Journal of Anesthesia (2025) 39:555–561
https://doi.org/10.1007/s00540-025-03503-z

ORIGINAL ARTICLE

Ultrasound-guided serratus posterior superior muscle block: an anatomical study investigating the extent of injected dye and the mechanism of action of a simulated injection in Thiel soft-embalmed cadavers

Atsushi Sawada[1] · Tatsuya Kunigo[1] · Yuki Ohsaki[2] · Kanna Nagaishi[3] · Michiaki Yamakage[1]

Received: 24 January 2025 / Accepted: 6 April 2025 / Published online: 17 April 2025

Abstract

Purpose The extent of local anesthetic spread and mechanism of action of serratus posterior superior muscle (SPSM) block is still debatable. This cadaveric study aimed to evaluate the anatomical spread of 30 or 20 mL of dye following a simulated SPSM block in Thiel soft-embalmed cadavers.

Methods Simulated SPSM block injections were administered bilaterally in four cadavers (left side: 30 mL, right side: 20 mL). Anatomical dissection was performed to evaluate the extent of spread of the injected dye over the ribcage, and to document staining of the musculature of the back following a simulated SPSM block.

Results The extents of spread (mean ± SD) of 30 mL and 20 mL of dye over the ribcage were 8.5 ± 3.9 cm and 5.5 ± 1.6 cm, respectively. Dye spread to the peri-scapular fascia was observed in all four of the simulated SPSM blocks with 30 mL of dye, but not with 20 mL. Dye spread into the rhomboid major muscle was observed in two of the simulated SPSM blocks with 30 mL of dye.

Conclusion Our findings suggest that the SPSM block using 30 mL of dye has a tendency to spread wider compared to the SPSM block using 20 mL of injectate, and that the block might serve as an interfascial block rather than a segmental nerve block. Further studies in a large sample of human participants are required to confirm the optimal volume of local anesthetic in the SPSM block.

Keywords Serratus posterior superior muscle block · Myofascial pain syndrome · Thiel soft-embalmed cadavers · Interfascial block · Regional anesthesia

Introduction

Myofascial pain syndrome (MPS), which originates from the muscles and surrounding fascia, presents with musculoskeletal pain, and is most often described as a chronic pain condition [1, 2]. A prevalence rate of MPS of 21% has been reported in the general orthopedic population [2]. Patients with MPS usually present sensory, motor and autonomic complaints in various parts of the body, most commonly in the neck, shoulder and back [2]. The goal of treatment for MPS is to minimize pain, restore the patient's functional status, and improve their quality of life. Clinical guidelines for the management of MPS recommend pharmacological treatments, physical therapy, and interventional procedures [3]. The interventional procedures performed include dry needling, acupuncture, transcutaneous electrical nerve stimulation, or trigger point injections [2]. However, some patients do not respond adequately to these treatments, with progressive worsening of their symptoms to a chronic pain status. Recently, interfascial blocks, with injection of local anesthetics or physiological saline between the affected muscles, have been reported to reduce the intensity of pain

✉ Atsushi Sawada
atusihon7@gmail.com

1 Department of Anesthesiology, Sapporo Medical University School of Medicine, South 1, West 16, Chuo-Ku, Sapporo 060-8543, Japan

2 Department of Anatomy (I), Sapporo Medical University School of Medicine, Sapporo, Japan

3 Department of Anatomy (II), Sapporo Medical University School of Medicine, Sapporo, Japan

in patients with MPS [4–6]. Taketa et al. reported that the serratus posterior superior muscle (SPSM) block, in which 15 mL of 0.25% ropivacaine is applied to the surface of the SPSM, alleviated lower cervical and shoulder pain in 15 patients with MPS [7]. They also suggested that the SPSM block is a kind of fascial block similar to the serratus anterior muscle block, and the SPSM block is advantageous in terms of requiring only a single injection on each side, compared to conventional multiple trigger point injections. However, there is still no consensus on the extent of local analgesic spread and the mechanism of action of the SPSM block. Considering that the SPSM block is a kind of fascial block, we hypothesized that performing the SPSM block using a higher volume of local anesthetics than 15 mL would effectively reduce the intensity of pain in patients with MPS. Therefore, we performed this cadaveric study with the aim to evaluate the anatomical spread of two different volumes of colored dye, 20 and 30 mL, injected to simulate an SPSM block in Thiel soft-embalmed cadavers.

