Professional Gaps

One of all the orthopedic procedures performed today, the most common involve the shoulder joint. Recently, the Anesthesia Patient Safety Foundation - in response to several reports of neurologic damage following surgery in the beach chair position - founded a registry to collect data to determine the cause of injury and to provide improvement measures. It is important that all anesthesiologists involved in orthopedic cases involving the shoulder joint be aware of the recommendations.

Learning Objectives

At the completion of the activity, the reader will be able to:

1. Describe the basics of arthroscopic shoulder surgery
2. List the positions for performing shoulder surgery
3. Understand the advantages of the beach chair position
4. Realize the possible complication that may be associated with the beach chair position
5. Determine appropriate preanesthetic assessment for the case described
6. Draw up an anesthetic plan
7. Know the elements that comprise the rotator cuff
8. List monitors appropriate for cases in the beach chair position
9. Describe the role of cerebral oximetry in these cases
10. Have a plan for postoperative pain control

Case

A 56 year old man was on a ladder attempting to secure some loose tiles on the roof of his house. As he reached with his right arm, he felt a tearing and sudden pain in his right shoulder, which caused him to lose his balance and fall. He sustained several cuts and bruise and a sprained right ankle but no
other life threatening injuries. He had severe shoulder pain which he treated with cold compresses and non-steroidal analgesic agents for a week. When there was little improvement in the pain, he sought medical advice and was found to have torn his rotator cuff.

He gave a history of hypertension, relatively well controlled with hydrochlorothiazide, amlodipine and nicardipine. He had recently been diagnosed with diabetes and was taking metformin. Other findings included weight 205lbs, height 5’9”, BP 160/90, and blood sugar 163mg/l.

Introduction

The rotator cuff is a group of muscles and tendons that cover the shoulder joint and connect the humerus to scapula. The rotator cuff tendons provide stability to the shoulder while the muscles allow shoulder rotation.

The muscles in the rotator cuff include the teres minor, infraspinatus, supraspinatus and subscapularis. (See Figure 1.) These muscles insert at the scapula and have tendons that attach to the humerus. Any part of this complex mechanism can be injured by repetitive movement, general wear and tear or sudden trauma, causing partial or complete tearing.

Figure 1. Muscles comprising the rotator cuff

![Muscles of the Rotator Cuff](image)

Surgical Approach

There are 2 main approaches to repairing rotator cuff injuries: open or arthroscopic. During open repair, an incision is made and the large muscles are moved aside to allow for a complete view of the area. Open repair is generally recommended for large or more complex tears. During arthroscopy, the arthroscope is inserted through a very small incision and connected to a video monitor which allows the surgeon and staff to view the operative procedure. One to three additional small incisions allow other instruments to be inserted for manipulation, tissue extraction, irrigation and suction. Damaged tissue or bone spurs can be removed or repaired by instruments placed through these entry holes. The rotator cuff is directly repaired and the tendons re-attached to the bone by suture anchors made of metal or plastic.

A recent published 10 year review of shoulder surgery indicated a 141% increase in rotator cuff repairs. In 2006, some 272,000 rotator cuff repairs were completed arthroscopically (a 600% increase over the
prior ten years) and only 20,000 required in-patient care.¹ Open repair increased 34% over this time period.

**Positioning**

Two basic positions are advocated for shoulder arthroscopy - lateral decubitus (LDP) and the beach chair position (BCP).² Both positions have advantages and disadvantages. Most types of shoulder arthroscopy can be completed with the patient placed in either position. Choice of patient position is influenced by the surgeon’s training, positioning of the joint, available equipment and orientation. Whichever position is used, it is most important that careful attention is given to ensuring adequate padding, balanced suspension forces and a complete head set-up so that the risk of complications is minimized. Achieving this optimal operative position requires the cooperation of all members of the surgical team - surgeon, anesthesiologists and operating room nurses - each of whom play an integral part. The American Academy of Orthopaedic Surgery published an excellent illustrative document with step-by-step instructions to successfully and safely achieve either of these positions.²

