Radiofrequency techniques: Complications and troubleshooting

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\textbf{Abstract}

Radiofrequency (RF) is a minimally invasive, target-selective technique that has demonstrated success in reducing pain in several chronic pain conditions. The lack of standard continuous RF ablation protocols for specific targets makes it difficult to compare the percentage of complications of RF between different studies addressing the same pain syndrome. The present article reviews the most frequent complications associated with the most widely used percutaneous continuous RF techniques in pain treatment, and the strategies used to minimize such complications.

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\textbf{Introduction}

Radiofrequency (RF) is a minimally invasive, target-selective technique that has demonstrated success in reducing pain in several chronic pain conditions. However, the growing use of RF is still not based on good-quality evidence. Regarding this, the difficulty in conducting methodologically sound studies is because of problems in assessing chronic pain (a subjective variable) and in obtaining a homogeneous study population, as in many chronic pain syndromes, it is not easy to establish a precise etiological diagnosis. Conversely, evaluation of the balance between the analgesic efficacy and complications of an interventional technique adds both difficulties in designing the comparator arm and bias generated by the experience of the individual performing the technique.\textsuperscript{1}

Furthermore, the lack of standard continuous RF ablation protocols for specific targets makes it difficult to compare the percentage complications of RF between different studies addressing the same pain syndrome.

The present article reviews the most frequent complications associated with the most widely used percutaneous continuous RF techniques in pain treatment and the strategies used to minimize such complications.

\textbf{Complications related to the circuit}

Monopolar RF systems use grounding pads to complete the RF circuit. Thermal injuries at the grounding pad site have been increasingly reported with the use of higher currents...
and more powerful systems, as in the cooled RF treatment of malignant tumors. The incidence of skin burns has decreased following the publication of the guidelines by Goldberg et al. However, no thermal injuries at the grounding pads have been described within the current ranges used for the RF management of pain.

**Types of RF**

Cooled RF ablation is gaining popularity over conventional thermal RF in the treatment of targets characterized by important anatomical variability, as it generates greater thermal injuries and thus increases the probability of successful denervation. Furthermore, the spherical shape of the lesions minimizes the need to position the needle as parallel as possible to the target to optimize the volume of damaged tissue, as in conventional RF ablation.

As cooled RF is comparatively more expensive, there is growing interest in simply using the bipolar circuit to produce lesions of certain target structures equal to or greater than those obtained with cooled RF. However, in this case, we need to use larger caliber needles, with a certain maximum distance between them, and longer RF application times. However, no comparative studies have yet appeared in the literature.

The first case of third-degree burns has recently been reported with cooled RF for the treatment of thoracic facet syndrome (Figures 1 and 2). In summary, the distance between the target and the skin should be taken into account, particularly in thin patients with little subcutaneous or muscle tissue in selecting both the type of RF and the caliber and active tip of the needle.

**Electromagnetic field**

The protocol for applying RF in patients with a defibrillator or pacemaker is well known to interventional physicians. However, the same cannot be said of other types of implants. In this respect, a recent study has described the unexpected activation of a cervical neurostimulation electrode during RF targeted to the third occipital nerve. As the use of neurostimulators is increasingly becoming widespread, special caution is required when RF electrodes are positioned close to implants of this kind.

**Cranial procedures**

**Trigeminal ganglion RF ablation**

RF ablation of the trigeminal (Gasser) ganglion is a percutaneous technique used to treat trigeminal neuralgia when drug therapy proves ineffective. Although RF has been defined as the first option in most algorithms in elderly patients, ahead of other neuroablation techniques, a critical analysis of the studies published to date shows that there is little evidence on which to base the best surgical option. The most important complications are related to incorrect placement of the needle during extracranial and intracranial approaches to the foramen ovale, which is not always easy to visualize. Some authors have tried to optimize the anatomical references during the procedure. One of the latest attempts in this sense corresponds to the study published by Peris-Celda et al., in which the 40°–45° inferior transfacial, –20° oblique radiographic projection visualized 96.2% of the
Regarding dysesthesia. The incidence of dysesthesia differs in morbidity than other ablation techniques, particularly thermal injury. RF ablation of the trigeminal (Gasser) ganglion varies among different series, the most frequent complication is cheek hematoma, usually caused by puncture of the maxillary artery in the first 2 days. Although most complications associated with the technique are transient, there is sound evidence that RF and the rest of the ablative techniques produce sensory loss. However, the lack of definition of such problems in the literature makes the comparison of results difficult. Regarding this, although some authors consider loss of sensitivity to be an adverse effect rather than a complication of the technique, in some cases, sensory loss is perceived as interfering with patient quality of life.

