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MUSCULOSKELETAL REHABILITATION (B SCHNEIDER, SECTION EDITOR)

Evidence Analysis of Sympathetic Blocks for Visceral Pain

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Abstract

Purpose of Review This paper aims to review common sympathetic nerve blocks to treat visceral pain.

Recent Findings Extensive reviews exist exploring the approach to care for those with visceral pain due to malignancy. These often include interventional pain procedures. Research demonstrates these procedures may reduce opioid use. Research is ongoing to assess the efficacy when treating non-malignant source of visceral pain. Recently, several case reports and small-scale studies demonstrate benefits for non-painful entities, such as improved cardiac function after such procedures.

Summary The management of visceral algesia is complex. The approach to visceral pain should recognize the benefit of early discussions for the use of sympathetic blocks. Additionally, since most procedures have multiple techniques, analgesia can be achieved even in the setting of distorted anatomy due to tumor mass effects or post-radiation fibrosis, among other etiologies.

Keywords Cancer pain · Coccydynia · Sympathetic blocks · Visceral pain · Pancreatic pain · Pelvic pain

Introduction

Visceral pain is a physiologically and clinically separate entity from somatic pain. Instead of painful responses to nociceptive stimuli such as cutting or burning, the viscera responds primarily to ischemia, inflammation, and distension [1••]. Patients typically describe visceral pain as diffuse and poorly defined, with descriptors such as deep, twisting, squeezing, or dull [2]. These painful conditions can range from mild, such as with viral gastroenteritis, to severely debilitating, such as with pancreatic cancer.

Sympathetic blocks for chronic pain have been utilized in pain medicine for decades. However, a distinction must be made between sympathetic blocks employed for presumed sympathetically maintained pain (i.e., complex regional pain syndrome (CRPS)) as compared to sympathetic blocks used for the treatment of visceral ailments. While the primary goal of the former is to interrupt the sympathetic efferent outflow to an extremity or body region, the purpose of the latter is to block afferent signals from visceral sources.

The cell bodies for the sympathetic nervous system originate from the intermediolateral column of the spinal cord between T1 and L2/3. These fibers typically leave the central canal via the ventral root, and the preganglionic B fibers exit the spinal nerve via the white rami communicantes between these levels to synapse with the postganglionic neurons in the sympathetic ganglia. The paravertebral sympathetic ganglia are arranged in two chains spanning from the skull to the coccyx along the anterior aspect of the vertebral column and terminate in the only unpaired ganglion of the sympathetic chain, the ganglion impar (ganglion of Walther) on the ventral surface of the coccyx. The preganglionic fibers may synapse in this chain at their exiting level, ascend or descend in the sympathetic chain prior to synapsing, or travel uninterrupted through the sympathetic chain to a prevertebral ganglion in the body (i.e., splanchnic nerves to the celiac plexus). After synapsing in the sympathetic ganglia, these postganglionic C fibers can rejoin the spinal nerve via the gray rami communicates that exist at any spinal level and continue onward as postganglionic fibers to exert their end effect. If synapsing at a ganglion outside of the sympathetic chain (i.e., celiac plexus), they may travel directly to the end organ by following arteries rather than traveling in the gray rami [3].

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Pain fibers from the viscera, which are Aδ or C fibers, follow a similar path as described above with the sympathetics but in an afferent manner [4]. Typically, this consists of a fiber leaving the end organ and traveling in the opposite direction as the sympathetic fibers, potentially traversing both prevertebral and paravertebral ganglia and/or white/gray rami communicantes, but without synapsing in the associated sympathetic ganglion, as they return to the spinal cord [5, 6]. Projections from these fibers to the wide dynamic range (WDR) neurons in Rexed lamina V are thought to be responsible for referred pain, as somatic fibers also project to these WDR neurons [7]. Some pain fibers may also return via a similar route but mirroring the parasympathetic efferent fibers rather than the sympathetics [4, 6]. It is these peripheral, afferent fibers that are truly the target of a sympathetic nerve block for visceral pain. Calling them sympathetic blocks, therefore, is somewhat of a misnomer given that the blocks are named after the side effect of the block, not its main purpose. As mentioned earlier, this is in stark contrast to sympathetic blocks designed to interrupt sympathetic outflow itself rather than blocking pain afferent fibers, such as those performed when treating CRPS [8]. The side effects of a successful block are primarily from the resultant sympathectomy and include orthostatic hypotension from the resultant vasodilation and increased GI motility (diarrhea) due to unopposed parasympathetic activity [9].

