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Coracoid approach brachial plexus block combined with posterior suprascapular nerve block provides analgesia for shoulder arthroscopy: a randomized controlled trial

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Shoulder arthroscopy has become a common procedure, but it is often associated with severe postoperative pain. This study aims to evaluate the analgesic effect of ultrasound-guided coracoid approach brachial plexus block combined with posterior suprascapular nerve block in shoulder arthroscopy. To this end, fifty patients undergoing right shoulder arthroscopy were randomly divided into two groups with 25 patients in each group. Before induction of general anesthesia, patients in the two groups received different nerve blocks. In Group A, participants received ultrasound-guided supraclavicular brachial plexus block with 25 mL 0.3% ropivacaine. In Group B, coracoid approach brachial plexus block and posterior suprascapular nerve block were carried out under ultrasound guidance. M-mode ultrasound was used to measure diaphragm movement before and 30 min after the block, and the presence of hemidiaphragm paralysis was recorded during calm breathing and deep breathing. Pain scores were recorded at 1, 6, 12, 24 and 48 h after surgery. The actual press times of the PCA pump and consumption of sufentanil were also recorded.A total of 45 patients completed this study. The incidence of hemidiaphragm paralysis in Group B was significantly lower than that in Group A under both calm breathing and deep breathing. The two groups displayed similar pain scores at 1, 6, 12, 24 and 48 h after surgery. Compared with supraclavicular brachial plexus block, coracoid approach brachial plexus block combined with posterior suprascapular nerve block can significantly reduce the occurrence of hemidiaphragm paralysis with an equivalent postoperative analgesic effect for shoulder arthroscopy. Therefore, the latter may be beneficial for early postoperative recovery in patients who cannot tolerate hemidiaphragm paralysis. Trial registration: This study was registered in the Chinese Clinical Trial Register (ID ChiCTR2100043069) on 04/02/2021.

Compared with traditional open surgery, shoulder arthroscopy has become increasingly popular because of its smaller incision and less soft tissue damage. However, there is significant pain after shoulder arthroscopy, which affects early recovery from the operation[1]. To manage postoperative pain after shoulder arthroscopy, interscalene brachial plexus block is considered the gold standard[2]. However, this type of nerve block is accompanied by an almost 100% incidence of hemidiaphragmatic paresis due to phrenic nerve block[3,4], which is a relative contraindication for patients with pulmonary pathology. Evidence suggests that supraclavicular brachial plexus block is an alternative to interscalene block, but it is also associated with hemidiaphragm paralysis[5]. The brachial plexus at the coracoid level is far from the phrenic nerve and, consequently, rarely leads to phrenic nerve block[6]. At the same time, the suprascapular nerve is involved in sensory innervation of the shoulder joint[7]. Therefore, coracoid approach brachial plexus block combined with posterior suprascapular nerve block was used to evaluate the influence of anesthetic factors on shoulder arthroscopy.

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Methods

This study was approved by the hospital ethics committee (201601A013) and registered in the Chinese Clinical Trial Register (ID: ChiCTR2100043069). The informed consent form was signed by the patients and their families. The inclusion criteria for study enrollment were patients scheduled for elective right shoulder arthroscopy under general anesthesia, regardless of sex, age 18 to 60 years, with a body mass index (BMI) of 18–28 kg·m^{-2} and an American Society of Anesthesiologists (ASA) physical status classification of I or II. Preoperative exclusion criteria were previous local anesthetic allergy, severe systemic infection or puncture site infection, coagulation dysfunction, neuromuscular disease, lung disease or long-term smoking without quitting. This study was conducted between January 2020 and December 2021 at The First Hospital of Qinhuangdao.

Participants were randomly divided into two groups: Group A and Group B. The random number was generated via a computer and sealed in an opaque envelope that was opened immediately before anesthesia. Different nerve blocks were performed before induction of general anesthesia. In Group A, a supraclavicular brachial plexus block was performed. In Group B, brachial plexus block via coracoid approach and posterior suprascapular nerve block were performed.

