REVIEW ARTICLE

Review of Sympathetic Blocks
Anatomy, Sonoanatomy, Evidence, and Techniques

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Abstract: The autonomic nervous system is composed of the sympathetic and parasympathetic nervous systems. The sympathetic nervous system is implicated in situations involving emergent action by the body and additionally plays a role in mediating pain states and pathologies in the body. Painful conditions thought to have a sympathetically mediated component may respond to blockade of the corresponding sympathetic fibers. The paravertebral sympathetic chain has been targeted for various painful conditions. Although initially injected using landmark-based techniques, fluoroscopy and more recently ultrasound imaging have allowed greater visualization and facilitated injections of these structures. In addition to treating painful conditions, sympathetic blockade has been used to improve perfusion, treat angina, and even suppress posttraumatic stress disorder symptoms. This review explores the anatomy, sonoanatomy, and evidence supporting these injections and focuses on ultrasound-guided/assisted technique for the performance of these blocks.

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The autonomic nervous system is composed of the sympathetic (SNS) and parasympathetic (PNS) nervous systems. The cell bodies of the SNS are located anterolaterally in the spinal cord from levels T2 to L2. The preganglionic fibers from the spinal cord reach the sympathetic trunk through the white rami communicantes. Those that synapse at the paravertebral ganglia continue as the postganglionic fibers and join the ventral ramus through the gray rami communicantes. The SNS is implicated in situations that involve emergent action by the body and additionally plays a role in mediating pain states and pathologies in the body. Those painful conditions thought to have a sympathetically mediated component may respond to blockade of the corresponding sympathetic fibers.[1] Cepeda and colleagues[2] perhaps most definitively showed this in a meta-analysis of the role of sympathetic blockade in complex regional pain syndrome (CRPS). The authors found that the general quality of the 29 reviewed studies was "poor" and consisted mostly of retrospective and case studies.

METHODS

In this narrative review, we examine the anatomy, sonoanatomy, techniques, and available evidence for ultrasound (US)–guided/assisted sympathetic blocks.

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Search Strategy

We performed a PubMed and MEDLINE search of all articles published in English from the years 1916 to 2015 using the key words "ultrasound," "ultrasound guided," "sympathetic blockade," "sympathetically mediated pain," "stellate ganglion blockade," "celiac plexus blockade,", "lumbar sympathetic blockade," "hypogastric plexus blockade," and "ganglion impar blockade." In order to capture the breadth of available evidence, because there were only a few controlled trials, case reports were also included. There were an insufficient number of reports to perform a systematic review. Hence, we elected to perform a narrative review.

DISCUSSION

Stellate Ganglion Block

Stellate ganglion block (SGB) was first performed by René Leriche for the treatment of angina pectoris. Today, it is used for diagnosis and management of sympathetically mediated pain states and vascular insufficiency of the upper extremity. These indications include tinnitus, CRPS I and II, and Raynaud disease.[3,4] Although systematic evidence is lacking, extensive case reports also exist for the use of SGB in phantom pain, postherpetic neuralgia, cancer pain, cardiac arrhythmias, orofacial pain, and vascular headache. More recently, SGB has been used with some success in treating psychiatric conditions including anxiety and posttraumatic stress disorder (PTSD).[4]

Anatomy

The cervical portion of the sympathetic chain has 4 major ganglia: the cervicothoracic or stellate, the middle, the intermediate, and the superior cervical ganglia. Because the stellate ganglion is most often targeted for pain in the upper extremities, the focus will be on this ganglion. The stellate ganglion is a sympathetic ganglion located on the head of the first rib beneath the prevertebral fascia. It is formed by the fusion of the inferior cervical ganglion with the first, and occasionally the second, thoracic ganglion.[5] Anteriorly, the sympathetic ganglion borders with the subclavian artery, carotid sheath, sternocleidomastoid muscle, and subcutaneous tissue (Fig. 1). The anterior scalene muscle, neck of first rib, transverse process of C7, vertebral artery, and longus colli muscle together form the posterior border of the ganglion.[6] The superior intercostal vessels and the ventral ramus of the first thoracic nerve lie lateral to the ganglion. The medial border of the ganglion is composed of prevertebral fascia, the vertebral body of C7, the esophagus, and the thoracic duct (on the left). Inferiorly, the ganglion borders with the pleural dome over the lung's apex.[5–8]

Sonoanatomy

A linear array transducer is recommended because it provides good spatial resolution. The scanning sequence is started just above the sternum. Trachea may be visualized in the middle. Anterior to the trachea is thyroid gland, which has a characteristic

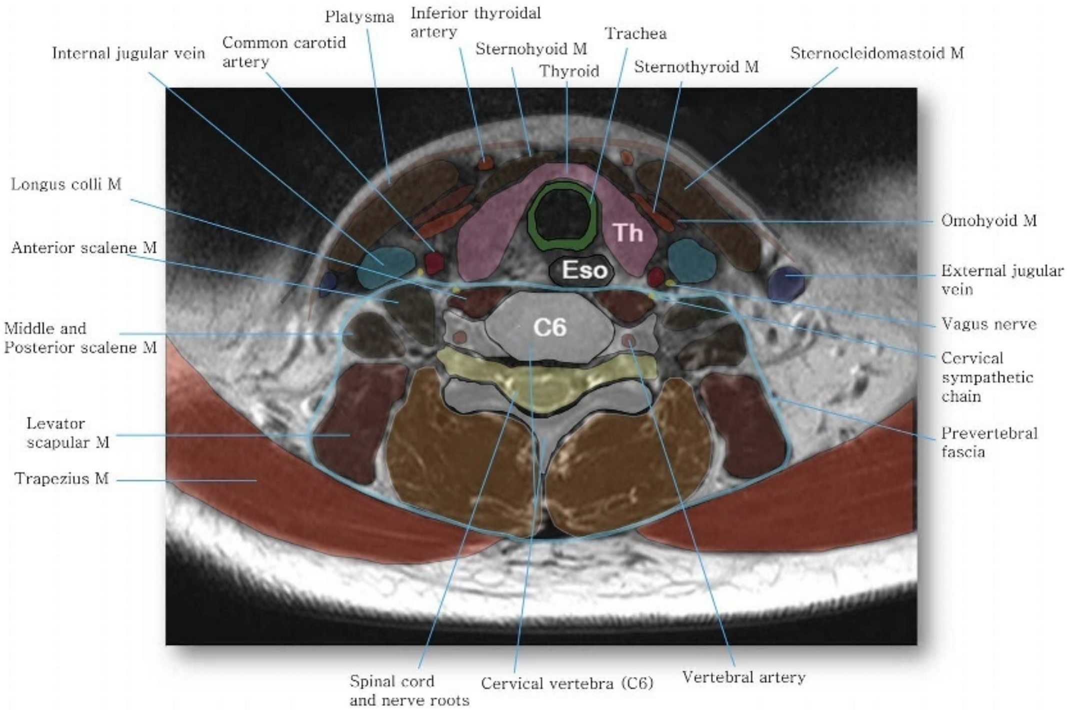

FIGURE 1. Cross-sectional view of structures at the C6 vertebral body level. ESO indicates esophagus; Th, thyroid; C6, cervical 6 vertebral body.

ground-glass echogenicity. The esophagus may be visualized on the left side with its muscular wall and a lumen. When the patient is asked to swallow, air bubbles may be seen real time as bright hyperechoic structures moving down (Fig. 2). The strap muscles may be visualized above the trachea. The omohyoid is more anterior, and just above is the sternocleidomastoid just lateral to the midline. When the transducer is moved slightly lateral, the anterior and middle scalene muscles are identified with the brachial plexus between them (Fig. 2). With color flow Doppler, the carotid artery medially and the internal jugular vein laterally may be identified. In addition, beneath the carotid artery and traveling medially into the thyroid is the inferior thyroidal artery more medially (Fig. 3). The vertebral artery travels lateral to the longus colli muscle. Once it enters the foramen in the transverse process, it is hidden by bone but can be seen between the transverse processes. As we scan further cephalad, the tall anterior tubercle may be identified as a hyperechoic curved line with an acoustic shadow beneath and in continuity with the lamina and posterior tubercle. The C6 nerve root may be seen entering the foramen. The longus capitus starts at this level from the top of the tubercle. The longus colli muscle lies anterior to the lamina and medial to the tubercle. This is covered by the prevertebral fascia (Fig. 4). Scanning further cephalad, the anterior and posterior tubercles of C5 may be identified. If the scanning sequence is continued caudad from C6, the posterior tubercle of C7 is identified as a curved hyperechoic line. Traveling further caudad, the pleura and portion of the first rib may be seen as hyperechoic lines. The major advantage of US imaging is the ability to visualize the surrounding structures, vessels, and nerves,

