP 93 mmHg). If the height of the external auditory meatus (representing the base of the brain) is 20 cm above the heart, the difference in BP at the heart compared to the brain will be 15 mmHg. Thus, the BP at the base of the brain will be 105/65 mmHg (MAP 78 mmHg). Most patients undergoing relatively straightforward procedures such as shoulder arthroscopy or even open shoulder surgery do not have intra-arterial BP monitoring available. Therefore, they do not have a transducer placed at the level of the external auditory meatus to monitor BP at the base of the brain. Instead, it is up to the anesthesiologist and/or nurse anesthetist to correct the BP readings at the arm to account for the height of the brain above the arm. Even accounting for the hydrostatic gradient between the external auditory meatus (base of brain) and the arm does not take into account the added distance from the base of the brain, at the Circle of Willis, to the most cephalic portion of the cerebral cortex, an additional distance of 10-12 cm (depending on the patient's height), which represents a further gradient of about 9 mmHg.

The case presented at the beginning of this article suggests that the gradient between the arm and brain was not appreciated. Blood pressure was measured at the arm with a non-invasive cuff, but was not adjusted upward to maintain an adequate MAP at the level of the brain during the procedure. Systolic BPs of 80-100 mmHg probably corresponded to MAPs of 50-80 mmHg, but in the beach chair or upright position, MAP at the base of the brain was probably 15-20 mmHg lower, and at the top of the cerebral cortex, another 9 mmHg lower. It is reasonable to estimate a MAP of 30-40 mmHg at the cerebral cortex and a little higher at the brainstem. CAT scan on the fifth postoperative day showed brain swelling and obliteration of the cistern. MRI 1 week later showed cortical infarcts in both cerebral hemispheres and no intracranial bleed. The injury was consistent with the hypoperfusion that occurred intraoperatively.

Estimates of the MAP at the head can be made once the patient is in the beach chair position. The **critical** variable is the vertical distance between the external auditory meatus and the BP cuff. Once that distance is known, it should be converted to a hydrostatic pressure gradient that then must be incorporated into BP management during the procedure.

To quantitate the hydrostatic gradient, there is a 0.77 mmHg decrease for every centimeter gradient (1 mmHg for each 1.25 cm). In general, the approximate distance between the brain and the site of the BP cuff on the arm in the seated position will be 10-30 cm depending on the angle of the sitting position and the height of the patient; hence the brain MAP will be 8-24 mmHg lower than the measured mean brachial artery pressure. If the beach chair position is combined with the use of deliberate hypotension, cerebral perfusion will be severely compromised. An even more exaggerated occurrence may develop when the BP cuff must be placed on the leg because the contralateral arm is not available for BP measurement, e.g., in a patient with prior lymph node dissection for breast cancer. In the beach chair position, the legs are considerably lower than the trunk, therefore the BP difference between the BP cuff measured on the leg and the BP in the brain will be even greater than the gradient between the arm and the brain.

The following case illustrates this point. A 54-year-old woman underwent left shoulder replacement surgery in the beach chair position. The patient had no history of hypertension or myocardial infarction. Preoperative electrocardiogram, echocardiogram, thallium scan, and exercise tolerance test were normal. The patient received an interscalene block with 40 ml of 0.5% bupivacaine with epinephrine (1:200,000). Because of a previous mastectomy, a 20-gauge intravenous catheter was placed in the right foot and a noninvasive BP cuff was placed on the calf. There was no documentation that the calf BP was validated to the left arm BP before the patient was anesthetized and the left arm became unavailable. No arterial catheter was placed although deliberate hypotension was used. Anesthesia was induced with 100 mg propofol, 250 mg sodium pentothal, 50 mg rocuronium, and 250 mcg fentanyl. Anesthesia was maintained with 3.5% sevoflurane and 67% nitrous oxide in oxygen. Nitroglycerin, 50 mcg times 3 doses, and labetalol, 5 mg times 4 doses, were used to produce deliberate hypotension. One hour after induction, her systolic BP was between 85-100 mmHg. Two hours later, her BP was 70/40 mmHg and then remained around 90/60 mmHg for the next 40 min, when it decreased to 50/25 and was treated with phenylephrine. Electrocardiography showed sinus rhythm throughout, oxygen saturations were always high, and end-tidal CO_2 was in the high 20s for most of the case. In the PACU, emergence was delayed, and she did not breathe spontaneously. A radial artery catheter was finally placed while she was in the PACU, and BPs were normal. Apnea persisted and her pupils were fixed and dilated. Blood gas analysis on controlled ventilation showed a PaO_2 of 236 mmHg, $PaCO_2$ of 35 mmHg, and pH of 7.4, with glucose of 92 mg/dl. Neurologic evaluation revealed brain death with no CBF, flat electroencephalogram, no reflexes, no response to pain, and no lesions on the CAT scan. At autopsy the upper spinal cord and medulla were infarcted. The anesthesia equipment tested normal. In this case, not only was deliberate hypotension used to very low values, but BP was measured in the leg while the patient was in the sitting position. One can only imagine how low the BP was in the brain when BP in the leg was 70/40 or 90/60.