The advantages of the LDP include improved access for glenohumeral arthroscopy and better approach to the posterior and inferior aspects of the glenohumeral joint. The position may be preferred for instability repairs and biceps work. It usually requires that the patient be given general anesthesia thereby increasing the risk of airway disconnect or malpositioning during movement. An arm-holding boom and balanced suspension devices are also needed. It may be difficult to convert to an open technique should that become necessary. The BCP allows better visualization as the weight of the arm helps to distract the joint; and does not require additional equipment because a standard table can be used. Setup is easier and the airway is less compromised. Regional anesthesia, such as an interscalene block, may suffice. Surgeon fatigue is more likely to occur and an assistant may be necessary to provide adequate balanced suspension. Nerve and vascular complications, including hypoglossal dysfunction and cerebrovascular insults, have been reported. Correct head and neck position are important, ensuring neutral neck position in both coronal and sagittal planes. Head positioners with straps and gel foam hold the head in place. Pillows and pads at the knees avoid peroneal nerve injuries. Special attention should be paid to ensure no pressure on the eyes, ears or lips. The table is often rotated 45 degrees for better surgical access. An arm-mounted device may be added that allows precise control of rotation without the need for an assistant. Balanced suspension in several planes is possible but set up time is longer and additional drapes are required adding cost. Pneumatic arm holders require a nitrogen supply.

**Complications**

The positioning process poses risks of patient injury on several levels. Extension and abduction in the LDP may cause: stretching and neuropraxia of the nerves, especially the musculocutaneous; thromboembolic events; difficulty with airway access; and the potential need to convert to an open approach.³ Areas not adequately padded may be subject to compression injury. Complete airway obstruction and spontaneous pneumothorax have also been reported as a result of the lateral position.⁴,⁵ The BCP has been associated with hypoglossal nerve injury (C12)⁶; vasovagal episodes⁷; visual loss and ophthalmoplegia⁸; cardiac and embolic events³; and cerebral ischemia.⁹ Satin et al described 4 cases of lateral femoral cutaneous nerve palsy following surgery in a sitting position.¹⁰ Injuries to cranial nerves 9 and 10 have also been reported and attributed to mechanical extracranial causes such as positional injury or undue traction. An intracranial episode such as embolism or hypoperfusion were ruled out as causes as subsequent scans were negative.¹¹
Neurologic Injury after Non-Supine Surgery

Using data from medico legal reviews, Pohl and Cullen were among the first to draw attention to ischemic brain and spinal cord injury after shoulder surgery performed in the BCP. Their analysis suggested that the sitting position combined with general anesthesia created specific physiologic conditions conducive to ischemia. They described four cases that were all in good health with a low correlation between cardiovascular risk factors and cerebral ischemic complications. They suggest that in these cases, venous return is decreased, aggravated by the depressant myocardial effects of anesthetics and vasodilation, creating a reduction in stroke volume that is not compensated by an increase in systemic vascular resistance. In the sitting position, blood pressure is unchanged in the awake patient; but under anesthesia, it is significantly decreased. Similar findings pertain to cerebral perfusion pressure. Positive pressure ventilation during general anesthesia does not allow the increase in venous return that occurs during spontaneous respiration. If the head is flexed, internal jugular compression may further impede cerebral venous return.

Concern over catastrophic neurologic complications prompted the Anesthesia Patient Safety Foundation (APSF) and the ASA committee on professional liability, in collaboration with the Anesthesia Closed Claims Project, to investigate the specific mechanism of injury. The etiology is unknown but several theories, as partly noted above by Pohl and Cullen, speculate about the role of deliberate or permissive hypotension, cerebral perfusion in the BCP, dynamic vertebral artery stenosis, occlusion with rotation of the head, air emboli, or other factors. Because the incidence of neurologic injury in non-supine position is very low, reporting through a national voluntary registry using models developed through the Anesthesia Closed Claims Project was seen as the best means to collect enough cases to determine shared perioperative characteristics. This registry can be accessed via the APSF website (www.apsf.org).

In 2010, APSF funded research to assess cerebral blood flow autoregulation in the head-up versus supine position during general anesthesia and its relationship with postoperative neurocognitive changes and serum biomarkers of brain injury. A group of 109 patients operated in the lateral decubitus position (LDP) were compared with 109 patients operated in the beach chair position (BCP). There was a higher cerebral oximetry index (a coefficient calculated from the mean arterial blood pressure and regional cerebral oxygen saturation [rScO2]) and a lower rScO2 level in the BCP group, indicating diminished cerebral autoregulation. No differences in serum biomarker levels were found between the 2 groups and there were no differences in postoperative psychometric testing. While this study might indicate that adverse cognitive outcome is not a problem, other factors may still be important such as co-morbidities and anesthetic technique.

