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Ultrasound-Guided Stellate Ganglion Block: Safety and Efficacy

Samer Narouze

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Abstract Cervical sympathetic and stellate ganglion blocks (SGB) provide a valuable diagnostic and therapeutic benefit to sympathetically maintained pain syndromes in the head, neck, and upper extremity. With the ongoing efforts to improve the safety of the procedure, the techniques for SGB have evolved over time, from the use of the standard blind technique, to fluoroscopy, and recently to the ultrasound (US)-guided approach. Over the past few years, there has been a growing interest in the ultrasound-guided technique and the many advantages that it might offer. Fluoroscopy is a reliable method for identifying bony surfaces, which facilitates identifying the C6 and C7 transverse processes. However, this is only a surrogate marker for the cervical sympathetic trunk. The ideal placement of the needle tip should be anterolateral to the longus colli muscle, deep to the prevertebral fascia (to avoid spread along the carotid sheath) but superficial to the fascia investing the longus colli muscle (to avoid injecting into the muscle substance). Identifying the correct fascial plane can be achieved with ultrasound guidance, thus facilitating the caudal spread of the injectate to reach the stellate ganglion at C7-T1 level, even if the needle is placed at C6 level. This allows for a more effective and precise sympathetic block with the use of a small injectate volume. Ultrasound-guided SGB may also improve the safety of the procedure by direct visualization of vascular structures (inferior thyroidal, cervical, vertebral, and carotid arteries) and soft tissue structures (thyroid, esophagus, and nerve roots). Accordingly, the risk of vascular and soft tissue injury may be minimized.

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S. Narouze (✉)
Summa Western Reserve Hospital, Cuyahoga Falls, OH, USA
e-mail: narouzs@hotmail.com

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Introduction

Ultrasound is a valuable tool for imaging soft tissue structures and bony surfaces, guiding needle advancement and confirming the spread of injectate around the target without exposing healthcare providers and patients to the risks of radiation. There is a rapidly growing interest in ultrasound-guided pain management procedures (USPM), as evidenced by the surging number of publications in the last few years. However, most of these publications are small feasibility or observational studies, with few randomized controlled trials (RCT).

As of the last evidence-based medicine review in 2010, there was only weak evidence (one small RCT) supporting the superiority of ultrasound to CT in lumbar facet intra-articular injections. At that time, the recommendations were "although we do have a few reports suggesting that ultrasound-guided cervical injections have advantages over fluoroscopy-guided approaches (especially in stellate ganglion and cervical nerve root blocks), we don't have RCT-driven data to support this" [1••]. Since that time, there have been quite a few studies on ultrasound-guided neck and cervical spine injections, primarily cervical medial branch, cervical nerve root, and stellate ganglion blocks (SGB) [2, 3]. This review will focus on ultrasound-guided stellate ganglion block (cervical sympathetic block) as a safe and efficacious intervention for chronic pain syndromes.

Anatomy of the Stellate Ganglion and Cervical Sympathetic Chain

The cervical sympathetic chain is composed of superior, middle, and inferior cervical ganglia. In about 80 % of the population, the inferior cervical ganglion is fused with the first thoracic ganglion, forming the cervicothoracic ganglion, also known as the stellate ganglion [4, 5]. The stellate ganglion is located medial to the scalene muscles; lateral to the longus colli muscle, esophagus and trachea, along with the recurrent laryngeal nerve in between; anterior to the transverse processes; superior to the subclavian artery and the posterior aspect of the pleura; and posterior to the vertebral vessels at the C7 level [6]. This explains the increased risk of pneumothorax and vertebral artery injury when performing the blockade at the C7 level.

The stellate ganglion measures approximately 2.5 cm in length, 1 cm in width, and 0.5 cm in thickness. It is located posteriorly in the chest in front of the neck of the first rib and may extend to the seventh cervical (C7) vertebral body [6, 7]. If the inferior cervical ganglion and first thoracic ganglion are not fused, the inferior cervical ganglion lies in front of the C7 transverse process and the first thoracic ganglion lies in front of the neck of the first rib [6, 7]. Accordingly, by using the blind technique at C6, the ganglion that is primarily blocked is the middle cervical ganglion, while the stellate ganglion is blocked if the injectate spreads down to C7-T1 level.