The two main purposes of sympathetic blocks are for diagnosis and treatment [10••]. While one cannot exclude other causes of pain after a successful block due to a potential false positive result, sympathetic blocks providing significant benefit to pain localized in the thorax, abdomen, or pelvis lend support to a visceral origin of a patient's pain. Local anesthetics are most commonly used for these procedures, but some practitioners also utilize corticosteroids as well to enhance or prolong the effects as a treatment. For visceral cancer pain, more aggressive injectates can be utilized; neurolytics such as alcohol or phenol have demonstrated excellent results for visceral cancers, such as a celiac plexus neurolysis for pancreatic cancer [11, 12]. These neurolytic techniques have the potential to relieve pain for months, though their use for non-malignant pain sources is controversial [13]. Table 1 provides a summary of common sympathetic nerve or ganglion blocks used in the management of visceral pain.

Celiac Plexus Block

Chronic abdominal pain associated with malignancy secondary to direct invasion or mass effect on viscera and surrounding structures by pancreatic, biliary, and gastric cancers, or metastases from the hematogenous or lymphatic spread, is a common indication for sympathetic blocks. Non-malignant sources of chronic abdominal pain include chronic pancreatitis from inflammatory processes or from biliary pathology like common bile duct stenosis [23] and is composed of pre- and postganglionic sympathetic, parasympathetic, and visceral sensory afferents fibers. The splanchnic nerves carry preganglionic sympathetic fibers of T5–T12, while the celiac branch of the right vagus nerve contributes parasympathetic fibers [24]. The celiac plexus provides visceral nociception to organs of the upper abdomen including the distal esophagus, stomach, pancreas, liver, gallbladder, and the lower esophageal sphincter to the mid-transverse colon.

The celiac plexus block (CPB) may be used to treat patients suffering from chronic abdominal pain of malignant origin as an adjunct to systemic multimodal pain regimens. Although few reports have evaluated optimal timing for celiac plexus neurolysis, some suggest for those with malignant disease, neurolysis may be more effective when performed early before development of a substantial viscero-somatic component, leading some authors to advocate for its use as a first-line treatment modality [25••]. Fewer systemic side effects may be encountered with celiac plexus block compared to opioid therapy [26•]. The contraindications to celiac plexus block include systemic infection, infection in the path of injection, bowel obstruction, thrombocytopenia, and uncorrectable coagulopathy [24].

Generally considered to be a low-risk procedure, most adverse effects are transient and serious complications occur in less than 2% of cases [25••]. Complications include retroperitoneal bleeding, infection, hematoma, aortic injury, and direct nerve injury or nerve compromise secondary to damage and interruption to vascular supply [25••]. The most common side effects include diarrhea and orthostatic hypotension secondary to unopposed parasympathetic activity. Orthostasis is primarily due to loss of sympathetic tone and consequent splanchnic vasodilatation and warrants attention in 10–30% of patients [24], typically in geriatric, arteriosclerotic, or hypovolemic patients. Several techniques are practiced to achieve a celiac plexus block, which has been described in Table 2. A posterior approach may be taken for neurolysis of the celiac plexus [34]. Endoscopic approaches have also been described [35]. A meta-analysis was performed to evaluate the effectiveness of neurolytic celiac plexus block on relief of chronic pain [36•] which included follow-up over different periods of time. At a follow-up period less than 2 weeks, approximately 89% of patients reported complete and partial pain relief, and 89.4% reported complete and partial relief at 2 to 12 weeks. At a follow-up of greater than 12 weeks, 90.2% of patients reported complete and partial pain relief. It is important to note that the number of patients reporting decreased as follow-up time increased. One group found that neurolytic celiac plexus block improved pain relief in patients with pancreatic cancer compared to opioid therapy alone. The study did not find an effect on the overall quality of life or survival [37].

A meta-analysis evaluated randomized controlled trials, case series, case reports, and one survey for the effects of CPB on pain, opioid consumption, quality of life, and associated side effects [38•]. It was found that for percutaneous neurolytic CPB, patients

Table 1 Comparison of common percutaneous sympathetic blocks utilized for visceral pain

