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Does Awake Open Shoulder Surgery Provide Advantages for Time and Cost-Efficiency? A Single Center Experience

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Abstract

BACKGROUND/AIMS: Operating room usage time and the preferred anesthesia technique for surgery are among the factors affecting total hospital costs. Regional or general anesthesia may be preferred during shoulder surgery. This study investigated comparisons in time and the cost-effectiveness between ultrasonography-guided regional anesthesia and general anesthesia for open shoulder surgery.

MATERIALS AND METHODS: Data of those patients who underwent open shoulder surgery between August, 2021 and March, 2022 were evaluated retrospectively. Ultrasonography-guided interscalene and superficial cervical plexus blocks were preferred for awake open shoulder surgery and the middle trunk block was added to this combination. Regional anesthesia was compared with general anesthesia in terms of time and cost-effectiveness.

RESULTS: The data of 22 patients in the regional anesthesia group (group RA) and 28 patients in the general anesthesia group (group GA) were included in this study. The descriptive data and surgery types were similar between the groups ($p>0.05$). The Operating Room Usage Costs, Equipment and Medication Costs and total costs were significantly lower in the group RA compared to the group GA ($p=0.00012$, $p=0.00025$, $p=0.00001$, respectively). There was a statistically significant difference between the two groups with regards to the time of anesthesia administration and positioning (3.77 ± 1.47 vs 12.82 ± 1.72 minutes, $p<0.0001$), and the total operating room usage time (65.68 ± 21.18 vs 98.78 ± 34.43 minutes, $p=0.0001$).

CONCLUSION: In our study, it was shown that the operating room usage time and cost in awake open shoulder surgeries were less than surgeries performed under general anesthesia.

Keywords: Cost-effectiveness, regional anesthesia, shoulder

INTRODUCTION

Shoulder pain is an important clinical condition in pain medicine. Depending on the severity of the pain and/or the type of pathology, surgery may be required.[1,2] Repair of the shoulder capsule by means of open or arthroscopic procedures is a common orthopedic procedure.[3] In recent years, minimally invasive arthroscopic procedures have become increasingly popular due to their positive features such as wound healing, postoperative recovery quality, and length of hospital stay. However, because of its lower cost and the limited effect of its surgical approach on healing quality, open repair is still a frequently selected method in many facilities.[4-6]

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Although there are a few publications in the literature which express contrasting viewpoints, it has been reported that open shoulder surgery is generally more cost-effective, and the majority of studies regarding cost-effectiveness have focused on the surgical approach.[4] Regional anesthesia is routinely utilized during awake shoulder surgery. For this, interscalene block, superficial cervical block, suprascapular block, or axillary block can be used alone or in combination.[7-9] Some studies have suggested that awake shoulder surgery with an interscalene block is more advantageous with regards to cost when compared to using general anesthesia.[10] However, the success rate, potential complications, and patient satisfaction with interscalene block applications in awake shoulder surgery remain a subject of debate.[11] Diaphragm sparing is recommended for regional anesthesia techniques applied in both awake surgery and perioperative analgesia in shoulder surgery.[12]

In this study, we aimed to examine the cost-effectiveness of the anesthetic strategy utilized during shoulder surgery, rather than focusing on the comparison of conventional or arthroscopic approaches in shoulder surgery. Also, we aimed for our data to be a feasibility study for a less conventional block combination used in awake shoulder surgery.