Effect of Blood Pressure

Cerebral desaturation events (CDE) may be attributed to low cerebral perfusion pressure which can be caused by a number of factors including: treating the patient’s blood pressure based on measurements taken on the arm or leg in the BCP without correction for height; deliberate hypotension; positional changes causing poor venous return and relative hypovolemia; occlusion of vertebral arteries from head rotation; and air emboli. Autoregulation in the elderly may be impaired affecting the ability of the posterior cerebral artery to compensate with changes in posture. Moreover, over half of the population has an “incomplete” Circle of Willis, decreasing the ability to autoregulate with blood pressure changes.
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 BCP, 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. At a distance of 20 cm above the heart (the distance from the cuff placed on the arm to the external auditory meatus) there is a 15 mmHg drop in pressure at the level of the brain.

Although the traditionally acceptable lower limit of mean arterial blood pressure (MAP) was thought to be about 50mmHg, recent evidence indicate that it might be as high as 90mmHg in awake normotensive individuals. The results of a national survey reported in 2012 indicated that 28% of 104 responders used deliberate hypotension to 30% of baseline and 72% of this group did so with patients in the BCP. Blood pressure was measured in the contralateral arm with less correction for height and use of arterial lines for patients receiving deliberate hypotension.

Another study of 7 patients in the BCP, related brachial MAP with estimated temporal MAP (eTMAP). Patients received interscalene block and general anesthesia. A strong correlation between brachial MAP and eTMAP was found at supine position but as the incline increased there was a statistically significant decrease in the ratio of eTMAP to non-invasive blood pressure (eTMAP/NIBP) because of the drop in eTMAP. In another review of 384 patients who underwent surgery in the BCP, preoperative use of antihypertensive medication was associated with an increased incidence of intraoperative hypotension.

**Monitoring**

Given the concern that cerebral perfusion pressure may be compromised in the BCP, standard monitors of blood pressure, EKG and SpO2 as described by the ASA may be insufficient. A cerebral oximeter that uses near infrared spectroscopy can determine absolute cerebral oxygen saturation (SctO2) at the microvascular level by using 4 wavelengths. This is accomplished in a non-invasive and inexpensive manner. In a study of 48 healthy adults, a change in SctO2 of about 4% was noted when the BCP was achieved.

Cerebral oximetry has shown a >20% decrease in SctO2 in up to 43% of patients in the BCP, a drop that was not reflected in SpO2 but did correlate with decreases in blood pressure. Other studies have indicated up to 80% of cerebral desaturation events (CDE) in patients undergoing surgery in the BCP have occurred under general anesthesia with controlled ventilation with changes confirmed using different technologies of oximeters.

A systematic review sought to determine the incidence of CDEs as measured by cerebral oximetry, finding 9 relevant studies. The mean incidence of CDEs was 28.8% with a strong correlation with the...
degree of elevation in the BCP. Evidence suggested that patients could be stratified on the basis of age, past history of hypertension and stroke, body mass index, diabetes, obstructive sleep apnea and height.22

Thus, while the degree of cerebral desaturation or ischemia that produced cognitive changes is unknown and probably varies within the patient population, near infrared spectroscopy allows prompt identification and treatment of decreased cerebral perfusion.23

Similar decreases in jugular desaturation of 40% have been found.24 However, jugular venous bulb monitoring is much more invasive. A significant decrease for patients in the BCP can also be seen using bispectral index values.25

**Anesthetic Management**

Anesthetic management has a significant effect on the incidence of CDEs. For surgical patients that are placed in the BCP, cerebral oxygenation is significantly improved when ventilation is adjusted to maintain ETCO2 at 40-42 mmHg as compared to 30-32 mmHg.26 A similar study is underway evaluating the influence of increasing oxygen concentration and ETCO2 and the effects of different anesthetic agents using the INVOS 5100c® monitor.27

Another study of 90 patients indicated that those in a regional anesthesia group (n=45) showed less CDEs, fewer drops in SctO2 values and significantly better neurobehavioral test results on the following day.28 Intraoperative hemodynamic stability also improved.

