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Total intravenous anesthesia compared to traditional general anesthesia in shoulder arthroscopy with interscalene block in the beach chair position

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Background: Shoulder arthroscopy is commonly performed in the beach chair position, which has been linked to cerebral oxygen desaturation. Previous studies comparing general anesthesia (GA) to total intravenous anesthesia (TIVA) using propofol indicate that TIVA can preserve cerebral perfusion and autoregulation, as well as shorten recovery time and reduce the incidence of postoperative nausea and vomiting. However, few studies have evaluated the use of TIVA in shoulder arthroscopy. Thus, this study seeks to determine if TIVA is superior to traditional GA methods in terms of improving operating room efficiency, shortening recovery time, and reducing adverse events while theoretically preserving cerebral autoregulation in patients undergoing shoulder arthroscopy in the beach chair position.
Methods: This is a retrospective study of patients undergoing shoulder arthroscopy in the beach chair position, comparing 2 anesthetic techniques. One hundred fifty patients were included (75 TIVA and 75 GA). Unpaired *t*-tests were used to determine statistical significance. Outcome measures included operating room times, recovery times, and adverse events.
Results: Compared to GA, TIVA significantly improved phase 1 recovery time (53.2 ± 32.9 min compared to 65.8 ± 41.3 min; $P = .037$) and total recovery time (120.3 ± 31.0 min compared to 131.5 ± 36.8 min; $P = .048$). TIVA also decreased time from case finish to out-of-room (6.5 ± 3.5 min compared to 8.4 ± 6.3 min; $P = .021$). However, the in-room to case start time was slightly longer for the TIVA group (31.8 ± 7.22 min compared to 29.2 ± 4.92 min; $P = .012$). Although not statistically significant, there were fewer readmissions in the TIVA group compared to the GA group ($P = .08$), and TIVA had lower rates of postoperative nausea and vomiting ($P = .22$) and higher intraoperative mean arterial pressures (87.1 ± 11.4 mmHg in the TIVA group compared to 85.0 ± 9.3 mmHg in the GA group; $P = .22$).
Conclusion: TIVA may be a safe and efficient alternative to GA in shoulder arthroscopy in the beach chair position. Larger scale studies are needed to evaluate the risk of adverse events related to impaired cerebral autoregulation in the beach chair position.

Approximately two-thirds of arthroscopic shoulder surgeries in the United States are performed in the beach chair position, as of 2014.[4] The beach chair position was first developed in the early 1980s by Skyhar et al on 50 patients. They reported no complications and multiple advantages of the beach chair positioning, including ease of setup, lack of brachial plexus strain, excellent intra-articular visualization for all types of arthroscopic shoulder procedures, and ease of conversion to open approach if needed.[10] Furthermore, the beach chair position maintains anatomic orientation, creating a favorable teaching environment for surgeons in training.[7] It also allows easy manipulation of the arm to visualize different areas of the shoulder, including the anterior shoulder structures, posterosuperior rotator cuff, subacromial space, and glenohumeral joint.[7] This setup does not require the traction/weight used in the lateral decubitus position, decreasing the risk for brachial plexus injury.[7]

However, there are also potential disadvantages to beach chair positioning. Several studies have raised concerns about the loss of cerebral autoregulation, cerebral hypoperfusion, and ischemia when raising a patient from the supine to sitting position while

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under general anesthesia (GA).[7] A number of clinical trials have found a decrease in regional brain oxygenation and a higher incidence of cerebral desaturation events with beach chair positioning.[7] Hypotension can occur when positioning a patient from the supine to beach chair position, and GA blunts baroreceptor responses, resulting in reductions in systemic vascular resistance and cardiac output.[7] This may increase the risk of neurological injury.[7] While there are case reports describing significant neurological injuries after beach chair positioning including stroke, coma, and quadriplegia, the degree and duration of cerebral ischemia required to produce neurocognitive dysfunction remains undefined.[7,9]