MATERIALS AND METHODS

Study Design

This study was designed as a retrospective data analysis. Approval from the Local Ethics Committee of Samsun Ondokuz Mayıs University Faculty of Medicine (approval number: 2022/152) was obtained and this study was registered at clinicaltrials.gov (NCT05406609) prior to its commencement. Our study is based on data from the FONET, Hospital Information Management System, v4.22.6.1, Türkiye database, in which patients who had shoulder surgery between August 1st, 2021 and March 31st, 2022 were evaluated. The patients received either general anesthesia or regional anesthesia according to the anesthesiologists experience and the availability of the technical devices at the time of their surgery. As the data was collected retrospectively from this data pool, no randomized sampling was possible. All of the patients who were operated on between the selected dates were planned to be included in this study. The data of those patients who underwent arthroscopic or emergency surgery, those <18 years of age, those who received peripheral nerve blocks for perioperative analgesia and those whose records were missing or incomplete were excluded from this study. The patients were grouped according to whether they underwent shoulder surgery under either regional anesthesia (group RA) or general anesthesia (group GA). After the inclusion and exclusion criteria were applied, it was found that 22 patients had received regional anesthesia and 28 patients had received general anesthesia during the selected time period. All of these were then allocated to either group RA or group GA.

Data Collection

Data was gathered from the perioperative anesthetic follow-up form, which was recorded as standard for each procedure. Aside from general patient information such as age, gender, and American Society of Anesthesiologists Classification (ASA), the type of anesthesia, the surgical procedure, and the medicines and materials utilized by the anesthesia team were all recorded. The operating room utilization was assessed in four stages:

Time of anesthesia administration: time of induction, intubation, and time to commencement of mechanical ventilation,

Positioning time: to get the patient into the proper surgical position,

Surgical time: from the commencement of surgery until its completion,

Recovery time: between the end of the surgery and the patient leaving the operating room; extubation and recovery.

The total time is the sum of these four sections.

For the *total cost* calculation, the purchase costs of the medications and materials recorded in the hospital system, excluding those utilized within the scope of the surgical procedure, were obtained and calculated independently for each patient. The price information of the equipment and drugs was taken from the price data of 2021. For the purpose of the standardization of operating room working costs, a fixed value (constant/minute) was determined on a per-minute basis, excluding the salaries of the healthcare workers. Operating room usage cost was calculated by multiplying this fixed value by the minutes for which the operating room was utilized for each patient (constant multiplied by minutes).

General Anesthesia Protocol

Each patient received standard monitoring, which included 3-channel electrocardiography (ECG), non-invasive blood pressure, and pulse oximetry. For induction, 2% lidocaine 1 mg/kg, 1-2 mcg/kg fentanyl, 2-3 mg/kg propofol, and 0.6 mg/kg rocuronium were used. 1 minimum alveolar concentration sevoflurane or desflurane was used for anesthesia maintenance. While paracetamol 1 gr was routinely used for postoperative analgesia, the choice of nonsteroidal anti-inflammatory, single-dose intravenous opioid, or intravenous patient-controlled analgesia was at the discretion of the anesthetist. In our country (Türkiye), atropine and neostigmine are frequently used to reverse neuromuscular blockade, while sugammadex is used only when absolutely essential (difficult intubation, prolonged neuromuscular block etc.).

Regional Anesthesia Protocol

For open shoulder surgery, ultrasound-guided brachial plexus blocks such as interscalene and superficial cervical blocks are favored. In our practice, the middle trunk block is added to the interscalene and superficial cervical plexus blocks to avoid discomfort due to the arm abduction position used during awake shoulder surgery. Peripheral block applications are carried out in the peripheral block procedure room preoperatively. After standard monitoring, 0.01-0.02 mg/kg midazolam and 0.15 mg/kg ketamine are administered intravenously, for sedoanalgesia. Following sterile prep, the patient's head is rotated 30 degrees away from shoulder which is to be operated on. Using ultrasound guidance, a block needle is used to administer a total of 20-25 mL of a mixture of 1% lidocaine and 0.25% bupivacaine of which 6-8 mL is administered to the interscalene region, 8-10 mL to the superficial cervical region, and 6-8 mL between the middle and inferior trunks. Conventional superficial cervical plexus block is applied more cephalically than the point where interscalen block is applied. As a modified cervical plexus block, we fix the ultrasound transducer where the interscalen block is applied, and without making a second skin puncture, we perform the superficial servical plexus block on this plane. Furthermore, after this combined procedure, the ultrasound

transducer is located more caudally to the supraclavicular fossa where superior, middle and inferior trunks are identified sonoanatomically. A needle is advanced towards the middle trunk and local anesthetic solution is injected as it surrounds the trunk in circular manner.