Targeted sympathetic block	Clinically relevant anatomy	Indications	Side effects and possible complications
Celiac plexus block (CPB) [14, 15]	• Formed by the termination of the greater splanchnic nerve and lesser splanchnic nerve. •Organs innervated include the liver, gallbladder, pancreas, spleen, adrenal glands, kidneys, stomach, distal esophagus, and bowel to the level of the distal transverse colon. •The celiac plexus is anterior to the crus of the diaphragm.	•Cancer pain from intra-abdominal pathology •Differentiate whether flank, retroperitoneal, or upper abdominal pain is sympathetically mediated via the splanchnic nerves. •Acute and chronic pancreatitis •Visceral arterial insufficiency associated ischemia	•Transient pain •Bleeding •Retroperitoneal hematoma •Intravascular injection •Intrathecal or epidural injection •Perforation of nearby viscera •Pneumothorax •Infection •Hypotension •Diarrhea •Impotence •Paraplegia •Thrombosis or embolism
Splanchnic nerve block (SNB) [16, 17]	•Splanchnic nerves provide the major preganglionic contribution to the celiac plexus and transmit the majority of nociceptive information from the viscera. •The greater splanchnic nerve has its origin from the T5 to T8 thoracic sympathetic ganglia. •The lesser splanchnic nerve arises from the T9 and T10 thoracic sympathetic ganglia. •The least splanchnic nerve arises from the T11 and T12 thoracic sympathetic ganglia. •Organs innervated include much of the distal esophagus, stomach, duodenum, small intestine, ascending and proximal transverse colon, adrenal glands, pancreas, spleen, liver, and biliary system. •The number of ganglia varies from one to five. •The ganglia lie anterior and anterolateral to the aorta. •The ganglia usually lie about at the level of the first lumbar vertebra.	•Similar to CPB	•Transient pain •Bleeding •Retroperitoneal hematoma •Intravascular injection •Intrathecal or epidural injection •Perforation of nearby viscera •Pneumothorax •Infection •Hypotension •Diarrhea •Impotence •Paraplegia •Thrombosis or embolism
Superior hypogastric plexus block (SHPB) [18]	•The superior hypogastric plexus is formed via branches from the aortic plexus (sympathetic and parasympathetic), lumbar splanchnic nerves (sympathetic), and pelvic splanchnic nerves (parasympathetic). •The superior hypogastric plexus lies anterior to the L5 vertebral body and the sacral promontory on both sides of the midline.	•Evaluate whether pelvic pain is sympathetically mediated. •Primarily utilized in pain relief for pelvic cancer pain syndromes that are otherwise difficult to treat. •Common indications: malignancy, endometriosis, reflex sympathetic dystrophy, causalgia, proctalgia fugax, and radiation enteritis	•Paraspinous muscle spasm •Inadvertent intravascular injection •Bleeding or hematoma •Lumbar or sacral somatic nerve injury •Renal or ureteral puncture •Decreases in sexual function •Bowel or bladder changes •Injury to pelvic viscera •Epidural, subdural, or subarachnoid injection or trauma to the intervertebral disk, spinal cord, and exiting nerve roots •Infection
Inferior hypogastric plexus block (IHPB) [18, 19]	•A presacral plexus which is formed by sympathetic efferent fibers from the hypogastric nerves, preganglionic parasympathetic fibers from pelvic splanchnic nerves, and afferents from pelvic viscera. •The inferior hypogastric nerves lie within the bilateral presacral tissues on either side of the rectum ventral to the S2, S3, and S4 spinal segments.	•Diagnosing and treating sympathetically mediated chronic pelvic pain of the lower pelvic viscera including the bladder, vagina, penis, rectum, anus, and perineum. •Post-radiation-induced tenesmus •Acute herpes zoster and post-herpetic neuralgia involving the sacral dermatomes	•Transient paresthesia •Sacral spinal nerve injury •Rectal puncture •Inadvertent intravascular injection •Hematoma •Dural puncture •Infection

Table 1 (continued)