Prior to surgery, all patients underwent ultrasound-guided nerve block and diaphragm movement scan in the preparation room. Electrocardiography, pulse oxygen saturation and noninvasive blood pressure were monitored. The peripheral venous channel of the contralateral upper or lower extremity was opened, and a nasal catheter was used to administer oxygen (2 L/min).

First, the diaphragm movement was scanned in B-mode using an ultrasonic diagnostic instrument[8,9] (M7 expert, Shenzhen Mindray Biological Medical Electronics Co. Ltd., Shenzhen, China) and a low frequency convex array probe. The probe was placed between the midclavicular line and the anterior axillary line below the right costal arch and directed to the head, with the liver as the acoustic window. When the highest point of the diaphragm was found, the ultrasound machine was switched to M-mode. In M-mode, the diaphragm appeared as a highlighted white line that rose and fell with the breathing movement. After the appearance of a stable waveform, the image was frozen, and the extent of diaphragmatic excursion was measured, as the distance from the upward level to downward level using the average of three breathing cycles(Fig. 1). The diaphragmatic excursion was measured during calm breathing and deep breathing.
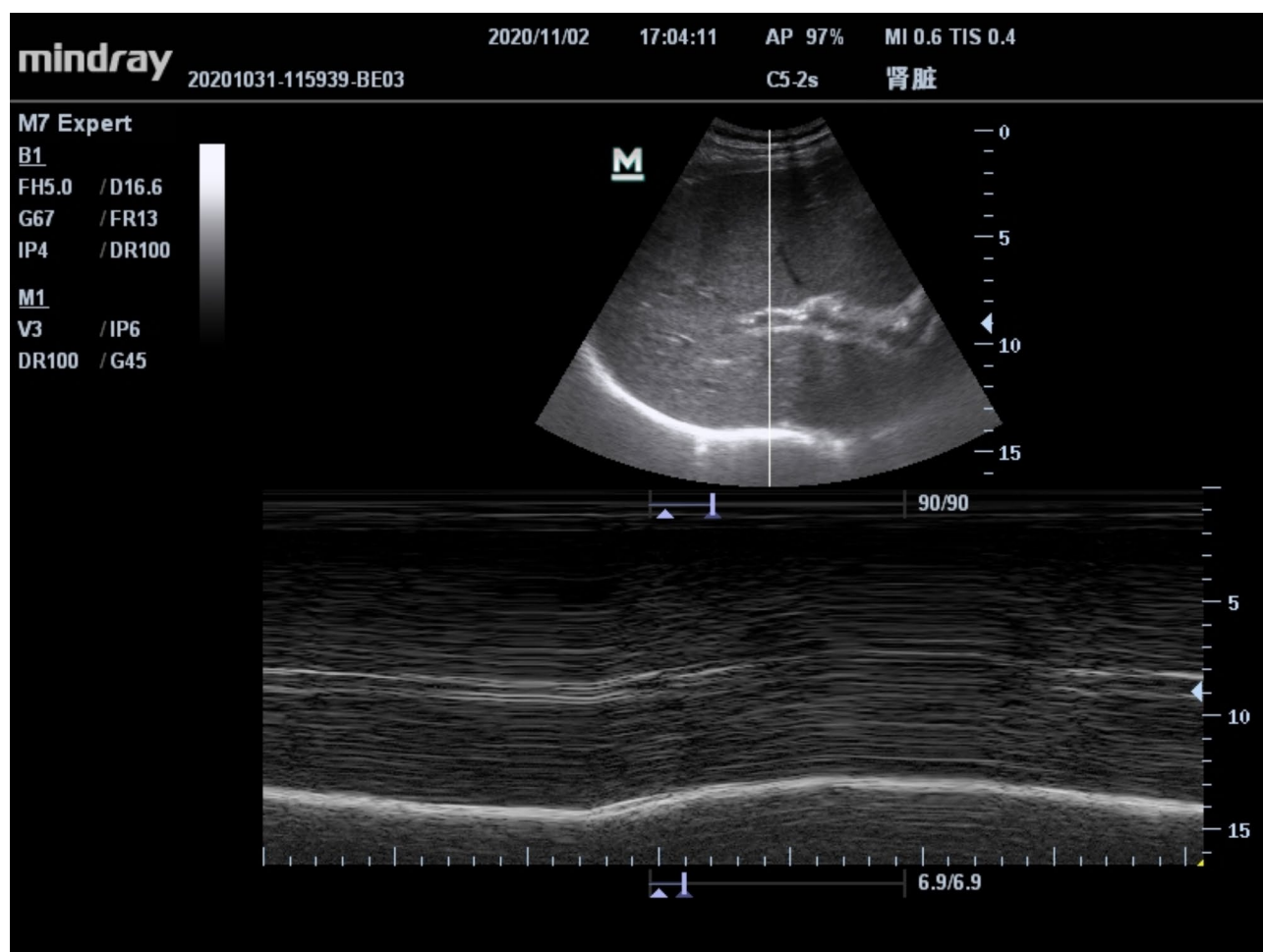