Twenty minutes after block performance, the patient is transported to the operating room. In the operating room, the surgical site is evaluated for sensory block and, if successful, the surgical procedure is started.

Statistical Analysis

The Statistical Package for the Social Sciences (SPSS) 16.0 statistical package program (SPSS Inc.; Chicago, IL, USA) was used for statistical analysis. Descriptive statistics were expressed as mean ± standard deviation. A univariate analysis compared means between the groups using a two-sample, Independent t-test assuming equal variances for continuous variables. Ratios were compared using the chi-squared test. For data without normal distribution, the Mann-Whitney U test was performed. A p-value<0.05 was considered statistically significant.

RESULTS

The data of the 164 patients who underwent shoulder surgery were evaluated. The data of 98 patients who underwent arthroscopy, 4 patients who were <18 y of age, and 12 patients who received peripheral nerve block for perioperative analgesia were excluded from this study. The remaining 50 patients were divided into group RA (n=22) and group GA (n=28), respectively (Figure 1). There was no significant difference between the two groups with regards to their demographics, including their ages, genders, and their ASA (Table 1). The surgery procedures are shown in Table 1.

All patients in group RA received peripheral nerve block as described previously. All blocks were successful and no complications were observed. Two patients reported mild perioperative pain and discomfort and were administered 1 mg/kg/hr propofol infusion. No increases in infusion rates were required in these patients. General anesthesia was not required in any of the patients.

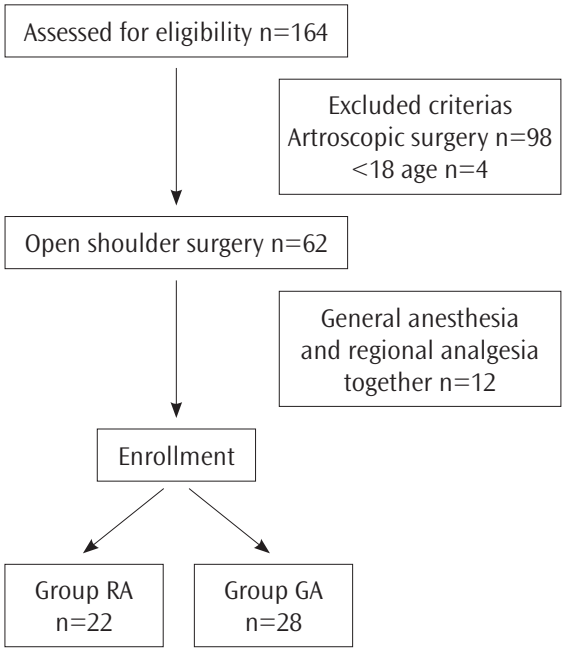

Figure 1. Flow chart of this study.

The surgical times were similar between group RA and group GA (61.9±21.84 vs 62.42±34.33 minutes, p=0.94). However, there was a statistically significant difference between the two groups with regards to time of anesthesia administration and positioning (group RA: 3.77±1.47 vs group GA: 12.82±1.72 minutes, p<0.0001), and the total operating room usage time (group RA: 65.68±21.18 vs group GA: 98.78±34.43 minutes, p=0.0001) (Table 2). The monitoring time of the patients on the operating table was accepted as being standard and not included in the analysis.

Comparisons of costs are shown in Table 2 and Figure 2. Equipment and medication costs (120.67±7.76 vs 205.95±106.89 TL, p=0.00025) as well as total operating room costs (1,090.31±351.59 vs 1,639.84±571.55 TL, p=0.00012) were found to be higher in group GA when compared to group RA. Similarly, total costs were higher in group GA (p=0.00001).