Targeted sympathetic block	Clinically relevant anatomy	Indications	Side effects and possible complications
Ganglion impar block (GIB) [20, 21]	•The terminal coalescence of the sympathetic chain which innervates the pelvic viscera and genitalia •Receive fibers from the lumbar and sacral portions of the sympathetic and parasympathetic nervous systems	•Evaluation and management of sympathetically mediated pain of the perineum, rectum, and genitalia •Primarily used to treat malignant pain •In appropriate circumstances, may be used to treat benign pain syndromes secondary to endometriosis, reflex sympathetic dystrophy, causalgia, proctalgia fugax, and radiation enteritis; can be considered if the pain has failed to respond to more conservative therapies •Coccydynia	•Rectal perforation •Post-procedure fistula •Infection •Cauda equina injury •Sacral nerve injury
Thoracic sympathetic chain block (TSCB) [22]	•The T1 sympathetic ganglion, which is located within the cervicothoracic junction forms part of the stellate ganglion, and is located just anterior to the head of the first rib •The T2–T12 sympathetic ganglia are located adjacent to their respective vertebral bodies and rest along the posterolateral surface of the respective vertebral body •The lower thoracic sympathetic ganglia subserve the splanchnic nerves and celiac plexus	•Evaluation and management of sympathetically mediated pain of the upper thorax, chest wall, and thoracic and upper abdominal viscera •Intractable cardiac and abdominal angina •Post-thoracotomy pain •Acute herpes zoster •Palmar hyperhidrosis, post-herpetic neuralgia •Phantom breast pain after mastectomy •Upper essential hyperhidrosis •CRPS •Raynaud's phenomenon	•Thoracic somatic nerve blockade •Injury to spinal cord or exiting thoracic nerve roots •Pneumothorax •Epidural, subdural, or subarachnoid injections •Infection

CPB, celiac plexus block; *SNB*, splanchnic nerve block; *SHPB*, superior hypogastric plexus block; *IHPB*, inferior hypogastric plexus block; *GIB*, ganglion impar block; *TSCB*, thoracic sympathetic chain block; *CRPS*, complex regional pain syndrome

demonstrated lower pain scores weeks to 1 month compared to systemic opioid therapy, but no difference after 2 months; however, opioid consumption was significantly ($p < 0.001$) lower at all time points compared with those treated with analgesic therapy alone. Of the studies reviewed, participant group size was insufficient to demonstrate statistically significant differences in pain in groups who had celiac plexus neurolysis versus systemic opioid therapy. Diarrhea, back pain, and transient hypotension were among the most common side effects seen in groups who received celiac plexus nerve block compared to patients receiving systemic opioid therapy. In an earlier review of 5 randomized controlled trials of patients with unresectable pancreatic cancer, benefit in reducing opioid use was significant with neurolytic CPB and yielded decreased visual analog pain scores and opioid use at 2, 4, and 8 weeks [39]. Review of short-term relief of pain in 87 patients undergoing CT-guided neurolysis of the celiac plexus for chronic abdominal pain demonstrated that the majority of patients experienced relief with a low rate of complications. Of those patients, 40% experienced what was classified as major relief from pain with a decrease in opioid use [40].

In a study of 19 pancreatic cancer patients who underwent CPB and 17 control patients, the intervention group demonstrated a significantly lower use of opioids 10 days after the said intervention and at a follow-up of 2 days prior to death [41]. The celiac plexus block group was found to have significantly less terminal delirium compared to the control group. Within celiac plexus block and control groups, there was no significant difference found in daily opioid use in patients who experienced delirium. Regarding patients of younger ages (8–20) with abdominal pain of malignant origin, celiac plexus block was found to reduce mean daily pain score, though the authors noted that the block tended to be performed late in the disease process [42]. Two patients required higher daily morphine equivalents secondary to extra-abdominal disease progression [42].

More recently, celiac sympathetic blocks have been implemented in non-malignant pain. In reviewing data from 10 patients who underwent radiofrequency ablation of the celiac plexus for non-malignant chronic abdominal pain, there was a significant decrease in the amount of pain experience and self-reported anxiety with improvements in categories of quality of life [43]. It can be inferred from a systematic review of celiac plexus block studies that the procedure is quite effective in treating pain associated with pancreatic cancer, but more studies of quality need to be pooled to better characterize opioid reduction using different methods of celiac plexus blocks [44].

Splanchnic Nerve Block

The splanchnic nerve block is another available intervention for upper abdominal and retroperitoneal pain that fails to

Table 2 Comparison of common fluoroscopically guided percutaneous sympathetic block techniques utilized for visceral pain

