



## THE INVOS™ CEREBRAL/SOMATIC OXIMETER: MONITORING CEREBRAL PERFUSION IN ORTHOPEDIC SHOULDER SURGERY IN THE BEACH CHAIR POSITION

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The beach chair position (BCP) is commonly used in orthopedic shoulder surgery procedures. This position allows easier intra-articular visualization due to the elevation of the patient's head above the horizontal plane. However, elevation of the patient's head may contribute to gravitational effects on cerebral perfusion and rotation of the patient's head may contribute to obstruction of cerebral vessels.<sup>1,2</sup> These gravitational effects should be tolerated if the patient's blood pressure remains within the auto-regulation range.<sup>1</sup>

Laflam et al concluded that patients undergoing shoulder surgery in the beach chair position may have impaired auto regulation and lower cerebral perfusion (rSO<sub>2</sub>)<sup>1</sup> than those in the lateral decubitus position. Additionally, there is an anesthetic effect on cerebral perfusion. As Aguirre et al demonstrated, patients undergoing shoulder surgery in the beach chair position with general anesthesia have significant decrease in cerebral perfusion as compared to those under regional anesthesia.<sup>3</sup>

Maintaining adequate cerebral perfusion during surgery is imperative to preventing cerebral ischemia. In order to prevent cerebral ischemia, the patient's blood pressure is taken at the arm and the leg to estimate cerebral blood

pressure. However, this method may be unreliable as Jacobs et al demonstrated that in the beach chair positions non-invasive blood pressure and estimated temporal mean arterial blood pressure are "unreliable methods for identifying a cerebral desaturation event."

Moreover, rare but devastating neurologic complications, including stroke<sup>4</sup> and spinal cord ischemia<sup>2,5</sup> and visual loss<sup>6</sup> have been associated with cerebral desaturation and have been reported in relatively healthy patients undergoing shoulder surgery in the beach chair position.

The Society for Neuroscience in Anesthesiology and Critical Care state that the results of Laflam et al. study "suggest the need for strict hemodynamic management with higher blood pressure" in shoulder surgery utilizing the beach chair position.<sup>7</sup> Moerman et al concluded, the occurrence of cerebral desaturation during shoulder surgery in the beach chair position suggests the need for perioperative cerebral perfusion monitoring.

Cerebral desaturation can be monitored in the beach chair position by the INVOS™ system enabling clinicians to detect changes in order to make timely, critical lifesaving decisions for improved patient outcomes.





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# Cerebral oximetry provides additional information along with noninvasive blood pressure and mean arterial pressure to provide a more accurate estimate of cerebral desaturation

## Cerebral desaturation events in the beach chair position: correlation of noninvasive blood pressure and estimated temporal mean arterial pressure

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<b>Study design</b>	Single center prospective trial
<b>Methods</b>	Values recorded in supine position (0°) after induction and beach chair position (70°) after a CDE occurred for: <ul style="list-style-type: none"> <li>▪ eTMAP</li> <li>▪ NIBP</li> <li>▪ rSO<sub>2</sub></li> </ul>
<b>N</b>	Total enrolled: 56 adult patients
<b>Population</b>	Elective shoulder surgery
<b>Definition of desaturation</b>	20% drop in rSO <sub>2</sub> from baseline (after induction, supine)
<b>Threshold for intervention</b>	When a CDE occurred, no single variable was used to justify an intervention however; blood pressure, end-tidal carbon dioxide, head position, and sensor were checked. The sensor or patient position was changed if needed.
<b>Results</b>	26 patients experienced 45 cerebral desaturation events and during CDEs no significant correlations were found between rSO <sub>2</sub> and NIBP or between rSO <sub>2</sub> and eTMAP. <ul style="list-style-type: none"> <li>▪ No statistically significant correlation between the decrease in rSO<sub>2</sub> and the decrease in NIBP from baseline to CDE</li> <li>▪ No association between the decrease in rSO<sub>2</sub> and the decrease in eTMAP from baseline to CDE</li> </ul>
<b>Conclusions</b>	NIBP, eTMAP, and rSO <sub>2</sub> should all be jointly considered for the most accurate estimate of cerebral perfusion because NIBP and eTMAP alone can not reliably establish a CDE





# For patients in BCP, ventilation strategy positively influences cerebral perfusion regardless of anesthetic technique

## Influence of ventilation strategies and anesthetic techniques on regional cerebral oximetry in the beach chair position

