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Retrospective Analysis of Anesthesia Approaches in Clavicle Surgery: Experience from A Single Center

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Abstract

BACKGROUND/AIMS: Due to the complex and variable innervation of the clavicle, clavicle fracture repair is usually performed under general anesthesia (GA). Ultrasound-guided regional anesthesia (UGRA), which targets multiple innervation zones, may offer an effective and resource-efficient alternative.

MATERIALS AND METHODS: This single-center retrospective cohort study by the Samsun University Non-Interventional Clinical Research Ethics Committee (approval number: 2025/10/26, date: 14.05.2025) examined adults aged 18-70 years [American Society of Anesthesiologists (ASA) I-III] who underwent clavicle surgery between January 1, 2022, and April 1, 2025. UGRA consisted of a predefined combination of modified interscalene, modified superficial cervical plexus, and clavipectoral fascial plane blocks, using 30 mL of local anesthetic (0.25% bupivacaine and 0.5% lidocaine). Outcomes included operating room (OR) time components, anesthetic and analgesic requirements, complications, hospital length of stay, and cost analysis modeled with a constant coefficient of 1 United States Dollar/min, using 2025 unit prices.

RESULTS: Twenty-six patients were analyzed: UGRA, (n=19) (73%), and GA, (n=7). The groups were similar in age, sex, ASA class, fracture type, surgical time, and time to discharge. All UGRA cases were completed without conversion; no block-related complications occurred. Two UGRA patients experienced mild intraoperative discomfort, which was managed with propofol infusion (1 mg/kg/h). Compared with GA, UGRA demonstrated significantly shorter OR occupancy and lower OR costs (both $p=0.032$), lower equipment and medication costs ($p<0.001$ and $p=0.004$, respectively), and lower total costs ($p=0.007$). Variable medication costs were observed only with GA.

CONCLUSION: Combined UGRA enabled safe awake clavicle surgery without conversion to GA and was associated with shorter OR occupancy and lower overall costs compared with GA. Larger prospective studies are needed to confirm efficacy, improve patient selection, and evaluate long-term outcomes.

Keywords: Regional anesthesia, clavicle fracture, awake surgery

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INTRODUCTION

Clavicle fractures account for approximately 2.6-4% of all adult fractures and represent about 44% of shoulder-girdle injuries. The midshaft is the most frequently affected region. Surgical treatment typically involves open reduction and internal fixation, necessitating effective anesthesia management, particularly with regard to postoperative analgesia.[1,2]

The clavicle has a complex and variable innervation pattern that is not yet fully elucidated, leading to an ongoing debate about the optimal regional anesthesia technique for surgical repair of the clavicle.[3] While the cutaneous innervation overlying the clavicle is clearly supplied by the supraclavicular nerve (a branch of the superficial cervical plexus), the source of deep sensory innervation is controversial. Some studies suggest the supraclavicular nerve also provides deep innervation, whereas others implicate contributions from the brachial plexus branches, including the subclavian nerve, long thoracic nerve, and suprascapular nerve.[4]

This anatomical complexity limits the effectiveness of single-site regional blocks and has led many centers to favor general anesthesia (GA). However, GA has drawbacks, including delayed postoperative recovery, increased analgesic requirements, and higher overall costs.[5]

The advent of ultrasound-guided regional anesthesia ((UGRA) has transformed clinical practice by enabling direct visualization of nerve structures and the safer, more effective administration of nerve blocks. Techniques such as interscalene brachial plexus block, superficial cervical plexus block, and the recently introduced clavipectoral fascial plane block have emerged as viable alternatives to GA for clavicle surgery.[5,6] Combining blocks that target multiple innervation zones has been shown to enhance both intraoperative and postoperative analgesia while reducing complication rates. Importantly, some of these techniques avoid phrenic nerve involvement, thereby preserving respiratory function-an advantage for patients with pulmonary compromise.[7] Furthermore, several studies have demonstrated that clavicle fracture surgery can be successfully performed under combined regional blocks in awake patients, providing adequate surgical anesthesia and excellent patient comfort.[8]

Beyond clinical outcomes, cost-effectiveness is also a critical factor in selecting anesthetic techniques. Regional anesthesia reduces intraoperative opioid use, shortens recovery times, and promotes more efficient use of healthcare resources, benefits that are especially relevant in resource-limited settings.[9]

The purpose of this study was to retrospectively evaluate our institutional experience in clavicle surgery and to compare GA and ultrasound-guided regional techniques in terms of efficacy, safety, resource use, and postoperative outcomes.

