Journal of Anesthesia (2025) 39:56–60
https://doi.org/10.1007/s00540-024-03422-5

ORIGINAL ARTICLE

Ultrasound assessment of the frequency and variation of arteries in the interscalene region

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Received: 29 December 2023 / Accepted: 18 October 2024 / Published online: 6 November 2024

Abstract

Purpose Given the abundance of arteries in the neck, a significant risk of puncturing arteries exists when performing a brachial plexus block. Therefore, it is important to confirm the presence of arteries when performing a brachial plexus block via the interscalene approach. This study aimed to investigate the frequency and variations of arteries in the interscalene region in healthy Japanese adults using ultrasonography.

Methods This is an observational study at a university hospital. We analyzed videos of the brachial plexus recorded in another study using an ultrasound device and then investigated the frequency of the presence of arteries and the location of arteries in the interscalene region.

Results Among 68 cases, 48 (70.6%) had one or more arteries in the interscalene region (63 arteries in total). The artery frequency on the ventral side of the 5th cervical nerve (C5), between C5 and the 6th cervical nerve (C6), between C6 and the 7th cervical nerve (C7), between C7 and the 8th cervical nerve (C8), and on the dorsal side of C8 was 19.1%, 1.5%, 35.3%, 29.4%, and 7.4%, respectively. The artery frequencies between C6 and C7 and between C7 and C8 were higher than those between C5 and C6 and on the dorsal side of C8.

Conclusion Interscalene observations using ultrasound devices revealed a high artery frequency, with numerous topographic variations.

Keywords Brachial plexus block · Hematoma · Complication · Anatomical study · Variation of arteries

Introduction

Brachial plexus blocks have an important role in shoulder and upper extremity pain management during the perioperative period and in pain clinics. Given the numerous arteries in the neck, including the common carotid, ascending cervical, vertebral, dorsal scapular, superficial cervical, transverse cervical, and suprascapular arteries, there is a significant risk of puncturing arteries when performing a brachial plexus block via the interscalene approach [1]. Furthermore, arteries between the scalene muscles prevent the spread of drug solutions, resulting in an insufficient blocking effect [2]. Therefore, confirming the presence or absence of arteries using an ultrasound device when conducting a brachial plexus block is important.

Muhly and Orebaugh used an ultrasound device to observe blood vessels in the interscalene region in American participants [3]. They reported that arteries were present near the brachial plexus in 90% of the cases; most arteries (83.7%) were located at the scalene muscles contour and were rarely located between the nerves (6.3%). To our knowledge, no further studies have investigated arteries in the interscalene region using ultrasonography. In clinical practice, when checking for the presence of perineural arteries during ultrasound guided brachial plexus block, we observed that arteries were often present between scalene muscles.

In this study, we aimed to investigate the frequency and variations of arteries in the interscalene region in healthy Japanese adults using an ultrasound device.

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Methods

This study was approved by the Ethics Committee of Fukushima Medical University (approval number: 2022-027). The ethics committee granted a waiver of written informed consent, with consent obtained through an opt-out form on the website.

From 2020 to 2022, we conducted research entitled "Practical application of a navigation system for ultrasound guiding of peripheral nerve blocks" (approval number 2020-241; Research A). Our aim in Research A was to develop a navigation system for peripheral nerve blocks using artificial intelligence. Artificial intelligence learning requires training data; therefore, we recorded ultrasound videos of the brachial plexus of adults aged 20 years or older, American Society of Anesthesiologists Physical Status classification (ASA-PS-Class) 1–2. We used an ultrasound device (SonoSite Edge II and Sonosite PX; Fujifilm, Tokyo, Japan) and a 13–6 Hz linear probe to record videos with the participants in the supine position. The probe was used gently to avoid artery compression, and color Doppler ultrasound was applied around the brachial plexus. Exertion of light pressure on veins can cause their collapse. Research A did not emphasize the depiction of veins, because its prioritization would reduce image quality in the training data. Nerves and blood vessels were marked in the videos, which were then used as training data.