Fig. 1. Measurement of diaphragmatic excursion.

Then, ultrasound-guided nerve block was performed. For all patients, the local anesthetic was 25 mL 0.3% ropivacaine (AstraZeneca AB, Goteborg, Sweden). Supraclavicular brachial plexus block was performed in Group A. With the patient lying in a supine position, a high-frequency linear array probe was placed in the supraclavicular fossa to hunt for the subclavian artery. The short axis image of the brachial plexus nerve was located in the superior lateral quadrant of the subclavian artery. After skin sterilization and subcutaneous infiltration, the needle was inserted under the in-plane technique in a lateral-to-medial approach. The initial target of the needle was the corner pocket between the first rib and the subclavian artery. 15 ml of local anesthetic was injected. Subsequently, the needle was redirected toward the neural cluster. 10 mL of local anesthetic was injected.

Patients in Group B were treated with brachial plexus block via coracoid approach and posterior suprascapular nerve block. With the patient in a supine position, the ultrasonic probe was placed medial to the coracoid process under the clavicle and scanned sagittally. The angle of the probe was adjusted to capture an unambiguous image of the pectoralis major muscle, pectoralis minor muscle, axillary artery and pleura. Then, the needle was positioned cephalically and posteriorly to the axillary artery using the in-plane technique. 15 mL of local anesthetic was injected. Subsequently, the patient was changed to a lateral decubitus position with the surgical shoulder upward. The ultrasound probe was placed in the suprascapular fossa perpendicularly to the spine to locate the scapular notch and suprascapular artery. The needle was positioned near the suprascapular artery using the in-plane technique with a medial-to-lateral approach. 10 mL of local anesthetic was injected.

30 min after the nerve block, diaphragmatic excursion was measured again during calm breathing and deep breathing and compared with the pre-nerve block values. Ultrasound images of nerve blocks at different locations are shown in Supplementary Figs. 1, 2 and 3.

General anesthesia was performed in the operating room. The patients were given 100% oxygen. For all patients, midazolam 0.04 mg·kg^{-1}, propofol 1.5 mg·kg^{-1}, sufentanil 0.4 μg·kg^{-1} and cisatracurium 0.15 mg·kg^{-1} were intravenously injected for endotracheal intubation. After confirming the position and depth of the endotracheal tube, the respiratory parameters were adjusted to RR 10~12 beats per minute and VT 8 mL·kg^{-1}, maintained $P_{ET}CO_2$ 35~45 mmHg. Sevoflurane (2%~3%) and remifentanil (0.05~0.15 μg·kg^{-1}·min^{-1}) were used during the operation, and cisatracurium was added as needed. All patients were placed in the beach chair position. Sufentanil 0.1 μg·kg^{-1} was administered 20 min before the end of surgery.

After the operation, the patient was transferred to the PACU. All patients were treated with patient-controlled analgesia (PCA). The analgesic drugs were 150 μg sufentanil + 4 mg tropisetron, diluted to 150 mL with saline, background infusion 2 ml·h^{-1}, bolus dose 2 mL, and locking time 30 min.