MATERIALS AND METHODS

Study Design and Ethical Approval

This retrospective cohort study was approved by the Samsun University Non-Interventional Clinical Research Ethics Committee (approval number: 2025/10/26, date: 14.05.2025). Medical records of patients aged 18-70 years with an American Society of Anesthesiologists (ASA) physical status of I-III who underwent clavicle surgery between January 1, 2022, and April 1, 2025, were reviewed. Patients were excluded if they had neurological deficits in the upper extremity; a history of neck surgery or radiotherapy; moderate or severe pulmonary disease; contraindications to peripheral nerve block (e.g., allergy to local anesthetics, coagulopathy, or infection at the injection site); preoperative opioid therapy; had psychiatric conditions likely to affect pain perception; or had incomplete clinical records.

Data Collection

Eligible patients were identified using the hospital information management system (FONET, v4.22.6.1). Data were extracted from electronic records and patient files. Variables recorded included demographic characteristics, ASA classification, comorbidities, anesthesia type, volume of local anesthetic administered, additional intraoperative anesthetic and analgesic requirements, surgical fracture type, duration of surgery, drug and material costs, operating room (OR) charges, length of hospital stay, and postoperative complaints.

Operating Room Time Components

OR utilization was assessed across four time intervals, each measured in minutes:

Anesthesia duration: From the start of induction to tracheal intubation and the start of mechanical ventilation,

Positioning time: The time required to properly position the patient for surgery,

Operating time: From skin incision to completion of surgery,

Recovery time: From the end of surgery to discharge from the OR (including extubation and recovery).

Total OR time was defined as the sum of these four components.

Costing Approach

Patient-level drug and consumable costs, excluding procedure-specific surgical materials (e.g., implants, plates/screws, staples), were calculated separately as unit price × quantity based on hospital purchasing records. For comparability, unit prices for devices and medications were fixed according to the 2025 price list. To standardize OR operating costs, a minute-based fixed coefficient (k), excluding personnel salaries, was used; in this study, k=1 US dollar per minute. When Turkish-lira-denominated results were converted to TL using the exchange rate prevailing on the reporting date.

Patients were categorized into two groups based on the type of anesthesia received:

Group UGRA: Ultrasound-guided regional anesthesia

Group GA: General anesthesia

Routine Ultrasound-Guided Regional Anesthesia Procedure in Our Clinic

Patients in the UGRA group were those who had routinely received, as part of standard care for clavicle fracture surgery, a predefined combination of UGRA blocks (modified interscalene, modified superficial cervical plexus, and clavipectoral fascial plane blocks). According to anesthesia records, all blocks were performed under aseptic conditions using a high-frequency linear ultrasound transducer, an in-plane approach, and a 22-gauge Stimuplex® needle. A total of 30 mL of local anesthetic (0.25% bupivacaine and 0.5% lidocaine) was

administered, distributed across three planes as follows: 7.5 mL to the interscalene level, 12.5 mL to the superficial cervical plexus level, and 10 mL to the clavipectoral fascial plane. The modified interscalene technique targeted the C5 nerve root with circumferential deposition, aiming to limit spread to adjacent cervical roots. The superficial cervical plexus block was performed through the same skin entry used for the interscalene block. After completing the deeper injection, the needle was redirected slightly upward into a more superficial layer just beneath the deep fascia of the sternocleidomastoid muscle, while the ultrasound probe remained steady. For the clavipectoral fascial plane block, two injections (one medial and one lateral to the fracture line) were performed, with caudal-to-cranial needle advancement to deposit local anesthetic within the clavipectoral fascia.

Standard monitoring (3-lead electrocardiogram, non-invasive blood pressure, and pulse oximetry) was applied. Procedural sedation/analgesia was provided according to departmental practice, using intravenous midazolam (0.01-0.02 mg/kg) and ketamine (0.15 mg/kg). Approximately 20 minutes after block placement, patients were transferred to the OR. The surgical field was assessed for sensory block, and surgery commenced when adequate anesthesia was documented.

General Anesthesia Management

In Group GA, GA was administered according to our clinic's routine protocol for clavicle fracture surgery. With standard monitoring in place, induction was achieved with propofol (1.5-2.5 mg/kg), fentanyl (1-2 µg/kg), lidocaine (1 mg/kg), and rocuronium (0.6 mg/kg). Maintenance was provided with sevoflurane or desflurane at minimum alveolar concentration. Neuromuscular blockade was reversed using atropine (0.02 mg/kg) and neostigmine (0.05 mg/kg). Patients who underwent alternative anesthesia approaches (e.g., non-standard or combined regional techniques, deep sedation without airway instrumentation) or whose anesthesia documentation was incomplete were excluded from the study. No additional regional anesthesia techniques were included in the GA group.