In the present study, we analyzed videos recorded in Research A to determine the frequency and location of blood vessels in the interscalene region. The "interscalene region" was defined as follows: between the anterior and middle scalene muscles; cranially from the height where all three of the 5th cervical nerve (C5), anterior scalene muscle, and middle scalene muscle can be confirmed (Fig. 1a); and caudally to the height where the 8th cervical nerve (C8) and first rib can be seen (Fig. 1b). Furthermore, the interscalene region was categorized into five zones as follows: ventral side of C5 (Zone A), between the nerves (C5–C8) (Zones B–D), and between the C8 and the first rib (Zone E) (Fig. 2).

We analyzed the videos taken in Research A and determined the presence or absence of blood vessels in the interscalene region. Blood vessels were defined as arteries when clear pulsations or arterial pulsations were observed on color Doppler ultrasound. If no pulsation was observed and the lumen collapsed caused by probe pressure, the vessels were defined as veins.

The presence or absence of blood vessels and their position in Zones A–E were recorded. The frequencies of arteries in the five zones were compared using the chi-squared test with Bonferroni corrections. A P value of < 0.05 was considered statistically significant. Additionally, we investigated where arteries branched and their course to the extent that could be confirmed.

Results

We analyzed 68 videos of the bilateral brachial plexuses of 34 participants. Table 1 presents the characteristics of the 34 participants.

Among the 68 cases, 48 (70.6%) had one or more arteries in the interscalene region (63 arteries in total). Table 2 presents the frequencies of arteries in each zone. Thirteen cases had arteries on the ventral side of C5 (Zone A), and 38 cases had arteries between the cervical nerves (Zones B–E). The frequencies of arteries differed significantly among the five zones ($P < 0.01$).

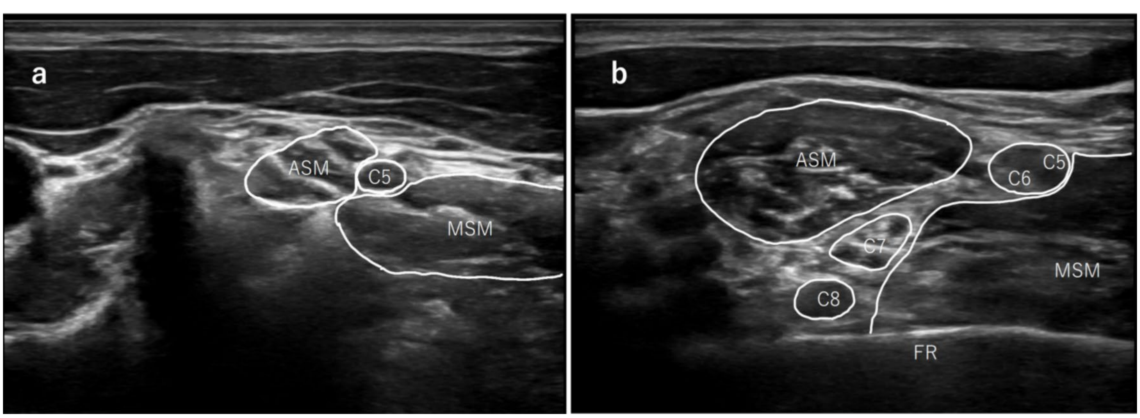

Fig. 1 Interscalene region. **a** The cranial side of the interscalene region was defined as the height where the C5 nerve, ASM, and MSM can be confirmed. **b** The caudal side of the interscalene area was defined as the height where C8 and the first rib can be seen. *C5* the 5th cervical nerve, *C6* the 6th cervical nerve, *C7* the 7th cervical nerve, *C8* the 8th cervical nerve, *ASM* anterior scalene muscle, *MSM* middle scalene muscle, *FR* first rib