Methods

Anatomical study

This study was approved by the Ethics Committee of Sapporo Medical University, Japan (No. 5-1-14). Four Thiel-embalmed adult human cadavers (three females and one male) that were donated to the body donation program (Shiragiku-kai) run by Sapporo Medical University for medical scientific research were studied. None of the cadavers had previously undergone spinal, back or shoulder surgery during their lifetime.

Ultrasound-guided SPSM block procedure

The simulated SPSM block injections were administered bilaterally in four cadavers by a single experienced anesthesiologist (AS) familiar with the SPSM block. The cadavers were placed in the prone position. A SonoSite S II ultrasound machine (Fujifilm Sonosite, Tokyo, Japan) with a high-frequency linear probe (6–13 MHz) was used for ultrasound imaging. After placing the linear probe in the sagittal direction at the scapular spine level, we identified the second rib, the SPSM, rhomboid major muscle (RMM), and the trapezius muscle (TM) (Fig. 1a). Next, an 80 mm 22 G non-insulated echogenic needle (Ultraplex 360®, B. Braun, Melsungen, Germany) was inserted in the cranial direction using the in-plane technique, so that the needle contacted the surface of the SPSM at the second rib level (Fig. 1b). After the needle tip was confirmed by ultrasound as being in the appropriate space (Fig. 1c), we injected a saline-soluble dye (left side: 30 mL of blue dye, right side: 20 mL of green dye) into the space between the SPSM and RMM (Fig. 1d).

Anatomic dissection and evaluation of dye spread

In all cadavers, the same dissection procedure for documentation of dye distribution was commenced approximately 30 min following the simulated SPSM block, and was performed on both sides by two investigators working together (AS and TK), both of whom were familiar with the anatomy of the back and shoulder. With the cadaver in the prone position, a sagittal skin incision was made from the spinous process of C7 to that of T12. Next, the cranial edge of the sagittal skin incision was extended laterally to the acromion process, and the caudal edge of the sagittal skin incision was extended laterally over the costal margins. A flap consisting of the skin and subcutaneous adipose tissue was raised and reflected laterally. The trapezius muscle was exposed and a trapezius muscle flap was subsequently elevated to expose the underlying RMM and rhomboid minor muscle (RmM). The RMM and RmM flaps were then dissected from the spinous process to separate the scapula from the ribcage. The spread of dye on the surface of the ribcage was assessed as the distance from the midline to the lateral edge of dye spread along the ribs between T1 and T10. The spread of dye to the peri-scapular fascia was assessed by the presence of injected dye on the anterior aspect of the scapula. The erector spinae muscle (ESM) and each intercostal muscle (ICM) between T1 and T10 were subsequently dissected to assess the presence of injected dye within the muscles. Dye staining of the TM, RMM, RmM, SPSM, ESM, each ICM between T1 and T10, and the dorsal scapular nerve, which runs in the peri-scapular space, was graded as stained or not stained. The primary outcome of this anatomical study was evaluation of the extent of injectate spread, as measured by the distance from the midline to the lateral edge of the dye following the simulated SPSM block. The secondary outcome was determination of the spread of dye to the peri-scapular fascia, and dye staining of the TM, RMM, RmM, SPSM, ESM, each ICM between T1 and T10, and the dorsal scapular nerve following the simulated SPSM block in cadavers.

Results

We used four Thiel soft-embalmed cadavers (three females and one male) aged between 87 and 91 years at the time of death. Simulated SPSM blocks were successfully performed on both sides in all four cadavers (n = 4, left side: 30 mL of blue dye, right side: 20 mL of green dye). The typical anatomic spread of dye bilaterally in cadaver #3 is illustrated in Fig. 2 (Fig. 2a: left side, Fig. 2b: right side). In terms of