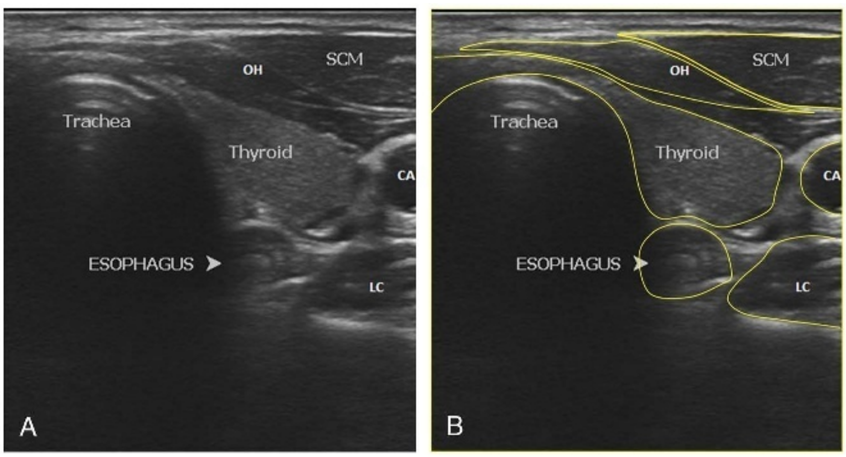

FIGURE 2. Transverse sonographic image at cervical level of showing trachea, esophagus, thyroid, carotid (CA), longus colli (LC), sternocleidomastoid (SCM), and omohyoid (OH).

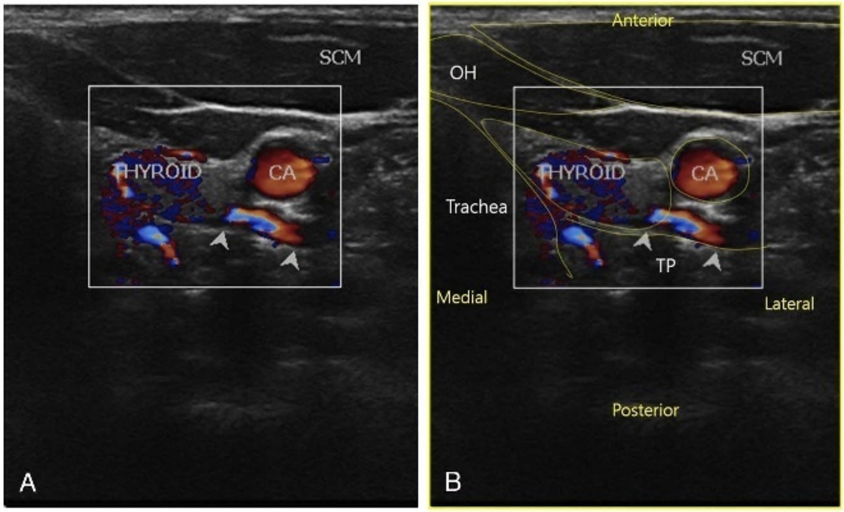

FIGURE 3. Transverse sonographic image with color Doppler showing the inferior thyroidal artery. CA indicates carotid artery; SCM, sternocleidomastoid.

which aids in planning the trajectory, especially when at the level of C7 where the vertebral artery lies without a bony protection. In addition, unlike fluoroscopy, US imaging aids in the identification and avoidance of incidentalomas.

Evidence

Evidence for SGB is limited mostly to case reports and case series; however, there exist a number of moderately sized studies aimed at systematically evaluating its efficacy. Malmqvist et al[9] blindly performed 54 SGBs with bupivacaine. Criterion for "effective sympathetic blockade" was defined as Horner syndrome in combination with increased skin temperature, increased skin blood flow, and a completely abolished skin resistance response on both the radial and ulnar sides of the blocked hand. Surprisingly, only 15 of 54 blocks met 4 of these 5 criteria for an effective block validating the need for image guidance.[9] In some individuals, the intrathoracic somatic branches from the second thoracic spinal nerve join the first thoracic spinal nerve and the gray rami communicantes that carry sympathetic fibers from the second thoracic sympathetic ganglia. These nerves together may bypass the stellate ganglion and comprise Kuntz nerves; failure to block these pathways may lead to incomplete sympathectomy of the upper extremity.[10]

A study by Ackerman and Zhang[11] showed that pain relief and improved skin perfusion were observed in 40% of patients who had CRPS symptoms for 12 or fewer weeks, but no improvement occurred in the group with more protracted disease (35.8 ± 27 weeks). Forouzaner and colleagues[12] performed radiofrequency ablation (RFA) of the stellate ganglion on 86 patients with CRPS, ischemic pain, cervicobrachialgia, or postthoracotomy pain and found that 41% noted a more than 50% reduction of pain, 55% reported no effect on pain, and 5% showed worsening of pain. However, a literature search by the same authors of 31 studies of the same modality showed partial pain relief in 41% of patients, complete pain relief in 38%, and no pain relief in 21%.[12] Price and colleagues[13] found no statistical difference in pain reduction between patients who received SGB or placebo for CRPS. Patients with SGB did have longer duration of pain relief, however.[13] In a series of 77 patients with postherpetic neuralgia,

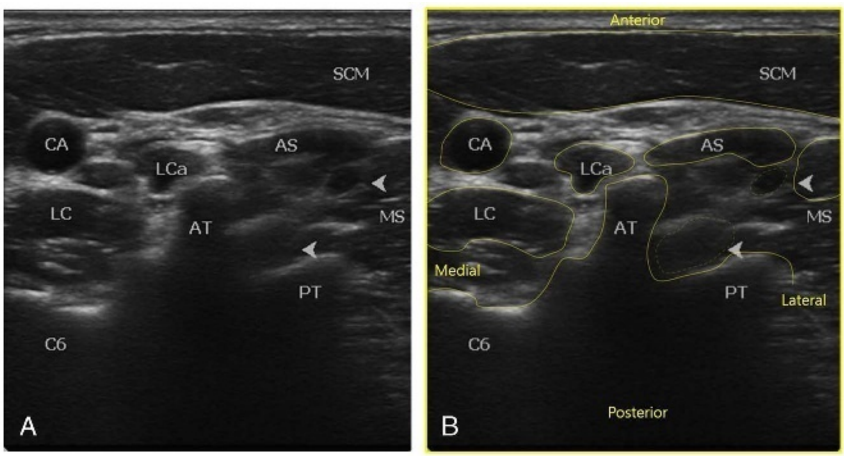

FIGURE 4. Transverse sonographic image at the level of C6 showing the prominent anterior tubercle. CA indicates carotid artery; SCM, sternocleidomastoid; LC, longus colli; LCa, Longus capitus; AS, anterior scalene; MS, middle scalene; AT, anterior tubercle; PT, posterior tubercle; C6, C6 vertebral body. Arrowheads point to C6 and C5 roots.

Milligan and Nash[14] found SGB made 40% of patients pain-free, whereas with traditional treatment 15% of patients became pain-free. Erickson and Hogan[15] performed computed tomography (CT)–guided SGBs in 7 patients. Successful blocks were achieved in all cases, evidenced by production of Horner syndrome and ipsilateral hand temperature elevations. Five patients preferred the CT-guided procedure over the conventional technique, and 2 patients noted no difference.[15]

More recently, SGB has been used in the perioperative setting. Choi and colleagues[16] showed no benefit to US-guided SGB with levobupivacaine in 40 patients undergoing upper-extremity arthroscopic surgery. Conversely, in a series of 30 patients, Kumar and colleagues[17] showed that postoperative tramadol consumption was significantly less for those who received US-guided SGB with lidocaine for upper-extremity orthopedic surgery.