Targeted sympathetic block	Patient position	Needle entry	Needle approach
Celiac plexus block: transaortic technique [15, 27]	•Prone with head turned to one side and mild thoracolumbar flexion	•Obliquely rotate the fluoroscope 20–30 degrees until the tip of the L1 transverse process overlies the anterolateral L1 vertebral body. •Needle entry is roughly 2.5 in. inferolateral to each side of the L1 transverse process.	•This approach is similar to a left side transcrural celiac plexus block approach with the needle directed at L1 vertebra. •The needle is reinserted to vertebral body depth and advanced until pulsation of the aorta is appreciated and then advanced into the posterior aortic wall. A brisk arterial blood pulsation confirms intra-arterial placement. •The needle tip is advanced until it is passed through the anterior aortic wall which is performed with a continuous loss-of-resistance technique with saline to the penetration of the anterior wall. • Needle tip placement should be confirmed with radiographic contrast: o On the posterolateral view, contrast dye should remain midline with some tendency toward greater concentration around the lateral margins of the aorta. o Lateral view should demonstrate pulsatile pre-aortic T12–L2 spread. o The absence of a narrow longitudinal "line" is suggestive of aortic wall dissection. •Ultimately, the tip of the needle should be completely through the anterior wall of the aorta, at which the needle tip is within the pre-aortic fatty connective tissue and the substance of the celiac plexus.
Celiac plexus block: classic two needle retrocrural Technique [27, 28]	•Prone with head turned to one side with a pillow beneath the abdomen to reverse the thoracolumbar lordosis.	•Identify the T12 vertebral body via a PA view. Then, rotate the fluoroscope obliquely to locate the print of entry of the tunnel view. •Needle entry should be approximately 7.5-cm lateral to the midline, just beneath the 12th ribs.	•Needles are initially oriented 45 degrees toward the midline and about 15 degrees cephalad in order to contact the L1 vertebral body •After osseous contact, with the L1 vertebral body, the needles are withdrawn, after noting needle depth, and redirected roughly 60 degrees lateral of midline, while "walking" off the lateral surface of the L1 vertebral body •The needles are reinserted to vertebral body depth and if no bone is contacted, the left-sided needle is advanced 1–2 cm or until aortic pulsations are appreciated. •The right-sided needle is then advanced 3–4 cm past contact with the L1 vertebral body. •Ultimately, the needle tips should be just posterior to the aorta on the left and to the anterolateral aspect of the aorta on the right.
Celiac plexus block: transcrural technique [29, 30]	•Prone with head turned to one side and mild thoracolumbar flexion.	•Obliquely rotate the fluoroscope 20–30 degrees until the tip of the L1 transverse process overlies the anterolateral L1 vertebral body. •Needle entry is roughly 2.5 in. inferolateral to each side of the L1 transverse process. •By placing the left-sided needle first can sometimes eliminate the need for two needles.	•Advance the needle caudal to the 12th rib margin and cephalad to the L1 transverse process, while directing the needle to the anterolateral L1 vertebral body surface. •Ensure coaxial alignment of needle advancement with serial imaging every 1–2 cm •Once contact with the anterolateral margin of L1 vertebral body is made, rotate the

Table 2 (continued)

Targeted sympathetic block	Patient position	Needle entry	Needle approach
			fluoroscope laterally to guide the needle tip further anterior so it rests anterior of the margin of L1 on the anterior surface of the aorta (approximately 1.5–5 cm). •Confirm needle tip placement with radiographic contrast under live fluoroscopy, which should spread over the anterior surface of the aorta in a pulsatile manner. •If the aorta is inadvertently penetrated, the technique can be converted into a transaortic approach—thus, the left side is typically performed first.
Splanchnic nerve block: classic two needle technique [17, 30]	•Prone with head turned to one side and mild thoracolumbar flexion.	•Roughly 2 in. inferolateral to each side of the L1 transverse process.	•Minimal variation from the retrocrural approach for the celiac plexus block: o Angle the fluoroscope more cephalad to bring the inferior margin of the 12th rib more cephalad to the T12 vertebral body. •Ultimately, the final needle position should lie at the anterior 1/3 of the T12 vertebral body.
Superior hypogastric plexus block: classic two needle technique [31, 32]	•Prone with head turned to one side and mild lumbar flexion.	•Identify the lumbosacral junction by rotating the fluoroscope 25–35 degrees obliquely. Then, add 25–35 degrees cephalad rotation to bring the L5/S1 disc into view. •Next, identify a small triangular window that is composed of the L5 transverse process (superolateral boundary), inferior margin of the pedicle (superomedial boundary), iliac crest (lateral boundary), and the superior articular process of S1 (inferomedial). •Needle insertion should be made at the most inferior point of the identified triangle (roughly 5–7 cm from midline at the level of the L5 spinous process).	•Advance the needle anterolateral to the L5/S1 intervertebral disc or the inferior margin of the L5 vertebral body. •Confirm needle placement with radiographic contrast, which should spread along the anterior surface of the lumbosacral junction •The same procedure is then carried out on the contralateral side. •It is possible that placement of a single needle can achieve bilateral spread, at which point, the contralateral needle is not required.
Ganglion impar block: transsacrococcygeal technique [33]	•Prone with pillow under lumbar spine to overcome lumbar lordosis.	•Midline, through the sacrococcygeal disc space	•Direct the needle midline through the sacrococcygeal disc to access the anterior sacrococcygeal ligament •As the needle is advanced, a loss of resistance will signify the needle tip as anterior to the ventral sacrococcygeal ligament. •Ultimately, the needle tip should rest midline on AP views and anterior to the ventral aspect of the coccyx, at the sacrococcygeal junction on lateral views.
Thoracic sympathetic chain block: prone technique [22]	•Prone with mild thoracic flexion	•1.5 in. lateral to the spinous process of the vertebra just above the targeted nerve to block.	•The needle is aimed toward the middle of the transverse process. •Advance the needle 1.5 in. until os is encountered and then withdraw into subcutaneous tissue. •Redirect the needle inferiorly and "walk" it off the inferior margin of the transverse process. •Once contact with os is lost, advance the needle about 1 in. to target