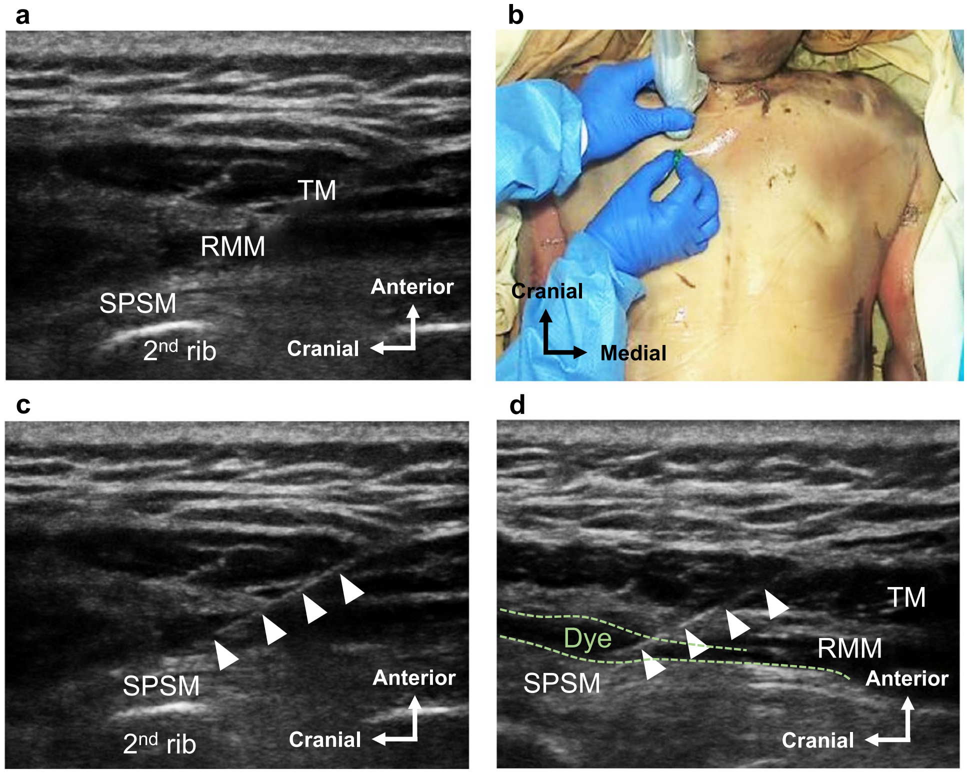
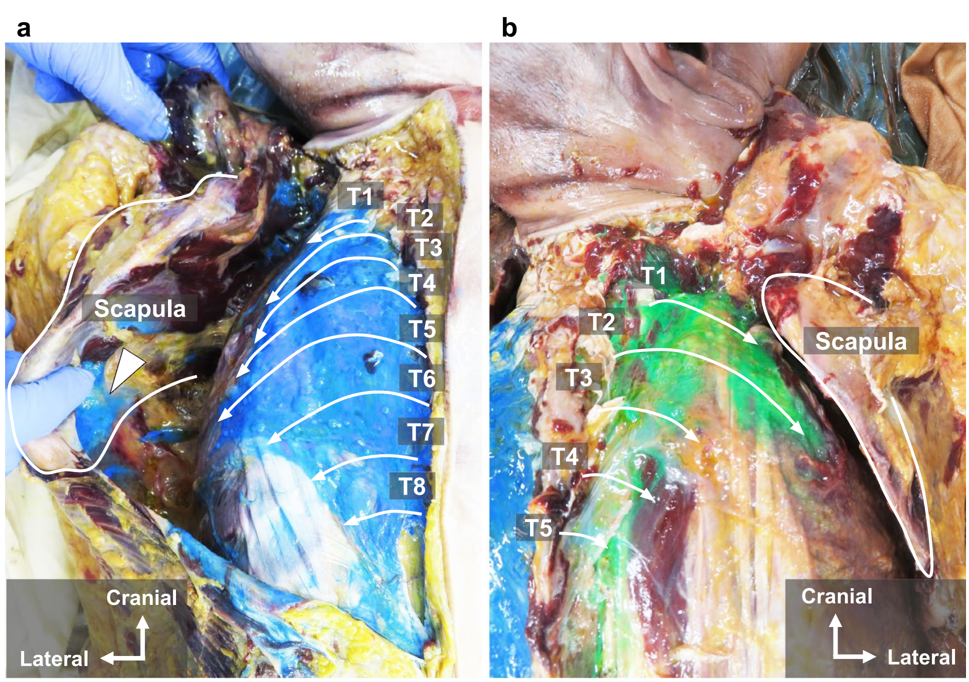