Statistical Analysis

Were performed using SPSS version 16.0 (SPSS Inc., Chicago, IL, USA). Continuous variables were expressed as mean ± standard deviation and compared using the Independent samples t-test or the Mann-Whitney U test, depending on the normality of the distribution. Categorical variables were analyzed using the chi-square test, with Yates' continuity correction applied when appropriate. A p-value of <0.05 was considered statistically significant.

RESULTS

Data from 26 patients who underwent clavicle surgery were included in the final analysis after excluding 14 patients who did not meet the inclusion criteria or had missing data. Patients were divided into two groups: UGRA (n=19) and GA (n=7) (Figure 1). There were no statistically significant differences between the groups in terms of age, gender, ASA classification, or fracture type. Although the difference in discharge time did not reach statistical significance (p=0.054), the observed trend toward earlier discharge in the UGRA group may indicate faster postoperative recovery. Surgical duration and discharge times are summarized in Table 1.

All patients in the UGRA group received the combined peripheral nerve block technique as previously described. All blocks were successful, and no complications were reported. Two patients experienced mild intraoperative discomfort and were managed with a propofol infusion at 1 mg/kg/h; neither required dose escalation nor conversion to GA. The discomfort was attributed to mild anxiety rather than inadequate sensory blockade, as ultrasound guidance showed no evidence of incomplete nerve coverage in either patient.

The comparison of cost parameters between the groups is presented in Table 2. OR usage time and fees were significantly lower in the UGRA group than in the GA group (p=0.032 for both). Equipment and medicine costs were also reduced in the UGRA group ($p<0.001$ and p=0.004, respectively). The gas cost, present only in the GA group, was included in the "Medicine cost" category rather than listed separately, as it represents a pharmacologic anesthetic expense calculated on the same cost line. Consequently, the total cost was significantly lower in the UGRA group (p=0.007). A detailed breakdown of materials and medications used per group is provided in Table 3.

DISCUSSION

This study showed that UGRA was the predominant anesthetic technique for clavicular surgeries at our clinic. Of the 26 patients evaluated, 73% underwent surgery under UGRA. The combination of modified interscalene block, superficial cervical plexus block, and clavipectoral fascial plane blocks provided effective anesthesia and analgesia without conversion to GA, and no complications were observed.

Regional anesthesia is well established for awake surgery in the arm and forearm, but its use in shoulder and clavicular procedures is still relatively uncommon.[10,11] In our series, we focused on clavicular surgery and found that these operations can be completed safely and effectively without GA. The approach we used proved technically feasible and was well tolerated by patients. Our results are consistent with those of Akyurt et al.[12], who reported similar benefits for awake shoulder surgery, including lower perioperative costs. In our study, a comparable reduction in cost was also observed for clavicular procedures.

The primary aim of this study was not to perform a detailed cost analysis but to demonstrate that awake clavicular surgery is feasible in routine practice. GA is often preferred in these cases, partly because of the clavicle's complex sensory innervation and concerns that regional techniques alone may not provide a complete surgical block.[13] This tendency may discourage attempts to perform awake surgery during such procedures.

Similar findings were reported by Kaciroğlu et al.[8], who successfully performed surgical repair of clavicle fractures using a combination of ultrasound-guided interscalene and superficial cervical plexus blocks in awake patients. Their results, which were similar to ours, demonstrated effective surgical anesthesia and excellent patient comfort without the need for GA. Building on these findings, Balci et al.[14] described a different combination-the clavipectoral plane and serratus posterior superior intercostal plane blocks-and reported satisfactory postoperative analgesia for clavicular surgery.