respond to CPB or those with pre-aortic adenopathy, tumor burden, or postoperative scarring [16, 45]. Although some describe splanchnic nerve blocks and CPB interchangeable, they are in fact different procedures. The splanchnic nerves (greater, lesser, and least) are exclusively preganglionic nerves that synapse at the celiac ganglion. The splanchnic nerves are contained in a 20-mL compartment made up of the vertebral body and the pleura laterally, the posterior mediastinum ventrally, and the pleural attachment to the vertebra dorsally [17].

Current literature suggests splanchnic nerve blocks are a useful tool to treat upper abdominal pain secondary to malignancy, to include inoperable upper GIT tumors, including cancer of the lower third of the esophagus, stomach cancer, pancreatic cancer, and cancer of the biliary tract. Koyyalagunta et al. found that out of 93 patients, 44.57% reported a reduction in pain greater than or equal to 30%, 31.52% reporting a greater than or equal to 50% reduction in pain, and 17.39% reporting a greater than or equal to reduction in pain of 70% after a 1-month follow-up via telephone or office visit and then at a clinic visit 2–6 month post-procedure [45]. There was also a statistically significant decrease in depression scores using the Edmonton Symptom Assessment System, as well as significant decreases in reported anxiety and difficulty thinking clearly [45]. A retrospective study involving patients with abdominal pain secondary to malignancy and an anatomically distorted celiac plexus exhibited a 50% reduction in reported pain in 21 patients at 1 and 3 months of follow-up, along with a significant decrease in opioid use with splanchnic nerve neurolysis [46]. In those 21 patients, there was a non-significant improvement in the Karnofsky score, but a significant improvement in the quality of life. A small study involving non-malignant chronic abdominal pain suggests that bilateral T11 splanchnic nerve block may possibly provide longer relief than celiac plexus block [47].

In comparing celiac plexus blocks against splanchnic nerve blocks, Shwita et al. demonstrated similar efficacy when comparing fluoroscopy-guided bilateral needle retrocrural celiac plexus block versus splanchnic nerve block with a bilateral needle technique [48]. They assessed opioid consumption and quality of life with 79 patients with inoperable upper gastrointestinal tumors, including cancer of the lower third of the esophagus, stomach cancer, pancreatic cancer, and cancer of the biliary tract, with severe uncontrolled visceral pain (visual analog scale $\geq 70/100$) and who were taking the maximum tolerable dose of opioids (the dose which achieved an acceptable analgesic effect for patients with side effects tolerable for them). Patients were randomly allocated to either celiac plexus or splanchnic blocks. The visual analog scale decreased significantly in both groups in comparison with its value before the block ($p = 0.001$), though significantly more patients retained good analgesia with only tramadol in the splanchnic group from 16 weeks onwards ($p = 0.005$, 0.001, 0.005, 0.001, 0.01). Both groups demonstrated similar rates of post-procedure postural hypotension and the survival of both groups was comparable. These findings are important, as Gangi et al. noted that a splanchnic nerve block requires a smaller volume of alcohol, which may be of a benefit to reduce adverse effects and complications [49].

A review of the literature suggests that celiac plexus neurolysis and splanchnic nerve block are effective and relatively safe procedures that demonstrate pain relief with decreased opioid use. However, more studies are required to better characterize the opioid reduction. More extensive research is needed to further characterize the effects of celiac plexus blocks on quality of life in patients with abdominal pain of malignant origin, as well as pain relief across varying degrees of tumor burden. Currently, there is a dearth of evidence to recommend one technique of celiac plexus block over another. Additionally, further studies comparing splanchnic nerve blocks against celiac plexus block with longer follow-up periods and more patients are needed to find statistically significant differences if they exist.

