Prevalence of Cerebrovascular Events During Shoulder Surgery and Association With Patient Position

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abstract

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The beach chair position is commonly used in both arthroscopic and open shoulder procedures. There has been recent concern that beach chair positioning may be an independent risk factor for intraoperative cerebrovascular insult, especially in concert with hypotensive anesthesia. We attempted to quantify the prevalence of intraoperative cerebrovascular events during shoulder surgery in the beach chair position.

Two hundred and eighty-seven members of the American Shoulder and Elbow Surgeons (ASES) Society were e-mailed surveys, and 93 (32%) responded. The majority of these surgeons average >300 shoulder cases annually. Most of these cases are arthroscopic, and patient position is primarily beach chair. The total number of beach chair–position surgeries was estimated between 173,370 and 209,628, and lateral decubitus–position surgeries were estimated between 64,597 and 100,855. The overall rate of intraoperative cerebrovascular event was 0.00291% (8/274,225). All cerebrovascular events were associated with surgeries in the beach chair position. The rate in the beach chair position ranged from 0.00382% (8/209,628) to 0.00461% (8/173,370). If reported primary patient position was used ⩾75% of the time, no significant difference in observed cerebrovascular event rates was found between positions (P=.051–.0233).

In relation to orthopedic procedures performed in the supine position, beach chair positioning does not appear to increase the risk of intraoperative cerebrovascular event.

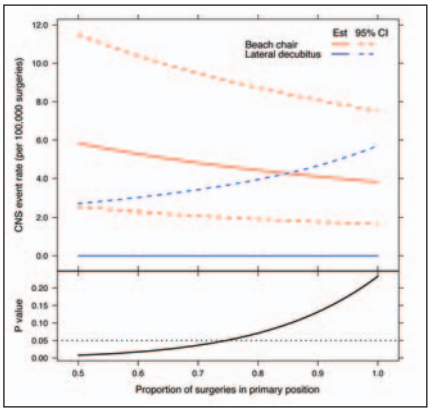

Figure: Intraoperative cerebrovascular event rates per position across a range of probability and corresponding trend in P values. Abbreviation: CNS, cerebrovascular.

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Surgery on or about the shoulder is one of the most common procedures performed by orthopedic surgeons.[1] The beach chair position is commonly used in both arthroscopic and open shoulder procedures. The majority of these procedures are tolerated well by the patient without any residual sequalea. The beach chair position allows access to both the anterior and posterior aspects of the shoulder without placing undue tension across the joint and surrounding soft tissues. Anesthesiologists have direct access to the airway and there may be less bleeding in the upright position. For these reasons beach chair positioning has gained wide acceptance among orthopedic surgeons. However, there has been recent concern that beach chair positioning may be an independent risk factor for intraoperative cerebrovascular insult, especially in concert with hypotensive anesthesia.[2-4]

The beach chair position for shoulder arthroscopy has been used since the early 1980s. Skyhar et al[5] reported their clinical experience and technique after treating 50 consecutive patients in this position in 1987. Patients are positioned sitting up at $\geq 70°$ with the operative shoulder draped free.[5,6] The head is secured in a well-padded headrest. The arm is either placed in a mechanical arm holder or controlled by an assistant. This allows for unimpeded positioning of the glenohumeral joint without distortion of the intra-articular anatomy with minimal to no traction on the brachial plexus.

Perioperative stroke is an uncommon complication. Hart and Hindman[7] found that perioperative cerebral infarction occurs in $<1\%$ of general surgical procedures and that the mechanism is usually unknown. Landercasper et al[8] reported a 0.01% to 0.5% incidence of new stroke occurring in the postoperative period in patients with a prior history of stroke. Despite its relatively low incidence, perioperative stroke can be a devastating complication. The overall mortality rate for stroke in general is between 15% and 46%, while in the perioperative setting the mortality rate may be as high as 60%.[7]

Data on the incidence of intraoperative stroke on those undergoing shoulder surgery are limited. Small[9] reported on 14,329 shoulder arthroscopies and found 3 brachial plexus injuries, 1 axillary nerve injury, and no perioperative cerebrovascular events. However, it is unclear how many of the reported cases were performed in the beach chair position.

Based on the paucity of literature regarding this subject, we attempted to determine the frequency of intraoperative cerebrovascular events during shoulder surgery as well as any association with patient position. We conducted a survey of practicing orthopedic physicians with a specialty in shoulder surgery to clarify the incidence and potential risk of this complication.

