The sitting position: is it safe?

Glenn S Murphy, MD*

* Director, Cardiac Anesthesia and Clinical Research. North Shore University Health System. Clinical Professor, University of Chicago Pritzker School of Medicine.

DISCLOSURE INFORMATION

- I have the following financial relationship to disclose: Consultant for: CASMED, Inc.
- I will not discuss off-label use and/or investigational use in my presentation
- Is there clinical data supporting (or questioning) the safety of sitting surgery?
- What can we do to potentially reduce the risk of adverse neurologic events in our BCP patients?

INCIDENCE

Case reports:
- Pohl and Cullen → 4 cases of ischemic brain and spinal cord injury (J Clin Anesth 2005;17:463-9.)
- Drummond, et al. → hemiparesis in 50 year old man (Anesth Analg-in press)
- Survey study
  - Survey sent to 287 members of the ASES Society to assess incidence of CVA after shoulder surgery
  - 93 surgeons responded
  - 8 cerebrovascular events reported (all in BCP) (Friedman DJ, et al. Orthopedics 2009;32:256-240.)
- Personal communications
  - David Cullen → 11 additional cases in which patients suffered severe brain damage (APSF Newsletter 2010)
  - Jeffery S. Vender → 5 cases of brain injury after shoulder surgery in the BCP
  - Glenn Murphy → 3 cases in the Chicago area of CVA after sitting shoulder surgery
  - APSF 2011 BOD Meeting → 17% of audience observed postoperative cognitive dysfunction following anesthesia in the BCP (Winter APSF Newsletter)
  - Rare event → National Registry
  - Similar to ASA postoperative visual loss registry

Are patients undergoing surgery in the sitting or beach chair position (BCP) at increased risk of adverse neurologic events in the postoperative period?

OVERVIEW

- What is the incidence of postoperative neurologic deficits following BCP surgery?
- What is the etiology of adverse neurologic events after surgery in the sitting position?
BLOOD PRESSURE MANAGEMENT IN THE BEACH CHAIR POSITION: NATIONAL SURVEY RESULTS
Lee LA, et al. ASA 2010; Annual meeting.

- 24 question survey distributed by APSF. Newsletter and website (www.apsf.org)

  Results
  - 104 completed surveys returned over 3 months
  - Position: BCP (65%); lateral (12%); both (21%)
  - Deliberate hypotension used by 28% of respondents; > 70% of this group used BCP
  - BP goal: 10% baseline 26%; 30% baseline 9%
    - 20% baseline 49%
  - Arterial line use 14%
  - BP correction for height 48%
  - # cases of severe brain damage reported: 12 (12% of institutions)

ETIOLOGY/MECHANISMS OF CEREBRAL ISCHEMIA IN THE BCP

Air embolus
- 7 cases of VAE reported when CO₂ used as joint distending agent → 1 case brain stem ischemia (Anaesthesia 2005;60:501-4.)

Cerebral intraluminal artherosclerosis

Absence of an intact or «classic» circle of Willis
- In a MR angiography study of 150 healthy volunteers, only 42% had an entirely complete circle of Willis (Radiology 1998;207:103-111.)

Deviations from classic vessel configuration in the neck
- In a study of 168 volunteers, congenital variations in the vertebral arteries were noted in 42 subjects (Wang Y, et al. J Ultrasound Med 2009;28:1481-6.)

- Compression/obstruction of venous or arterial vessels during head flexion/extension/rotation

- Decreases in cardiac output due to the effects of general anesthesia in the sitting position
- Decreases in systemic blood pressure due to the effects of general anesthesia in the sitting position → inadequate CPP
HYPOTENSION IN THE SITTING POSITION

<table>
<thead>
<tr>
<th>Year</th>
<th>Author</th>
<th>#</th>
<th>Def ↓ BP</th>
<th>Incidence(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976</td>
<td>Albin</td>
<td>180</td>
<td>&gt; 10% ↓ MAP</td>
<td>32%</td>
</tr>
<tr>
<td>1985</td>
<td>Matjasko</td>
<td>554</td>
<td>20% ↓ SAP</td>
<td>5%</td>
</tr>
<tr>
<td>1986</td>
<td>Young</td>
<td>225</td>
<td>&gt; 10 mmHg ↓ MAP</td>
<td>12%</td>
</tr>
<tr>
<td>1988</td>
<td>Black</td>
<td>333</td>
<td>&gt; 20% ↓ SAP</td>
<td>19%</td>
</tr>
</tbody>
</table>


CURRENT DEBATE: HOW SHOULD BLOOD PRESSURE BE MANAGED DURING BCP SURGERY?

- What is the lower limit of acceptable blood pressure during anesthesia?
- Should blood pressure be corrected for the difference in height between the site of measurement and the brain?