By sharing our clinical experience, we aim to challenge this perception. With appropriate patient selection and block technique, awake

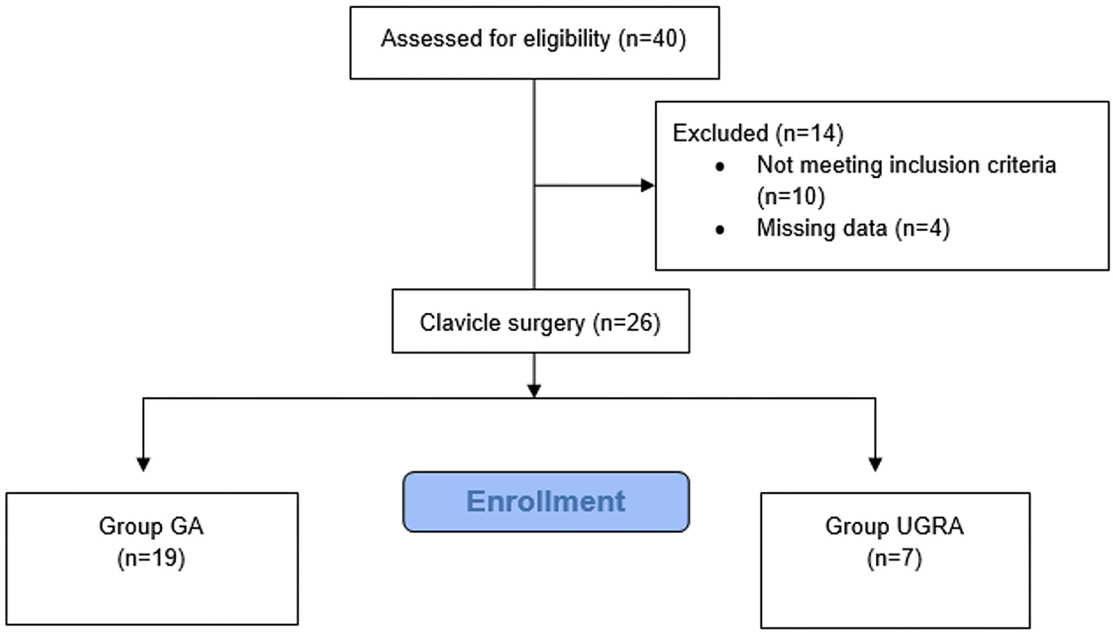

Figure 1. Flow chart of this study. A total of 40 patients were screened for eligibility; 14 were excluded (missing data, n=4; not meeting inclusion criteria, n=10). Finally, 26 patients were analyzed (UGRA=19, GA=7).

GA: General anesthesia, UGRA: Ultrasound-guided regional anesthesia.

Table 1. Patient demographic data and fracture type

	GA (n=7)	UGRA (n=19)	p
Age (years)	45.42±18.48	39.78±15.59	0.490
Gender (F/M)	1/6	5/14	0.904
Height	171.14±8.49	171.26±7.26	0.974
Weight	80.86±7.31	76.53±11.07	0.265
ASA* I/II/III	1/4/2	3/15/1	0.904
Fracture type (M/L)	5/2	17/2	0.604
Surgical time	89.85±26.99	72.10±26.78	0.165
Discharge time(<12hour/>12 hour)	2/5	15/4	0.054

Data are expressed as mean ± standard deviation or median (25th-75th percentiles). Normality of the data distribution was assessed using the Kolmogorov-Smirnov test. Continuous variables were compared using the Independent samples t-test for normally distributed data and the Mann-Whitney U test for non-normally distributed data. Categorical variables were analyzed using the chi-square test or Fisher's exact test, as appropriate.
F: Female, M: Male, ASA*: American Society of Anesthesiologists Classification, M: Middle, L: Lateral, GA: General anesthesia, UGRA: Ultrasound-guided regional anesthesia.

Table 2. Cost comparison by groups

	GA (n= 7)	UGRA (n=19)	p
Operating room usage time (minute)	114±27.56	84.05±26.46	0.032
Operating room usage fee (TL)	4689.96±1133.82	3457.82±1088.56	0.032
Equipment cost (TL)	378.14±31.76	189±3.74	<0.001
Medicine cost (TL)	408.88±120.57	177.36±29.30	0.001
Total cost (TL)	5476.97±1138.80	3.824.18±1.088.96	0.007

Data are expressed as mean ± standard deviation or median (25^{th}-75^{th} percentiles). Normality of data distribution was assessed using the Kolmogorov-Smirnov test. Continuous variables were compared using the Independent samples t-test for normally distributed data and the Mann-Whitney U test for non-normally distributed data. Categorical variables were analyzed using the chi-square test or Fisher's exact test, as appropriate. TL: Turkish lira, data are presented as mean ± standard deviation.
GA: General anesthesia, UGRA: Ultrasound-guided regional anesthesia.

clavicular surgery can be a practical alternative to GA. This study should be regarded as a proof-of-concept, demonstrating that such an approach is both feasible and beneficial in selected cases. Broader adoption could expand the role of regional anesthesia in upper-trunk surgery and optimize perioperative resource utilization.