Limitations of the Blind or Fluoroscopy-Guided Techniques

SGB may be associated with a number of serious complications due to the stellate ganglion's close proximity to various vital structures. With efforts to increase the safety of the procedure, the techniques for SGB have evolved over time, from the use of the standard blind technique, to fluoroscopy, and recently to the ultrasound (US)-guided technique. Although computerized tomography (CT) [8] and magnetic resonance imaging (MRI) [6, 9] approaches have been described, these techniques are not practical in daily clinical practice.

Fluoroscopy, and particularly the oblique fluoroscopic approach, has been suggested as a safer and more effective way to perform SGB than the traditional blind approach [10, 11]. Fluoroscopic guidance has become a routine practice for performing SGB despite a lack of scientific evidence demonstrating improved safety or efficacy.

Fluoroscopy is a reliable method for the identification of bony surfaces, which facilitates identification of the C6 and C7 transverse processes. With fluoroscopy, the needle can be accurately directed to the bony landmark, the anterior tubercle of C6 transverse process. The anterior tubercle is only a surrogate anatomical marker, however, as the location of the cervical sympathetic trunk is defined by the fascial plane of the prevertebral fascia, which cannot be visualized with fluoroscopy. Vascular structures (such as the inferior thyroidal, cervical, vertebral, and carotid arteries) and soft tissue structures (such as the thyroid, esophagus, and nerve roots) that can be seen with ultrasound cannot be seen with fluoroscopy, and therefore these structures are at risk of injury with fluoroscopy-guided techniques [12].

Ultrasound-guided SGB can improve the safety of the procedure by direct visualization of the related anatomical structures, and therefore can minimize the risk of vascular and soft tissue injury. In addition, ultrasound guidance allows direct monitoring of the spread of the injectate, and hence may minimize complications such as recurrent laryngeal nerve (RLN) palsy and intrathecal, epidural, or intravascular spread [13••].

Sonoanatomy Relevant to SGB

The key anatomical structures in ultrasound-guided SGB are the carotid sheath, longus colli muscle, and the anterior tubercle of the sixth cervical vertebra (Fig. 1a and b). When utilizing the traditional approach, the needle is inserted in the vicinity of the cervical sympathetic trunk, which occupies a space anterior and lateral to the cervical vertebral bodies. Contrary to the fluoroscopy-guided approach, the end point of the needle is not contact with bone but the plane between the lateral part of the longus colli muscle posteriorly and the prevertebral fascia covering the posterior aspect of the carotid sheath anteriorly. Ultrasound allows direct visualization of vessels and soft tissues in the vicinity of the sympathetic chain and potentially minimizes damage to these structures (Fig. 1a, b).

Safety and Efficacy of Ultrasound-Guided SGB

Identification of the Correct Fascia Plane

The target with the fluoroscopy-guided approach is the C6 transverse process or anterior tubercle. The needle is advanced until bone is reached, and then withdrawn a few millimeters. The injectate may be deposited into the substance of the longus colli muscle, resulting in a possible block failure. This can be avoided using a US-guided approach, as the tip of the needle is placed in the fascial plane where the sympathetic chain runs, deep to the prevertebral fascia contributing the posterior fascial layer of the carotid sheath, and superficial to the fascia investing the longus colli muscle. A few reports have shown that injections made deep to the prevertebral fascia tend to have more caudal spread and, hence, improved efficacy [14–16].

On the other hand, if the injectate is deposited anterior to the prevertebral fascia, it tends to spread around the carotid sheath. Therefore, the risk of hoarseness is greater due to