SHOULD BLOOD PRESSURE BE CORRECTED?

- **SIPHON CONCEPT**
  - Also called «closed model»
  - Depends on the presence of a continuous column of blood in the arterial and venous limbs of the loop (aorta → brain → SVC)

###Author### | Hipotensive technique | CBF Method | LLA mean (range) |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>McCall*(4)</td>
<td>Hydralazine</td>
<td>K-S/N2O</td>
<td>&lt; 64 (33-80)</td>
</tr>
<tr>
<td></td>
<td>Veratrum viride</td>
<td>K-S/N2O</td>
<td>&lt; 57 (40-72)</td>
</tr>
<tr>
<td></td>
<td>Trimethaphan</td>
<td>K-S/N2O</td>
<td>&gt; 57 (44-75)</td>
</tr>
<tr>
<td></td>
<td>Pendiomide</td>
<td>K-S/N2O</td>
<td>&lt; 61 (54-72)</td>
</tr>
<tr>
<td>Strandgaard(8)</td>
<td>Trimethaphan/tilt</td>
<td>1/A-VDO2</td>
<td>73 ± 9</td>
</tr>
<tr>
<td>Waldemar, et al(10)</td>
<td>Trimethaphan/ lower body negative pressure + captopril</td>
<td>1/A-VDO2</td>
<td>79 (57-101)</td>
</tr>
<tr>
<td>Larsen, et al(11)</td>
<td>Lower body negative pressure/labetalol</td>
<td>1/A-VDO2</td>
<td>79 (53-113)</td>
</tr>
</tbody>
</table>

Drummond JC. Anesthesiology 1997;86:1431-3.
SHOULD BLOOD PRESSURE BE CORRECTED?

**WATERFALL CONCEPT**

- Also called «open model»
- Collapsible veins prevent gravitational pressure gradients from being matched on the arterial and venous sides of the vascular loop → preventing the siphon effect from operating
- Blood «falls» in the descending limb and does not aid the ascending limb
- Heart is solely responsible for pumping blood to the brain → pressure gradient exist from the heart to the brain → arteral pressure related to weight of a column of blood (1 mmHg for each 1.35 cm height difference)
- If MAP at arm 80 mmHg → 38 cm vertical distance to frontal lobes → «corrected» MAP at brain 51.8 mmHg

**CLINICAL STUDIES-SAFETY BCP**

- Most studies have used cerebral oximetry (NIRS) to assess evidence of inadequate oxygen supply to brain
- Measure regional tissue oxygenation (SctO₂) in area of brain vulnerable to changes in oxygen supply / demand (frontal cortex-watershed area)
- Represents primarily venous (75-85%) vs arterial (15-25%) blood
- Critical threshold: decreases in SctO₂ of 15-25%
  - Symptoms cerebral ischemia in awake patients undergoing CEA
  - 20X increased risk of developing cerebral ischemia on EEG (CEA)
  - Cognitive dysfunction /organ dysfunction aftercardiac surgery
  - Longer hospital LOS after abdominal surgery

**REGIONAL CEREBRAL OXYGEN SATURATION AND EEG CHANGES CAUSED BY BEACH CHAIR POSITION**


<table>
<thead>
<tr>
<th>Before BCP</th>
<th>After BCP</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBP (mmHg)</td>
<td>95 ± 13</td>
</tr>
<tr>
<td>DBP (mmHg)</td>
<td>44 ± 7</td>
</tr>
<tr>
<td>HR (bpm)</td>
<td>59 ± 8</td>
</tr>
</tbody>
</table>

All changes were statistically significant

**ABSOLUTE CEREBRAL OXIMETRY IN BENCHCHAIR POSITIONING FOR SHOULDER SURGERY**


- Data collected on 90 patients undergoing shoulder surgery in the BCP (n = 45) or LDP (n = 45)
- GA used in all patients
- SctO₂ assessed in all subjects

**Results**

- BCP resulted in immediate 16.9% decrease in SctO₂
  - No difference in MAP between BCP and LDP groups
  - CDE (defined as SctO₂ below 55%) occurred in 38 of 45 patients in the BCP group, and in 0 of 45 patients in the LDP group

**EUROANESTHESIA 2009**

**TITLE: MONITORING OF ABSOLUTE CEREBRAL OXYGEN SATURATION (FORE-SIGHT TECHNOLOGY) DURING ENDOSCOPIC SHOULDER SURGERY: BENCHCHAIR POSITIONING COMPARED TO CONVENTIONAL POSITIONING**


- SctO₂ data collected on 28 patients undergoing endoscopic shoulder surgery in the BCP (n = 14) or LDP (n = 14)