Total intravenous anesthesia (TIVA) is GA given through only intravenous agents. In general, TIVA has been shown to be superior to inhalational anesthesia for prevention of postoperative nausea and vomiting (PONV).[6] Studies indicate that TIVA use is associated with improved recovery, including shorter recovery room stay, earlier discharge, and greater patient satisfaction.[6] While studies have demonstrated that inhaled anesthetics can impair cerebral autoregulation, intravenous agents, such as propofol, have been shown to preserve it.[12] However, one concern with TIVA is patient alertness, with most cases of self-reported awareness occurring in patients who received a neuromuscular blocking drug.[8] Therefore, processed EEG monitoring is recommended when a neuromuscular blocking drug is used with TIVA.[8]

Overall, TIVA has become more popular over the past 20 years in a number of patient groups and settings.[6] However, there are very few studies in the orthopedic literature evaluating the use of TIVA in shoulder arthroscopy in the beach chair position.

The purpose of this study is to determine if TIVA is superior to traditional GA methods in terms of improving operating room (OR) efficiency, shortening recovery time, and reducing adverse events while theoretically preserving cerebral autoregulation in patients undergoing shoulder arthroscopy in the beach chair position. We hypothesize that TIVA will improve the ability to maintain appropriate mean arterial pressure (MAP) with minimal medication and will decrease overall OR time, time spent in postanesthesia care unit, and will have a decreased incidence of PONV and readmission rates compared to traditional GA in patients undergoing shoulder arthroscopy in the beach chair position.

Methods

This is a retrospective study of 150 total patients, that is, 75 sequentially selected patients who underwent shoulder arthroscopy in the beach chair position with TIVA and 75 sequentially selected patients who underwent shoulder arthroscopy in the beach chair position with traditional GA. An institutional review board approval was obtained for this study. Surgeries were performed by a single surgeon at our institution between 2018 and 2020. All patients in the TIVA group received an interscalene block with 0.5% ropivicaine. All patients except 3 (96%) in the GA group received an interscalene block with 0.5% ropivicaine. TIVA consisted of propofol around 50-75 mcg/kg/min plus a small amount of ketamine if biceps tenodesis was performed. Airway protection was not used for TIVA, and there were no patients who required conversion to endotracheal intubation. Neuromuscular blocking drugs were not used in patients who underwent TIVA. Therefore, processed EEG monitoring was not routinely performed. GA consisted of both inhalational and intravenous anesthesia, and patients underwent endotracheal intubation.

Exclusion criteria for this study were (1) patients younger than 18 years at the time of the study, (2) pregnant women, (3) patients unfit for day surgery, and (4) patients who underwent shoulder arthroscopy in the lateral decubitus position.

Table I
Demographics.

	General (n = 75)	TIVA (n = 75)	*P* value
Age	63.0 ± 10.5 y	64.3 ± 9.4 y	.76
Sex	46 M : 29 F	44 M : 21 F	.85
BMI	30.6 ± 6.1	30.8 ± 5.6	.9
ASA score	2.6 ± 0.6	2.3 ± 0.53	.1

BMI, body mass index; *ASA*, American Society of Anesthesiologists; *TIVA*, total intravenous anesthesia.

Table II
Operating room and recovery times.

	General (n = 75)	TIVA (n = 75)	*P* value
In-room to case start (min)	29.2 ± 4.92	31.8 ± 7.22	.012*
Case finish to out-room (min)	8.4 ± 6.3	6.5 ± 3.5	.021*
Time in phase 1 recovery (min)	65.8 ± 41.3	53.2 ± 32.9	.037*
Time in phase 2 (min)	65.7 ± 32.3	67.1 ± 31	.78
Total recovery time (min)	131.5 ± 36.8	120.3 ± 32	.048*

TIVA, total intravenous anesthesia.
* Statistically significant ($P < .05$).

For each subject, MAP, time from patient entering the OR to incision, time from end of procedure to patient out-of-room, duration in phase 1 and 2 postanesthesia care, PONV, and readmission rates were collected from the electronic medical record. Phase 1 is defined as care focused on the patient's recovery from anesthesia and return to baseline vital signs, while the goal of phase 2 is to prepare the patient to be transferred home or to an extended care facility. Statistical analysis (*t*-test) was performed using Excel (Microsoft, Richmond, VA, USA) for means and standard deviation. An unpaired *t*-test was performed to determine statistical significance between the TIVA group and the GA group with respect to the above variables. The alpha value or significance level for this study is $P = .05$. A power analysis for the above variables was performed and revealed that 60 patients are needed in each group to have a well-powered study (power > 0.8).