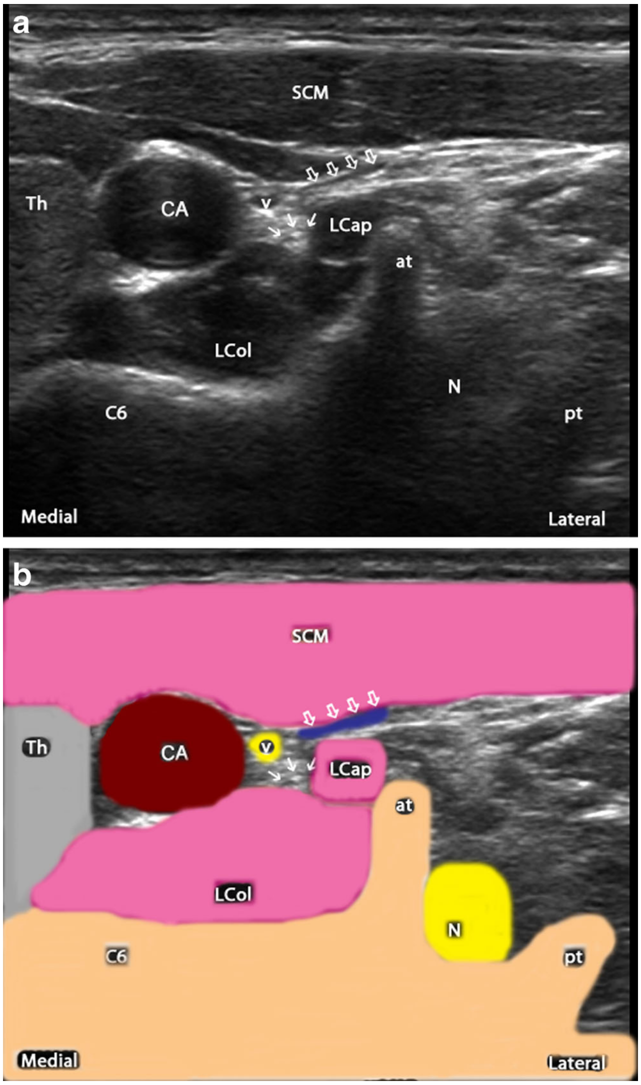

Fig. 1 **a** and **b** Short axis sonogram at C6. The transducer is moved slowly laterally and cephalad until the characteristic sharp anterior tubercle of C6 comes into the image (at). SCM, sternocleidomastoid muscle; Th, thyroid; V, vagus nerve posteriorly in the carotid sheet between the carotid artery (CA) and the compressed internal jugular vein (hollow arrows). The sympathetic chain at the level of the middle cervical ganglion (as indicated by the 3 small arrows) is located at the groove between the longus colli muscle (LCol) and the longus capitis muscle (LCap). (Reprinted with permission from Samer Narouze, MD, PhD; Ohio Pain and Headache Institute)

blockade of the vagus nerve within the carotid sheath or the RLN medial to the carotid sheath.

SGB is usually performed to assist in the diagnosis of sympathetically mediated pain syndromes. As such, to ensure an effective block, it is critical that the procedure is selective to the sympathetic chain. The author believes that identifying the correct fascial plane is the single greatest advantage that ultrasound can provide in helping to make the procedure more "specific" to the sympathetic chain and to avoid blocking the vagus nerve (parasympathetic) or the nearby cervical nerve roots (somatic).

The Esophagus

Ultrasound imaging can also identify the esophagus, particularly on the left side, and consequently can prevent esophageal puncture or injury. The esophagus is deviated to the left of the trachea in approximately 50–70 % of the population, as shown by different imaging modalities [17–20]. The esophagus usually appears as an outpouching behind the trachea and can be better identified by the change in shape and shadowing during swallowing. Mediastinitis can result from esophageal injury, particularly if the patient has an unrecognized diverticulum [12].

The Vertebral Artery

The vertebral artery runs anteriorly at the C7 level before it enters the foramen of the C6 transverse process in about 90 % of cases, and enters at C5 or higher in the remaining cases [21]. Consequently, the vertebral artery may be more vulnerable to injury during cervical sympathetic block at C7. However, vertebral artery injury is still a possibility at higher levels whenever that artery is exposed between the cervical transverse processes. The vertebral artery can be easily identified and avoided with ultrasound imaging.

Two observational studies recently reported the estimated risk of esophageal and vascular puncture after conventional stellate ganglion block [19, 20]. The European study showed that the esophagus, on the left, was located along the needle path in 22 and 39 of 60 cases at the C6 and C7 levels, respectively. The vertebral artery was located in the needle path in 8 of 60 cases. Other arteries were located in the needle path in 17 of 60 cases [19]. The Canadian study showed that the esophagus was found to be variable but lateral to the airway in 50 % and 74 % of the subjects at C6 and C7, respectively. With the anterior approach, a vessel was observed in up to 29 % and 43 % of patients at the C6 and C7 levels, respectively, and the vertebral artery was outside the foramen transversarium in 7 % of subjects at C6 level [20].

