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Radiofrequency ablation of splanchnic nerves for control of chronic abdominal pain

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ABSTRACT

Chronic abdominal pain is a complex physical and psychological problem that requires comprehensive treatment options tailored to the needs of patients. Splanchnic nerve blocks and radiofrequency denervation of greater and lesser splanchnic nerves may provide prolonged treatment effect that still needs to be studied in a randomized prospective fashion. Here we describe improved fluoroscopy-guided technique for the radiofrequency ablation of splanchnic nerves, details on approach, technique, and potential complications.

Introduction

The prevalence of chronic abdominal pain (CAP) is surprisingly high, 22.9 per 1000 individual-years, affecting approximately quarter of adult population at least once in their lifetime, women more frequently than men.[1-3] Although chronic pain is present in approximately 80%-90% of patients with chronic pancreatitis, postsurgical adhesions may be the cause of persistent pain in 45%-90% of patients, most frequently after cholecystectomy, herniorraphy, or adhesiolysis.[4] Chronic abdominal wall pain (CAWP), defined as pain with a fixed location of abdominal wall tenderness of <2.5 cm of diameter, must be differentiated from visceral sources of abdominal pain.[5-7] Up to 30% of patients with CAP may have CAWP, caused most frequently by the entrapment of cutaneous abdominal nerve branches (ACNES; 7). Chronic abdominal visceral pain is a complex process with presence of hyperalgesia and sometimes allodynia. After putative diagnosis and less invasive treatments, diagnostic splanchnic block followed by radiofrequency (RF) ablation should be considered.[4] Properly executed, this may provide high quality prolonged pain relief. This article focusses on initial outcomes, proper technique, possible complications, and tips on how to improve outcomes.

Establishing diagnosis

Clinical presentations of CAP are varied. Proper initial inspection of the abdomen may provide clues to the chronic pain source. For example, surgical scars associated with localized allodynia or hyperalgesia or both may lead to diagnosis of nerve damage or neuroma or both. CAWP is usually well localized with point tenderness on palpation, whereas visceral pain is usually poorly localized. Carnett test helps to determine if abdominal wall pain is present; in supine position and with the knees and hips flexed to decrease abdominal wall tension, the patient is asked to tense the abdominal muscles by lifting the head and shoulders off the bed. A positive Carnett test is increased pain on palpation as the patient contracts the abdominal muscles, but false-positives are high, especially in visceral diseases involving peritoneum.[4-7]

When attempting to understand CAP, nerve blocks may be of diagnostic, therapeutic, or even prognostic value. Not infrequently, the cause of abdominal pain may remain elusive in a small subgroup of patients despite extensive imaging, endoscopies, and other studies. In these circumstances, various nerve blocks may have both diagnostic and therapeutic values. Both sympathetic and somatic nerve

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blocks may be valuable in understanding and treating abdominal pain. Sympathetic nerve blocks are used to block the splanchnic nerves, celiac plexus, superior hypogastric nerve plexus, or ganglion *impar*. Somatic nerve blocks include paravertebral nerve block, intercostal nerve block, transversus abdominis plane block, rectus abdominis sheath block, and blocks of the ilioinguinal, iliohypogastric, and genitofemoral nerves. By differentiation of visceral pain origin from somatic pain origin, these diagnostic nerve blocks guide appropriate treatment.[4,7,8]

Differential retrograde epidural block (DREB) may be used to help differentiate visceral from nonvisceral sources of pain. Case series suggest that responses to DREB may be a useful predictor of treatment responses. The diagnostic value of DREB relies on the sensitivity of various nerve fiber types to local anesthetic neural blockade. Sympathetic nerve fibers and visceral afferent nerves have a higher C to Aδ fiber ratio (10:1) and are more sensitive to local anesthetic neural blockade than the somatic nociceptive fibers. DREB involves placement of an epidural catheter under fluoroscopy and injection of saline twice (placebo), followed by incremental injection of local anesthetic with close monitoring of vital signs and serial neurological examination. A local anesthetic (usually 2% 3-chlorprocaine or 1% lidocaine 10-30 ml) serves to differentiate between predominantly visceral, somatosensory, and central chronic pain, whereas the saline injections may help differentiate placebo effects, malingering, and sometimes psychogenic source of pain. Despite its use in case series, the absolute validity of DREB remains to be established. Accurate interpretation can be difficult for several reasons including a significant overlap between visceral and somatic nociceptive nerves, visceral pain that may coexist with somatic abdominal pain, and the role played by central sensitization as a component of abdominal pain. In addition, contributions from the vagal nerves to abdominal pain cannot be determined by DREB. Furthermore, the sensitivity and specificity of DREB is relatively low. Thus, responses to DREB combined with other clinical information are only suggestive of visceral, somatic, or central source of pain.[9,10]