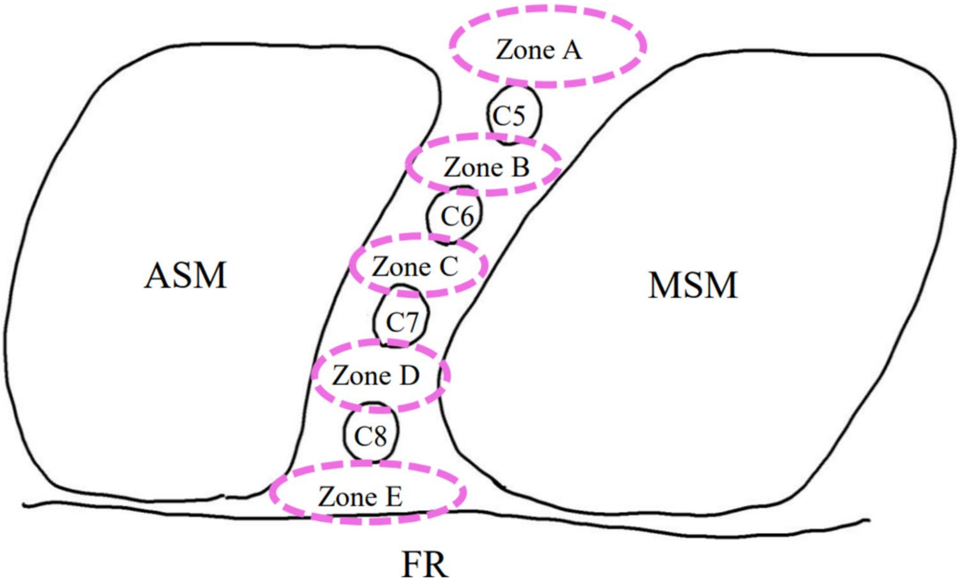

Fig. 2 Interscalene region was categorized into five zones as follows: *Zone A* ventral side of C5, *Zone B* between C5 and C6, *Zone C* between C6 and C7, *Zone D* between C7 and C8, *Zone E* between C8 and FR. *C5* 5th cervical nerve, *C6* 6th cervical nerve, *C7* 7th cervical nerve, *C8* 8th cervical nerve, *FR* first rib, *ASM* anterior scalene muscle, *MSM* middle scalene muscle

Table 1 Characteristics of the participants ($n = 34$)

Sex (male/female)	18/16
Age (years)	28.1 ± 7.3 (22–52)
Height (cm)	166.6 ± 8.7 (152–183)
Weight (kg)	60.1 ± 11.4 (40–86)

Values are presented as *n* or mean ± standard deviation (range)

Table 2 Frequencies of arteries in zones

Zone	Artery frequency	Comparison of frequency between zones
A	13/68 (19.1%)	A vs. B $P = 0.01$
		A vs. C $P = 0.5$
		A vs. D $P = 1.0$
		A vs. E $P = 0.7$
B	1/68 (1.5%)	B vs. A $P = 0.01$
		B vs. C $P < 0.01$
		B vs. D $P < 0.01$
		B vs. E $P = 1.0$
C	24/68 (35.3%)	C vs. A $P = 0.5$
		C vs. B $P < 0.01$
		C vs. D $P = 1.0$
		C vs. E $P < 0.01$
D	20/68 (29.4%)	D vs. A $P = 1.0$
		D vs. B $P < 0.01$
		D vs. C $P = 1.0$
		D vs. E $P = 0.02$
E	5/68 (7.4%)	E vs. A $P = 0.7$
		E vs. B $P = 1.0$
		E vs. C $P < 0.01$
		E vs. D $P = 0.02$

Figure 3 depicts arteries in the interscalene region. Arteries in Zone A, in front of the scalene muscles, were believed to be the ascending cervical, transverse cervical, and suprascapular arteries (Fig. 3a). Arteries in Zones C and D were believed to be the transverse cervical, suprascapular, and feeding arteries of the spinal cord, which are branches of the ascending cervical and vertebral arteries. Some of these arteries were confirmed to penetrate the middle scalene muscle and run toward the shoulder. Therefore, these arteries were believed to be the transverse cervical or suprascapular arteries (Fig. 3b, c). Additionally, arteries running toward the intervertebral foramen were believed to be the spinal feeding arteries (Fig. 3d). The feeding arteries in the spinal cord were mostly small, but some were large. Arteries in Zone E on the dorsal side of C8 were believed to be the transverse cervical or suprascapular arteries passing under the brachial plexus; however, they could also be part of the subclavian artery.