Evidence for Ultrasound Guidance

In the initial report of US-guided SGB by Kapral and colleagues[18] in 1995, US-guided block was shown to require less volume of local anesthetic and have more rapid onset of Horner syndrome than landmark-based block. The US group also had no hematomas compared with 3 hematomas in the landmark-based group.[18]

Shibata and colleagues[19] modified Kapral and colleagues'[18] technique in 2007 to specifically penetrate the prevertebral fascia, yielding more reliable onset of Horner syndrome and less hoarseness than a technique that did not penetrate the fascia. Bhatia et al[20] compared proximity to major vessels and viscera during the anterior approach used in the landmark- and fluoroscopy-guided techniques with the lateral approach used in most US-guided techniques and found less proximity to vessels in the latter. Narouze[21] has argued that only US can truly prevent complications with direct visualization, whereas fluoroscopy can detect only complications. Despite these, there remains a dearth of adequately powered randomized controlled trials (RCTs) comparing the modality to injection guided by fluoroscopy or CT. Siegenthaler and colleagues[22] were able to show a 95% simulated block success rate in a series of 20 US-guided superior cervical ganglion blocks in cadavers (Table 1).

TABLE 1. Selected Studies on Stellate Ganglion Block

Publication	Target	Imaging	Study Design	N	Findings	Complications
Malmqvist et al[9]	SGB	None	Prospective study	54	15/54 met criteria for sympathectomy	None
Ackerman and Zhang[11]	SGB	Fluoroscopy	Prospective study	25	10/25 had complete symptom relief	None
Forouzaner et al[12]	SGB	Fluoroscopy	Retrospective study	86	40.7% noted a >50% reduction of pain, 54.7% reported no effect on pain, and 4.7% showed worsening of pain	None
Price et al[13]	SGB	None	Randomized, blind-controlled trial	4	No difference in pain reduction between SBG and placebo for CRPS	None
Milligan and Nash[14]	SGB	None	Retrospective study	77	40% SGB patients were pain-free	4 ataxia and diplopia, 1 urine retention
Erickson and Hogan[15]	SGB	CT	Case series	7	Successful block achieved in all cases	2 brachial plexus blockade 1 headache and nausea; 1 warm face, fullness in the ear, and stuffy nose; 1 shoulder, neck, and jaw soreness with facial hot flashes; 1 subpleural hemorrhage
Choi et al[16]	SGB	US	Randomized, blind-controlled trial	40	No benefit to SGB over traditional pain management	Not quantified
Kumar et al[17]	SGB	US	Randomized, double-blind, placebo-controlled trial	30	Less tramadol consumption for those with SGB	None
Kapral et al[18]	SGB	US	Prospective study	12	12/12 patients with US blocked successfully, 10/12 with landmark-based blocked successfully	3 hematomas in landmark-based group
Shibata et al[19]	SGB	US	Prospective study	11	Subfascial technique has more reliable onset, less hoarseness than suprafascial	2 subfascial injections paresthesias, 4 suprafascial injections hoarseness
Bhatia et al[20]	SGB	US	Prospective study	100	Lateral approach may confer greater safety than anterior approach	None
Siegenthaler et al[22]	SBG	US	Observational study	20	19/20 blocks were located at or near the stellate ganglion	None

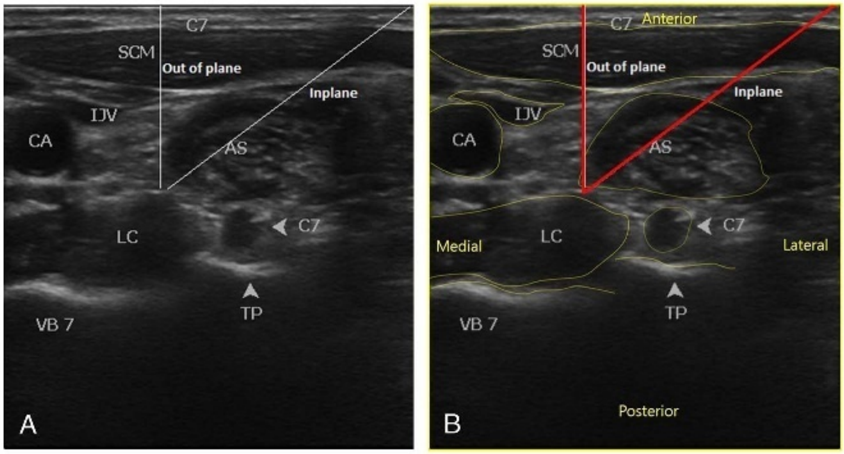

FIGURE 5. Transverse sonographic image at the cervical level showing the possible needle trajectories. CA indicates carotid artery; IJV, internal jugular vein; SCM, sternocleidomastoid; LC, longus colli; AS, anterior scalene; MS, middle scalene; AT, anterior tubercle; PT, posterior tubercle; C7, C7 nerve root; VB7, vertebral body of C7; TP, transverse process. White lines indicate possible trajectories.

Technique

Following a scout scan, the transducer is moved either cephalad or caudal from C6 until a safe trajectory is identified. A safe needle trajectory is planned based on the location of the vascular and nervous structures and esophagus. The target for injection is just anterior to the longus colli muscle within the prevertebral fascia. Regular 2.5-cm, 25-gauge hypodermic needles may be used. The needle may be advanced in an out-of-plane or in-plane approach, depending on individual preference and safety decided during trajectory planning (Fig. 5). There is a wide variation in approach among individual practitioners. Proponents of in-plane approach claim better needle-tip visualization and hence less chance for inadvertent injury or vascular complications. On the other hand out-of-plane approach provides a shorter trajectory and less trauma to tissues when combined with hydrolocalization, which aids accurate identification of the needle tip. Newer advances in US and needle technology may obviate the need for any specific approach. If available, echogenic needles may be used for an in-plane approach. Injectate 2 to 4 mL is usually adequate to obtain a spread along 2 to 4 vertebral levels.[23–26] Further confirmation of appropriate spread above the longus colli may be done using a longitudinal view (Fig. 6).

Complications

Development of Horner syndrome is a sign of successful sympathetic denervation to the head and is easily documented by the presence of miosis, ptosis, and enophthalmos, as well as conjunctival injection, facial anhydrosis, and nasal congestion. Evidence for sympathetic blockade to the upper extremity includes engorgement of the veins of the arm, positive sweat test, and increase in skin temperature.

In addition, other reported adverse events include pneumothorax, intravascular injection, hematoma formation (usually from injury to the inferior thyroid artery or the thyrocervical trunk), esophageal puncture, and damage to the thyroid gland (Table 2). Inadvertent injection into cervical nerve roots, vertebral discs, or intrathecal space has also been reported.[20,36–41] Most of the reported complications were reported following landmark-based and fluoroscopic techniques. This may be because of the relative infancy of US-guided blocks.

Celiac Plexus Block

The definite origin of celiac plexus block (CPB) is unclear but may have originated with Bonica, who first described

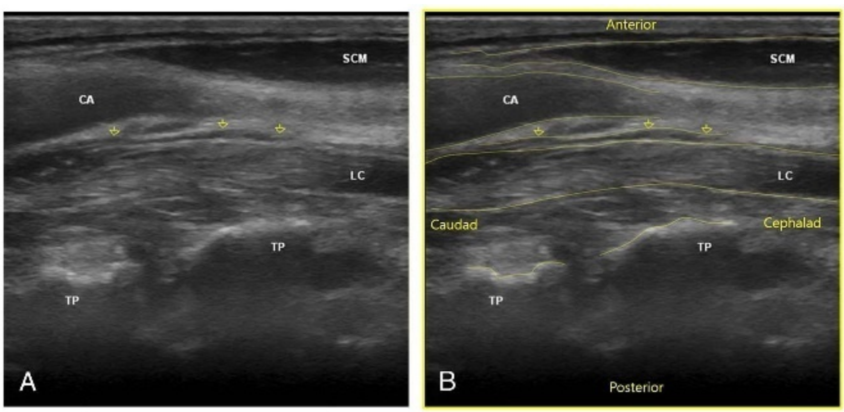

FIGURE 6. Longitudinal sonographic view over the longus colli showing the injectate spread (arrowheads). CA indicates carotid artery; SCM, sternocleidomastoid; LC, longus colli; TP, transverse process.