The Inferior Thyroid Vessels

The inferior thyroid vessels run a tortuous and variable course, and they may be a major source of retropharyngeal hematoma after SGB. The inferior thyroid artery originates from the thyrocervical trunk of the subclavian artery, and ascends anteriorly to the vertebral artery and the longus colli muscle, and then curves medially behind the carotid sheath to enter the inferior part of the thyroid lobe. It is vulnerable to injury during SGB when it crosses behind the carotid artery from lateral to medial, at C6-C7 level, as it terminates into the thyroid gland. Injury of the inferior thyroid artery can be prevented by using an ultrasound-guided technique [22, 23]. The course of the inferior thyroid artery needs to be identified first with ultrasound pre-scanning, and accordingly, one should plan on a safe needle trajectory.

Small Volume of Injectate

Ultrasound allows the use of a small volume of injectate while maintaining the same degree of efficacy. Using ultrasound guidance, the needle can be placed closer to the target in the correct fascial plane (as previously described), which will minimize the amount of local anesthetic needed and thus improve patient safety. Wulf et al. [24] reported toxic plasma levels in 30 % of patients undergoing SGB using 10 ml of 0.5 % bupivacaine. Two studies recently reported on the optimal volume of local anesthetic required for successful ultrasound-guided SGB compared to the traditional approach [25, 26]. One study showed that 2 ml of 0.5 % mepivacaine was sufficient for a successful block [26], while the other showed the optimal volume was 4 ml of 0.2 % ropivacaine [26]. We usually inject only 2–5 ml to ensure that the procedure is as selective to sympathetic block as possible. The limiting factor is the spread of the injectate with real-time sonography to avoid any contamination to the nearby vagus nerve, RLN, cervical nerve roots, or brachial plexus.

Risk of Hematoma and Intravascular Injection

The most serious complications of stellate ganglion block include intravascular injections and retropharyngeal hematoma. The proximity of the stellate ganglion to the inferior thyroid, cervical, vertebral, or carotid arteries provides the potential for intravascular injection or vascular trauma, with resulting bleeding and hematoma [22, 27]. Intravascular injection of even small volumes of local anesthetic may result in loss of consciousness, apnea, and seizure [28].

Retropharyngeal hematoma varies in severity, from mild and asymptomatic to severe and life-threatening, causing tracheal compression requiring emergency tracheotomy [29, 30]. The frequency of catastrophic retropharyngeal hematoma after stellate ganglion block, with resulting airway compromise and obstruction, has been reported at 1/100,000 cases [29]. However, Kapral et al. reported a much higher incidence of asymptomatic hematoma when using the blind technique [31].

Conclusions

Ultrasound is a valuable tool for imaging critical soft tissue structures relevant to the cervical sympathetic chain, guiding needle advancement, and confirming the spread of injectate in the proper fascial plane, without exposing healthcare providers and patients to the risks of radiation.

There are only a few reports and observational studies that have demonstrated the advantages of ultrasound-guided SGB over the traditional fluoroscopy-guided technique. RCT-driven data is currently not available. However, despite a lack of scientific evidence in the past, pain practitioners followed a common-sense and sound-judgment approach when they transitioned from the blind approach to the now-routine fluoroscopic-guided approach for performing SGB. And with the introduction of ultrasound guidance in pain management, many pain practitioners are following the same path.

Ultrasound-guided SGB, with direct visualization of the multiple vulnerable soft tissue structures compacted in a tight vascular space around the sympathetic chain, appears to be safer and more effective than traditional approaches. While future clinical studies will undoubtedly further establish ultrasound-guided SGB as the superior approach, the concept is already very appealing today, to the point that RCTs comparing ultrasound-guided SGB to the blind approach, or even to the fluoroscopy-guided technique, may not be necessary in the future.

Compliance with Ethics Guidelines

Conflict of Interest Dr. Samer Narouze declares no potential conflicts of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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