Fig. 1 Simulated serratus posterior superior muscle (SPSM) block. **a** Ultrasound image of relevant anatomical structures in the simulated SPSM block in the cadaver. **b** The ultrasound transducer was positioned in the sagittal direction at the scapular spine level for performance of the simulated SPSM block using an in-plane technique. **c** Ultrasound image during the simulated SPSM block in the cadaver. The target position of the needle tip was the surface of the SPSM at the second rib level, following test injection of the dye to identify the needle tip. The white arrowheads point to the 22 G non-insulated echogenic needle. **d** Ultrasound image following the simulated SPSM block with administration of dye in the cadaver. The white arrowheads point to the 22 G non-insulated echogenic needle. The dotted green lines show the boundaries of the administered dye. *RMM* rhomboid major muscle; *SPSM* serratus posterior superior muscle; *TM* trapezius muscle

Fig. 2 Cadaveric dissection showing the spread of dye in the muscles overlying the ribcage following dissection of the rhomboid major and minor muscles to separate the scapula from the ribcage. **a** Image of the left side of cadaver #3 showing the spread of 30 mL of the blue dye. **b** Image of the right side of cadaver #3 showing the spread of 20 mL of the green dye. The curved white arrows represent the distances from the midline to the lateral edge of the area of spread. The curved white lines represent the scapulae. The white arrowhead points to the injected dye on the anterior aspect of the scapula



the extent of injectate spread, the extent of spread over the ribcage (mean ± SD) of 30 mL of injectate was 8.5 ± 3.9 cm and that of 20 mL of the dye was 5.5 ± 1.6 cm (Fig. 3a). The extent of injectate spread over the ribcage between T1 and T10, to the peri-scapular fascia, and dye staining of the TM, RMM, RmM, SPSM, ESM, ICM, and the dorsal scapular nerve are summarized in Fig. 3b, and dye spread and staining characteristics are summarized in Table 1. With respect to dye spread to the peri-scapular fascia, the injected dye spread to the anterior aspect of the scapula in all four of the simulated SPSM blocks with 30 mL of dye, but not with 20 mL of the dye (Figs. 2a, b, and 3b). With respect to dye spread in the musculature of the back, the injected dye did not penetrate into the SPSM itself, the ESM, and the ICM between T1 and T8 in the eight simulated SPSM blocks with both 30 mL and 20 mL of dye (Fig. 3b). However, the injected dye spread into the RMM in two of the simulated SPSM blocks with 30 mL of dye (Figs. 3b and 4). Staining of the dorsal scapular nerve could not be assessed in all eight simulated SPSM blocks with both 30 mL and 20 mL of dye, because the dorsal scapular nerve was not detected in the anatomical dissection due to its fragility in Thiel soft-embalmed cadavers (Fig. 3b).