There is no protocol on the number of lesions and the temperature used. Consequently, there are no comparative thermocoagulation studies defining which complications are most inherent to the way in which thermal injury is produced. It seems that mild hypoesthesia generates a lesser percentage of dysesthesia, though the incidence of relapse is greater when compared with patients presenting with more intense hypoesthesia. However, it is generally very difficult to monitor puncture analgesia during the procedure, with moderate tactile hypoesthesia minimally exceeding the limits of the painful region. Awakening after sedation in predominantly elderly patients is not predictable and can complicate mapping between lesions.

The worst sensory complication is painful anesthesia, with an incidence of 4% in large series. The best way to prevent the risk of keratitis is to control preservation of the corneal reflex during thermocoagulation under sedation that is sufficiently light to allow assessment of the reflex but also allow injury. This is more frequent with V1 lesions. The regular use of eye drops is advised to prevent the complications derived from such hypoesthesia, with evaluation by an ophthalmologist 48 hours after ablation. Permanent masseter muscle weakness is infrequent, with an incidence of approximately 2%. This problem probably could be reduced by repositioning the electrode outside the motor fibers of the trigeminal nerve when stimulation induces masticatory responses at less than 0.3 V or by adopting more complex and precise stimulation protocols.

Overall, the frequency and severity of complications after RF ablation of the Gasser ganglion vary among different series, and comparisons are difficult to establish—mainly because of the different lesion induction and follow-up protocols used.

**Sphenopalatine ganglion RF ablation**

The sphenopalatine ganglion (SPG) is the largest extracranial neural structure and is located in the pterygopalatine fossa. It has sensory, motor, and autonomic components of a predominantly parasympathetic nature. The SPG is involved in several pain syndromes, such as cluster headaches, Sluder neuralgia, and so-called atypical facial pain. RF ablation of the SPG is considered when drug treatment fails and previous ganglion block with local anesthetic is found to offer good, though obviously temporary, analgesia. According to the published series, the most frequent complication is cheek hematoma, usually caused by puncture of the maxillary artery in the pterygopalatine fossa. Although the technique is performed under fluoroscopic guidance via the infrazygomatic route, this kind of complication could be reduced by the combined use of ultrasound, with a view to affording real-time visualization. Accidental puncture usually causes no problems, but if a...
hematoma is produced, pressure applied to the cheek and to the hematoma itself usually offers effective containment. Epistaxis (nose bleeding) is another problem that occurs if the needle is advanced too far medially through the lateral nasal wall. Tamponade of the affected fossa should be considered in such cases, depending on the magnitude of the bleeding. This underscores the importance of repeatedly monitoring advancement of the needle in the anteroposterior projection. Such maneuvering also helps to avoid perforating the mucosa, which could give rise to infection at a lesion level.

Improved confirmation of positioning of the needle tip can be obtained through nonionic contrast administration before and after stimulation.24 Dryness of the eye because of interruption of the parasympathetic supply is usually temporary and should be treated using eye drops and subjected to ophthalmologic control.

Reflex bradycardia during ablation requires patient monitoring during the procedure and the availability of preloaded drug doses.

Anesthesia, hyperesthesia, or dysesthesia, often described as transient rather than permanent, in the region of the palate or maxilla or posterior region of the pharynx can be avoided by adequate understanding of the anatomy. This allows the clinician to predict correct needle placement according to the result of the stimulation before ablation is performed. Correct paresthesia should be noted only at the root of the nose.25

Cervical procedures

Third occipital nerve RF ablation

The third occipital nerve is the superficial medial branch of the C3 dorsal ramus, which crosses the C2-C3 zygapophyseal joint laterally. It is a thick nerve, with broad anatomical variability, and its RF ablation is considered following a good analgesic response after correct nerve block with local anesthetic as treatment for pain generated by the mentioned joint.

The technique is performed under fluoroscopic guidance and requires constant monitoring in the lateral and anteroposterior projections of advancement of the needle to avoid morbidity.