Three cases had one vein each, which were located in Zones C, D, and E, respectively.

Discussion

This study revealed a high frequency of arteries (70.6%) in the interscalene region in healthy Japanese adults. The comparison of artery frequency between the five zones showed that artery frequency between the 6th cervical nerve (C6) and the 7th cervical nerve (C7) (Zone C) and that between C7 and C8 (Zone D) were higher than that between C5 and C6 (Zone B) and on the dorsal side of C8 (Zone E).

In this study, 19.1% (13/68 cases) had arteries in ventral side of C5 (Zone A). Anatomically, many arteries, such as

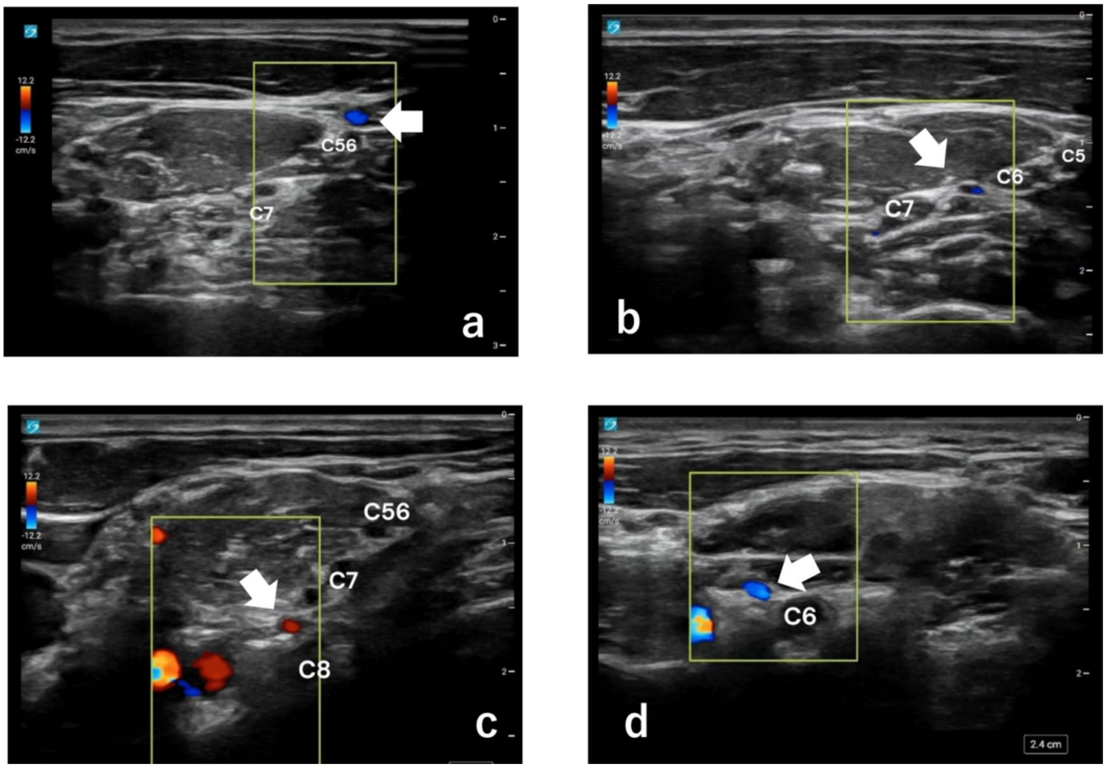

Fig. 3 Arteries in the interscalene region. **a** The white arrow indicates an artery on the ventral side of C5. **b** The white arrow indicates an artery between C6 and C7. **c** The white arrow indicates an artery between C7 and C8. **d** The white arrow indicates an artery running towards the intervertebral foramen. *C5* 5th cervical nerve, *C6* 6th cervical nerve, *C7* 7th cervical nerve, *C8* 8th cervical nerve