A detailed list of the materials and medicines used included in the cost-calculation per group is given in Table 3.

DISCUSSION

Our study demonstrated that regional anesthesia techniques, when used as the primary anesthetic method in patients undergoing open shoulder surgery, are more cost-effective and significantly reduce the amount of time spent in the operating room, when compared to the use of general anesthesia. Additionally, our study demonstrated that the regional anesthesia combination described in this study and utilized in our clinic is a viable anesthetic technique for open shoulder surgery.

Ultrasound-guided regional anesthesia techniques can be a beneficial option, especially in orthopedic surgeries. Anesthesia for awake shoulder surgery can be achieved with interscalene block applied with a relatively high volume of LA (20 mL and above), but since respiratory complications such as hemidiaphragmatic paralysis are common, clinicians have sought phrenic nerve sparing techniques.[7,13-16] There are many studies reporting that techniques such as the combination of suprascapular nerve and axillary nerve block, sub-omohyoidal plane block, etc. have similar effects to interscalene block in postoperative analgesia, but it is not possible to use these techniques as the main anesthetic method.[15,17]

The superficial cervical plexus and the brachial plexus actively participate in the innervation of the region affected by shoulder surgery.[18] With high volume interscalene block, spread to both plexuses occurs, and effective anesthesia can be achieved.[14,19] In our clinic, we apply a combination of 20-25 mL of LA with interscalene block (6-8 mL), modified superficial cervical plexus block (8-10 mL) and selective trunk block (6-8 mL between middle and inferior). To the best of our knowledge, there exists no data on the use of such a combination in shoulder surgery. This combination was chosen in order to achieve sensory blockade in all areas which may cause perioperative pain in open shoulder surgery, and to achieve complete sensory/motor blockage of the arm on the relevant side, reducing the patient's exposure to discomfort during perioperative shoulder-arm-hand manipulations and thus, to increase patient satisfaction.

Cost studies in shoulder surgeries have mostly focused on the cost of the surgical procedure.[4,5] However, when total hospital expenses

Table 1. Patient demographics and Surgery Types based on the groups

		Group RA, (n=22)	Group GA, (n=28)	p
Age (year)		58.5±7.5	60±12.5	0.6
Gender (F/M)		12/10	19/9	0.92
ASA*	I	1	3	0.51
	II	18	19	
	III	3	6	
Type of surgery	Rotator cuff repair	2	1	0.62
	Rotator cuff repair and acromioplasty	16	13	
	Others (fracture, neoplasm, etc.)	4	14	

*ASA: American Society of Anesthesiologists Classification.

Table 2. Comparisons of perioperative times and costs according to groups

	Group RA, (n=22)	Group GA, (n=28)	p
Anesthesia Administration time (m*)	0.0±0.0	8.53±2.2	N/A
Positioning time (m)	3.77±1.47	12.82±1.72	**<0.0001**
Surgical time (m)	61.9±21.84	62.42±34.33	0.94
Operating room usage time (m)	65.68±21.18	98.78±34.43	**0.00012**
Operating room usage cost (TL**)	1,090.31±351.59	1,639.84±571.55	**0.00012**
Equipment and medication costs (TL)	120.67±7.76	205.95±106.89	**0.00025**
Total costs (TL)	1,210.99±354.25	1,845.80±576.08	**0.00001**

*m: minutes, **TL: Turkish Lira.