The absence of cutaneous anesthesia in the distribution of the nerve indicates technical failure. The use of 3 needles with the creation of consecutive lesions improves the results obtained. In this context, rather than a complication of the technique, hypoesthesia is regarded as a well-tolerated adverse effect. However, neuropathic pain may appear in 19%–55% of the cases, depending on the series, with a highly variable duration.26,27 Thus, although Govind et al found that none of the reported adverse effects required intervention, 83% of the patients with neuropathic pain in the series by Gazelka et al needed drug treatment.

Therefore, it is important to consider this possibility before conventional ablation is performed.

Cervical medial branch RF ablation

RF ablation of the cervical medial branch is supported by moderate evidence and can be used in patients with neck pain of facet joint origin.28 Although cervical facet RF ablation is widely used, research on its potential complications is limited. Such complications include problems associated with placement of the needle and the temperature over target.

If the technique is performed according to the ISIS guidelines, the medial branch approach should be a safe procedure. A critical requirement for safe RF ablation in the cervical area is obtaining a correct, true lateral view of the cervical spine. Neurologic or vascular complications only manifest if the needle is malpositioned or is outside the target zone. At C7 level, special attention must be given to the vertebral artery. If the latter is punctured, it is advisable to abort the procedure, apply local pressure, and monitor the patient to avoid the risk of hematoma formation with compression of the airway. The posterior approach with the patient in the parasagittal prone position is more painful than the lateral posterior approach, but it affords better anchoring of the needle, with less frequent malpositioning in an area where maneuvering and the distance between the different targets are very limited. Frequent monitoring of needle advancement is necessary with both techniques.

Spinal cord complications have been described in anesthetized patients. Therefore, the technique should always be performed with the patient either awake or under mild sedation. The anteroposterior projection helps confirm the depth of the needle tip before ablation is performed. The stimulation protocol is the same as that used with any medial branch.

The most commonly reported complication is denervation pain or dysesthesias generated by thermocoagulation.28,29 Cutaneous sensory alterations are so frequent that they have even been a cause of criticism of poor blinding conditions when comparing against placebo in the only randomized, placebo-controlled study published to date.30 Protocols advocating a progressive increase in needle caliber (less gauge), positioning the active tip parallel to the nerve, and generating more than one lesion per level have revealed great analgesic efficacy,31 though there is no evidence as to whether greater denervation results in greater neuropathic pain. Dropped head syndrome after multilevel cervical RF ablation has been reported recently. Severe cervical muscle weakness poses a risk of paraspinous muscle denervation27,33 (Figures 4 and 5).

We must remain alert to the possible appearance of this weakening complication and its possible association with protocols that recommend larger denervation volumes.

Stellate ganglion RF ablation

In 75.7% of all cases, the stellate ganglion is formed by the fusion of both inferior cervical and the first thoracic sympathetic ganglia. An excellent anatomical study of 110 sympathetic trunks has revealed greater variability than in previous studies regarding the location of the stellate ganglion with respect to the spine.34 RF ablation of the ganglion is contemplated mainly after a good result with anesthetic block using very low volumes in a broad range of situations affecting the face, head, neck, and upper extremity.35 The nature of the surrounding structures implies that the potential complications can be very serious and even life threatening for the
The best way to avoid such problems is to place the patient in the supine position, use imaging guidance techniques, and adopt exhaustive safety controls. The risk of puncturing the vertebral, carotid, or thyroid artery requires hemodynamic monitoring of the patient, the availability of a venous access, and performance of the technique in an area with resuscitation equipment, including preloaded drug doses, as the lesion itself may produce bradycardia and hypotension. Aspiration should always be performed before administering any drug. Apart from such measures, a small amount of contrast is to be administered to discard intravascular positioning and to confirm its correct diffusion.

Of all the described techniques involving fluoroscopy, the approach that most reduces the risk of intravascular injection is probably that published by Abdi et al. If a puncture occurs, the procedure should be aborted and the patient should be monitored to evaluate possible prevertebral or retropharyngeal hematoma formation with airway compression.

The same oblique projection allows us to check the location of the needle and contrast outside the axial neurologic structures. Nevertheless, it is essential to maintain verbal communication with the patient to monitor any possible incident. Careful adherence to the stimulation protocol is essential for detecting the presence of neurologic structures. Loss of speech, limb contraction, or contraction of the diaphragm requires needle repositioning to avoid the recurrent laryngeal nerve, the nerve root, and the phrenic nerve, respectively.