TABLE 2. Selected Studies on Celiac Plexus Block

Publication	Target	Imaging	Study Design	N	Findings	Complications
Eisenberg et al[27]	CPB	N/A	Meta-analysis	N/A	70%–90% visceral upper abdominal cancer respond well to CPB	N/A
Erdek et al[28]	CPB	CT guided, fluoroscopy	Retrospective review	45	CPB may provide intermediate relief to cancer patients with lower opioid use and short disease duration	None reported
Ischia et al[29]	CPB	Fluoroscopy	Prospective randomized clinical trial	61	48% with CPB had complete pain reduction	Orthostatic hypotension, transient diarrhea, dysesthesia, back pain, pleurisy, hematuria, hiccoughing
Wong et al[30]	CPB	Fluoroscopy	Randomized, double-blind clinical trial	100	Significant pain reduction but no improvement in quality of life or survival	None reported
Lillemoe et al[31]	CPB	None	Prospective, randomized, double-blind clinical trial	137	Significant reduction in pain score for those with CPB	None
Gress et al[32]	CPB	US vs CT	Prospective, single-blind, randomized trial	18	US provided more persistent pain relief	None
Santosh et al[33]	CPB	US vs fluoroscopy	Prospective RCT	56	US provided significantly more pain relief	Postural hypotension, diarrhea
Marcy et al[34]	CPB	US vs CT	Retrospective review	34	Technical success rate was equal between US and CPG	Chemical peritonitis, orthostatic hypotension, left shoulder pain
Das and Chapman[35]	CPB	US	Prospective study	9	Significantly less sedation needed during gastrointestinal procedures	None

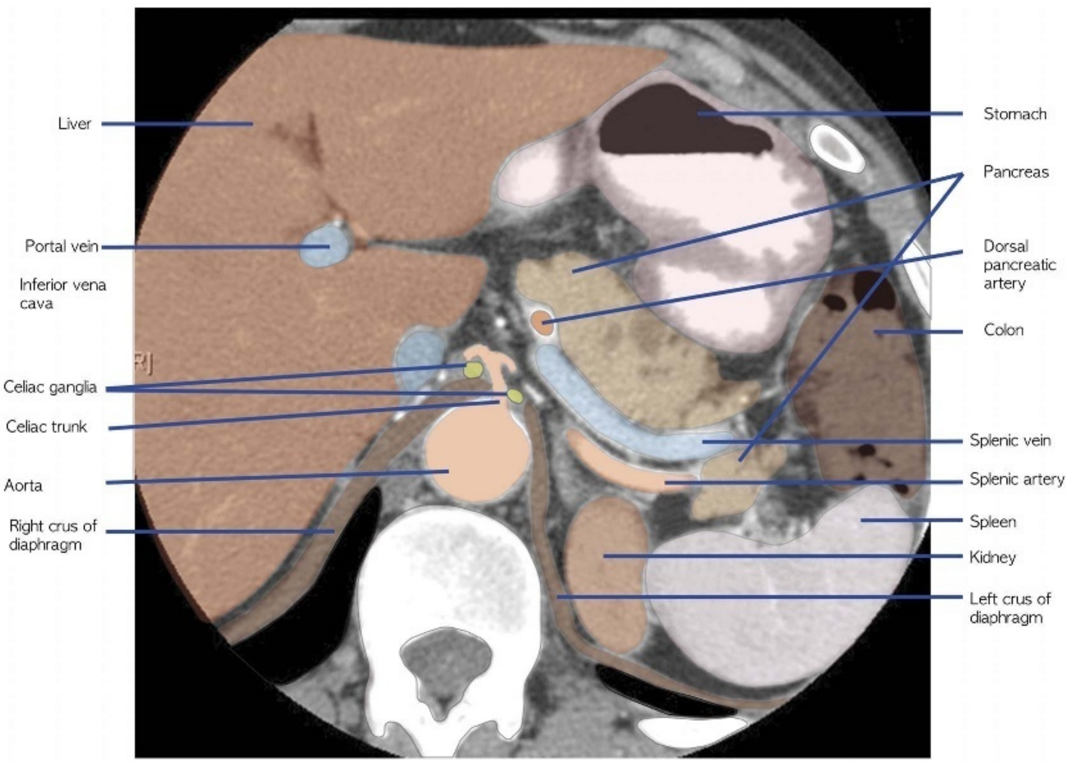

FIGURE 7. Cross-sectional view of abdomen showing the aorta, liver, pancreas, and celiac trunk and its branches.

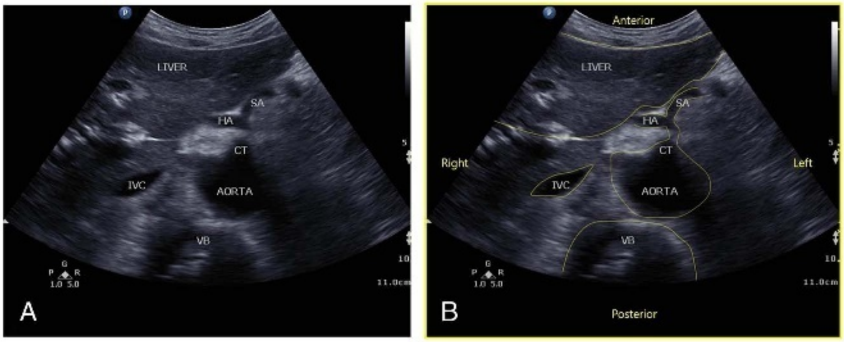

FIGURE 8. Transverse sonographic image of vertebral body and aorta below the xiphisternum showing the possible location of the celiac plexus. IVC indicates inferior vena cava; CT, celiac trunk; HA, hepatic artery; SA, splenic artery; VB, vertebral body.

percutaneous and fluoroscopic-guided techniques. Celiac plexus block has since been developed primarily for cancer-related abdominal pain, usually from the pancreas, but also including the stomach, duodenum, proximal small bowel, and corresponding lymph nodes. Chronic functional gastrointestinal disorders, including chronic pancreatitis and benign gut neoplasms, may also be amenable to CPB.[27,42,43]

Anatomy

The celiac plexus originates from the sympathetic nerve fibers derived from the greater (T5–T9), lesser (T10–T11), and least (T12) splanchnic nerves and is located retroperitoneally on the anterolateral surface of the aorta in close proximity to the origin of celiac trunk and superior mesenteric artery.[1,27,28,42] The plexus consists of right and left celiac ganglia. The ganglia vary in number from 1 to 5 and range from 0.5 to 4.5 cm. The celiac plexus borders with stomach and the pancreas anteriorly and is separated from the vertebral column posteriorly by the aorta and diaphragmatic crura (Fig. 7). The plexus serves as a relay station for sympathetic fibers supplying the abdominal viscera through multiple ganglia. These viscera include the pancreas, liver, biliary tree, and the gallbladder, spleen, stomach, small bowel, adrenals, kidneys, mesentery, and ascending and partially the transverse colon.[1,27,28,42]

Sonoanatomy

The scanning sequence starts with a curved array transducer in an axial view just beneath the xiphisternum. The liver is identified on the right side with its characteristic echogenicity. Stomach and intestines are located midline and to the left. Air within these organs may impair visualization of deeper structures. As we scan further caudad, the aorta and inferior vena cava may be seen as round structures better identified with color flow Doppler. Portal veins may also be seen within the liver. Just beneath these structures is the curved hyperechoic line of the vertebral body with an acoustic shadow (Fig. 8). Further scanning downward will help identify the bifurcation of the celiac trunk into the hepatic artery and splenic artery and more distally the superior mesenteric artery. The transducer is then rotated to get a longitudinal view of the aorta. This will show the celiac trunk and superior mesenteric arteries coming out of the aorta (Fig. 9). The celiac plexus is located around the celiac trunk.

Evidence

A meta-analysis by Eisenberg et al[27] showed that 70% to 90% of patients with cancers of the upper abdomen with a significant visceral component to their pain respond well to CPB. Erdek et al[28] found that CPB and neurolysis may provide intermediate pain relief to patients with pancreatic cancer especially those who are on lower doses of opioids and have a shorter duration of the disease. In a prospective, randomized study of 61 patients with pancreatic cancer pain, Ischia et al[29] reported that 29 (48%) experienced complete pain relief after neurolytic CPB. A seminal double-blind, randomized clinical trial by Wong and colleagues[30] showed an improvement in pain but not quality of life or survival with neurolytic CPB in 100 patients with unresectable pancreatic cancer. Another prospective, randomized, double-blind study by Lillemoe and colleagues[31] showed significant pain reduction in unresectable pancreatic cancer pain with CPB with 50% alcohol when compared with placebo. There is an increasing trend to utilize the splanchnic block instead of the CPB due to perceived increase in successful pain relief especially in situations where there is encroachment of the tumor into the location of the celiac plexus.

