



The impact of the pore position of a self-coiling catheter for continuous interscalene brachial plexus block on postoperative pain in patients undergoing arthroscopic rotator cuff repair surgery: a prospective observational study

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Abstract

This prospective observational study aimed to investigate the usefulness of the self-coiling catheter for continuous interscalene brachial plexus block (CISB) in patients undergoing arthroscopic rotator cuff repair (ARCR). In 22 patients, the self-coiling tip of catheter was placed anterior to the C5 and C6 roots under ultrasound guidance. The primary outcome is the relationship between the distance from the distal side pore of the catheter to the C5/C6 nerve roots and the visual analogue scale (VAS) of postoperative pain. The distance was recorded as a positive value when the distal pore was anterior to the C5/C6 nerve roots, and as a negative value when it was posterior to the roots. The median distance from the distal pore to C5/C6 nerve roots was 5.0 [4.1, 6.5] mm at catheter placement before surgery and 0.0 [− 4.3, 2.2] mm at catheter removal the day after surgery. The distance between the distal pore and the cervical nerve roots was associated with the VAS score at catheter removal ($r = -0.455$, $P = 0.033$). These findings suggest that the distance between the distal pore of the self-coiling catheter and the C5/C6 nerve roots may affect the analgesic effect of CISB after ARCR.

Keywords Interscalene block catheter · Postoperative pain · Arthroscopic rotator cuff repair surgery

Introduction

After shoulder surgery, many patients may experience significant pain once the effect of a single-shot brachial plexus block dissipates. Continuous interscalene brachial plexus block (CISB) is a crucial anesthetic technique that effectively provides postoperative analgesia for patients undergoing shoulder surgery [1–4]. However, despite proper catheter placement, the analgesic effect is not always sufficient, often due to catheter displacement or leakage [5–8]. While the distance between the pore of the catheter and the nerve roots may affect the analgesic effectiveness of CISB, the precise

relationship between catheter positioning relative to cervical nerve roots and postoperative pain remains insufficiently clarified.

The self-coiling catheter, which has recently begun to be used in continuous peripheral nerve blocks, is expected to prevent catheter migration [9–12]. Conversely, the effectiveness of the self-coiling catheter remains a subject of debate, and further evidence is needed [11, 12].

The present study was performed to determine the pre- and postoperative position of CISB catheter with a self-coiling tip using color Doppler ultrasonography in patients undergoing arthroscopic rotator cuff repair surgery (ARCR). We investigated the correlation between the distal pore of the self-coiling catheter and the C5/C6 nerve roots and the visual analogue scale (VAS) score of shoulder pain at rest at the time of catheter removal the day after surgery.

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Materials and methods

This prospective, single-center, observational study was approved by the Ethics Committee of Kumamoto University Hospital and registered with the UMIN Clinical Trials Registry on January 14th, 2020 (UMIN000039157).

Adult consecutive patients with American Society of Anesthesiologists physical status 1 or 2 who underwent ARCR were enrolled. Patients were informed of the experimental protocol before the procedure.

All ultrasound-guided interscalene catheter placements were performed before the induction of general anesthesia. The patient was then placed in the side-lying position, turned to the non-operative side, and administered 25–50 μ g of fentanyl intravenously to relieve anxiety and

pain. We scanned the interscalene region preoperatively and identified the C5 and C6 roots in the short-axis view using an ultrasound probe (12L-SC linear array probe, Venue 50; GE Healthcare Japan, Tokyo, Japan). Under sterile conditions, we infiltrated 2–3 mL of 1% lidocaine into the skin with a 26-gauge needle.

The catheter set (HS type, Hakko Co. Ltd., Chikuma, Japan) that was used for CISB contained an 18-gauge Tuohy needle and a self-coiling catheter (Fig. 1). We inserted the needle from the posterior to anterior direction into the interscalene region without nerve stimulation. We moved the needle tip close to the cervical nerve roots through the middle scalene muscle and injected 15 mL of 0.25% levobupivacaine. The catheter tip coiled was placed anterior to the C5 and C6 roots (Fig. 2a). The catheter insertion site was sealed with securement dressing (SorbaView SHIELD