Treatment

Managing pain, rather than curing disease, is often main objective. Lifestyle changes, use of membrane stabilizers and antidepressants or ketamine infusions, in various doses can be attempted. Short-acting opioids may be used for severe breakthrough pain; however, chronic opioid therapy should be avoided where possible, owing to potential risks including opioid tolerance, dependence, opioid-induced hyperalgesia, overdose, abuse, addiction, and death.[11-13]

RF ablation of splanchnic nerves

RF ablation of the splanchnic nerves is used to interrupt or modulate neural or pain conduction or transmission or all these. Historically, the splanchnic nerves, mainly the greater, lesser, and least and the celiac plexus were considered possible targets for visceral pain control. Sympathetic innervation of the abdominal organs includes preganglionic fibers of T5-T12 that merge to travel with the ventral ramus. Together with communicating rami, visceral sympathetic fibers course in the direction of the sympathetic chain and then make synaptic contacts with postganglionic neurons at the celiac, aortorenal, and superior mesenteric ganglion. Splanchnic nerves branch with the vagal preganglionic parasympathetic fibers, sensory fibers of the phrenic nerve, and postganglionic sympathetic fibers to form a large celiac plexus spread wide around the abdominal aorta. In contrast, greater, lesser, and least splanchnic nerves are localized in a relatively narrow space between the lateral border of the vertebra and pleura (Figure 1).[14]

Splanchnic and celiac plexus blocks are commonly performed for control of visceral abdominal pain percutaneously under fluoroscopic guidance.[4] Celiac plexus blocks may be performed through a transaortic, retrocrural, or transdiscal approach without clear diagnostic advantage seen with any specific technique. Classical description of celiac plexus block involves placement of the needle through the paraspinal area of the middle back (L1 vertebral body). Bilateral splanchnic block is performed at T11 to deliver local anthetic or steroid combination to the paravertebral compartment medial to the pleural cavity and near to the greater and lesser splanchnic nerves (needle tip positioned at the posterior third of T11 vertebral body).[4]

Anatomical considerations

The anterolateral horn in the spinal cord is important in innervation of abdominal contents. Preganglionic fibers, as described earlier, leave the spinal column at T5-T12 and then merge with the ventral ramus. There are also communicating rami between these fibers, which course together in the direction of the sympathetic chain. There are no synapses in the sympathetic chain, but these occur only more peripherally at the level of the ganglia; celiac, aorticorenal, and superior mesenteric. More importantly, those preganglionic fibers are grouped into the 3 splanchnic nerves (greater, lesser, and least) that course in predictable anatomical locations in the anterolateral paravertebral space. This space is limited by the lateral boarder of the vertebral body, medial pleura, and crus of the diaphragm. Owing to predictable nerve

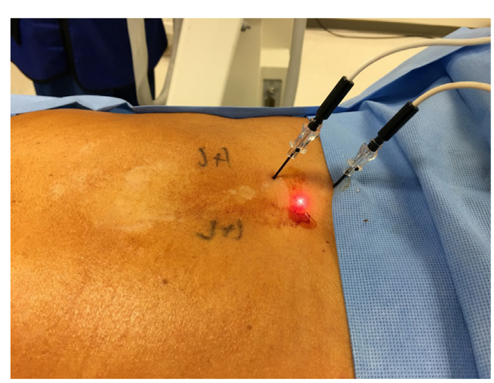

Fig. 1 – Appropriate angle of two 18 G RF needles piercing the skin at the right mid-paraspinal thoracolumbar area. Notice that only 1 side (right or left splanchnic nerves) is denervated at a single operative setting owing to the remote risk of bilateral pneumothorax. (Color version of figure is available online.)