Results

One hundred fifty total patients were included in the study (75 TIVA and 75 GA). All patients were aged more than 18 years, with the average age for the TIVA cohort being 64.3 ± 9.4 years, compared to 63.0 ± 10.5 years for the GA cohort. There were no differences between the 2 groups with respect to age, gender, body mass index, and American Society of Anesthesiologists scores (Table I). All patients underwent arthroscopic shoulder surgery in the beach chair position. The majority of patients underwent surgery for rotator cuff repair (144/150; 96%). In the TIVA group, 73 patients underwent arthroscopic rotator cuff repair. One patient had a distal claviculectomy, and 1 patient had an arthroscopic labral repair and biceps tenodesis. In the GA group, 71 patients underwent arthroscopic rotator cuff repair. There was 1 arthroscopic shoulder débridement, 1 distal claviculectomy, and 2 arthroscopic labral repairs.

Compared to GA, the patients who received TIVA had faster recovery times (Table II and Fig. 1). The patients in the TIVA group had a significantly faster time in phase 1 recovery (53.2 ± 32.9 min compared to 65.8 ± 41.3 min; $P = .021$) and had a faster total recovery time (120.3 ± 31.0 min compared to 131.5 ± 36.8 min; $P = .048$). While the time spent in phase 2 recovery for TIVA (67.1 ± 31.0 min) was longer than that of the GA group (65.7 ± 32.3 min), this was not statistically significant ($P = .78$).

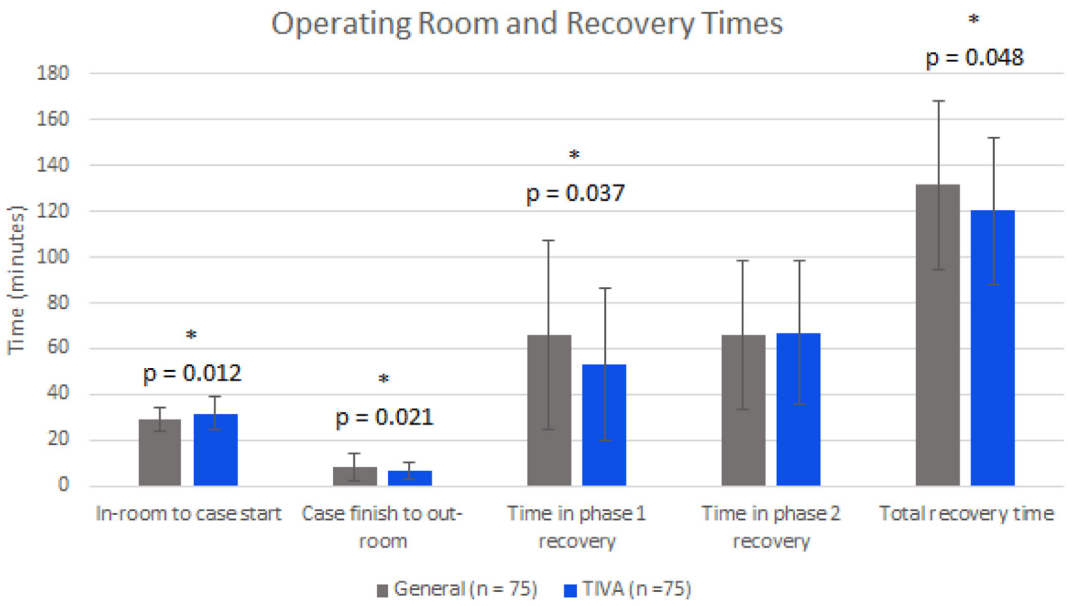

Figure 1 Operating room and recovery times. General anesthesia had a significantly shorter in-room to case start time than TIVA ($P = .012$). However, the TIVA cohort had a significantly shorter case finish to out-room time ($P = .021$), time in phase 1 recovery ($P = .037$), and total recovery time ($P = .048$). *TIVA*, total intravenous anesthesia.

Table III
Adverse events.