Fig. 1 The structure of the self-coiling catheter tip used in the present study

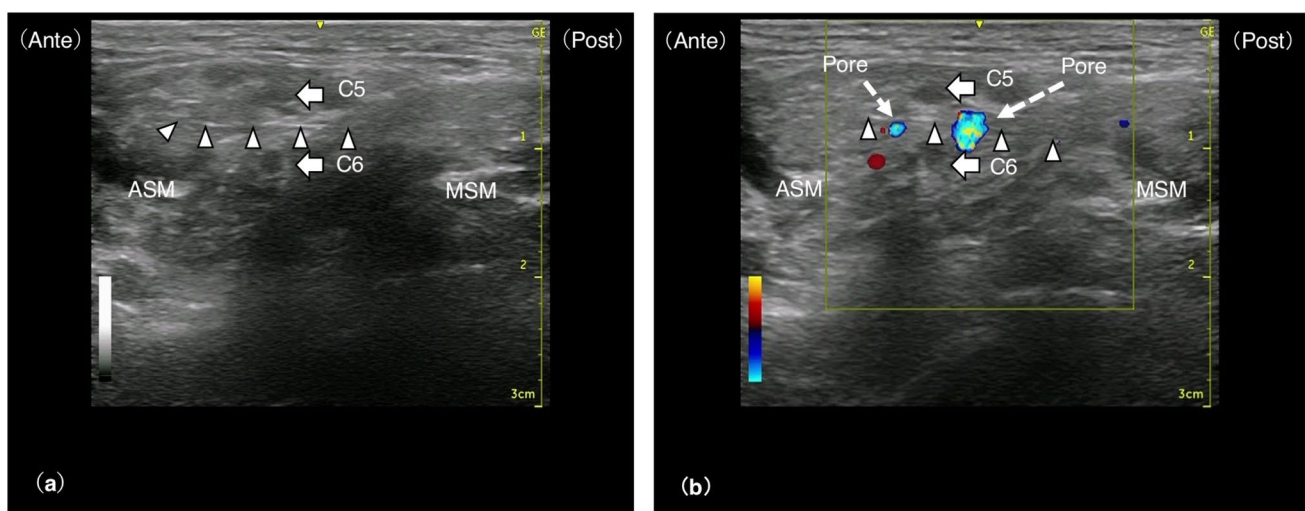
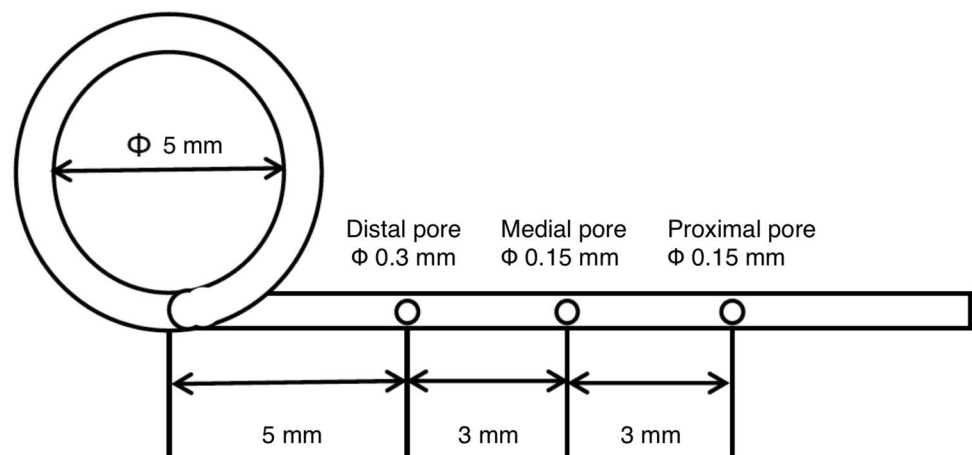


Fig. 2 **a** Cross-sectional ultrasound image of the brachial plexus and catheter after catheter placement. **b** Side pores of the catheter as shown by color Doppler ultrasonography. Ante, anterior; Post, pos-

terior; ASM, anterior scalene muscle; MSM, middle scalene muscle; C5/C6, C5/C6 nerve roots; Pore, side pore of catheter; arrows heads, catheter

Plus IV; Centurion Medical Products Corp., Williamston, MI, USA).

We measured the distance between the distal pore of the self-coiling catheter and C5/C6 nerve roots at three time points: just after catheter placement, immediately after surgery, and at catheter removal, using color Doppler ultrasonography (Fig. 2b). The distance from the catheter to the cervical nerve roots was defined as the distance from the midpoint between the C5 and C6 root to the distal side pore of the catheter. We recorded the distance as a positive value when the distal pore was anterior to the C5 and C6 nerve roots, and as a negative value when it was posterior to the roots. After catheter placement, general anesthesia was induced with propofol, remifentanyl, and rocuronium to facilitate tracheal intubation and maintained with sevoflurane, propofol, remifentanyl, or fentanyl depending on each anesthesiologist's preference. Flurbiprofen axetil at 50 mg or acetaminophen at 15 mg/kg (body weight \geq 50 kg, 1000 mg) was administered intravenously at the end of surgery. After the patient had emerged from anesthesia, the patient received an infusion of 0.125% levobupivacaine at 5 mL/h without a patient control system. In the evening of postoperative day 1, we removed the catheter.