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<b>Study design</b>	Single center within-group prospective trial
<b>Methods</b>	Patients randomly assigned to receive either propofol or desflurane
<b>Objective</b>	To examine the effect of modulation of $F_{IO_2}$ and $PET_{CO_2}$ and changes in $rSO_2$ in patients anesthetized in the BCP
<b>N</b>	Total enrolled: 56 adult patients
<b>Population</b>	Elective shoulder surgery
<b>Definition of desaturation</b>	20% drop in $rSO_2$ from baseline (after induction, supine) Absolute $rSO_2$ value <55%
<b>Threshold for intervention</b>	Five set points were established for ventilation interventions <ol style="list-style-type: none"> <li>1. <math>F_{IO_2}</math> at 0.3 and <math>PET_{CO_2}</math> at 30 mmHg – supine position</li> <li>2. <math>F_{IO_2}</math> at 0.3 and <math>PET_{CO_2}</math> at 30 mmHg – BCP</li> <li>3. <math>F_{IO_2}</math> at 1.0 and <math>PET_{CO_2}</math> at 30 mmHg – BCP</li> <li>4. <math>F_{IO_2}</math> at 1.0 and <math>PET_{CO_2}</math> at 45 mmHg – BCP</li> <li>5. <math>F_{IO_2}</math> at 0.3 and <math>PET_{CO_2}</math> at 30 mmHg – BCP</li> </ol>
<b>Results</b>	In the BCP, with $F_{IO_2}$ at 0.3 and $PET_{CO_2}$ at 30 mmHg, $rSO_2$ decreased from 68% to 61% compared to patients in the supine position with the same ventilation parameters. In the BCP, $rSO_2$ values were 14% higher when $F_{IO_2} = 1.0$ and $PET_{CO_2} = 45$ mmHg than when $F_{IO_2} = 0.3$ and $PET_{CO_2} = 30$ mmHg. In addition, patients in the BCP $rSO_2$ values were 7% higher than patients in the supine position when $F_{IO_2} = 0.3$ and $PET_{CO_2} = 30$ mmHg. Overall, ventilation strategies have an effect on $rSO_2$ whereas $rSO_2$ values change directionally with changes in $F_{IO_2}$ at 0.3 and $PET_{CO_2}$ .
<b>Conclusions</b>	For patients in BCP, modulation of inspired gas composition results in an increase in cerebral perfusion regardless of anesthetic.





# Patients undergoing shoulder surgery in the beach chair position with general anesthesia have significant decrease in cerebral desaturation as compared those under regional aesthesia

Cerebral oxygenation in patients undergoing shoulder surgery in beach chair position: Comparing general to regional anesthesia and the impact on neurobehavioral outcome

Aguirre J, et al.

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<b>Study design</b>	Prospective, assessor-blinded study
<b>Methods</b>	<p>Pre-surgery, standardized neurological control and neurobehavioral tests were conducted for baseline measurements INVOS™ monitoring was used to measure cerebral saturation levels (rSO<sub>2</sub>)</p> <ul style="list-style-type: none"> <li>▪ rSO<sub>2</sub> were recorded at the following times: <ul style="list-style-type: none"> <li>▪ Before induction</li> <li>▪ 5 minutes after induction of general/regional anesthesia</li> <li>▪ 5 minutes after beach-chair position</li> <li>▪ At surgery start</li> <li>▪ Every 20 minutes until discharge to PACU/ward and at periods of undesirable events</li> </ul> </li> </ul>
<b>Objective</b>	<ul style="list-style-type: none"> <li>▪ To compare the effects of regional vs general anesthesia on cerebral desaturation events and the impact on neurobehavioral and neurological outcomes</li> <li>▪ To focus on the influence of cardiovascular risk factors on intraoperative cerebral desaturation events and the associated impact on length of stay</li> </ul>
<b>N</b>	<ul style="list-style-type: none"> <li>▪ 90</li> <li>▪ General Anesthesia Group = n=45</li> <li>▪ Regional Anesthesia Group = n=45</li> </ul>
<b>Population</b>	Elective shoulder surgery in beach chair position with general or regional anesthesia
<b>Definition of desaturation</b>	≥20% from baseline or absolute value <55% for >15secs
<b>Threshold for intervention</b>	N/A
<b>Results</b>	<p>Compared to patients in the general anesthesia beach chair position group, the regional anesthesia group had:</p> <ul style="list-style-type: none"> <li>▪ Significantly less cerebral desaturation events</li> <li>▪ Drops in cerebral saturation values</li> <li>▪ Significantly better neurobehavioral test results the day after surgery</li> <li>▪ Greater hemodynamic stability</li> </ul>
<b>Conclusions</b>	General anesthesia in beach chair position has a negative impact on both cerebral desaturation events and neurobehavioral outcomes associated with systemic and regional hypotension.





# The occurrence of cerebral desaturation during shoulder surgery in the beach chair position suggests the need for cerebral perfusion monitoring with INVOS™ technology

## Cerebral oxygen desaturation during beach chair position

Moerman AT, De Hert SG, Jacobs TF, De Wilde LF, Wouters PF.