Materials and Methods

Questionnaire Development

We developed a questionnaire to examine surgeons' experience in shoulder surgery, surgical volume, preference in patient positioning, preference in intraoperative blood pressure monitoring, and history of intraoperative cerebrovascular insult. Four shoulder-trained orthopedic surgeons were involved in the development of the questionnaire. The questionnaire was pretested by an independent group of 3 shoulder-trained orthopedic surgeons to evaluate the following: 1) does the questionnaire as a whole appear to adequately address the question of incidence of intraoperative stroke during shoulder surgery and determine association with patient position (face validity), and 2) do the individual questions adequately reflect the broad domains of surgeon operative shoulder experience, patient positioning preferences, intraoperative monitoring, and history of intraoperative stroke (content validity).[10] The surgeons also commented on the clarity and comprehensiveness of the questionnaire.

The final questionnaire framed the response options with multiple choices. There were no open-ended questions. It has been shown that closed-ended questions result in fewer incomplete responses than open-ended questions.[11] The respondents indicated if they were fellowship-trained in shoulder surgery. The respondents indicated how many years they have been in clinical practice, the number of shoulder cases they perform annually, and the total number of cases they have performed in their career. They also answered questions regarding their preference for intraoperative blood pressure monitoring as well as what value they request during arthroscopy. All responses offered a range of values. The respondents indicated their preferred patient position during arthroscopy and open surgery. Lastly, the respondents noted if any of their patients had sustained an intraoperative cerebrovascular insult resulting in transient or permanent sensory or motor disability, and if so, how many times this had happened.

Questionnaire Administration

We identified all surgeons who were members of the American Shoulder and Elbow Surgeons (ASES) Society through the ASES administrative office. Each surgeon received a cover letter with instructions and survey via electronic mail sent from an ASES administrator. All surveys were completed electronically and sent back either to the ASES or directly to us. Individual responses remained confidential, and questionnaire completion was voluntary.

Statistical Analysis

All question responses that consisted of a range of values were calculated using the average value of the range. A P value ranging from .75 to 1.0 was set to reflect the probability of a surgeon using his or her reported primary patient position. If the primary position indicated for both open and arthroscopic surgery was beach chair, then total number of beach chair surgeries was calculated as P multiplied by the estimated total, and total number of

Table 1

Estimated Surgeries, Cerebrovascular Events, and *P* Values Across a Range of Probability

Beach Chair Position				Lateral Decubitus Position			
Surgeries	Cerebrovascular Events	Rate[a] (95% CI)	*P* Value	Surgeries	Cerebrovascular Events	Rate[a] (95% CI)	*P* Value
138,563	8	5.77 (2.49,11.4)	.51	135,662	0	0.00 (0.00,2.72)	.008
173,370	8	4.61 (1.99,9.09)	.75	100,855	0	0.00 (0.00,3.66)	.051
209,628	8	3.82 (1.65,7.52)	1.00	64,597	0	0.00 (0.00,5.71)	.233

[a]*Number of cerebrovascular events per 100,000 surgeries.*

lateral decubitus surgeries was calculated as 1-*P* multiplied by the estimated total. If the primary position indicated for both open and arthroscopic surgery was lateral decubitus, then total number of lateral decubitus surgeries was calculated as *P* multiplied by the estimated total, and total number of beach chair surgeries was calculated as 1-*P* multiplied by the estimated total. If the primary position differed between open and arthroscopic surgeries, the total number of surgeries by position was determined independently for both open and arthroscopic surgery, with *P* ranging from .75 to 1.0.

As an approximation, the risk of intraoperative cerebrovascular event was assumed to be independent among all surgeries. As such, the number of cerebrovascular events is Poisson distributed. Point estimates of the cerebrovascular event rate were calculated as simple ratios of the number of cerebrovascular events observed in a given position and the estimated total number of surgeries performed in that position, separately for each value of *P*. Interval estimates were calculated as exact 95% confidence intervals under the assumption of Poisson-distributed events.

Point and interval estimates for event rates among surgeons reporting mean arterial pressure, systolic, or diastolic intraoperative blood pressure assessment were calculated assuming that the reported intraoperative assessment method was used for all surgeries conducted by a given surgeon.

Exact logistic regression was used to test whether cerebrovascular event rates were equal between beach chair and lateral decubitus surgeries, separately for each value of *P*, and among the 3 intraoperative blood pressure assessment methods.