The patients were given oral celecoxib at 200 mg every 12 h for routine analgesia from the morning of postoperative day 1. Oral acetaminophen at 500 mg or a diclofenac sodium suppository at 25–50 mg was administered for rescue analgesia. Pentazocine at 15 mg and hydroxyzine hydrochloride at 25 mg were given intravenously when the effects of acetaminophen or diclofenac are insufficient.

The VAS score, which ranged from 0 (no pain) to 100 (worst pain imaginable) mm, was measured just after catheter placement, immediately after surgery, and at the time of catheter removal. The frequency of using rescue analgesia and block-related complications were also investigated.

The primary outcome is the assessment of the relationship between the distance from the distal side pore of the self-coiling catheter to the C5/C6 nerve roots and the VAS score of postoperative pain at catheter removal. The secondary outcome is the assessment of correlations between postoperative VAS scores and the frequency of analgesic use prior to catheter removal, operative time, and perfusion fluid volume. In a preliminary study of 7 patients, the correlation coefficient between the distance of the catheter from the cervical nerve roots (1.2 [– 3.3, 2.9] mm) and the postoperative VAS (24 [12, 42.5] mm) at catheter removal was – 0.52. A power analysis using the data from the preliminary study demonstrated that a sample size of 22 subjects was sufficient to detect a significant correlation with a power of 0.80 and alpha of 0.05. Correlations between postoperative VAS scores and the distance of catheter from the cervical nerve roots, the frequency of analgesic use, operative time, and perfusion fluid volume

were statistically analyzed using Spearman's rank correlation. Statistical significance was considered at $P < 0.05$. The statistical analysis was performed using EZR [13].

Results

Twenty-two patients were analyzed. The patients' characteristics and a summary of the operative procedures are provided in Table 1.

The median distance from the distal pore of the catheter to the midpoint between the C5 and C6 roots was 5.0 [interquartile range, 4.1, 6.5] mm at the time of catheter placement, 2.8 [0.1, 5.0] mm immediately after surgery and 0.0 [– 4.3, 2.2] mm at the time of catheter removal the day after surgery. While the position of the catheter at the insertion site has not changed in all patients, the catheter moved posteriorly by the first postoperative day in 20 of 22 patients (90.9%). The median VAS score for shoulder pain immediately after surgery was 0 [0, 0] mm, while at rest upon catheter removal, it was 11.5 [5.0, 32.0] mm.

Regarding the primary outcome, there was an association between the distance from the distal pore of the catheter to the C5/C6 cervical nerve roots and the VAS score at the time of catheter removal. ($r = -0.455$, $P = 0.033$) (Fig. 3).

No correlation was found between VAS and the frequency of analgesic uses ($P = 0.92$), VAS and surgery time ($P = 0.45$), or VAS and the amount of perfusate ($P = 0.46$).

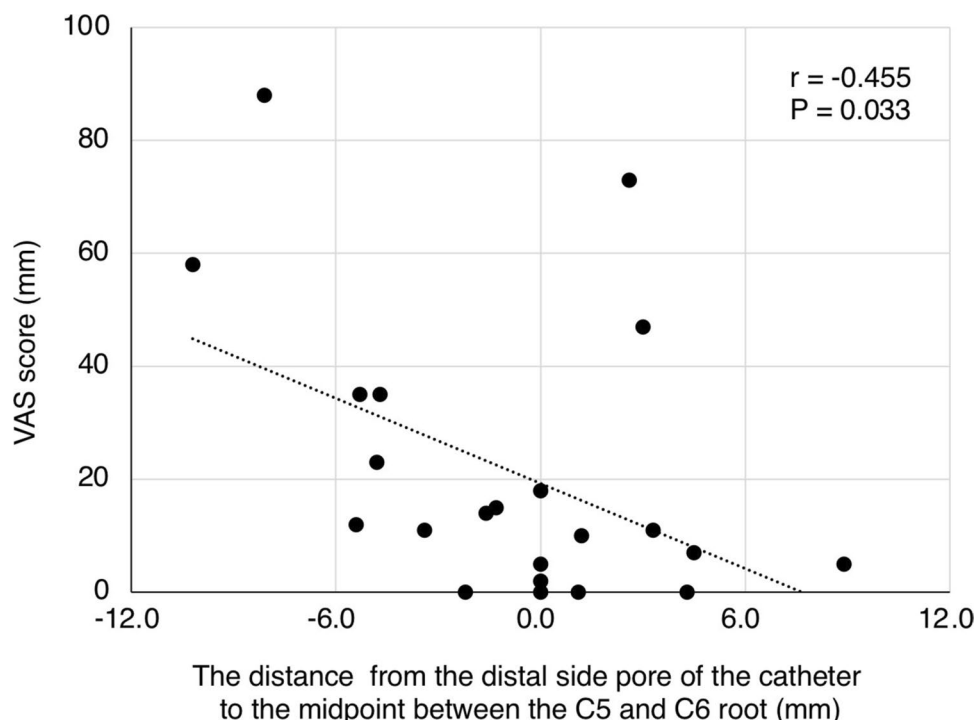
Symptomatic phrenic nerve palsy was observed in 2 of 22 patients (9.0%) and Horner's syndrome was observed in 1 of 22 patients (4.5%) until the night on the day of surgery, which required no treatment.