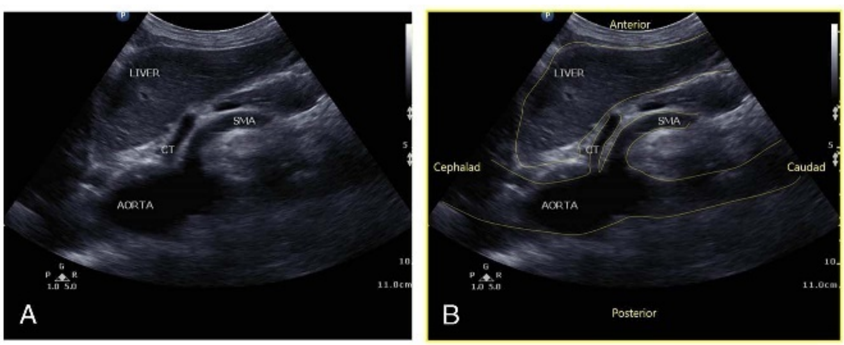

FIGURE 9. Longitudinal view of the aorta, showing the aorta, celiac trunk, and the superior mesenteric artery (SMA) and the celiac trunk (CT).

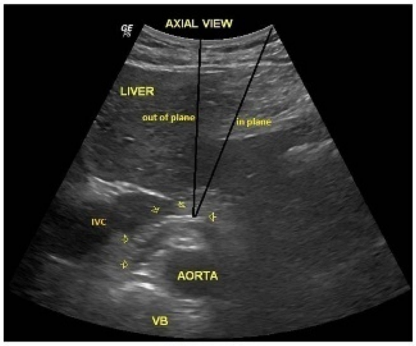

FIGURE 10. Cross-sectional sonographic image showing injectate spread (arrowheads). IVC indicates inferior vena cava; VB, vertebral body. Black lines show needle trajectory for an out-of-plane approach and in-plane approach.

Evidence for Ultrasound Guidance

Like other interventional procedures, the use of US in CPB has gained popularity. Gress and colleagues[32] were able to show in a series of 18 patients that US-guided endoscopic CPB provided more persistent pain relief than CT-guided CPB and was the preferred method in patients who experienced both techniques. Furthermore, Santosh and colleagues[33] found that endoscopic US–guided CPB significantly improved pain scores in 56 chronic pancreatitis patients compared with fluoroscopy-guided block. Marcy et al[34] were able to show in 27 of 34 cancer patients having reasonable pain control that the technical success rate of US-guided injections was comparable to CT-guided injections (93% vs 100%). They preferred the trajectory through the liver and encountered only minor complications. Das and Chapman[35] were able to show satisfactory block via the anterior approach in 8 of 9 patients undergoing gastrointestinal procedures and significantly less sedation and analgesia needed to treat pain during procedure compared with control patients who received on intercostal block during similar procedures. The endoscopic approach provides poor visualization, and many complications have been reported, including major bleeding and spinal cord injury.[43,44] The anterior percutaneous US-guided approach was originally described by Bhatnagar et al[44] (Table 2).

Technique

The anterior percutaneous US-guided approach to celiac plexus is recommended only for patients unable to lay prone and should be performed only by practitioners with extensive experience in US-guided techniques. It is performed with the patient in supine position. Preprocedural intravenous antibiotic is recommended because there is a risk of bowel puncture. A scout scan is performed to identify the structures in the upper abdomen. Once the trajectory is planned, the skin over epigastrium is prepared with chlorhexidine and draped, and a sterile sleeve is applied over the transducer. After raising a skin wheal using 1% lidocaine solution, a 20-gauge, 15-cm Chiba spinal needle is advanced either out of plane or in plane under US guidance. Although there is a general preference for an in-plane approach for all US-guided procedures, it is important to understand that the target and the trajectory dictate the approach to avoid injury to major structures, and a fixation for a particular approach should be scorned as long as hydrolocalization is used. The needle is guided anterior to the aorta between or above the celiac trunk and the superior mesenteric artery. After negative aspiration and hydrolocalization, local anesthetic is injected in increments. It may be necessary to go through the liver, which is unlikely to be of major concern as long as the hepatic vascular structures are not in the trajectory. In addition, those with coagulopathy may not be ideal candidates for this approach. Following confirmation of pain relief with local anesthetic, neurolytic injections may be performed (Fig. 10). The 2 most commonly used neurolytic solutions for CPB are alcohol and phenol.[27,28,42,43] Injection of alcohol in concentrations greater than 50% produces irreversible neuronal damage; however, alcohol injection is painful.[27] Phenol has a slower onset and has a

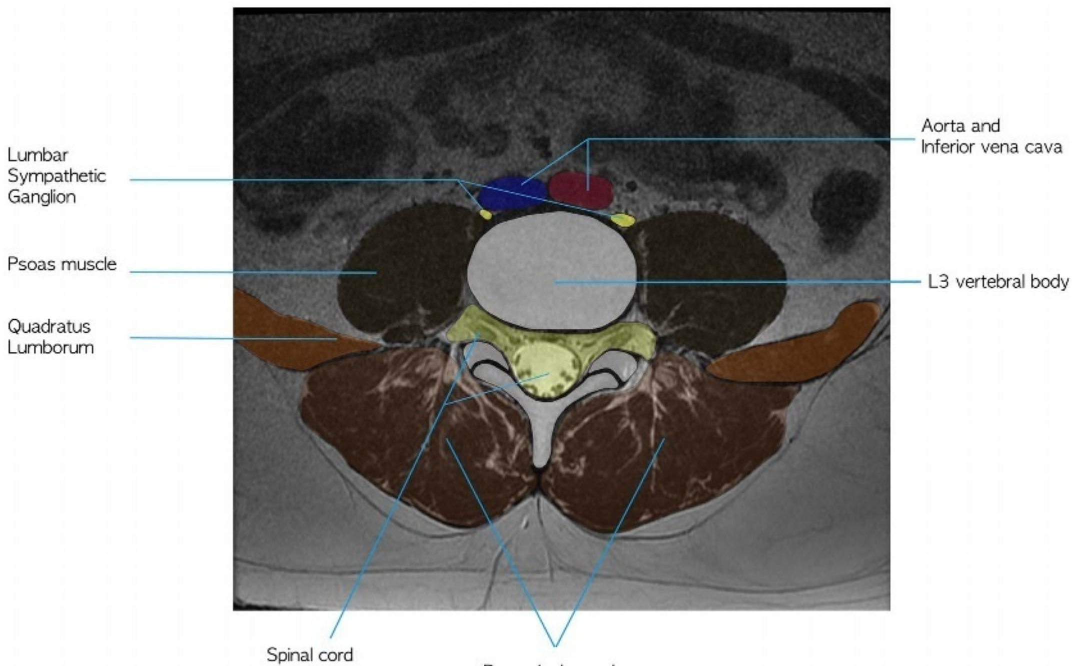

FIGURE 11. Cross-sectional view of abdomen at the level of lumbar vertebra 3.

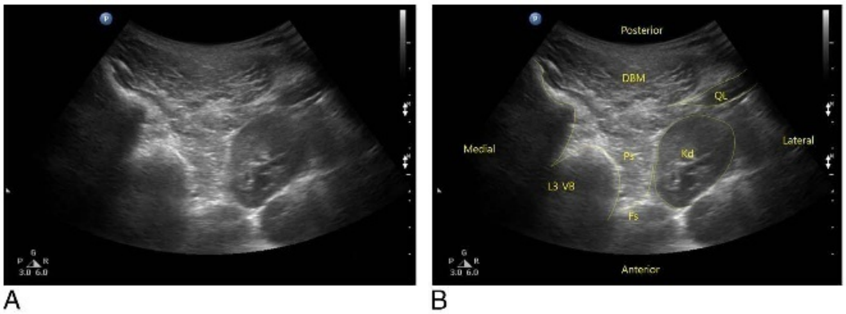

FIGURE 12. Transverse sonographic image at the level of the L3 vertebral body (VB) showing the psoas muscle (Ps), anterior fascia of the psoas muscle (Fs), quadratus lumborum (QL), kidney (Kd), and erector spinae (DBM).

shorter duration of action; it is commonly used in concentrations of 7% to 15%.

Complications

The reported complications are from the performance of CPBs using fluoroscopy-, CT-, and endoscopic US–guided approaches. Orthostatic hypotension and diarrhea occur and may be considered adverse effects. Other complications include impotence, gastroparesis, superior mesenteric vein thrombosis, chylothorax, pneumothorax, chemical pericarditis, chemical peritonitis, aortic pseudoaneurysm, aortic dissection, retroperitoneal hemorrhage, and retroperitoneal fibrosis.[27,28,42,43,45–47] No complications have been reported with the anterior percutaneous technique; however, because of its scarcity, the body of literature is insufficient to draw conclusions.