**Results**

- Mean SctO₂ values were similar between groups at baseline (73%)
- Positioning in BCP resulted in 17.2% decrease in SctO₂ values
- Despite MAP values of 80-90 mmHg in BCP group, ↓ in SctO₂ > 25% were observed in 12 of 14 patients
- No critical drops in SctO₂ were observed in LDP group

**BEACH CHAIR POSITIONING RESULTS IN SIGNIFICANTLY LOWER CEREBRAL OXYGEN SATURATION**


- SctO₂ data collected on 180 patients undergoing shoulder surgery in the BCP (n = 90) or LDP (n = 90)
- All received propofol/remifentenyl GA with block
CEREBRAL OXIMETRY IN PATIENTS UNDERGOING SHOULDER ARTHROSCOPY IN THE SITTING POSITION
Liu SS, et al. ASA Annual Meeting 2010 (A959)

- Examined association of BP management to SctO2 and stroke
- 61 patients received regional anesthesia and sedation

Results
- Baseline SBP 134 mmHg baseline MAP 99 mmHg
- 31% had at least 30% decrease in MAP
- 20% had MAP < 66 mmHg
- 15% had a SBP < 90 mmHg
  - Sc(2) decreases of > 20% from baseline (or < 50%) were observed in only 2% of patients
- No strokes were observed
- Minimal correlations between SBP/MAP and Sc(2) noted

THE EFFECT OF ANESTHETIC TECHNIQUE ON CEREBRAL OXYGENATION IN THE BEACH CHAIR POSITION
Weiner MM, et al. ASA Annual Meeting 2010 (A1532)

- Investigated relationship between rSO2 and MAP/ETCO2
  - 3 groups of patients
    - ISB with propofol sedation (n = 44)  SV
    - ISB with LMA (sevoflurane) (n = 30)  SV
    - ISB with OETT (isoflurane) (n = 7)  MV

CEREBRAL OXYGEN DESATURATION EVENTS
Correlation of SctO2 with MAP at 0, 5 and 10 minutes lagged time

Correlation of SctO2 with ETCO2 at 0, 5 and 10 minutes lagged time

ASSESS By NEAR-INFRARED SPECTROSCOPY DURING SHOULDER ARTHROSCOPY IN THE BEACH CHAIR AND LATERAL DECUBITUS POSITIONS

- Data collected on 124 patients undergoing shoulder surgery in the BCP (n = 61) or LDP (n = 63)
- All patients received a standardized GA
- MAP maintained within 20% of baseline values in all subjects
- Sc(2) measured in all subjects
- CDE defined as a 20% drop in Sc(2) or a decrease in Sc(2) below 55%
- CDE treated according to a standardized protocol
- Postoperative recovery variables assessed to determine association between CDE → impaired clinical recovery
CEREBRAL OXYGENATION: MURPHY, ET AL.

- CDE observed in 80.3% of patients in the BCP group vs 0% in the LDP group (p < 0.0001)
- Median number of CDE was higher in BCP group (4) than the LDP group (0, p < 0.003), as was the median number of interventions to treat CDE (p < 0.0001)

CLINICAL RECOVERY: MURPHY, ET AL.

- Patients with CDE were compared to those without CDE
- No difference between CDE group and no CDE group in early recovery landmarks (open eyes, squeeze hand, tracheal extubation, PACU arrival)
- No difference between CDE group and no CDE group in Aldrete scores in PACU
- No difference between CDE group and no CDE group in PACU LOS

<table>
<thead>
<tr>
<th>CDE Group</th>
<th>No CDE group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nausea</td>
<td>50.0%</td>
</tr>
<tr>
<td>Vomiting</td>
<td>27.3%</td>
</tr>
</tbody>
</table>

CEREBRAL DESATURATION EVENTS DURING SHOULDER SURGERY IN THE BEACH CHAIR POSITION: GENERAL VERSUS REGIONAL ANESTHESIA
Table III. Cerebral desaturation events and treatments.