Table 1 Patients' characteristics and summary of operative procedures

Parameter	$n = 22$
Age	65 [58, 70]
Body mass index (kg/m ²)	25.8 [23.2, 26.2]
Sex (male)	18 (81.8)
Surgical site (right)	15 (68.1)
Surgical time (min)	133 [109, 174]
Total amount of perfusate (L)	29 [22, 36]
Intraoperative remifentanyl (μ g/kg/h)	9.7 [8.0, 11.9]
Intraoperative fentanyl (μ g/kg/h)	1.2 [0.9, 1.5]

Values are expressed as median [interquartile range] or n (%)

Fig. 3 Correlation between the distance from the distal side pore of the catheter to the nerve and the VAS score of shoulder pain at catheter removal. VAS visual analogue scale



Discussion

In the present study, we found that the self-coiling interscalene catheter had migrated posteriorly in most of the patients undergoing ARCR by the day after surgery while the position of the catheter at the insertion site had not changed. The distance between the distal pore of the self-coiling catheter and the C5/C6 nerve roots was significantly associated with the VAS score at the time of catheter removal the day after surgery.

While it has become possible to examine in greater detail the correlation between the condition of the inserted catheter for continuous catheter-based peripheral nerve blocks and postoperative pain [7, 8, 12, 14, 15], there have been few studies examining the relationship between the distance from the catheter to the nerves and postoperative pain. Our study demonstrated a new finding that the distance between catheters and the cervical nerve roots is associated with postoperative pain after shoulder surgery.

Although a relationship was observed between the distance from the catheter to the C5/C6 nerve roots and postoperative VAS, the correlation was weak. Furthermore, considering that adequate analgesia was achieved in the majority of cases, the clinical relevance of this correlation appears to be limited. Additionally, due to the inherent limitations of ultrasound imaging, we were unable to accurately determine the catheter's precise trajectory or the shortest distance between the catheter and the nerve roots. While the distal pore of the catheter was observed to shift posteriorly, other catheter pores may have moved closer to the nerve roots due

to catheter flexion. Therefore, the clinical significance of the distance between the distal pore and the nerve roots on analgesic efficacy remains uncertain.

This study used a coiled-tip catheter with the expectation of minimizing catheter migration. Although catheter migration posteriorly was observed in more than 90.9% (20/22) of patients by the day after surgery, the postoperative VAS of 11.5 [5.0, 32.0] mm was considered clinically acceptable for analgesia. The reason why the analgesic effect was maintained despite the migration of the catheter is presumably related to the position of the distal pore of the catheter. We positioned the distal pore of the catheter anterior to the C5/C6 nerve roots at the time of placement. Although the distal pore migrated posteriorly by approximately 5 mm during the postoperative period, it likely remained within the interscalene groove, continuing to provide effective analgesia. Our method of placing the coiled tip and the distal pore anterior to the nerve roots may decrease the loss of analgesic effect due to posterior catheter migration.

This study had several limitations. First, we did not assess the positions of the middle and proximal pores of the self-coiling catheter. Therefore, the analgesic effects may be influenced by the local anesthetic administered through both pores. The second limitation is the use of VAS score for postoperative assessment. The VAS is highly subjective and relies on the patient's self-reporting of pain, which can be influenced by various factors such as mood, attention, and understanding of the scale. Importantly, although no correlation was observed between the frequency of postoperative analgesic use and the VAS score, both the use and timing of

analgesic administration may have affected the VAS score at the time of catheter removal.

In conclusion, this study showed that the distance from the distal pore of the self-coiling catheter to the C5/C6 nerve roots was associated with postoperative pain after ARCR. The interscalene catheter, equipped with a self-coiling tip, may migrate posteriorly during the postoperative period; however, the extent of this migration is unlikely to have a significant clinical impact on postoperative pain.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s00540-025-03465-2>.

Author contributions Marie Hara and Yoshihiro Ikuta contributed to the study conception and design. They performed material preparation and data collection. Naoyuki Hirata supervised the study and performed data analysis. The first draft of the manuscript was written by Marie Hara and all co-authors reviewed and revised the manuscript. All authors read and approved the final manuscript.

Data availability The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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