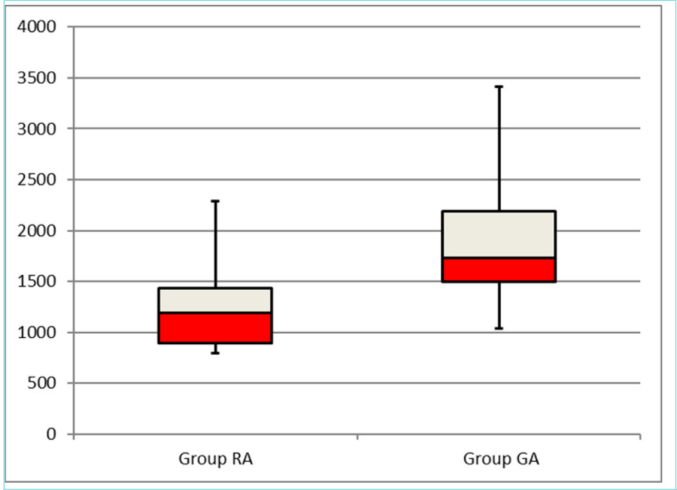

Figure 2. Box plot of total costs based on groups.

Distribution of total costs by groups. Minimum, first quartile, median, third quartile and maximum are shown. Y axis; demonstrates the total cost (Turkish Lira).

are considered, anesthetic management has a significant financial impact.[20] Hadzic et al.[21] found that interscalene block combined with low-dose propofol reduced surgical time, postoperative pain scores, the incidence of sore throat, nausea, and vomiting, and the time to discharge when compared to general anesthesia. They authors reported that same-day discharge would significantly reduce hospital costs.[21] In our study, we found that operating room usage times were reduced by up to 33% when regional anesthesia was used in comparison to general anesthesia. We did not include the time to discharge as one of our study's outcomes, since no standardized discharge criteria exist for open shoulder procedures in our institute.

Regional anesthesia is no longer merely a patient-focused technique in contemporary anesthetic practice. Today, the term "*Green-gional*" anesthesia has been coined, as the use of regional anesthesia techniques theoretically reduces the use of volatile agents, and indirectly, with the reduction in greenhouse gas emissions, and places the application of regional anesthesia well beyond the costs of the "*hospital*" or the "*operation*".[22,23]

Regional anesthesia techniques - whether for postoperative analgesia or as the primary anesthetic method - provide effective analgesia in the first postoperative hours, prevent muscle spasm, permit early mobilization of the shoulder joint, and enable early initiation of physiotherapeutic treatment.[24,25] In our study, however, we did not consider the potential long-term benefits or treatment expenses, especially those regarding postoperative physiotherapy. In addition, early mobilization was not performed on all patients, as this was a retrospective study which covered various types of open shoulder procedures. However, more comprehensive data can be gained through multidisciplinary research involving long-term evaluations and follow-ups after shoulder surgery. It should be noted that regional anesthetic procedures should not be presented as being fully harmless. Some studies have attributed complex regional pain syndrome following shoulder surgery to a complication of interscalene block.[26] It would be more appropriate to evaluate the postoperative effects of varying regional anesthesia techniques in homogenized patient groups and then to examine issues such as cost, postoperative chronic pain development, and early mobilization with comparative studies.

Study Limitations

Our study has some limitations. First of all, the study's retrospective design could have caused bias. In addition, even though all of the patients in this study underwent open shoulder surgery, their pathologies varied, leading to heterogeneity. Stronger findings can be

Table 3. Detailed List of materials and medicines included in cost-calculation per group