Hypogastric Plexus Blocks

For pelvic viscera-associated pain, possible interventions include superior hypogastric plexus (SHP) blocks, inferior hypogastric plexus (IHP) blocks, and the ganglion impar block. The SHP is a retroperitoneal complex network of fibers surrounding the abdominal aorta and consists of sympathetic and visceral afferent fibers [50•, 51, 52, 53•]. These fibers bifurcate as they continue caudally through the endopelvic fascia before forming the IHP [50•, 54, 55]. The SHP can be injured during spinal and abdominopelvic surgeries including aortocaval lymph node dissection, colorectal surgery, and anterior and anterolateral approaches to the lumbosacral spine [55].

The SHP block can be performed using the traditional two-needle posterior approach or newer single-needle approaches including a transdiscal approach [51]. The anterior approach to the SHP block under fluoroscopy is an alternative method that can be used which avoids contacting the lumbar nerve roots with a needle. This technique is technically easier to perform but increases the risk of perforation of structures above the plexus, including the bowel, bladder, and vasculature [50•, 56]. Other authors found the posterior paramedian transdiscal approach through L5 to S1 easier, faster, and more efficacious than the traditional approach described by Plancarte and associates [50•, 52]. The potential complications from puncturing the intervertebral disc include discitis, disc rupture, and herniation and this technique can be challenging to successfully perform in patients with osteophytes of the spine [50•, 57, 58].

Alternative approaches to SHP block include using an axial computed tomography (CT) and ultrasound imaging. Mishra and associates performed the first trial using an anterior ultrasound-guided approach in 22 patients with pelvic cancer

pain. The trial demonstrated similar efficacy to the traditional posterior fluoroscopic-guided approach with patients having a marked decrease in pain scores and morphine consumption [50•, 59]. This technique has the same disadvantages as other anterior approaches. The accuracy of a real-time anterior ultrasound-guided technique was evaluated in cadavers using fluoroscopy [52]. Bilateral spread similar to that seen with the traditional fluoroscopy-guided technique was visualized using ultrasound. Gofeld and associates report that this ultrasound technique could be as effective as the traditional approach in the clinical setting [52].

SHP blocks can be performed for visceral pelvic pain resulting from these injuries as well as neuropathic pain from trauma or endometriosis, inflammatory disease, postoperative adhesions, and cancer pain of the viscera unresponsive to more conservative measures [50•, 53•, 55, 60]. Other reports describe SHP blocks benefitting patients with sympathetically mediated rectal pain and post-prostatectomy penile and urethral pain [50•, 55, 58, 61]. In patients with severe pelvic pain secondary to cancer, De Leon-Casasola and colleagues reported a 69% success rate with neurolytic SHP blocks along with a 67% decrease in mean oral opioid therapy in the 2 weeks following the procedure [50•, 62••].

The inferior hypogastric plexus (IHP) is located presacral on either side of the rectum and makes up the caudal component of the sympathetic chain. IHP blocks are not commonly performed clinically but have been described in the literature for diagnosing and treating chronic pelvic pain of the lower pelvic viscera including the bladder, vagina, penis, rectum, anus, and perineum [19, 50•]. The IHP block was first described by Schultz [19] to treat 11 female patients with chronic pelvic pain involving the lower pelvic viscera. Under fluoroscopic guidance, a 73% success rate ($p < 0.05$) was achieved in pain score reduction with no complications. The most common adverse effect reported by Schultz was transient paresthesia in 5% of IHP blocks likely secondary to sacral spinal nerve injury from needle tip advancement [19]. In another manuscript, the paresthesias were described as severe and this discomfort limited the ability to perform these procedures in clinical settings [50•]. Mohamed and colleagues [63] were the first to use the approach described by Schultz to perform neurolytic IHP blocks in 20 patients with pelvic cancer pain. They used 6 to 8 mL of 10% phenol bilaterally with a reduction in pain levels by 43.8% after 1 week with no complications [50•, 63].