Lumbar Sympathetic Block

Lumbar sympathetic block (LSB) was first performed by Felix Mandl in 1924 using a blind technique and evolved into a fluoroscopy-assisted technique in 1944. Today, LSB is performed with fluoroscopy-, CT-, and very rarely US-guided techniques. Lumbar sympathetic block is most commonly used for the diagnosis and treatment of various lower-extremity pain states including CRPS I and II, peripheral neuropathic pain, and ischemia-related pain, which are thought to have sympathetic components. It can also be used to palliate pain in lower extremities because of vascular insufficiency, including frostbites, Berger disease, atherosclerosis, and collagen vascular diseases.[48–50]

Anatomy

The lumbar sympathetic chain consists of 4 to 5 paired ganglia that lie over the anterolateral surface of the second through the fourth lumbar vertebrae. The cell bodies lie in the anterolateral region of the spinal cord from T11–L2 with some contribution from T10 and L3. Preganglionic fibers leave the spinal canal with the corresponding spinal nerves, join the sympathetic chain as white communicating rami, and then synapse with the appropriate ganglion.[48–50] Postganglionic fibers exit the chain and join the diffuse perivascular plexus around the iliac and femoral arteries or travel via the gray communicating rami to join the spinal nerves that form the lumbar and lumbosacral plexuses (Fig. 11). Sympathetic fibers accompany all major nerves to the lower extremities. The majority of sympathetic innervation passes through the second and third lumbar sympathetic ganglia.[48–50]

Sonoanatomy

A curved array transducer is used. The vertebral levels are first identified by counting from the sacrum. Once the spinous process of L3 is identified, the transducer is rotated to obtain an axial view. The spinous process is seen as a curved hyperechoic line continuing laterally as the lamina and articular pillars. At a slightly deeper location and in continuity with this, another hyperechoic transverse line, the transverse process, may appear. Between the transverse processes, the psoas major muscle is seen to span. Deeper to the psoas muscle and medially is the curved hyperechoic vertebral body (Fig. 12). With color flow Doppler, radicular artery may be seen within the psoas muscle. The aorta may

TABLE 3. Selected Studies on Lumbar Sympathetic Block

Publication	Target	Imaging	Study Design	N	Findings	Complications
Alexander[49]	LSB	Fluoroscopy	Retrospective review	489	Improvement in rest pain, skin blood flow, and ischemic ulcers in 72% of patients	Hypotension, convulsions, severe nausea and vomiting
Cross and Cotton[50]	LSB	None	Randomized, double-blind, controlled trial	37	Reduction in rest pain at 1 week and 6 mo in LSBs performed with phenol compared with bupivacaine	None
Haynsworth and Noe[51]	LSB	Fluoroscopy	Prospective, randomized study	17	89% of patients in the phenol group had evidence of sympathetic block compared with 12% in the RFA group	None
Kirvelä et al[54]	LSB	US	Prospective study	42	100% achievement of sympathectomy	Transient quadriceps weakness (1)

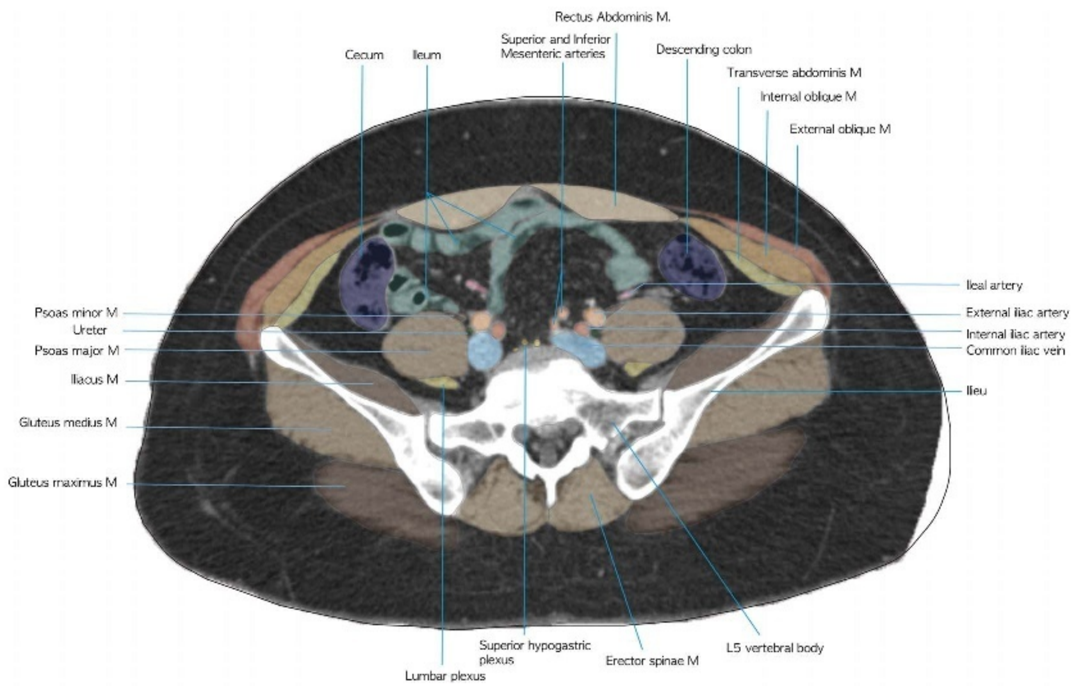

FIGURE 13. Cross-sectional view at the lower border of the L5 vertebra.

also be seen deeper and anterior to the vertebral body on the left side.

Evidence

Despite the long history of its use, LSB, like other sympathetic blocks, currently lacks a strong RCT basis for its use in sympathetically mediated pain, with most publications revolving around case reports or case series.[48–51] Alexander[49] has performed perhaps the largest retrospective review of the modality with their retrospective review of 544 fluoroscopy-assisted chemical LSBs in 489 patients with lower-limb ischemia over a 13-year period. Alexander[49] found improvement in rest pain, skin blood flow, and ischemic ulcers in 72% of patients. The largest double-blind RCT for LSB thus far was performed by Cross and Cotton,[50] who observed statistically significant reduction in rest pain at 1 week and 6 months in LSBs performed with phenol compared with bupivacaine. A prospective randomized study by Haynsworth and Noe[51] compared LSB with phenol compared with RFA and found 89% of patients in the phenol group had evidence of sympathetic block compared with 12% in the RFA group. Meier and colleagues[52] performed a double-blind, placebo-controlled trial in children aged 10 to 18 years and found significantly more pain reduction for patients who received LSB compared with placebo. In a series of 15 patients, Redman et al[53] performed LSB block guided by CT, seeing 13 of the patients receive "significant benefit" from the procedure.

Evidence for Ultrasound Usage

Systematic comparative study between US-guided and landmark-based or other imaging modality–based guidance has yet to be performed. Kirvelä and colleagues[54] did perform a series of 46 LSBs and achieved objective signs of sympathectomy in all cases, with "good but variable" pain relief. The quality of the images was poor as they were performed in 1990s when US imaging equipment was not as advanced as at present and hence difficult to make a valid interpretation. Only 1 complication, a transient quadriceps weakness, was observed (Table 3).[54]

Technique

Lumbar sympathetic block is conventionally done with the patient in the prone position under fluoroscopic or CT guidance. The following is the technical description used in the published literature as the authors have not yet found it safe and practical using US guidance. Patients are usually placed in the lateral decubitus position with the waist supported by a pillow for a US-guided posterior approach. The 12th rib, iliac crest, and lumbar spines are

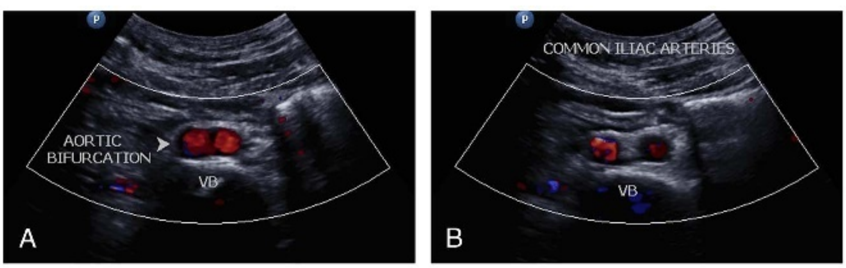

FIGURE 14. A, Transverse sonographic image showing the iliac vessels just as they bifurcate from aorta. B, The iliac vessels after they bifurcate. VB indicates vertebral body.