Outcome parameters were recorded by independent observers who were unaware of the grouping situation. The incidence of hemidiaphragm paralysis in the two groups was recorded during calm breathing and deep breathing. Hemidiaphragmatic paresis was divided into three grades according to the percentage of diaphragmatic excursion compared to the baseline: no paresis (>75% of the baseline), partial paresis (25-75% of the baseline), and complete paresis (<25% of the baseline, diaphragm immobility or contradictory movement).

The pain score (VAS) of the two groups was recorded at 1, 6, 12, 24 and 48 h after the operation. The actual press times of the PCA pump and consumption of sufentanil during the first 48 h after surgery were recorded.

Perioperative complications such as nausea, vomiting, pruritus, respiratory depression and upper limb sensorimotor dysfunction were observed.

Data synthesis and statistical analysis

We projected the minimum sample size for this trial on the basis of an a priori power analysis. The reported incidence of hemidiaphragmatic paralysis following supraclavicular blockade ranged from 27.8 to 66.7%, so the incidence was estimated at 45% based on an approximate average[10,11]. We assumed that the incidence could be reduced to 10% with the improvement of technology. On this basis, to detect a 35% decrease, the minimum required sample size was 22 per group at α = 0.05 and β = 0.8. Considering the loss rate, we set the sample size to 25 patients in each group.

SPSS 17.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. The measurement variables with a normal distribution were expressed as the mean ± standard deviation, and the independent sample t-test was used for comparisons between groups. The enumeration variables were expressed as the number of cases and percentage (%), and the Mann–Whitney U test was used for comparisons between groups. Differences were considered statistically significant if $P < 0.05$.

Results

50 patients undergoing right shoulder arthroscopic surgery were randomly divided into two groups with 25 patients in each group. A total of 45 patients completed this study, 22 patients in group A and 23 patients in group B. There were no significant differences in sex, age, BMI, ASA physical status or surgical duration between the two groups (Table 1).

Group	Sex (M/F)	Age (year)	BMI(kg·m^{-2})	ASA physical status (I/II)	Surgical duration (min)
A	12/10	40.5 ± 10.3	23.7 ± 2.4	12/10	111 ± 28.8
B	15/8	41.8 ± 12.0	23.3 ± 3.3	9/14	112.8 ± 29.3

Table 1. Patient demographics and clinical characteristics. Data are presented as the mean ± standard deviation or frequency. There were no significant differences between the two groups.

		Hemidiaphragm paralysis			
	Group	No	Partial	Complete	*P* value
Calm breathing	A	11 (50%)	5 (23%)	6 (27%)	0.044
	B*	18 (78%)	3 (13%)	2 (9%)	
Deep breathing	A	13 (59%)	5 (23%)	4 (18%)	0.035
	B*	20 (87%)	2 (9%)	1 (4%)	

Table 2. Proportion of patients with hemidiaphragm paralysis (n, %). Data are presented as frequencies (percentages). *P<0.05 between the two groups.

	VAS at different time points						
Group	1 h	6 h	12 h	24 h	48 h	Effective press times of PCA pump	Consumption of sufentanil
A	0.95±0.72	1.55±0.91	2.22±1.07	2.73±1.03	3.18±1.26	10.9±2.7	117.7±5.3
B	1.13±0.76	1.39±0.58	2.22±1.00	2.52±0.73	2.91±1.12	12.6±2.9	121.2±5.8

Table 3. Postoperative analgesia effect ($\bar{x}\pm s$). Data are presented as the mean±standard deviation. There was no significant difference between the two groups.

Group	Breathing state	Pre-block diaphragmatic excursion (mm)	Post-block 30 min diaphragmatic excursion (mm)	Postoperative 6 h diaphragmatic excursion (mm)	Postoperative 24 h diaphragmatic excursion (mm)
Group A (supraclavicular block)	Calm breathing	22.5±3.5	15.3±4.2	17.8±3.9	21.0±4.1
Group B (coracoid approach block)	Calm breathing	23.0±3.2	20.5±3.8	22.1±4.0	22.8±3.5
P-value		0.619	<0.001	0.001	0.120

Table 4. Comparison of diaphragmatic excursion between groups A and B at different time points.