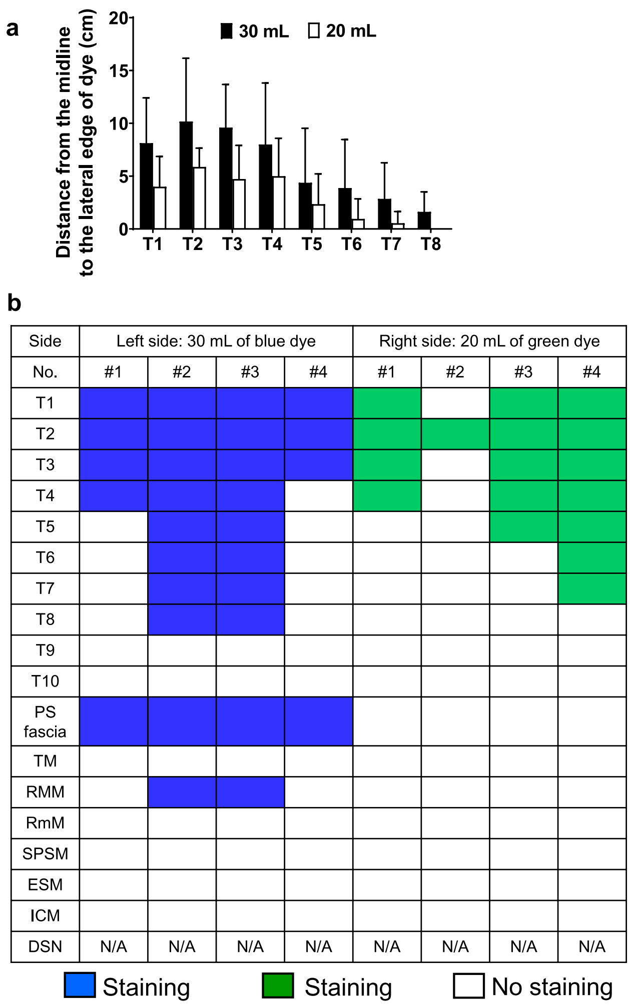


Fig. 3 Extent of dye spread following SPSM block in the four cadavers. **a** The distance from the midline to the lateral edge of the dye area following injection. Data are expressed as the mean ± SD (n = 4 / group). **b** Pictorial representation of the extent of injectate spread between T1 and T10 and to the peri-scapular fascia, and dye staining of the TM, RMM, RmM, SPSM, ESM, ICM, and the dorsal scapular nerve in each of the eight simulated SPSM blocks. Since spread of the dye was clearly distinguishable by the naked eye, we graded all results as stained or not stained. *DSN* dorsal scapular nerve; *ESM* erector spinae muscle; *ICM* intercostal muscle; *PS fascia* peri-scapular fascia; *RMM* rhomboid major muscle; *RmM* rhomboid minor muscle; *SPSM* serratus posterior superior muscle; *TM* trapezius muscle

Discussion

This is the first study to investigate the extent of spread of the injected dye and the mechanism of action of a simulated SPSM block using Thiel soft-embalmed cadavers. In our study, the SPSM block using 30 mL of dye had a tendency to spread wider compared to the SPSM block using 20 mL of the injectate. Furthermore, the injected dye spread to the peri-scapular fascia in all four of the simulated SPSM blocks with 30 mL of dye, but not with 20 mL of dye. The injected dye also spread into the RMM in two of the simulated SPSM blocks with 30 mL of dye. No dye was observed within the ESM or ICM in all eight simulated blocks. The results of the study suggest that the SPSM block likely provides pain relief by acting as an interfascial block rather than a segmental nerve block.

Although the pathophysiology of MPS is still unknown, one of the possible mechanisms of action of the SPSM block for MPS is related to pathophysiological changes in the fascia in MPS [8]. A systematic review by Laimi et al. suggested that tightened myofascial tissue with impaired sliding fascial mobility causes chronic musculoskeletal pain [8]. Ichikawa et al. reported that interfascial injection of physiological saline effectively decreases pain in patients with MPS by causing myofascial release, which restores the sliding function and flexibility of the myofascial tissue [9]. Another possible mechanism of action of the SPSM block for MPS is related to the histological fact that the interfascial space contains nociceptive nerve branches that innervate the fascia [10–12]. On the basis of these anatomical features, Domingo et al. reported that interfascial block provides rapid pain relief in patients with MPS by blocking the nociceptive nerve branches, leading to muscle relaxation and suppression of nociceptive free nerve fibers in the fascia [13]. These previous reports suggested that wide ranging myofascial release with the administration of local anesthetic can effectively provide rapid pain relief to patients with MPS. In our study, presence of the injected dye was observed within the RMM

Table 1 Dye spread and staining after the simulated serratus posterior superior muscle block in the cadaver study

Side	Left side: 30 mL of blue dye		Right side: 20 mL of green dye	
Anatomical structure	Staining	No staining	Staining	No staining
T1	4 (100%)	0 (0%)	3 (75%)	1 (25%)
T2	4 (100%)	0 (0%)	4 (100%)	0 (0%)
T3	4 (100%)	0 (0%)	3 (75%)	1 (25%)
T4	3 (75%)	1 (25%)	3 (75%)	1 (25%)
T5	2 (50%)	2 (50%)	2 (50%)	2 (50%)
T6	2 (50%)	2 (50%)	1 (25%)	3 (75%)
T7	2 (50%)	2 (50%)	1 (25%)	3 (75%)
T8	2 (50%)	2 (50%)	0 (0%)	4 (100%)
T9	0 (0%)	4 (100%)	0 (0%)	4 (100%)
T10	0 (0%)	4 (100%)	0 (0%)	4 (100%)
Peri-scapular fascia	4 (100%)	0 (0%)	0 (0%)	4 (100%)
Trapezius muscle	0 (0%)	4 (100%)	0 (0%)	4 (100%)
Rhomboid major muscle	2 (50%)	2 (50%)	0 (0%)	4 (100%)
Rhomboid minor muscle	0 (0%)	4 (100%)	0 (0%)	4 (100%)
Serratus posterior superior muscle	0 (0%)	4 (100%)	0 (0%)	4 (100%)
Erector spinae muscle	0 (0%)	4 (100%)	0 (0%)	4 (100%)
Intercostal muscles	0 (0%)	4 (100%)	0 (0%)	4 (100%)
Dorsal scapular nerve	Not applicable	Not applicable	Not applicable	Not applicable