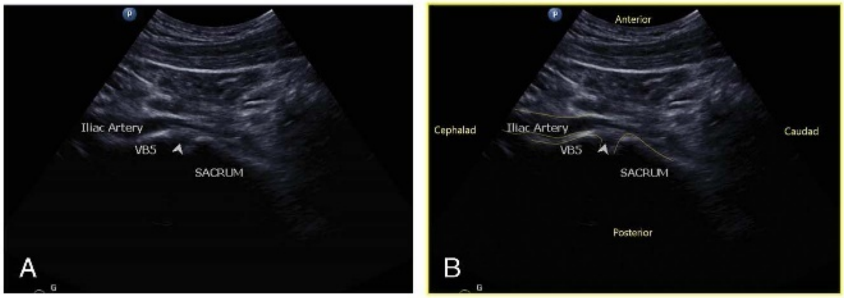

FIGURE 15. Longitudinal sonographic image showing the lumbar 5 vertebral body (VB5), L5–S1 disc (arrowhead) and the sacrum.

then marked. Usually blocks are performed at the levels of L2 and L3. After raising a skin wheal–appropriate skin sterilization and sterile precautions, a suitable-size needle is advanced through the paravertebral muscles to make contact with the lateral edge of the vertebral body. After contact, when the needle is advanced further, it emerges from the psoas muscle and is walked ventrally. At this point, it is extremely difficult to visualize the needle based on the authors' experience. An alternative technique based on the authors' experience may be to identify the L3 vertebra in a transverse view. When the curved array transducer is moved further lateral, the articular pillars and the transverse process come into view. When the transducer is slid caudad, the psoas muscle and vertebral body may be seen in cross section. Following hydrolocalization, 5 mL of local anesthetic is injected after negative aspiration at the level.[48–51] As US guidance for LSB has not been further validated and because of the potential for injection into the radicular artery or other major vascular structures, the authors do not recommend US guidance for this blockade at present.

Complications

Complications of LSB are similar to those of CPB. However, as the trajectory of the needle is posterolateral to medial, damage to the lumbar nerve roots and their branches and the neuraxis becomes more likely.[48–51] No complications have yet been reported for the US-guided approach.

Superior Hypogastric Nerve Block

Superior hypogastric plexus block (SHPB) was first described by Plancarte et al[55] in 1990 for pelvic pain. It has since gained popularity as a diagnostic technique used to determine if pelvic pain is sympathetically mediated via the hypogastric plexus. It is also used as therapy for sympathetically mediated pelvic pain. Destruction of the plexus may be therapeutic in patients with acute and chronic pelvic pain, cancer pain of the pelvic viscera, or neuropathic pain from trauma or endometriosis. Superior hypogastric plexus block has also shown utility in sympathetically mediated rectal pain.[56]

Anatomy

The hypogastric plexus is the caudal continuation of the paravertebral sympathetic chain. The superior hypogastric plexus lies in front of L5–S1 junction. This coalescence of fibers descends and at the level of S1 begins to divide into the hypogastric nerves in close proximity to the iliac vessels. They are accessible for neural blockade at the anterolateral surface of the lumbosacral junction. The iliac vessels lie anterior to the psoas muscle and lateral to the hypogastric plexus (Fig. 13).[55–57]

Sonoanatomy. A curvilinear low-frequency transducer is used for the anterior approach to the superior hypogastric plexus. The transducer is placed at the level of the umbilicus for an axial view of the aorta. The curvilinear hyperechoic line of the vertebral body may be seen just beneath the aorta. The transducer is then slowly slid caudally until the bifurcation of aorta into iliac arteries (Fig. 14). This is best seen with color flow Doppler. Subsequently, the transducer is rotated to get a longitudinal view of the vertebral bodies at this level. The L5 vertebral body will appear as a hyperechoic line. The L5–S1 disc is slightly less hyperechoic. The hyperechoic curved line of the sacrum gently continues down into the pelvis. The hypogastric plexus is targeted at the level of the L5–S1 disc (Fig. 15).

Evidence

The largest prospective cohort study evaluating SHPB was performed by Plancarte et al[55] in 1997. Over a 3-year period, 227 patients with pelvic pain were enrolled and received bilateral percutaneous neurolytic SHPB with 10% phenol after a successful diagnostic block with 0.25% bupivacaine. Seventy-two percent of the 159 patients who responded to a diagnostic block had a visual analog pain score 4/10 or less, 62% after 1 block, and 10% after a second block.[55] Gamal et al[58] compared posterior traditional blockade of the superior hypogastric plexus to a transdiscal technique in 20 patients prospectively randomized to either group. Both groups showed decreased pain scores and morphine

TABLE 4. Selected Studies on Superior Hypogastric Plexus Block

Publication	Target	Imaging	Study Design	N	Findings	Complications
Plancarte et al[55]	SHPB	Fluoroscopy	Cohort study	227	72% had a visual analog pain score ≤4/10	None
Gamal et al[58]	SHPB		Prospective randomized trial	20	Decreased pain scores, morphine consumption at 24 h, 1 wk, and 1 and 2 mo after procedure	None
Mishra et al[59]	SHPB	US	Prospective randomized trial	50	SHPB reported significantly less pain intensity and had lower morphine consumption than morphine only	Transient weakness (1), hypotension (1)

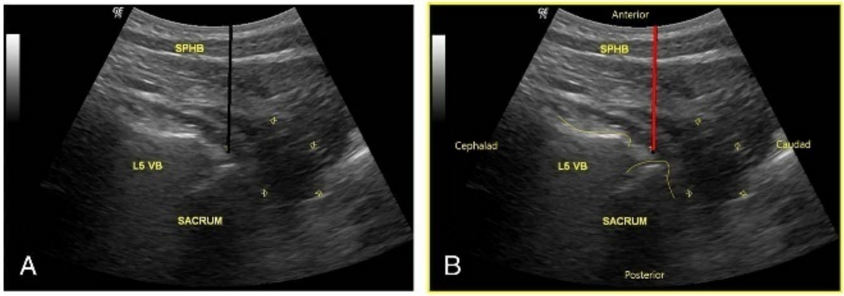

FIGURE 16. Longitudinal view of the lumbosacral junction showing an out-of-plane approach (black line) for the superior hypogastric plexus (SPHB). L5 VB indicates vertebral body of L5. Arrowheads point to injectate spread.

consumption at 24 hours, 1 week, 1 month, and 2 months after procedure.

Evidence for Ultrasound Usage

Mishra and colleagues[59] compared US-guided SHPB with oral morphine to oral morphine only in a group of 50 patients randomized to either group. The authors found that patients treated with SHPB reported significantly less pain intensity and had lower morphine consumption. No statistical differences were found in adverse events.[59] More recently, a small cadaveric study targeted the L5–S1 disc using an in-plane approach.[60] No systematic comparison has yet been performed comparing US-guided block to other image guidance techniques (Table 4).

Technique

Needle trajectory is planned after using color flow Doppler to identify the vessels. It is important to empty the bladder prior to needle entry. Because of the potential for complications and difficulty in visualizing the target, this procedure should be performed only by practitioners with significant experience in US imaging. The abdominal wall is prepared with chlorhexidine/alcohol. Using sterile precautions and after preprocedural antibiotics, a 15-cm, 22-gauge Chiba needle is introduced through the hypogastrium. A longitudinal view of the lumbosacral junction allows introducing the needle either in plane or out of plane (Fig. 16). After confirming a negative aspiration for blood and using hydrolocalization with saline to identify the needle tip, a diagnostic block may be performed by injecting 10 mL of local anesthetic. If the injection successfully relieves pain, 5-mL increments of a mixture containing equal volumes of 100% ethanol and 0.25% bupivacaine, usually 10 to 15 mL, may be injected.[59,61]

Complications

Intravascular injection, inadequate spread and incomplete pain relief, and damage to the bowel and bladder are all possible. Complications also include bowel and bladder hesitancy or urgency, as well as sexual dysfunction and retroperitoneal hematoma. Discitis is a unique complication to the transdiscal approach.[55,57–60]