RESULTS

Two hundred and eighty-seven surgeons were e-mailed the survey, and 93 responded (32%). The total number of reported shoulder surgeries was 274,225 among all surgeons. The total number of beach chair surgeries ranged from 173,370 ($P=.75$) to 209,628 ($P=1.0$). The total number of lateral decubitus surgeries ranged from 100,855 ($P=.75$) to 64,597 ($P=1.0$). A total of 8 intraoperative cerebrovascular events were reported among 7 surgeons. All reported cerebrovascular events were associated with surgeries in the beach chair position. The overall rate of cerebrovascular event was 0.00291% (8/274,225). The rate in the beach chair position ranged from 0.00382% (8/209,628; $P=1.0$) to 0.00461% (8/173,370; $P=.75$). Table 1 lists the estimated number of surgeries, cerebrovascular event rates, and *P* values for testing whether the rates differ between positions for a range of *P* values. The Figure illustrates the trend across the full range of *P* from .5 to 1.0. If surgeons used their reported primary patient position ⩾75% of the time (and the assumption of independent events holds), no statistically significant difference was found in the observed cerebrovascular event rates between positions ($P>.05$).

Table 2 lists the estimated number of surgeries and cerebrovascular event rates for the 3 intraoperative blood pressure assessment methods, assuming that the reported method was used for all surgeries performed by a given surgeon. There was no statistically significant difference between event rates and type of assessment method ($P=.59$). Too few events were observed to evaluate whether risk differed across the target blood pressure levels for a given intraoperative assessment method.

DISCUSSION

We could not identify the beach chair position to be an independent risk factor for intraoperative cerebrovascular event. In relation to orthopedic procedures performed in the supine position, beach chair positioning does not appear to increase the risk of intraoperative cerebrovascular event.

Parvizi et al[12] found 6 cases of stroke or transient ischemic attack in a series of 1636 cases (.37%) of lower extremity arthroplasty. This is roughly 90 times greater than our estimated rate of 0.00382% to 0.00461%. It is possible that this difference was due to an older patient population with more comorbidities, as well as increased intraoperative blood loss in relation to shoulder surgery. The results of our survey also indicate that shoulder surgery in the beach chair position

Table 2

Estimated Surgeries and Cerebrovascular Event Rates for 3 Blood Pressure Assessment Methods

Blood Pressure Method	Surgeons	Surgeries	Cerebrovascular Events	Rate[a] (95% CI)
Mean Arterial Pressure	25	89,675	4	4.46 (1.22,11.4)
Systolic	45	137,675	4	2.91 (0.79,7.44)
Diastolic	5	22,275	0	0.00 (0.00,16.6)