30 min after the block, partial and complete hemidiaphragm paralysis occurred in 5 and 6 cases in Group A and 3 cases and 2 case in Group B during calm breathing, respectively. Partial and complete hemidiaphragm paralysis occurred in 5 cases and 4 cases in Group A and 2 cases and 1 cases in Group B during deep breathing, respectively. The rate of hemidiaphragm paralysis in group B under two different breathing states was lower than that in group A, and the difference was statistically significant (*P*<0.05) (Table 2).

Pain scores at 1, 6, 12, 24 and 48 h after surgery were similar between the two groups. No intergroup differences were found in the effective press times of the PCA pump and consumption of sufentanil during the first 48 h after surgery (Table 3).

After the operation, there were 3 patients with nausea and 2 patients with vomiting in Group A and 4 patients with nausea and 1 patient with vomiting in Group B, and the differences were not statistically significant. There were no adverse reactions, such as pruritus, respiratory depression or upper limb sensorimotor dysfunction, in either group.

Preoperatively, there was no significant difference in diaphragmatic excursion between Group A and Group B (*P*>0.05). At 30 min post-block, diaphragmatic excursion in Group A significantly decreased (15.3±4.2 mm vs. 22.5±3.5 mm, *P*<0.05), whereas Group B showed minimal impact (20.5±3.8 mm vs. 23.0±3.2 mm, *P*>0.05). At 24 h postoperatively, diaphragmatic excursion in both groups approached baseline values; however, the recovery in Group A remained significantly lower than that in Group B (*P*<0.05) (Table 4).

Discussion

Postoperative pain remains an urgent problem to be solved in shoulder arthroscopy. Some studies have noted that the consumption dose of postoperative opioid analgesics in patients who underwent arthroscopic shoulder surgery is equivalent to that of postoperative thoracotomy patients[12]. Severe pain affects the early postoperative outcomes of patients.

Interscalene brachial plexus block is considered to be the gold standard for postoperative analgesia after shoulder arthroscopy, but it almost always leads to ipsilateral phrenic nerve block and hemidiaphragm paralysis, which limit its application in patients with preexisting pulmonary diseases[13,14].

It is necessary to seek an effective analgesic alternative to interscalene brachial plexus block for shoulder surgery. Supraclavicular brachial plexus block can provide the same analgesic effect as interscalene brachial plexus block, but the incidence of hemidiaphragm paralysis remains as high as 66.7%[15]. One study showed that injecting a local anesthetic mainly into the corner pocket (the conjunction formed by the first rib and the subclavian artery) can reduce the incidence of hemidiaphragm paralysis because the anterior scalene muscle acts as an anatomical barrier to separate the phrenic nerve from the corner pocket[16]. Even so, the occurrence of hemidiaphragm paralysis cannot be completely eradicated. This skill was applied in our study, and the incidence of hemidiaphragm paralysis was reduced to 45%. This incidence rate was close to the 47.5% reported in a

previous study[17]. A study by Ryu et al. showed that there was a 95.7% probability that the local anesthetic would spread to the interscalene area after the implementation of supraclavicular brachial plexus block[18]. This may explain why the supraclavicular brachial plexus block is associated with hemidiaphragm paralysis.

The innervation of the shoulder joint is complex. The ventral side is mainly innervated by the axillary nerve (originating from C5-6 and deriving from the posterior bundle), subscapular nerve (originating from C5-7 and deriving from the posterior bundle) and lateral thoracic nerve (originating from C5-7 and deriving from the lateral bundle). The dorsal side is mainly innervated by the suprascapular nerve (originating from C5-6 and deriving from the superior trunk) and axillary nerve[19]. Among them, the suprascapular nerve innervates 60% of the sensation of the shoulder joint capsule, and the axillary nerve innervates 30% of the sensation of the shoulder joint capsule[20]. Moreover, phrenic nerve is nearly indistinguishable from thebrachial plexus at the cricoid cartilage level (mean distance: 1.8 mm), but with additional 3 mm separation for every cm more caudal in the neck[21].