In addition to vascular or neurologic damage, tracheal, pleural, esophageal, and thyroid puncture may occur. The greater incidence of esophageal puncture associated with the left approach is also minimized using the technique by Abdi and the administration of contrast. Conversely, pneumothorax is always a risk, particularly when targeting the T1 level. At C7 level, pneumothorax is infrequent, except in
patients with emphysema. In any case, it may be advisable to perform a chest x-ray study before patient discharge.

All the aforementioned complications can be avoided by using ultrasound owing to real-time visualization of all the anatomical structures. This and the portability, low cost, and lack of radiation of ultrasound make it ideal for performing a block, though it does not obviate all potential complications. However, in the case of RF in the immediate proximity to the ganglion, it is mandatory for successful neurolysis, as the thermal ablation volume is quite small. Only with fluoroscopy and computed tomography has greater safety and more prolonged relief been reported when applying the RF technique to the stellate ganglion. The number of published cases is too small to evaluate the percentage of complications exclusively attributable to thermocoagulation. We seek to produce small lesions in an attempt to not affect the surrounding organs, but perform multiple lesions (generally 3) to secure sympathectomy.

Any possible case of Horner syndrome usually lasts no more than 3 weeks. Postsympathectomy neuralgia has not been described with RF ablation. The administration of a very small volume of local anesthetic before inducing the first lesion could adversely affect safety in checking the rest of the lesions.

**Thoracic procedures**

**Thoracic sympathetic RF ablation**

The most frequent indications of thoracic sympathetic RF ablation as analgesic treatment are ischemic pain secondary to perfusion alterations, neuropathic pain, and complex regional pain syndrome of the upper extremity. This technique has been the subject of systematic reviews in an attempt to evaluate the level of supporting evidence, which remains very low. The most common targets are the T2 and T3 sympathetic ganglia, from which most postganglionic fibers pass to the upper extremity.

The technique is considered following a good result with block using a correct volume of local anesthetic, usually in the T2 level. The procedure should be carried out in a surgical area with patient monitoring and minimum sedation. It is not suitable for physicians with little experience in interventional techniques. The ablation procedure is difficult because of the close relation to the pleura, vessels, and spinal nerves. The most frequent complication is pneumothorax, particularly when using the posterior approach vs the lateral approach. Good fluoroscopic resolution is required; alternatively, and for increased safety, computed tomography can be used. A correct technique, the use of curved blunt needles, insertion never more than 3–4 cm from the spinothereal process, and frequent monitoring of the position of the needle tip are safety measures that can help avoid pneumothorax. Nevertheless, postprocedural x-ray control is mandatory.

The use of small amounts of contrast helps visualize possible diffusion outside the axial territory when administering local anesthetic before ablation. Sensory and motor stimulation can assess response at the intercostal-brachial level of the arm or at the intercostal nerve level. If paresthesias appear, the needle tip should be directed in a more ventral direction.

The conventional procedure has been recently supplemented by the induction of a bipolar lesion technique. Lastly, in 50% of the cases, sympathectomy may be associated with compensatory hyperhidrosis, which should be explained to the patient.

Because of the limited supporting evidence, thoracic sympathectomy through RF ablation should be used with caution. In this regard, it may be an option before surgery, and when spinal cord stimulation is not available.

**Splanchnic nerves RF ablation**

The increase in interest in RF ablation of the splanchnic nerves results from confirmation that the procedure can be as effective as or more effective than celiac plexus neurolysis, when the latter fails, for controlling mainly pancreatic cancer pain.

Its advantages over the neurolytic procedures are that RF ablation is circumscribed and predictable, can be repeated, and has fewer adverse effects in the management of non-oncological visceral pain of the upper abdomen. There are not enough data to estimate the frequency of complications, though the best way to limit them is to perform the technique correctly under fluoroscopic control and with patient monitoring.

Hypotension secondary to denervation can be prevented by volume loading before the procedure. The best way to avoid pneumothorax is by adopting a 10°–15° oblique inclination, which ensures medial guidance of the needle and penetration no more than 3–4 cm from the spinous process.

Bilateral block should only be performed by experienced interventionists and only if the patient clinical condition is good and there is no background respiratory disease. Radiological control is essential before patient discharge to eliminate possible pneumothorax. The magnitude of possible pneumothorax conditions the need for drainage or patient admission.

Slow advancement with repeated lateral control ensures that the needle remains behind the aorta and thoracic duct. Contrast administration in turn allows us to visualize diffusion and eliminate possible anomalies. Regular aspiration is indicated to rule out the presence of blood or lymph. In the event of vessel puncture, the procedure should be aborted, and patient monitoring should be prolonged. The final control x-ray also allows us to assess the presence of pleural effusion.