Ganglion Impar Block

The ganglion impar is the termination of the bilateral paravertebral sympathetic chain and is believed to supply nociceptive and sympathetic fibers to the perineum, distal rectum, perianal region, distal urethra, vulva/scrotum, and distal one-third of the vagina and sympathetic innervation alone to the pelvic viscera [50•, 64, 65]. The ganglion impar is located just anterior to the upper coccyx or the lower sacrum in the retrorectal space. The ganglion impar block was initially performed by Plancarte and associates for perineal cancer pain relief mediated by the sympathetic nervous system [52]. Currently, this block is performed to treat benign and malignant sympathetic and visceral pelvic and perineal pain [64]. Idiopathic coccydynia is another indication as the coccygeal plexus or its branches can be involved. By injecting at the ganglion impar, medication can diffuse to the nearby somatic nerves of the coccygeal plexus [50•, 66].

A modified transsacrococcygeal approach to the ganglion impar is most commonly used currently, which is described in Table 2 [50•, 67]. For most non-malignant diagnostic blocks of the ganglion impair, 5 to 10 mL of 0.5% bupivacaine has been used with or without steroid. A neurolytic block using 4 to 6 mL of at least 6% aqueous phenol can be used for cases involving cancer pain [50•, 67]. Chemical neurolysis can cause neuritis, neuralgia and motor, sexual, bowel, or bladder dysfunction secondary to unintentional spread of the injected neurolytic agent. Several other approaches involving CT- and ultrasound-guided approaches have been described in the literature but are not commonly being used.

The literature on the ganglion impar block mostly consisted of descriptions of various techniques and case reports prior to the 2000s. More recently, several patient series are described evaluating the effectiveness of the block. Gunduz and associates reported that 82% of 22 patients with coccydynia had at least 50% relief of pain with a median duration of 6 months after the first injection of local anesthetic and corticosteroid to the ganglion impar under fluoroscopy using a transsacrococcygeal approach. However, they report three technical failures in this first injection group. Patients with successful outcomes experienced pain relief lasting a median duration of 6 months and a median duration of 17 months after a second injection [65].

Thoracic Sympathetic Blocks

Less commonly performed, thoracic sympathetic blocks can be utilized for the treatment of thoracic visceral pain. As of the time of this manuscript, no literature is available on the treatment of thoracic visceral pain with sympathetic blocks. This is likely due to the relatively low incidence of chronic pain syndromes affecting the heart or lungs as compared to chronic abdominal and pelvic visceral pain syndromes.

Despite the absence of data in the treatment of thoracic visceral pain, a small body of literature exists to suggest that there would be theoretical utility in blocking the thoracic sympathetic fibers for ischemic cardiac pain syndrome. A statistically significant decrease in myocardial necrosis and left ventricular dilation was seen in rats with congestive heart failure (CHF) who were administered a high thoracic sympathetic block as compared to controls [68]. In a human study, 18/19 patients with CHF had significant improvements in ejection

fraction, end-diastolic diameter, and N-terminal prohormone of brain natriuretic peptide following a thoracic sympathetic block [69•]. Another human study showed significant improvement in several parameters in subjects with CHF who had thoracic sympathetic blocks as compared to control groups [70•]. Nakamura et al. also demonstrated endoscopic transthoracic sympathectomy was able to significantly decrease myocardial oxygen demands in 21 subjects with primary palmar hydrosis [71].

Similarly, to the cardiac system, no literature exists on the treatment of chronic pulmonary pain syndrome with sympathetic blocks. It should be noted, however, that thoracic sympathetic blocks have been shown to decrease respiratory compliance [72]. For this reason, caution should be exercised in the consideration of performing sympathetic blocks for a pulmonary pain syndrome if a given patient already has a compromised respiratory system.

Conclusion

Early cancer diagnosis and advances in therapeutic options have extended the life expectancy of patients. However, pain management continues to be difficult in these patients. A multidisciplinary approach is recommended, which includes involving a combination of an interventional treatment with neurolysis (chemical neurolysis with alcohol or phenol) and pharmacotherapy. Interventional pain procedures targeting sympathetic nerves have improved outcomes in cancer-associated and non-cancer-associated visceral pain. Current evidence demonstrates the strongest evidence for celiac plexus blocks for abdominal-mediated cancer pain and hypogastric plexus blocks for pelvic visceral pain. Moderate evidence exists for ganglion impar blocks, while very limited data exists for ganglion impar blocks and emerging data exists for thoracic sympathetic blocks. Due to the high degree of overlap between viscera and somatic nerves, sympathetic blocks are useful tools for the diagnosis and treatment of visceral-mediated pain, which can thereby help clinicians formulate more appropriate management plans. Sympathetic nerve blocks—either repeated blocks or neurolysis procedures—should be considered in the management of those with known abdominal or pelvic visceral malignancies to improve quality of life and provide long-lasting relief.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict 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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- •• Of major importance

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