	General (n = 75)	TIVA (n = 75)	*P* value
MAPs during case	85 ± 9.3	87.1 ± 11.4	.22
Nausea/vomiting	1	0	.9
Readmissions	7	2	.08

TIVA, total intravenous anesthesia.

TIVA also had a significantly shorter case finish to out-room time (6.5 ± 3.5 min compared to 8.4 ± 6.3 min; $P = .021$). However, the in-room to case start time for the TIVA group was significantly longer (31.8 ± 7.22 min) compared to the GA group (29.2 ± 4.92 min; $P = .012$). These findings can be seen in Table II and Figure 1.

There was no statistically significant difference in adverse events between the 2 groups (Table III, Fig. 2). No patients developed PONV in the TIVA group, compared to 1 occurrence in the GA group ($P = .22$). There were 2 readmissions in the TIVA group, while the GA group had 7 readmissions ($P = .08$). Reasons for readmission in the TIVA group included "emergency department visit not related to shoulder" in 1 patient and "Endocrine visit" in 1 patient. Reasons for readmission in the GA group included "emergency department visit not related to shoulder" in 6 patients and "wound check" in 1 patient. Finally, TIVA had higher average MAPs during the case (87.1 ± 11.4 mmHg) than the GA group (85.0 ± 9.3 mmHg; $P = .22$), although not statistically significant.

Discussion

This study sought to determine if using TIVA instead of GA for shoulder arthroscopy in the beach chair position improves OR efficiency, shortens recovery time, and reduces adverse events while theoretically preserving cerebral autoregulation. There are very few studies in the orthopedic literature discussing the use of TIVA in shoulder arthroscopy, and this is the first study to compare TIVA to GA in shoulder arthroscopy in the beach chair position.

TIVA has been associated with improved recovery (quicker time to standing up and being "home ready"), greater patient satisfaction, and lower costs in superficial surgical procedures in an office-based surgical center.[6,13] Return of cognitive function has been shown to be significantly faster with TIVA compared to inhaled anesthetics when used in elective operative procedures.[5] Our study demonstrates that TIVA has significantly faster recovery times when compared to GA in shoulder arthroscopy in the beach chair position, by an average of about 11 minutes in total recovery time.

There are a number of risk factors for PONV, including factors related to the patient, the surgery, and the specific anesthetic used. Based on the new consensus guidelines for the management of PONV, anesthetic risk factors include volatile (inhaled) anesthetics, nitrous oxide, and postoperative opioids.[3] In a randomized controlled trial by Apfel et al, volatile anesthetics were the leading cause of early postoperative vomiting, suggesting that inhalational anesthesia should be avoided if possible in patients at high risk for PONV.[1] Our results are consistent with these data in that there were no cases of PONV in the TIVA group. However, there was only 1 case of PONV in the GA group.

Few studies have commented on postoperative readmission rates of TIVA compared to GA. However, a recent study looking at risk factors for admission after shoulder arthroscopy found that the absence of GA decreased the risk of admission.[2] They showed that regional combined with MAC anesthesia had a decreased risk for admission, compared with regional with GA or GA alone.[2] Therefore, they recommended avoiding GA for arthroscopic shoulder surgery. We had similar findings in our study, with 7 readmissions in the GA group compared to only 2 in the TIVA group ($P = .08$). This supports the use of anesthetics other than GA for outpatient shoulder arthroscopy. Further studies can be done to compare readmission rates between TIVA, MAC, regional, and GA and look more closely at the exact causes of readmission to determine if they are in fact anesthesia related.

This study showed that TIVA had a significantly shorter time from case finish to out-room when compared to GA methods. This is in contrast to a recent study comparing desflurane anesthesia to TIVA in ophthalmic ambulatory surgery, which showed that desflurane anesthesia enhanced OR efficiency by decreasing extubation time and OR exit time.[14] In patients undergoing shoulder arthroscopy in the beach chair position, it was hypothesized that