As usual, the probability of paresthesia can be reduced by using curved blunt needles, keeping the bevel lateral until passing the intervertebral foramen, and then placing it medial in close contact with the vertebral body.

Before thermocoagulation, it is essential to discard intercostal nerve stimulation or muscle contraction in which case the needle must be placed in a more ventral position.

If paresthesias are produced because of spinal or intercostal nerve contact, low-dose (and preferably nonparticulate) corticosteroids can be administered in an attempt to reduce postablation neuritis.
Posterior intestinal hypermotility may be bothersome, but it usually subsides quickly. Depending on the patient, analgesia may be prescribed before removing the intravenous line.

**Thoracic medial branch RF ablation**

Less than 5% of the patients who visit the pain unit have dorsal pain, and in only half of the cases the pain is of facet joint origin. There are very few controlled studies on RF ablation of the thoracic medial branch. The available supporting evidence is therefore limited. In principle, the complications can be the same as those in the cervical or lumbar region, though their incidence at thoracic level is not known.28

**Lumbar procedures**

**Lumbar medial branch RF ablation**

High-quality sham-controlled randomized clinical trials on lumbar facet joints provide robust evidence of the efficacy of continuous conventional RF ablation in reducing lumbar facet joint pain.26,52-55 However, the clinical relevance of the afforded pain relief and its duration are not clear, probably because of the different denervation techniques used.56,57 Currently, the correct technique is considered to involve placing the needle as parallel as possible to the medial branch. Regarding this, the technique described by the ISIS is considered to be the reference procedure, in view of its underlying anatomophysiologic denervation principles.

When performed correctly, lumbar medial branch neurotomy is a safe procedure. Checking the position of each electrode is the most important factor for avoiding complications. As fluoroscopy is misleading, checking of the needle depth must be made both before and after placement of the electrode in the lateral, oblique, and anteroposterior projections. When checking the anteroposterior and oblique views, it is important to ensure that the x-ray beam passes parallel to the disc space and vertebral end plates at the target level. In all cases, we must confirm final positioning of the needle tip on the base of the superior articular process.

Major complications have only been reported when the interventionist fails to follow the steps defining a safe technique or when the procedure is performed under general anesthesia. In this regard, it is essential for the patient to be only under superficial sedation, as final malpositioning of the electrode would cause pain that can allow us to abort ablation before irreversible damage is caused.

The stimulation protocol for less than 0.5 V is often not done with the needle tip parallel, though we consider motor stimulation to be mandatory before ablation even if fluoroscopic visualization appears correct, as a way to double check that we are far from the ventral branch.

Thus far continuous RF facet joint denervation has been described as a procedure involving only minor complications.58 Deafferentation injury and neuroma formation are well known and have been reported following chemical, surgical, and cryoablation neurolysis, and recently also after RF ablation.59 Although multifidus muscle atrophy is a complication of denervation,60 camptocormia has recently been described as an immediate complication of RF.61 It is presently not clear whether the use of a larger caliber needle and a larger number of lesions result in a greater percentage of adverse effects (eg, neuritis or myofascial pain) or whether the effects are more intense, as the studies carried out to date have been designed to assess whether greater denervation results in greater and more prolonged efficacy.

In addition to the empirical use of corticosteroids following ablation to avoid neuritis, some studies have found such treatment to reduce acute postprocedural pain,60 whereas others have described increased efficacy because of the administration of corticosteroids.61 At present, and despite attempts to extrapolate the well-known risks of corticosteroid therapy in certain targets to all the spinal targets, there is currently not enough evidence to recommend corticosteroid use to lessen postablation adverse effects.

**Lumbar sympathetic RF ablation**

The indications of percutaneous thermal lumbar sympathectomy are the same as those described at the thoracic level, though involving the lower extremities in a carefully selected group of patients in whom conservative treatment has failed and good analgesia was achieved with previous sympathetic block.