Data are presented as the frequency (percentage)

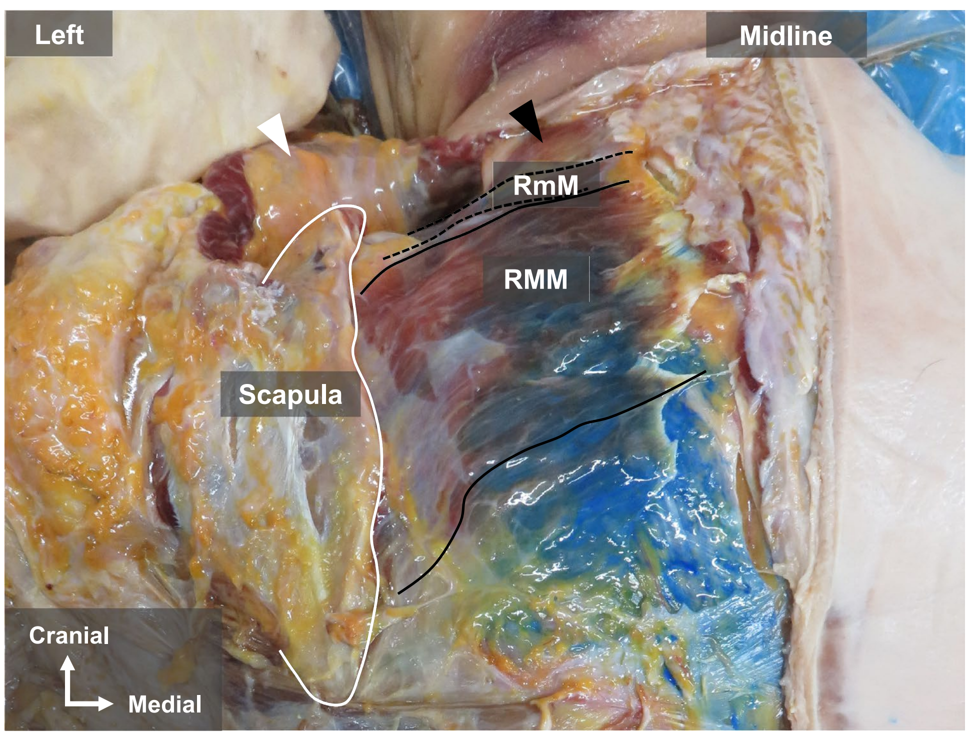


Fig. 4 The left side of cadaver #3 showing spread of the injected dye into the rhomboid major muscle following the simulated SPSM block with 30 mL of the blue dye. The black lines indicate the rhomboid major muscle. The black dotted lines delineate the rhomboid minor muscle. The white line represents the scapula. The white arrowhead points to the dissected trapezius muscle flap. The black arrowhead indicates the levator scapulae muscle. *RMM* rhomboid major muscle; *RmM* rhomboid minor muscle

in two of the simulated SPSM blocks with administration of 30 mL of the injectate. The RMM, which holds the scapula to the ribcage and retracts the scapula toward the vertebrae, is deeply related to musculoskeletal pain in the shoulder and upper back [14]. Seol et al. reported that trigger point injection into the RMM can provide temporary or long-term pain relief in patients with MPS. The results of our study suggest that SPSM block with 30 mL of local anesthetic might potentially provide rapid pain relief not only via an interfascial block, but also by intramuscular block of the

RMM. The dorsal scapular nerve, which provides motor innervation to the RMM, RmM, and levator scapulae muscle, runs in the target space of the SPSM block along the medial edge of the scapula. Blocking the action of the dorsal scapular nerve would produce good mobility of the scapula, as well as muscle relaxation of the neck and scapula. In our study, the injected dye spread to the peri-scapular fascia in all four of the simulated SPSM blocks with 30 mL of the injectate. Although our study and previous reports did not reveal whether the volume of 30 mL is adequate, the results of our study suggest that the SPSM block has the potential to block the action of the dorsal scapular nerve.