the ascending cervical, transverse cervical, and suprascapular arteries, should appear in front of the scalene muscles. Arteries on the surface are easily collapsed owing to the light pressure exerted by the probe. The ultrasound probe pressure easily collapses the superficial arteries, and some of the minor arteries along the contour of the scalene muscles may have been compressed in Research A.

In our observations, 55.9% (38/68 cases) had arteries between the adjacent cervical nerves (Zone B–E). In a study on Japanese cadavers, Adachi [4] reported that the suprascapular artery passed through the brachial plexus in 28% cadavers and the transverse cervical artery passed through the brachial plexus in 40% cadavers. The higher frequency of arteries in the interscalene region in this study compared to previous reports may be due to recent improvements in the resolution of ultrasound imaging to detect small vessels.

The higher artery frequency can also be attributed to the presence of racial differences in blood-vessel anatomy. Individual and racial differences in arterial branching in the neck have been reported [4–6]. Adachi reported that the transverse cervical artery branches off from the thyrocervical trunk and passes above the brachial plexus in “the United Kingdom type” (Online Resource Fig. 1a), which is prevalent in the United Kingdom; the prevalence of this branching pattern among Japanese people is 55% [5]. The transverse cervical artery branches directly from the subclavian artery and passes through the brachial plexus in “the German type” (Online Resource Fig. 1b), which is prevalent in Germany; the prevalence of this branching pattern among Japanese people is 40% [5]. In a study of Kenyan cadavers, “the United Kingdom type” was noted in 94% cadavers and “the Germany type” was noted in only 2% cadavers [6]. On the other hand, in a study of German and Austrian cadavers, the prevalence of “the United Kingdom type” was noted in 40% cadavers and that of the “German type” was noted in 40% cadavers [7]. Therefore, the rates at which the transverse cervical arteries pass through the brachial plexus differ by race.

Accidental puncture of arteries during nerve block can lead to complications such as hematoma and local anesthetic systemic toxicity. Furthermore, these arteries prevent the spread of drug solutions, resulting in an insufficient blocking effect [2]. Confirming the presence of arteries using color Doppler ultrasound during puncture is important, and aspiration should be performed before drug administration to confirm the absence of backflow of blood even if no blood vessels are found on ultrasound because blood vessels are often present in the interscalene region.

In this study, the frequency of veins was very low (4.4%). Compared to arteries, veins are more easily compressed owing to the pressure exerted by the probe. This study did not focus on veins because puncturing a small vein rarely results in a large neck hematoma that can cause airway obstruction.

This study has certain limitations. First, some blood vessels may have been overlooked owing to the pressure exerted by the probe and intravascular volume status. Second, we did not focus on veins in this study. In the future, detailed research involving ultrasound observation and dissection is necessary to understand the dynamics of blood-vessel flow.

In conclusion, our ultrasound observations in the interscalene region revealed that the artery frequency in that region was 70.6%, with numerous topographic variations. The frequency of arteries between C6 and C7 (35.3%) and C7 and C8 (29.4%) was higher than that between C5 and C6 (1.5%) and the dorsal side of C8 (7.4%).

Acknowledgements We would like to thank Editage (www.editage.jp) for English language editing.

Author contributions Rieko Oishi devised the project and the main conceptual ideas. Rieko Oishi carried out the investigations with support from Shinju Obara and Hiroyuki Yaginuma. Rieko Oishi wrote the manuscript with support from Shinju Obara, Keisuke Yoshida, Shin Kurosawa, and Satoki Inoue. Satoki Inoue supervised the project.

Declarations

Conflict of interest The authors have no conflict of interest.

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