Based on the innervation of the shoulder joint, some researchers combined suprascapular nerve and axillary nerve blocks and achieved positive analgesic effects, but the pain relief in early postoperative patients was relatively poor[20]. This might be related to pain stimulation in the unblocked area.

In this study, we combined coracoid approach brachial plexus block and posterior suprascapular nerve block to cover the innervation of the shoulder joint and preserve phrenic nerve function. The axillary nerve, subscapular nerve and lateral thoracic meridian nerve are derived from the lateral bundle and the posterior bundle of the brachial plexus. When implementing coracoid approach brachial plexus block, the puncture needle is advanced from the cranial side to the caudal side and more easily arrives at the lateral bundle and the posterior bundle, thus reducing unnecessary medial bundle block. The brachial plexus at the coracoid level is far from the phrenic nerve. Therefore, coracoid approach brachial plexus block leads to less phrenic nerve block and hemidiaphragm paralysis than supraclavicular brachial plexus block. Suprascapular nerve block could be performed through either an anterior or posterior approach. Compared with the posterior suprascapular nerve block, the anterior approach is close to the supraclavicular brachial plexus, which might also lead to phrenic nerve block.Therefore, the technique we chose develops less side effects on the phrenic nerve. Some researchers reported a case in which shoulder arthroplasty was performed in an obese female patient with moderate to severe chronic obstructive pulmonary disease[22]. Posterior suprascapular nerve block and selective lateral bundle-posterior bundle infraclavicular brachial plexus block were performed and achieved a balance between maximum analgesia and minimum hemidiaphragm paralysis. Our research results were similar to this case. Recent studies have shown that the combination of suprascapular and axillary nerve blocks can provide effective analgesia for shoulder procedures, with some reports suggesting comparable efficacy to interscalene block[23]. For instance, a study by Lee et al.[24]. demonstrated that this combination achieves similar analgesic outcomes to interscalene block while avoiding phrenic nerve involvement. These findings highlight the potential of this technique as a phrenic nerve-sparing alternative, particularly for patients at higher risk of respiratory complications. However, variability in results may arise from differences in methodologies, patient populations, and surgical contexts, underscoring the need for further comparative research.

However, 10-15% of the patients in our study developed hemidiaphragm paralysis, suggesting that coracoid approach brachial plexus block combined with posterior suprascapular nerve block cannot completely prevent hemidiaphragm paralysis. The reasons may be as follows: (1) During the implementation of coracoid approach brachial plexus block, local anesthetics could spread along the brachial plexus to the head and into the interscalene area[25], close to the phrenic nerve. (2) Accessory phrenic nerve could possibly be present and converges into phrenic nerve at the root of the neck or in the thoracic cavity, where it runs around the subclavian vein or the subclavian artery[26]. Coracoid approach brachial plexus block targeting the subclavian artery might result in accessory phrenic nerve paralysis and impair movement of the diaphragm. In this study, the suprascapular nerve block was included only in Group B to compare its combined effect with the coracoid approach brachial plexus block against the supraclavicular brachial plexus block. Including it in both groups could have masked the distinctions between the two block techniques. However, we recognize that anatomical variations in the suprascapular nerve's branching pattern may lead to incomplete sensory coverage in Group A, which is a limitation of our study.

In recent years, anterior suprascapular block has gained attention as an alternative technique for shoulder analgesia. Studies have shown that this block can achieve effective postoperative analgesia comparable to interscalene block (ISB) while significantly reducing the incidence of hemidiaphragm paralysis (HDP)[27,28]. This advantage arises from the anterior approach's ability to avoid direct phrenic nerve involvement by targeting the suprascapular nerve from the anterior chest wall rather than the interscalene groove. Given this evidence, anterior suprascapular block represents a promising alternative to ISB, especially for patients at higher risk of respiratory complications.