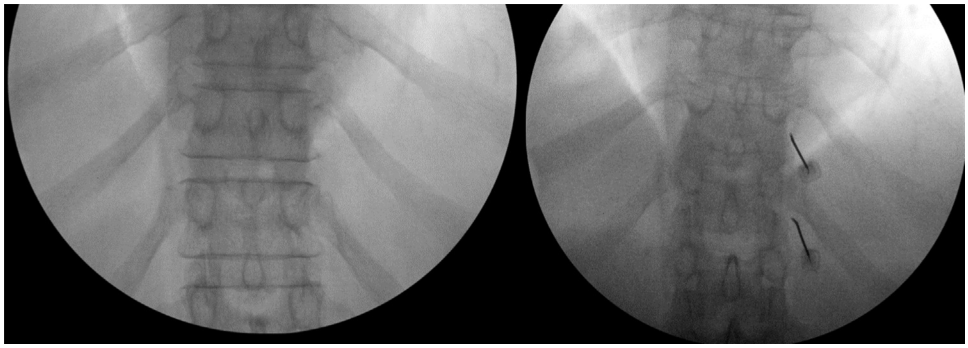

Fig. 2 – Anterior-posterior fluoroscopic view of T11 and T12 vertebral body, transverse processes, and ribs. *Left*: initial AP view with endplates aligned shows presence of transverse proces image overlappping waist (greatest concavity) of both T11 and T12 vertebral bodies. *Right*: declined caudal fluoroscopic angle of approximately 60° moves transverse processes cephalad and allows free passage of the radiofrequency needle with tips held closest to the greatest concavity (waist) of the vertebral body. This approach attempts to minimize the risk of pneumothorax. In addition, notice that only 1 side (this pic right) is denervated at the time approaching both T11 and T12 levels.

location, this target space may provide for the most consistent success in neural blockade of the splanchnic nerves.[14]

Splanchnic RF denervation provides prolonged relief of pain and is advantageous compared with neurolysis of celiac plexus using phenol or alcohol. Avoiding serious side effects after unpredictable spread of phenol or alcohol, causing neurolysis, retroperitoneal fibrosis, and even paraplegia (caused by anterior spinal artery spasm), repetitive RF denervation of splanchnic nerves represents a reasonable therapeutic alternative for patients with CAP.[14-17]

Published early case series on splanchnic RF ablation suggested significant improvements in pain scores, reduction of opioid consumption, and frequency of hospitalization after such denervation. Mean duration of pain relief was approximately 45 weeks. Repeated denervations provide comparable therapeutic effects. Return of abdominal pain may be a result of nerve regeneration. Complications may include pneumothorax, postprocedural neuritis, hypotension, or diarrhea.[15-17]

An alternative approach, thoracoscopic splanchnicectomy, provided continuous pain relief in only approximately 25% of the patients at 6-month follow-up. This approach has largely been abandoned in light of its low success rate, requirement for extensive dissection of the parietal pleura, and risks of anesthesia with a double-lumen endotracheal tube.

Patient selection

Proper patient selection is a key for succesful RF denervation of the splanchnic nerves. Splanchnic denervation should not conceal any life-threatening or chronic abdominal disease with exacerbations that may lead to bowel perforation, ileus, or metabolic deragements. Exclusion criteria include patients with concommittant progressive neurological disease such as multiple sclerosis, chronic inflammatory demyelinating polyneuropathy, rapidly progressive arachnoiditis, brain or spinal cord tumor, or central deafferentation syndrome. Patients with a current diagnosis of a coagulation disorder, bleeding diathesis, progressive peripheral vascular disease, or uncontrolled diabetes mellitus are not candidates for RF denervation. Patients with abdominal pain of spinal origin must to be identified as well as those who have active inflammatory bowel disease such as Crohn's or ulcerative colitis.