Ultrasound-guided rhomboid intercostal block (RIB) was described by Elsharkawy et al. in 2016 as a novel block technique in which a local anesthetic is applied to the plane between the rhomboid major and intercostal muscles at the T6-7 level, providing pain relief over both the anterior and posterior hemithorax [15]. Köse et al. reported the efficacy of ultrasound-guided RIB in patients with MPS in a prospective clinical study [16]. Although cadaveric studies of RIB have not been reported, Elsharkawy et al. conducted a cadaveric and clinical study of the rhomboid intercostal and subserratus plane block (RISS) block, a combination block of RIB and subserratus plane block, and reported that the RISS block demonstrated consistent spread of the injectate to lateral cutaneous branches from the T4 to T9 intercostal nerves in the cadaveric study, and consistent analgesia from T5 to T8 dermatomes in the clinical case series [17]. In our study, the extent of injectate spread over the ribcage from T1 to T3 was observed in seven of the eight simulated SPSM blocks, excluding right side in cadaver #2 (Fig. 3b). Although the RIB is different from the RISS block, the SPSM block, in which the target site is at the T2 level, would be preferable to the RIB or RISS block in patients with cervical and shoulder pain.

The present study has several limitations. First, only a small sample of cadavers was analyzed because of the limited availability of Thiel soft-embalmed cadavers, which are an important resource for medical research at the Department of Anatomy, Sapporo Medical University School of Medicine. Although our results suggest the tendency for a greater spread of the injected dye in the SPSM block performed using 30 mL of the dye compared to that with 20 mL of injectate, a difference between the SPSM block with 30 ml and that with 20 ml in terms of the extent of injectate spread is merely an impression in the present study. Further studies in a large sample of human participants are required to confirm the optimal volume and dose of local analgesics and the clinical effects of the SPSM block. Second, although Thiel soft-embalmed cadavers provide more realistic physical and functional properties for simulated ultrasound-guided regional anesthesia than fresh cadavers [18], the results of cadaveric studies do not necessarily reflect the results in living subjects [19]. Third, at the time of SPSM block administration, the cadavers were in the prone position, while the block in actual patients is performed with them in the sitting position. Hence, the results of this study cannot be directly extrapolated to living subjects due to the difference in the position between the cadavers and patients during the procedure. Finally, staining of the dorsal scapular nerve could not be assessed in all eight simulated SPSM blocks with both 30 mL and 20 mL of dye, because the dorsal scapular nerve was not detected in the anatomical dissection due to its fragility in Thiel soft-embalmed cadavers. Further clinical studies with a large sample of human participants are required to confirm the optimal volume of local anesthetics in the SPSM block that would block the dorsal scapular nerve.

In conclusion, our findings suggest that the SPSM block using 30 mL of injectate volume tends to demonstrate wider spread compared to the SPSM block using 20 mL of the injectate, and that the SPSM block probably provides pain relief by acting as an interfascial block rather than a segmental nerve block. Further studies with a large sample of human participants are required to confirm the optimal volume of local analgesic to be injected in the SPSM block.

Acknowledgements The authors thank Sho Kumita, Gorinbashi Orthopedic Hospital, Sapporo, Japan, and Yasuhiro Higuchi, Surgical Training Center, Sapporo Medical University School of Medicine, Sapporo, Japan, for assistance with the cadaver preparation.

Author contributions Sawada was involved in planning and design of the study, performing the cadaveric ultrasound-guided SPSM block and dissection, data review and collection, performing the ultrasound-guided SPSM block in the patients, and writing the manuscript. Kunigo was involved in the dissection and helped perform the ultrasound-guided SPSM block in the cadavers. Ohsaki and Nagaishi were involved in supervision of dissection and editing the manuscript. Yamakage was involved in conception of the study and editing the manuscript.

Funding The authors have no sources of funding to declare in relation to this manuscript.

Data availability The data that support the findings of this study are available from the corresponding author [A.S.] upon reasonable request.

Declarations

Conflict of interest The authors declare that no conflicts of interest exist.