[a]*Number of cerebrovascular events per 100,000 surgeries.*

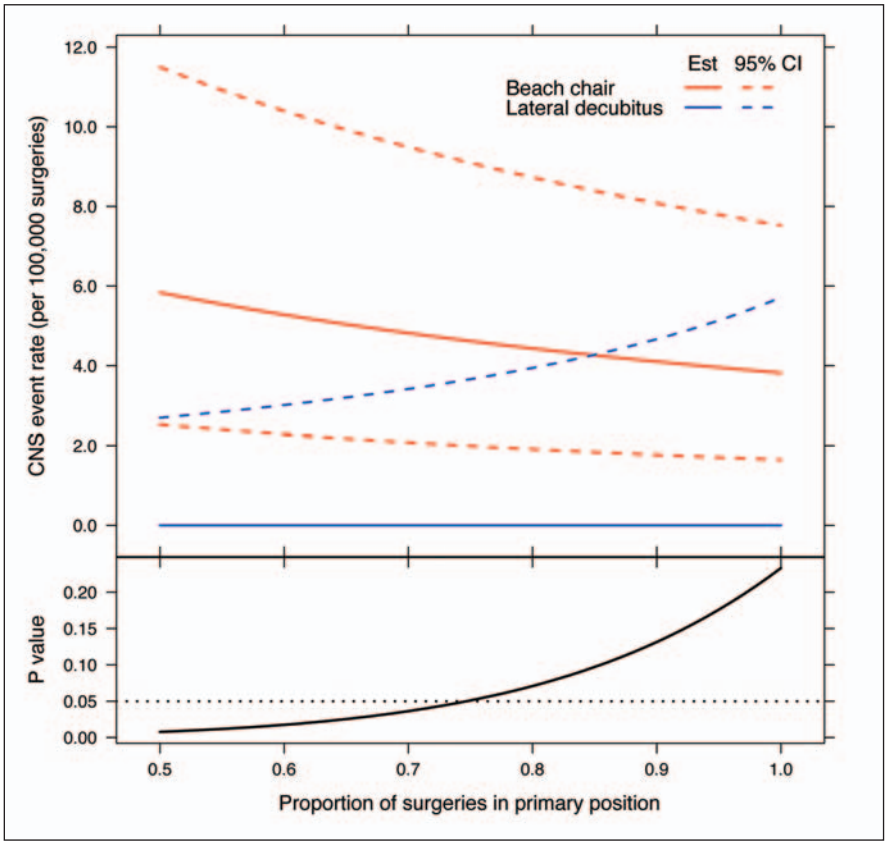

Figure: Intraoperative cerebrovascular event rates per position across a range of probability and corresponding trend in *P* values. Abbreviation: CNS, cerebrovascular.

is safer or commensurate with general surgical procedures regarding the risk of stroke. The risk of perioperative cerebral infarction is <1% after general surgery procedures and the mechanism is usually unknown.[7] Certain procedures have an inherent risk of cerebral infarction. Bucerius et al[13] determined the overall incidence of stroke was 4.6% in those undergoing open cardiac surgery, with rates up to 9.7% in those undergoing multiple valve replacement surgery.

Patient position does contribute to physiologic changes. In the beach chair position, the blood pressure at the calf is higher than at the head or arm. This difference is primarily due to hydrostatic gradients between the calf, heart, and head. The hydrostatic difference alone could be approximately 50 in, or equivalent to a 94-mmHg pressure variation from calf to head.[14] Intraoperative blood pressure monitoring via the calf will lead to falsely elevated readings, and titration of these values could result in insufficient blood flow to the brain.

Cerebral perfusion pressure decreases by approximately 15% in the sitting position in nonanesthetized patients and could further decrease under anesthesia due to vasodilatation and impaired venous return.[4] Pohl and Cullen reported a case series of 4 patients who sustained ischemic brain and spinal cord injury after shoulder surgery in the beach chair position.[4] They stated that "shoulder surgery in the beach chair position presents a unique risk for intraoperative stroke among orthopaedic procedures, which can be attributed to postural hypotension as well as head and neck manipulation leading to changes in cerebral blood flow."

While physiologic changes do occur in the sitting position, the findings of our survey are not consistent with this statement. These comments appear to be poorly substantiated as they are based on 4 unrelated cases, each confounded by multiple variables. Also, the location of the blood pressure cuff is not reported in 3 of the cases and in the fourth case was placed on the calf. Lastly, the exact role of hypoperfusion in cerebral infarction is unclear. Whitney et al[15] found that hypoperfusion ischemia is a rare cause of perioperative stroke, even in patients undergoing carotid endarterectomy with occlusion of the contralateral carotid artery. Similar results have been found by several other authors.[16,17]

Small[9] reported on complications in arthroscopy and found no evidence of stroke or transient ischemic attack after 395,566 arthroscopies. There was 1 reported grand mal seizure related to local anesthetic use. Four peripheral nerve injuries were reported after 14,329 cases of shoulder arthroscopy. The surgical position during

these cases was not reported; however, it is likely the majority were performed in the lateral decubitus position, as these results were published in 1986, prior to the popularization of beach chair positioning.

We did not assume that each surgeon used his or her primary patient position 100% of the time to ensure statistical validity. Probability values ranged from .75 to 1.0 to reflect the probability of a surgeon using his or her reported primary patient position. In our experience, we have found it extremely rare for a surgeon to consistently use both positions. One position is usually used for all or the vast majority of arthroscopic cases. However, statistical analysis revealed that even if surgeons only used their primary position 75% of the time, there was still no significant difference in the observed cerebrovascular event rates between positions.

An inherent weakness of this study is that it relies solely on the memory of the surgeon. It is possible that the number of procedures performed by each surgeon is fewer than stated and that the number of complications reported is greater than stated. The actual rate of intraoperative cerebrovascular insult may be greater than reported in this survey. Another weakness is that the survey was only sent to members of the ASES. Thus, the results here may not reflect the surgeon who occasionally performs arthroscopy. Lastly, all estimates assume independent events and may underestimate the true variance in event counts. If the risk of cerebrovascular event varies substantially among surgeons, then the calculated *P* values are anticonservative and thus should be interpreted with caution.

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