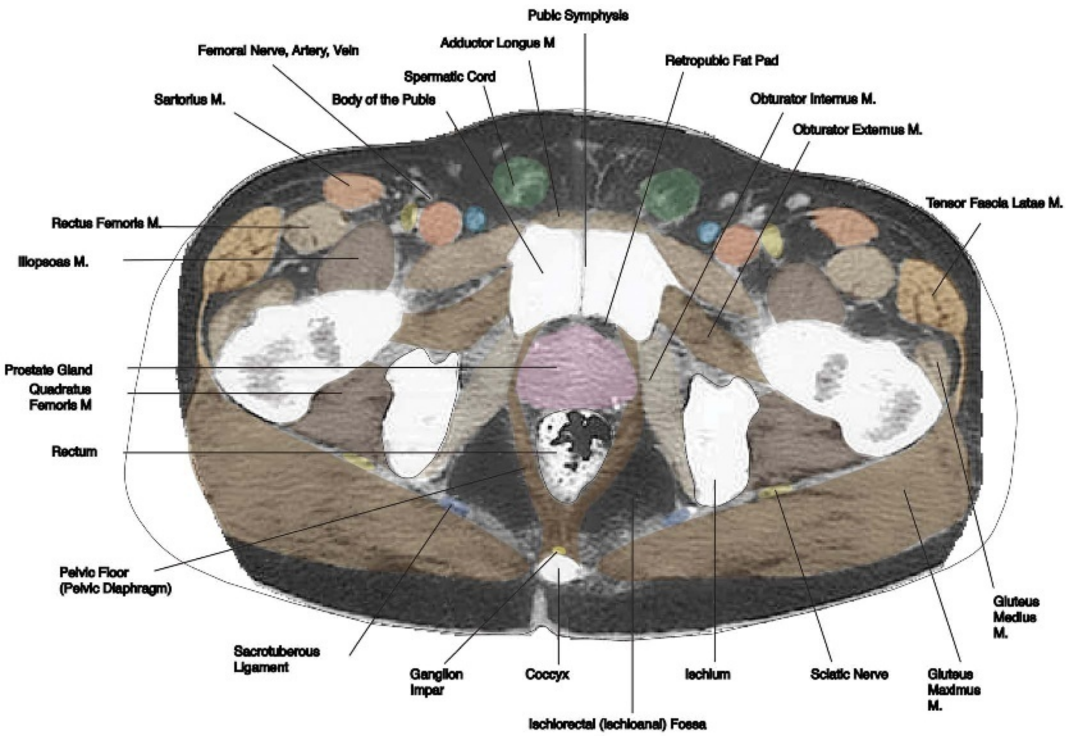

FIGURE 17. Cross-sectional view at the level of the coccyx.

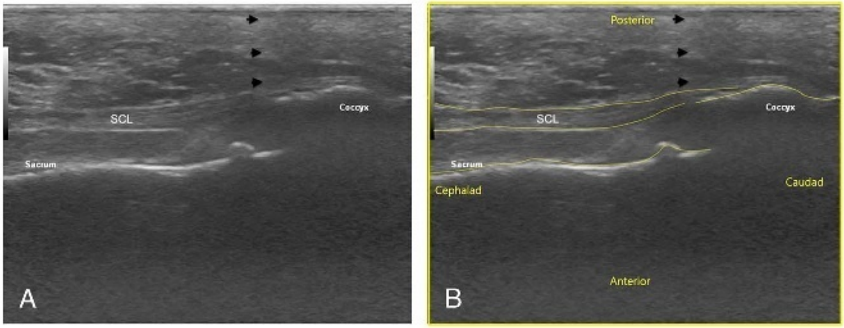

FIGURE 18. Longitudinal sonographic image showing the sacrum, sacrococcygeal ligament (SCL), and coccyx. The arrowheads point to the needle in a transsacrococcygeal approach.

Ganglion Impar Block

Ganglion impar block (GIB) was first described in 1990 by Plancarte et al,[55] who used a landmark-based technique. It has been used for the treatment of pain originating from the perineum, distal rectum, and the distal thirds of the urethra and vagina. Others have used GIB for chronic pelvic pain syndrome and coccygodynia. The landmark-based anococcygeal approach eventually fell out of favor because of a higher potential for rectal perforation. Fluoroscopy and CT guidance have been used. Ultrasound guidance more recently has brought an increased interest in GIB.[62–64]

Anatomy

The ganglion impar, also known as the ganglion of Walther or sacrococcygeal ganglion, is the lowest node in the paravertebral sympathetic chain formed by a fusion of the caudal end of the paired sacral sympathetic chains (Fig. 17). It is a singular 4-mm, semicircular, retroperitoneal structure located at or slightly below the anterior aspect of sacrococcygeal joint. Anterior to the ganglion is the rectum. The ganglion impar is usually centered on the first to second coccygeal vertebrae, and fibers from the ganglion travel through the sacral spinal nerves through the gray rami communicantes.[62–64]

Sonoanatomy

With the patient prone, a linear array transducer is placed transversely to obtain an axial view of the sacral hiatus. The transducer is then rotated 90 degrees into the sagittal plane to visualize the sacrum, sacrococcygeal ligament, and coocyx[65] (Fig. 18).

Evidence

Evidence for GIB is largely limited to case series and reports. Authors have been able to achieve a 50% reduction in pain scores after GIB under fluoroscopy.[62] A retrospective review was able to show a 75% decrease in pain scores after CT-guided GIB for up to 6 months.[63] According to the original description, the block is performed with a bent spinal needle directed cephalad through the anococcygeal ligament. However, a vertical transsacrococcygeal approach was later described to obviate the need to traverse through the perineum.[64] A paracoccygeal approach described by Huang[66] shortens the trajectory from needle entry to the ganglion. Munir and colleagues[67] described a needle in needle technique using fluoroscopy that may decrease trauma to intervertebral discs and the coccyx and additionally decrease infection rate and needle breakage.

Evidence for Ultrasound Usage

A recent study by Lin et al[68] described 15 cases of successful US-guided GIB. The authors used fluoroscopy to determine the needle depth and to assess the spread of the injectate as the needle tip is difficult to identify once the sacrum is penetrated. The described techniques are more a US-assisted technique because the needle tip may not be visualized (Table 5).

Technique

The ganglion impar block may be performed with the patient in lateral decubitus position or prone. The patient's legs are rotated internally, with the toes pointing inward to improve access to the gluteal cleft. The area is prepared and draped in a sterile fashion. Depending on body habitus, an appropriate-size needle is chosen. The needle may also be advanced through the sacrococcygeal disc, or the approach could be from the side of the junction as in a paracoccygeal approach in an out-of-plane approach. Once the needle advances beyond bone, it is difficult to visualize the needle. Fluoroscopic transverse view is obtained to confirm appropriate contrast spread (Fig. 19). Once placement is confirmed, local anesthetic solution (for diagnostic purposes) or neurolytic solution (for therapeutic purposes) is injected beneath the junction.

Complications

Besides block failure, unique complications of GIB include rectal perforation, sacral nerve root injury, periosteal injection, and inadvertent epidural injection. Motor weakness

TABLE 5. Selected Studies on Ganglion Impar Block

Publication	Target	Imaging	Study Design	N	Findings	Complications
Datir and Connel[62]	GIB	CT	Case series	8	75% had some symptomatic improvement	None
Agarwal-Kozlowski et al[63]	GIB	CT	Retrospective review	43	90% reported at least halving of initial pain intensity	None
Lin et al[68]	GIB	US	Case series	15	Ganglion impar was located in 100% of cases	None

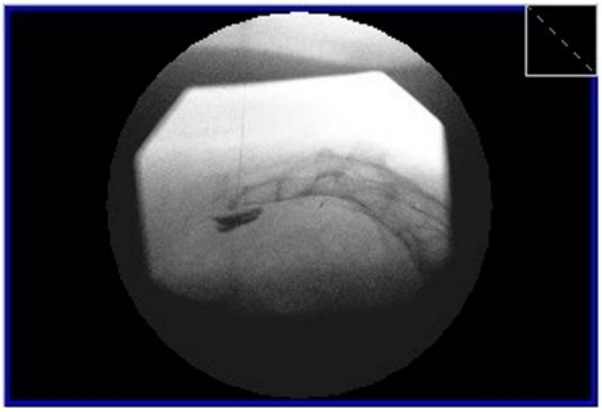

FIGURE 19. Fluoroscopic image of the longitudinal view of the sacrum and coccyx showing appropriate contrast spread.

and bowel, bladder, and sexual dysfunction are also theoretically possible.[68,69]

CONCLUSIONS

It is technically feasible to perform US-guided sympathetic blocks. The evidence at present is sparse for most of the US-guided sympathetic blocks, and there is insufficient information about the potential advantages and complications. Most of these techniques are technically challenging and should be performed in select patients and only by those adequately trained with the use of US guidance with full understanding of the sonoanatomy and potential complications.

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