References

1. Vázquez-Delgado E, Cascos-Romero J, Gay-Escoda C. Myofascial pain syndrome associated with trigger points: a literature review (I). Epidemiology, clinical treatment and etiopathology. Med Oral Patol Oral Cir Bucal. 2009;14:e494–8.

2. Galasso A, Urits I, An D, Nguyen D, Borchart M, Yazdi C, Manchikanti L, Kaye RJ, Kaye AD, Mancuso KF, Viswanath O. A comprehensive review of the treatment and management of myofascial pain syndrome. Curr Pain Headache Rep. 2020;24:43.
3. Urits I, Charipova K, Gress K, Schaaf AL, Gupta S, Kiernan HC, Choi PE, Jung JW, Cornett E, Kaye AD, Viswanath O. Treatment and management of myofascial pain syndrome. Best Pract Res Clin Anaesthesiol. 2020;4:427–48.
4. Kongsagul S, Vitoonpong T, Kitisomprayoonkul W, Tantisiriwat N. Ultrasound-guided physiological saline injection for patients with myofascial pain. J Med Ultrasound. 2020;28:99–103.
5. Tantanatip A, Patisumpitawong W, Lee S. Comparison of the effects of physiological saline interfascial and lidocaine trigger point injections in treatment of myofascial pain syndrome: a double-blinded randomized controlled trial. Arch Rehabil Res Clin Transl. 2021;3: 100119.
6. Arıcı T, Köken ÍŞ. Results of ultrasound-guided interfascial block of the trapezius muscle for myofascial pain. Agriculture. 2022;34:187–92.
7. Taketa Y, Irisawa Y, Fujitani T. Ultrasound guided serrates posterior superior muscle block relieves interscapular myofascial pain. J Clin Anesth. 2018;44:10–1.
8. Laimi K, Mäkilä A, Bärlund E, Katajapuu N, Oksanen A, Seikkula V, Karppinen J, Saltychev M. Effectiveness of myofascial release in treatment of chronic musculoskeletal pain: a systematic review. Clin Rehabil. 2018;32:440–50.
9. Ichikawa K, Takei H, Usa H, Mitomo S, Ogawa D. Comparative analysis of ultrasound changes in the vastus lateralis muscle following myofascial release and thermotherapy: a pilot study. J Bodyw Mov Ther. 2015;19:327–36.
10. Benjamin M. The fascia of the limbs and back: a review. J Anat. 2009;214:1–18.
11. Tesarz J, Hoheisel U, Wiedenhöfer B, Mense S. Sensory innervation of the thoracolumbar fascia in rats and humans. Neuroscience. 2011;27:302–8.
12. Kanamoto H, Orita S, Inage K, Shiga Y, Abe K, Eguchi Y, Ohtori S. Effect of ultrasound-guided hydrorelease of the multifidus muscle on acute low back pain. J Ultrasound Med. 2021;40:981–7.
13. Domingo T, Blasi J, Casals M, Mayoral V, Ortiz-Sagristá JC, Miguel-Pérez M. Is interfascial block with ultrasound-guided puncture useful in treatment of myofascial pain of the trapezius muscle? Clin J Pain. 2011;27:297–303.
14. Seol SJ, Cho H, Jang SH. Appropriate depth of needle insertion during rhomboid major trigger point block. Ann Rehabil Med. 2014;38:72–6.
15. Elsharkawy H, Saifullah T, Kolli S, Drake R. Rhomboid intercostal block. Anaesthesia. 2016;71:856–7.
16. Köse SG, Köse HC, Tulgar S, Akkaya ÖT. Ultrasound-guided rhomboid intercostal block for myofascial pain syndrome: a prospective clinical study. Turk J Med Sci. 2022;52(5):1737–43.
17. Elsharkawy H, Maniker R, Bolash R, Kalasbail P, Drake RL, Elkassabany N. Rhomboid intercostal and subserratus plane block: a cadaveric and clinical evaluation. Reg Anesth Pain Med. 2018;43(7):745–51.
18. Munirama S, Eisma R, Columb M, Corner GA, McLeod GA. Physical properties and functional alignment of soft-embalmed Thiel human cadaver when used as a simulator for ultrasound-guided regional anaesthesia. Br J Anaesth. 2016;116(5):699–707.
19. Behr AU, Chan VWS, Stecco C. Living versus cadaver fascial plane injection. Reg Anesth Pain Med. 2020;45:156–7.