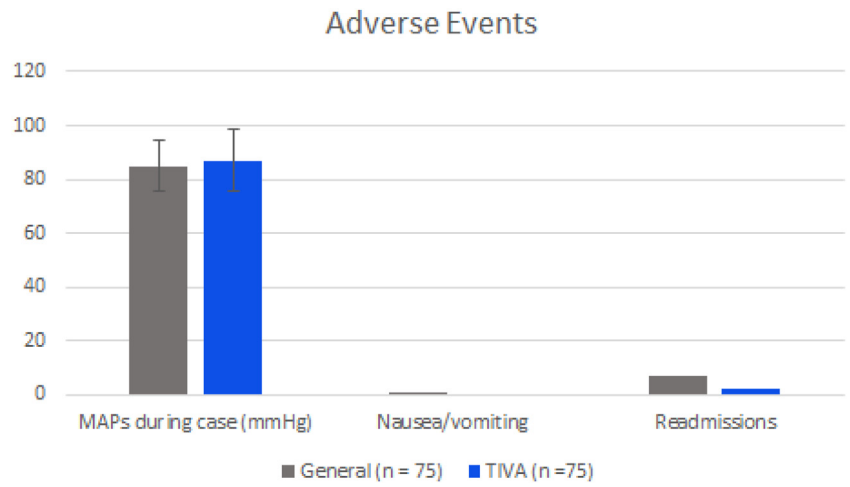

Figure 2 Adverse events. TIVA had higher average MAPs during the case, a lower incidence of postoperative nausea and vomiting, and decreased readmissions compared to general anesthesia, although none of these differences were statistically significant. *TIVA*, total intravenous anesthesia.

TIVA would decrease time from entering the OR to case start. This is because with TIVA, there is no need for induction while supine; therefore, the patient can help position themselves in the beach chair position and inform staff of pressure areas and neck discomfort. However, our study did not show a decrease in time from in-room to case start with TIVA. This could be due to variability between when the patient is in the room and when the patient is on the OR table and ready to be positioned. Future studies will need a more accurate way of recording this measure to determine if TIVA truly does improve OR efficiency.

Clinical trials have shown that beach chair positioning results in decreases in regional brain oxygenation, cerebral blood flow, jugular bulb oxygenation, and cerebral autoregulation.[7] This is due to reductions in blood pressure, cardiac output, and cerebral perfusion when moving an anesthetized patient from the supine to sitting position.[7] Although rare, this can result in serious adverse events such as stroke, coma, spinal cord ischemia, and visual loss.[7] TIVA has been shown to provide better hemodynamic stability when compared to GA in a study of patients undergoing laparoscopic cholecystectomy.[12] Studies have also demonstrated that inhaled anesthetics can impair cerebral autoregulation, while intravenous agents, such as propofol, preserve it.[11] Therefore, TIVA may be a safer option for patients undergoing shoulder arthroscopy in the beach chair position. In the present study, the TIVA group had higher average MAPs intraoperatively (87.1 ± 11.4 mmHg) compared to the GA group (85.0 ± 9.3 mmHg; $P = .22$), although not statistically significant. Both groups had average MAPs above values at which cerebral perfusion pressure is preserved. However, TIVA was able to maintain these MAPs with minimal medication. In addition, there were no differences between the 2 groups with respect to age, gender, body mass index, and American Society of Anesthesiologists scores. Therefore, patients were not selected to receive a certain type of anesthesia such that the healthier patients received TIVA. Due to the size of our study, we were unable to evaluate for major neurological injuries. Large-scale prospective or retrospective studies are needed to define the incidence of significant neurological injuries in the beach chair position with GA compared to TIVA.

Conclusion

Results from this study indicate that for patients undergoing shoulder arthroscopy in the beach chair position, TIVA has significantly shorter recovery time and shorter time from case finish to out-of-room compared to traditional GA (inhalation and intravenous anesthesia). TIVA did not save time from in-room to case start; however, this measure is highly variable. Patients receiving TIVA had lower rates of PONV and decreased readmissions compared to the GA group, although not statistically significant. In the current era of performing surgeries with optimal efficiency and cost control in mind, decreasing OR time, post-anesthesia care unit time, emergency department visits, and readmissions all add to the value of patient care. Finally, although TIVA had higher intraoperative MAPs compared to GA, this finding was not statistically significant. Larger scale studies are needed to evaluate the risk of adverse events related to impaired cerebral autoregulation in the beach chair position. Overall, this study demonstrates that TIVA may be a safe and efficient alternative to GA in shoulder arthroscopy in the beach chair position.

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