Medicine			Equipment	
Group RA	Group GA		Group RA	Group GA
Fentanyl 1-2 µg/kg	Fentanyl 1-2 µg/kg	Hypertonic fluid 500 mL/h	ECG pallet n=3	ECG pallet n=3
Midazolam 0.03 mg/kg	Midazolam 0.03 mg/kg	Ondansetron 4 mg	Injector 5 mL/20 mL	Injector 2 mL/5 mL/10 mL/20 mL
Lidocaine 2% 1-2 mg/kg (RA)	Lidocaine 2% 1 mg/kg (i.v.)	Proton pump inhibitor 40 mg	Intravenous cannula 20 G	Intravenous cannula 20 G
Paracetamol 1 g	Paracetamol 1 g	Atropine 0.01-0.03 mg/kg	Fluid line n=1	Fluid line n=1
Glyceryl trinitrate 1 µg/kg*	Glyceryl trinitrate 1 µg/kg*	Neostigmine 0.02-0.03 mg/kg	Oxygen mask n=1	Anesthetic face mask n=1
Dexamethasone 8 mg	Dexamethasone 8 mg	Theophylline 200 mg	Peripheral nerve block needle n=1	Airway n=1
Ephedrine 0.1 mg/kg**	Ephedrine 0.1 mg/kg**	Methylprednisolone 0.5-1 mg/kg		Endotracheal tube n=1
Metoprolol tartrate 5 mg***	Metoprolol tartrate 5 mg***	Sevoflurane 13 mL/h		Bacteria filter n=1
Saline 1,000 mL/h	Saline 1,000 mL/h	Desflurane 34.2 mL/h		Aspiration probe n=1
Propofol 0.5-1 mg/kg	Propofol 1.5-2.5 mg/kg	Sugammadex 2 mg/kg[4]		Ventilation line n=1
Ketamine 1-2 mg/kg	Rocuronium bromide 0.6 mg/kg	Tetracycline pomade Eye protection		
Bupivacaine 0.5% 0.5-1 mg/kg (RA)	Remifentanil 0.05-0.2 µg/kg/min	Tramadol 100 mg		
		NSAID 50 mg		

*If arterial blood pressure increases 20-30% more than preoperatively. **If arterial blood pressure decreases 20-30% more than preoperatively. ***If heart rate increases 20-30% more than preoperatively. [4]If there are some contraindications for the use of atropine and neostigmine. All of the materials are not used in all patients. They are used as needed selectively. ECG: Electrocardiography

achieved from a cost-effectiveness analysis which uses the same surgical technique, possibly even performed by the same surgeon, to treat the same clinical condition. However, the viability of our findings in terms of cost effectiveness, time effectiveness, and regional anesthesia combinations in awake shoulder surgery seems plausible. Our inability to reveal the postoperative analgesic requirements and long-term follow-up results and also not being able to include the wages of the personnel who worked in the operating and block rooms are the other limitations. Furthermore, although there were no unsuccessful blocks in our study, there is always a probability of an unsuccessful block because of anatomical variations or the lack of experience of the block operator. This may cause an increase in costs. This situation may be evaluated as another limitation.

CONCLUSION

In our study, it was shown that the operating room usage times and costs in awake open shoulder surgeries were less than surgeries performed under general anesthesia. However, further prospective, randomized and controlled studies are needed.

MAIN POINTS

- Ultrasound guided regional anesthesia techniques can be a useful option in orthopedic surgeries.
- The use of regional anesthesia techniques during shoulder surgery can be more cost-effective than general anesthesia and can significantly reduce the time spent in the operating room.
- The combination of interscalene block, modified superficial cervical plexus block and selective trunk block applied in our clinic can be used as a suitable anesthesia technique for open shoulder surgery.

Ethics Committee Approval: This study was approved by the Local Ethics Committee of Samsun Ondokuz Mayıs University Faculty of Medicine (approval number:2022/152).

Informed Consent: Retrospective study.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: D.A., S.T., M.Ü., A.E., N.G., Ş.C.A., H.B.A., M.S., Concept: D.A., S.T., M.Ü., A.E., N.G., Ş.C.A., H.B.A., M.S., Design: D.A., S.T., M.Ü., A.E., N.G., Ş.C.A., H.B.A., M.S., Data Collection and/or Processing: D.A., S.T., M.Ü., A.E., N.G., Ş.C.A., H.B.A., M.S., Analysis and/or Interpretation: D.A., S.T., M.Ü., A.E., N.G., Ş.C.A., H.B.A., M.S., Literature Search: D.A., S.T., M.Ü., A.E., N.G., Ş.C.A., H.B.A., M.S., Writing: D.A., S.T., M.Ü., A.E., N.G., Ş.C.A., H.B.A., M.S.

DISCLOSURES

Conflict of Interest: No conflict of interest was declared by the authors.

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