The volume and injection site in supraclavicular brachial plexus blocks significantly contribute to the risk of phrenic nerve blockade. A larger volume of local anesthetic may spread cephalad to the interscalene region, increasing the likelihood of phrenic nerve involvement, as supported by Ryu et al.[29]., who reported a 95.7% likelihood of anesthetic diffusion into the interscalene area following supraclavicular block. Despite efforts to confine the anesthetic to the "corner pocket" region, this phenomenon persists due to the anatomical proximity of the phrenic nerve to the brachial plexus in this area. By contrast, the coracoid approach brachial plexus block targets the brachial plexus at a site more distal to the phrenic nerve, thus reducing the likelihood of inadvertent phrenic nerve blockade even when comparable volumes of anesthetic are used. Additionally, the inclusion of the posterior suprascapular nerve block in our technique provides comprehensive analgesia while further mitigating the risk of hemidiaphragm paralysis.

Additionally, the combination of suprascapular and axillary nerve blocks has been investigated as another effective strategy to provide analgesia for shoulder procedures while avoiding HDP[30,31]. These blocks selectively

target the primary sensory nerves of the shoulder joint, thereby minimizing reliance on phrenic nerve-adjacent techniques. Research indicates that this combination achieves comparable analgesia to ISB but with a significantly lower risk of respiratory side effects. This makes it a particularly attractive option for patients with preexisting pulmonary conditions or those unable to tolerate phrenic nerve block. Our study adds to this evolving field by demonstrating the benefits of combining the coracoid approach brachial plexus block with a posterior suprascapular nerve block. This technique effectively covers the sensory innervation of the shoulder while minimizing the risk of HDP.

One important limitation of this study is the lack of interscalene block (ISB) as a comparator. ISB is widely regarded as the gold standard for postoperative analgesia in shoulder surgeries due to its superior efficacy compared to other nerve block techniques. However, ISB is associated with an almost 100% incidence of ipsilateral phrenic nerve blockade, which restricts its application in patients with preexisting pulmonary conditions. Since the primary aim of this study was to investigate a technique with a reduced risk of phrenic nerve involvement, we chose to compare the coracoid approach brachial plexus block combined with posterior suprascapular nerve block (CAPB + PSNB) to the supraclavicular block (SCB), which has a reported phrenic nerve blockade incidence of approximately 45%. We acknowledge that excluding ISB limits the generalizability of our findings, especially since ISB remains the preferred method in many clinical settings. Future studies should include ISB as a control group to provide a more comprehensive evaluation of the efficacy and safety of CAPB + PSNB. A direct comparison between CAPB + PSNB and ISB would better support clinical decision-making, particularly for patients who are unable to tolerate phrenic nerve blockade.

There are some shortcomings in this study. We only observe the movement of the diaphragm but did not observe respiratory function parameters such as vital capacity or partial pressure of oxygen, which needs further observation. In addition, only a single dose of ropivacaine is used in this study, and the appropriate concentration and capacity of ropivacaine need to be further explored.

Conclusion
Ultrasound-guided coracoid approach brachial plexus block combined with posterior suprascapular nerve block can provide perfect postoperative analgesia for shoulder surgery and has less side effects on diaphragm movement. Compared with supraclavicular brachial plexus block, its analgesic effect is equal, with a lower incidence of hemidiaphragm paralysis, which is conducive to enhancing the early postoperative rehabilitation of patients undergoing shoulder arthroscopy.

Data availability
The data used during the present study are available from the corresponding author upon reasonable request.

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Author contributions

All authors contributed to the study conception and design.Wensheng He, Zhenyu Wu, Shan Su, Zengping HuangStudy design/planning: Wensheng He, Shan Su, Zengping Huang.Study execution: Wensheng He, Zhenyu Wu, Shan Su.Data analysis: Zhenyu Wu, Zengping Huang.Writing paper: Wensheng He, Zhenyu Wu, Zengping Huang.Revising the paper: all authors.

Declarations

Competing interests

The authors declare no competing interests.

Ethics approval and consent to participate

This study was performed in line with the principles of the Declaration of Helsinki. The study was conducted after receiving approval from the medical ethics committee of the first hospital of Qinhuangdao, (IRB no. 201601A013). Written informed consent was obtained from each enrolled patient.

Additional information

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