Several factors may have influenced our results. Because this was a retrospective review, we could only use the information available in the records, and some variables could not be controlled. The number of awake clavicular surgery cases was small, which limits the strength of our statistical comparisons. Even so, the fact that most patients underwent the procedure while awake suggests that this technique can be applied in routine clinical practice. Cost figures should be viewed in context, as expenses vary widely between hospitals and countries. Ultimately, the real measure of success should be patient comfort and satisfaction rather than costs alone.

Study Limitations

This study has several limitations. Because it is retrospective, we relied on the accuracy and completeness of the medical records, and some potentially relevant clinical details were unavailable. The patient number was small and came from a single center with extensive experience in regional techniques; this may limit how well the findings can be applied to other settings. Cost estimates should also be

Table 3. Detailed list of drugs and supplies included in the cost analysis, by group

Equipment		Medicine/gas		
Group UGRA	**Group GA**	**Group UGRA**	**Group GA**	
EKG pallet	EKG pallet	Ketamine 1-2 mg/kg	Midazolam 0.03 mg/kg	Ephedrine 0.1 mg/kg**
İnjektor	İnjektor	Midazolam 0.03 mg/kg	Fentanyl 1-2 µg/kg	Paracetamol 1 g
İntravenous cannula	İntravenous cannula	Bupivacaine 0.5% 0.5-1 mg/kg (RA)	Lidocaine 2% 1 mg/kg (i.v.)	Ondansetron 4 mg
Fluid line	Fluid line	Lidocaine 2% 1-2 mg/kg (RA)	Propofol 1.5-2.5 mg/kg	Atropine 0.01-0.03 mg/kg
Oxygen mask	Anesthetic face mask	Fentanyl 1-2 µg/kg	Rocuronium bromide 0.6 mg/kg	Neostigmine 0.02-0.03 mg/kg
Peripheral nerve block needle	Ventilation line	Propofol 0.5-1 mg/kg	Remifentanil 0.05-0.2 µg/kg/ min	NSAID 50 mg
	Endotracheal tube	Saline 1,000 mL/h	Sugammadex 2 mg/kg	Sevoflurane 15 mL/h
	Bacteria filter	Ephedrine 0.1 mg/kg**	Tramadol 100 mg	Desflurane 35 mL/h
	Airway	Paracetamol 1 g	Saline 1,000 mL/h	

GA: General anesthesia, UGRA: Ultrasound-guided regional anesthesia, EKG: Elektrokardiyografi, NSAID: Non-steroidal anti-inflammatory drug, RA: Regional anesthesia.

interpreted with caution, as pricing structures vary among institutions. These factors should be considered when interpreting the results.

CONCLUSION

This retrospective study indicates that clavicular surgery can be carried out safely and at lower cost by combining regional anesthesia techniques. The results add to the growing body of evidence that awake surgery is a practical option even for procedures involving structures with complex innervation, such as the clavicle. While our experience supports its feasibility in everyday practice, these findings should be interpreted with caution given the study design and sample size. Larger observational and controlled trials are needed to validate these results, assess long-term outcomes, and better define patient selection criteria.

MAIN POINTS

- A predefined combined ultrasound-guided regional anesthesia (UGRA) protocol (modified interscalene, superficial cervical plexus, and clavipectoral fascial plane) enabled conversion-free, awake clavicle surgery without block-related complications.
- Compared with general anesthesia, UGRA was associated with shorter operating room utilization times, lower fees and reduced equipment and medication costs, yielding a lower total cost ($p=0.007$).
- Findings support UGRA as a feasible, resource-efficient alternative for clavicle fracture surgery; larger prospective studies are warranted.

ETHICS

Ethics Committee Approval: This retrospective cohort study was approved by the Samsun University Non-Interventional Clinical Research Ethics Committee (approval number: 2025/10/26, date: 14.05.2025)

Informed Consent: Since we only analyzed anonymized data from past patients, informed consent was not needed and was waived by the ethics committee. The study was conducted in line with the Declaration of Helsinki.

Footnotes

Authorship Contributions

Surgical and Medical Practices: G.R., A.Y., S.T., Concept: G.R., S.T., M.S., Design: G.R., S.T., Data Collection and/or Processing: G.R., H.Ş.Ç., A.Y., M.Y., Analysis and/or Interpretation: S.T., M.S., Literature Search: H.Ş.Ç., M.Y., Writing: G.R., S.T.

DISCLOSURES

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

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