In addition to avoiding deliberate hypotension, one must be extremely vigilant and treat aggressively the unexpected hypotension that often occurs during anesthesia in the beach chair position for the reasons enumerated above. These treatments are well known to all anesthesia providers and include careful control of the inhalation anesthetic concentration, adequate and timely fluid administration, and vasopressor infusion, as needed during the time of the procedure when the patient is upright and at risk.

Head position is also important because some degree of head manipulation is required when positioning the patient in the seated position. Most surgeons use a headrest to immobilize the head. Several studies suggest that CBF can be compromised by mechanical obstruction and injury to major veins or arteries. Blood flow reduction in the vertebral artery caused by extension and rotation or tilt of the head may result in posterior brain circulation infarcts.

Finally, hypotension and generalized circulatory instability can result from gas embolism. This rare complication has been reported with both air and carbon dioxide distension of the joint capsule followed by pressurized injection of irrigation fluid. Thus, anesthesiologists and CRNAs should keep the possibility of venous gas embolism in mind during shoulder arthroscopy in the sitting position if sudden cardiovascular collapse occurs.

Summary

Despite its low incidence, intraoperative stroke associated with shoulder surgery, particularly in healthy patients at no risk for stroke, is a totally unexpected and devastating complication. Patients in the beach chair position are at risk for an intraoperative stroke if borderline low BPs, as measured in the arm, are used without appreciating the effect on CPP and CBF. Because of the specific physiologic changes associated with the sitting position, great care should be applied when using and interpreting BP cuff measurements in the nonoperative arm or, even more so, if leg measurements of BP must be used. Blood pressure values <80% of preoperative resting values should be treated aggressively to enhance the margin of safety. Deliberate hypotension must be avoided. A thorough understanding of the physiologic changes associated with the upright position, and the physical effects of gravity on BP in the brain is crucial to prevent catastrophic neurologic outcome during shoulder surgery in the sitting position.

Dr. Cullen is formerly Chair of the Department of Anesthesia and Pain Medicine, Caritas St. Elizabeth's Medical Center and former Professor of Anesthesiology at Tufts University School of Medicine in Boston, MA.

Dr. Kirby is an Emeritus Professor of Anesthesiology at the University of Florida College of Medicine in Gainesville.

General References

1. Pohl A, Cullen DJ. Cerebral ischemia during shoulder surgery in the upright position: a case series. *J Clin Anesth* 2005;17:463-469.
2. Drummond JC. The lower limit of autoregulation: time to revise our thinking? *Anesthesiology* 1997;86:1431-1433.
3. Drummond JC, Patel PM. Neurosurgical anesthesia. In: Miller RD, Cucchiara RF, Miller ED, Jr., et al., eds. Anesthesia, 5th ed. Philadelphia: Churchill Livingstone, 2000:1903-5.
4. Faure EA, Cook RI, Miles D. Air embolism during anesthesia for shoulder arthroscopy. *Anesthesiology* 1998;89:805-6.