A recent report of almost 14,000 cases of shoulder surgery indicated that 99% were anesthetized with interscalene block followed by sedation with propofol, oxygen and spontaneous respiration.29 Thirty seven adverse events were reported: 9 cases of local anesthetic toxicity; 5 cases of nerve injury; 6 cases with dysrhythmias and hypotension; 3 cases of cognitive dysfunction; and 1 case of stroke. These findings are similar to those of Rohrbaugh et al who analyzed over 15,000 cases and estimated a total rate of adverse events of 0.37% for shoulder surgery that is performed in the BCP.30 They concluded that intraoperative or immediate stroke is rare if the surgery is done in conjunction with regional anesthesia with propofol sedation and spontaneous respiration.

**Management of the Case**

Standard ASA monitors were applied, including side stream capnography, with the blood pressure cuff on the contralateral arm for initial measurements. Because of his long standing history of hypertension and diabetes, an arterial cannula was placed following sedation with midazolam 2mg and fentanyl 25ug. The transducer was adjusted to the level of the ear. Using ultrasound guidance, an interscalene nerve block was placed while the patient was in the holding area. Bilateral sequential compression devices and cerebral oximetry were added. Propofol infusion, 2-4mg/kg/min was started and adjusted to maintain spontaneous respiration, monitored by capnography, while the patient remained comfortable. Small doses of fentanyl, 25ug, were added. The blood pressure was maintained within 10-15% of baseline using small doses of phenylephrine. After carefully securing the head, neck and hips to ensure no lateral movement, the table was adjusted to the required height. Nasal oxygen was given. A supraglottic airway was prepared but was not needed. In the PACU, the patient reported no pain. With a pump in place for continued pain relief, he was discharged later that day.
Conclusion

Surgery performed on patients in the BCP offers many advantages to the surgeon and the anesthesiologist. However, this position requires very careful attention to positioning to avoid neurologic damage. Blood pressure and ETCO2 must be maintained within a narrow range to prevent cerebral desaturation events and the risk of brain ischemia.

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**Post-test**

1. **Open repair of the shoulder is generally preferred for:**
   a. Obese patients
   b. Large or complex tears
   c. All patients without co-morbidities
   d. Surgeons who are skilled in the technique

2. **The muscles of the rotator cuff include:**
   a. The teres minor, infraspinatus and deltoid
   b. The teres minor, supraspinatus and subscapularis
   c. It varies from patient to patient
   d. The trapezius, infraspinatus and supraspinatus.

3. **The BCP is preferred over the LDP because:**
   a. Surgical visualization is improved
   b. The airway is less compromised
   c. Setup is easier
   d. All of the above

4. **Over the past decade rotator cuff repairs:**
   a. Are performed less frequently
   b. Are increasingly done in a LDP
   c. Remain unchanged
   d. Have increased by 141%

5. **The preferred anesthetic technique for shoulder surgery in the BCP is:**
   a. Regional block with sedation
   b. Sedation alone
   c. General anesthesia
   d. There is no preferred technique
6. **Cerebral desaturation events in the BCP are associated with:**
   a. Hypercapnia
   b. Hypertension
   c. Hypotension
   d. Hypervolemia

7. **Continuous cerebral oximetry monitoring:**
   a. Offers little more information than blood pressure
   b. Can detect CDEs early
   c. Is unreliable
   d. Is invasive and expensive

8. **Complications in the lateral decubitus position include:**
   a. Neuropraxia of the musculocutaneous nerve
   b. Femoral cutaneous nerve injury
   c. Vasovagal episodes
   d. All of the above

9. **In a study relating eTMAP to NIBP:**
   a. Strong correlation is found in all positions
   b. As incline increases there is a significant decrease in eTMAP/NIBP
   c. As incline increases there is a significant increase in eTMAP/NIBP
   d. There is no correlation between them

10. **The acceptable lower limit of MAP:**
    a. Is about 50-60mmHg
    b. May be as high as 90mmHg in awake normotensive individuals
    c. Cannot be related to co-morbidities
    d. Does not matter as deliberate hypotension is not associated with adverse events