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<b>Study design</b>	Single center prospective, observational, blinded study
<b>Methods</b>	Routine anesthesia management, standard monitoring, and INVOS™ monitoring for cerebral oxygen desaturation rSO <sub>2</sub> at the following times: <ul style="list-style-type: none"> <li>▪ Before induction</li> <li>▪ Before position change to beach chair</li> <li>▪ 5 minutes after beach-chair position</li> <li>▪ At the minimum rSO<sub>2</sub></li> </ul>
<b>Objective</b>	To identify cerebral desaturation during shoulder surgery in the beach chair position under general anesthesia using standard monitoring To identify potential physiological changes that might be associated cerebral desaturation due to postural changes
<b>N</b>	20
<b>Population</b>	Adult patients undergoing elective shoulder surgery in the beach chair position under general anesthesia
<b>Definition of desaturation</b>	20% from baseline
<b>Threshold for intervention</b>	N/A
<b>Results</b>	<ul style="list-style-type: none"> <li>▪ 80% of patients rSO<sub>2</sub> decreased 20% or more</li> <li>▪ 30% of patients rSO<sub>2</sub> absolute value decreased below 50%</li> </ul>
<b>Conclusions</b>	The occurrence of cerebral desaturation during shoulder surgery in the beach chair position suggests the need for cerebral perfusion monitoring.





# The beach chair position and induced hypotension significantly decreases cerebral saturation in patients undergoing arthroscopic shoulder surgery

## Effects of beach-chair position and induced hypotension on cerebral oxygen saturation in patients undergoing arthroscopic shoulder surgery

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<b>Study design</b>	Single center prospective trial
<b>Methods</b>	<p>INVOS™ monitoring and use of an interventional protocol to restore cerebral saturation levels (rSO<sub>2</sub>)</p> <p>MAP and rSO<sub>2</sub> were recorded at the following times:</p> <ul style="list-style-type: none"> <li>▪ Before induction (T0)</li> <li>▪ 5 minutes after induction (T1 [baseline])</li> <li>▪ 5 minutes after beach-chair position (T2)</li> <li>▪ 5 minutes after induced hypotension (T3)</li> <li>▪ 1 hour after induced hypotension (T4)</li> <li>▪ After supine position at the end of surgery (T5)</li> </ul>
<b>Objective</b>	<ul style="list-style-type: none"> <li>▪ Investigate the effects of the beach-chair position and induced hypotension on cerebral saturation (rSO<sub>2</sub>) in patients undergoing arthroscopic shoulder surgery with general anesthesia</li> <li>▪ Investigate the relationship between the change in rSO<sub>2</sub> and post-operative cognitive function</li> </ul>
<b>N</b>	27
<b>Population</b>	Adult patients undergoing elective arthroscopic shoulder surgery
<b>Definition of desaturation</b>	80% of baseline value
<b>Threshold for intervention</b>	<80% of baseline rSO <sub>2</sub>
<b>Results</b>	<ul style="list-style-type: none"> <li>▪ rSO<sub>2</sub> values were influenced by the beach chair position as indicated by the decrease in values after induction and after beach chair position</li> <li>▪ Significant decrease in MAP and rSO<sub>2</sub> in the beach chair position compared to the supine position</li> <li>▪ Induced hypotension decreased MAP values but did not impact rSO<sub>2</sub></li> <li>▪ A relationship exists between rSO<sub>2</sub> and MAP as demonstrated by the CDEs that occurred after MAP fell below 60 mm Hg and resolved after MAP increased to over 60 mm Hg</li> </ul>
<b>Conclusions</b>	Patients undergoing arthroscopic surgery under general anesthesia combined with induced hypotension had significantly decreased rSO <sub>2</sub> when placed in BCP.





## Clinical utility/outcomes improvement in shoulder surgery in the beach chair position

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Publication	Study Results
Triplet, et al, <i>Journal of Elbow Surgery</i> 2015	<ul style="list-style-type: none"> <li>▪ Cerebral desaturations events were common</li> <li>▪ NIBP, eTMAP and rSO<sub>2</sub> should all be used jointly</li> <li>▪ rSO<sub>2</sub> provides additional information to determine CDE</li> </ul>
Picton, et al, <i>Anesthesiology</i> 2015	For patients in BCP, modulation of inspired gas composition results in an increase in cerebral perfusion regardless of anesthetic
Aguirre J, et al, <i>Revista Española de Anestesiología y Reanimación</i> , 2013	General anesthesia in beach chair position has a negative impact on both cerebral desaturation events and neurobehavioral outcomes associated with systemic and regional hypotension
Moerman, et al, <i>European Journal of Anesthesiology</i> 2012	In the beach chair position 80% of patients rSO <sub>2</sub> decreased 20% or more suggesting a need for cerebral oxygenation monitoring during BCP
Jae Hoon Lee, et al, <i>The Journal of Arthroscopic and Related Surgery</i> , 2011	<ul style="list-style-type: none"> <li>▪ rSO<sub>2</sub> values were influenced by the beach chair position as evidenced by significant decrease in MAP and rSO<sub>2</sub></li> <li>▪ Induced hypotension decreased MAP values but did not impact rSO<sub>2</sub></li> </ul>







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