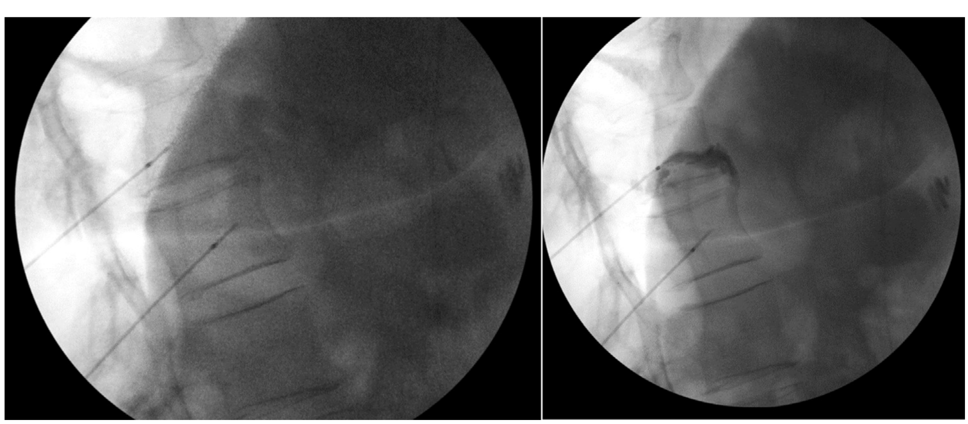

Fig. 3 – Advancement of 20 G radiofrequency needle in the lateral view. *Left*: initial caudal C-arm tilt would help to position tip of the RF needle at the top of the foramina and likely prevent any paresthesias during procedure. *Right*: after completion of sensory stimulation at 50 Hz, acheiving concordant abdominal stimuli, a small volume of the contrast is injected to confirm extravascular placement followed by local anesthetic to facilitate painless denervation (details in the text).

Exclusion criteria should also be applied to those with active systemic or local infection at the anticipated needle entry site or pregnant patients (use of fluoroscopy).

Good patient candidates include those having chronic pancreatitis without acute episodes with wide swings of amylase, lipases, and those with various dysmotility disorders including gastroparesis and severe irritable bowel syndrome, postsurgical visceral adhesions without impending ileus, and other defined chronic visceral abdominal pains without rapid disease progression.

Technique

Most RF ablation techniques use 450-1200 kHz alternating RF current administered through needle electrodes, insulated save for the most distal 2-10 mm. The electrode tip is positioned close to the anatomical target using image guidance and electrical nerve stimulation. In conventional RF neurotomy, the electrode tip is positioned parallel to the target nerve. A RF generator produces a rapidly varying electric field with greatest current density produced adjacent to the uninsulated electrode tip. The RF energy produces ionic friction that heats the tissues. Once the cells are heated above a critical time-temperature threshold, controlled tissue destruction produces an anatomical lesion surrounding the uninsulated electrode tip.

Pulsed RF ablation seems to be therapeutic because of the overall electrical effects on the target nerve. In pulsed RF ablation, a current of 500,000 Hz is usually delivered in 20-ms pulses at a frequency of 2 per second. A thermistor within the electrode limits maximum heating to 42°C to avoid a thermal lesion. For splanchnic RF, a thermal lesion RF technique at 80°C over a time interval of 90 seconds is typically chosen.

A dorsal approach for splanchnic RF, performed under fluoroscopy, can be accomplished by positioning the patient prone and identifying the T11 and T12 vertebral bodies using radiographic imaging (Figure 2).

Alternatively, ultrasound guidance can be used. Usually, mild intravenous sedation and pain medication suffice to keep patient relaxed and responsive. We use 50-100 μg of fentanyl and 1-2 mg of midazolam to complete the procedure. Intravenous placement is necessary to counteract potential hypotension caused by sympathectomy. Some patients require a soft cushion under the abdominal area, to complete procedure with minimal discomfort (Figure 3).

After anterior-posterior fluoroscopic view of the T11, T12 vertebral bodies is obtained with superior vertebral endplates squared off, use of a caudal angle of approximately 60°, or slightly greater, is used to expose more of the concavity of the target vertebral body. This declined angle also moves the transverse processes craniad, establishing the point where RF needle would be inserted through the skin just lateral to the midpoint of each vertebral body.