<table>
<thead>
<tr>
<th></th>
<th>GA group</th>
<th>ISB group</th>
<th>Difference or median difference (99% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>30</td>
<td>30</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Episodes ≥ 20% decrease SctO₂</td>
<td></td>
<td></td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Patients (%)</td>
<td>17 (56.7%)</td>
<td>0 (0%)</td>
<td>56.7% (34.2 to 76.7%)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Episodes in individuals</td>
<td>1 (0-20)</td>
<td>0 (0-0)</td>
<td>1 (0 to 2)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Episodes in group</td>
<td>72</td>
<td>0</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Episodes SctO₂ ≤ 55%</td>
<td></td>
<td></td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Patients (%)</td>
<td>7 (23.3%)</td>
<td>1 (3.3%)</td>
<td>20.0% (-3.6 to 44.5%)</td>
<td>0.052</td>
</tr>
<tr>
<td>Episodes in individuals</td>
<td>0 (0-6)</td>
<td>0 (0-1)</td>
<td>0 (0 to 0)</td>
<td>0.028</td>
</tr>
<tr>
<td>Episodes in group</td>
<td>18</td>
<td>1</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Interventions for SctO₂ drops</td>
<td></td>
<td></td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Patients (%)</td>
<td>13 (43.3%)</td>
<td>0 (0%)</td>
<td>43.3% (21.5 to 65.8%)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Interventions in individuals</td>
<td>0 (0-8)</td>
<td>0 (0-0)</td>
<td>0 (0 to 0)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Interventions in group</td>
<td>38</td>
<td>0</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Interventions for MAP drops</td>
<td></td>
<td></td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Patients (%)</td>
<td>22 (73.3%)</td>
<td>3 (10.0%)</td>
<td>63.3% (32.5 to 82.2%)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Interventions in individuals</td>
<td>2 (0-20)</td>
<td>0 (0-7)</td>
<td>2 (1 to 6)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Interventions in group</td>
<td>131</td>
<td>9</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Phenylephrine dose (micrograms)</td>
<td>400 (0-1,840)</td>
<td>0 (0-560)</td>
<td>320 (320 to 800)</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>

Murphy GS, et al. Submitted for publication

CEREBRAL OXYGEN SATURATION MEASURED BY NEAR-INFRARED SPECTROSCOPY AND JUGULAR VENOUS BULB OXYGEN SATURATION DURING ARTHROSCOPIC SHOULDER SURGERY IN BEACH CHAIR POSITION UNDER SEVOFLURANE-NITROUS OXIDE OR PROPOFOL-REMFENTANYL ANESTHESIA

- 40 patients randomized to receive either sevo-nitrous or propofol-remfentanyl during BCP shoulder surgery
- SjvO₂, SctO₂, and hemodynamics measured in all patients
- MAP decreased in both groups (P/R more than S/N)
- SjvO₂ decreased significantly both groups [P/R (23%) more than S/N (11%)]
- Incidences of CDE did not differ between groups
- SjvO₂ and SctO₂ only weakly correlated


WHAT CAN WE DO TO POTENTIALLY REDUCE THE RISK OF ADVERSE NEUROLOGIC EVENTS FOLLOWING SURGERY IN THE SITTING POSITION?

APSF BOD WORKSHOP RECOMMENDATIONS

Group 1: What further research needs to be done?
- APSF conduct a poll to determine the range of anesthetic practice for shoulder surgery in the BCP
- Establish a national database to identify association between surgery in the BCP and adverse neurologic outcomes
- Fund prospective studies using sensitive markers of cerebral ischemia (neurocognitive testing)
- Fund prospective studies examining how intraoperative factors may influence outcomes after BCP surgery (fluid administration, ventilation, head position)

Group 2: What can companies do to make a difference?
- Develop accurate continuous non-invasive BP monitoring
- Use «smart alarm» to warn clinicians when critical thresholds have been exceeded
- Standardizing the degree of incline used during these procedures
- User-friendly, non-invasive cerebral function monitors
- Educate surgeons about risks of BCP surgery

Group 3: What are the current best practices for BP management?
- No generally accepted method of defining baseline BP
- No non-invasive method of defining LLA for any given patient
- BP in the BCP should be adjusted to account for a hydrostatic gradient
- Deliberate hypotension should be avoided in the BCP
- Maximum reduction in BP from baseline should be 30% after accounting for hydrostatic gradient in BCP
- No consensus on best method to raise BP
- Non-invasive BP should be taken in arm, not leg
Group 4: What should the APSF recommend as the next best steps?

- Increased awareness of the presence of a hydrostatic gradient between BP measurement site in the arm and BP in the brain
- Increased awareness of importance of maintaining BP near baseline values
- Importance of maintaining head in neutral position
- APSF contact surgical journals about risks of deliberate hypotension in BCP
- Increased focus on informed consent and shared responsibility with the surgeon

THE RISKS OF SITTING POSITION SURGERY: CONCLUSIONS

- The incidence of major adverse neurologic events after surgery in the BCP is rare, but is likely under-reported
- The etiology of these events is uncertain, but is likely related to cerebral hypoperfusion due to reductions in CBF or CPP
- Clinical studies with cerebral oximetry/EEG suggest that cerebral ischemia is not a rare event in the BCP
- Deliberate hypotension should be avoided in the BCP
- MAP should be maintained at baseline values \(\rightarrow\) within 30% baseline values after accounting for hydrostatic gradient
- Further studies are urgently needed to assess the incidence, mechanisms, and safety of surgery in the BCP