After aseptic preparation of the injection site, a local anesthetic skin wheal is created, 2 curved tip RF needles of 18 or 20 gauge, with 10 mm active tips, are advanced coaxially under fluoroscopic guidance, hugging the lateral aspect of the mid-portion of each of the T11 and T12 vertebral bodies. Lateral needle trajectories risk pneumothorax. The needle trajectory should course along the mid-portion of the vertebral body to avoid inadvertent entry into the disc, or a more cephald course that would elicit paresthesia from the somatic nerve root. A cross-table lateral fluoroscopic image would reveal the needle advancing ventrally to lie at the junction of posterior and middle third of the T11 and junction of middle and anterior third of T12 vertebral body. A RF electrode is inserted through the needle and stimulation at 50 Hz is performed to help determine optimal placement of the electrode for the RF. Typically, we seek positive response from patient reporting concordant abdominal pain at or less

Fig. 4 – Anterior-posterior fluoroscopic view with aligned endplates of T11 and T12 vertebral bodies. At the conclusion of the procedure and after injection of bupivacaine, a wide spread of previously injected contrast is visible. Notice also the significant caudal angle of both RF needles and the close positioning of the curved needle tips to greatest lateral concavity of the vertebral bodies. (Color version of figure is available online.)

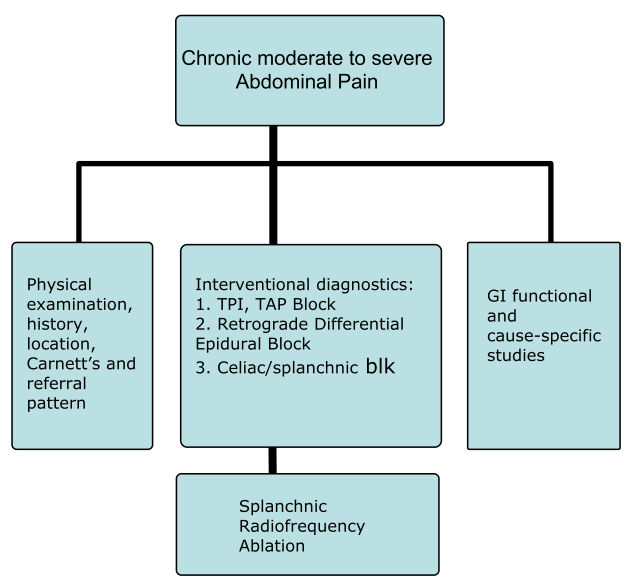

Fig. 5 – Proposed algorithm for diagnosis and treatment of chronic abdominal pain leading to radiofrequency ablation of splanchnics. To improve the outcomes of procedure, proper assesment is required that frequently involves interventional diagnostic techniques. (Color version of figure is available online.)

than 0.5 V at 50 Hz stimulation; however, 2 Hz stimulation is omitted. Once correct placement is verified, nonionic contrast (1-2 ml) is injected to rule out intravascular electrode placement (Figure 4).

After completion of unilateral RF denervation, typically at 80°C for 90 seconds, local anesthetic, such as 0.375% bupivacaine, 10-15 ml is injected using RF needles. We consider bilateral splanchnic RF performed in a single operative procedure to be contraindicated owing to the proximity of the pleura and risk of bilateral pneumothorax. The patient is monitored for 30-40 minutes in a postanesthetic care area and then discharged home. RF lesioning may produce mild postoperative discomfort in the back. Patients are typically followed up at approximately 16 weeks postoperatively, and sooner, if there is persisting pain.

Despite our experience showing more than 80% of the patients achieve more than 50% of pain relief shortly after denervation, the duration of the pain relief varies from 4-24 months. As yet, we have not identified reliable clinical or procedural predictors to explain this wide variation in the durability of the response to splanchnic RF (Figure 5).

Conclusions

CAP is a complex clinical problem that requires understanding the physical and psychosocial features of CAP and providing treatment options tailored to the needs of each patient. RF of the splanchnic nerves is a useful step in the algorithm for the treatment of visceral pain (Figure 1). Although celiac and splanchnic nerve blocks have been used for more than half a century, RF denervation of the splanchnic nerves deserves furthermore investigation in the form of randomized controlled trials to further refine an optimal technique and to determine its efficacy and safety for long-term relief of abdominal visceral pain.

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