Although thousands of patients have undergone thermal, chemical, or surgical lumbar sympathectomy, only 1 study—precisely involving thermal RF ablation at the lumbar level—complies with the requirements referred to evidence, in a review published by Straube.62 Recent anatomical studies have helped to better identify the targets that can be easily ablated with this technique. In this regard, we now know that there is an increased risk of kidney puncture at level L2 and a greater risk of vascular puncture at level L3 on the right side, because of the shorter distance to the inferior vena cava.63 The best way to avoid such problems is to operate under radiological control, maintain a safety distance with respect to the midline, and use contrast to confirm the true position of the needle tip. If puncture occurs with needles larger than 20 G, more exhaustive monitoring is required, especially if the patient is receiving antiplatelet medication (eg, low-dose aspirin) that cannot be suspended. As the target lies deep and the psoas muscle must be traversed, it is advisable to use short-beveled needles in an attempt to avoid lancing spinal nerve pain. Lumbar sympathectomy with RF involves a lesser risk of genitofemoral neuralgia than neurolytic block. Sensory stimulation at inguinal level requires us to reposition the needle and thus obviate the genitofemoral nerve. However, potential damage to the latter is another reason for using a short-beveled needle. A curved tip facilitates the induction of 2 lesions, cephalic and caudal, to increase the degree of ablation. It is not advisable to withdraw the needle and perform a second lesion in this target in an attempt to avoid damage to the genitofemoral nerve, particularly at levels L3-L4 and L4-L5.64 It is likewise not recommendable to perform bilateral lumbar RF ablation owing to the risk of sexual dysfunction in the form of retrograde ejaculation. There is great variability in the distribution of the sympathetic
ganglia, and although a series of anatomical targets and the performance of 2 lesions per level have been recommended, such anatomical variability can affect the intensity of the sympathectomy achieved.

Pelvic procedures

Sacroiliac joint RF ablation

Various methods of RF sacroiliac joint denervation have been described in the literature. Increased anatomical variability of the lateral branches of the sacral dorsal rami has been reported recently.65 This anatomical variability will have an effect on the efficacy of denervation. In this regard, it is clear that those techniques that afford greater lesions, such as cooled RF ablation and bipolar lesions, in principle will have greater chances of success. Although studies are lacking on the bipolar technique in palisade distribution,66 which in combination with thicker needles might be better suited to deal with such anatomical variability, the latest published review continues to point to cooled RF ablation as the best treatment option.28 Regardless of the technique used, with placement of the needles around the sacral foramina in or palisade distribution between them and the joint, we must check in lateral projection that the tip of the electrode is not positioned in the sacral foramen. A response to sensory stimulation is not sought, though the presence of a distal motor response in the extremity or in the perineal area must be discarded. Here we must actively consult the patient, as the response areas lie below the surgical field and are therefore not obvious to the interventionalist. In this way, we can avoid spinal nerve denervation, which could have dramatic consequences, such as incontinence.

When using techniques that seek to induce large or multiple lesions, we must make sure to adjust the active tip to the size of the buttocks to avoid skin burns. In thin patients, it is not uncommon to observe malpositioning of the needles as the latter may not be well anchored to the gluteal muscles. The incidence of discomfort with numbness or postablation neuropitic pain (in principle more likely because of the distribution of the cluneal nerves from the lateral rami) is not clear. Although a review published by Cohen et al describes postprocedural discomfort as being more frequent, affecting up to 20% of all individuals, a recent retrospective study of 490 cooled RF lesions does not report a greater percentage of neuropitic pain vs the study of Kornick et al,58 in relation to the lumbar medial ramus. Nevertheless, 3 cases required active treatment owing to the intensity of the discomfort.

Ganglion impar RF ablation

Since its initial description, ganglion impar block has become an alternative treatment for pelvic and perineal pain involving a broad range of underlying causes. However, as an ablative technique, continuous RF has been proposed as the last alternative within a management algorithm for coccygodynia, which conversely is the most widely studied clinical indication.69 Several approaches are available and have been very well summarized in a recent review on ganglion impar block.70 Nevertheless, the thermocoagulation technique has been described via the sacrococcygeal and transcoccygeal routes.71,72 No complications have been described in the few reported cases of RF ablation of the ganglion impar, though there are some potential risks associated with the approach involved. Hematoma and infection are inherent to any type of interventional technique, though in this case we must maximize asepsis both during the procedure and over the following days. Many obese and elderly patients lose skin integrity in the intergluteal fold, which is our target; therefore, no manipulation should be made on skin surfaces that are not intact. Discitis would be the most serious complication owing to skin contamination. Inadvertent damage to pelvic structures should be avoided by frequent lateral projection controls of needle advancement and the administration of contrast, which should trace the comma sign before thermal ablation is carried out. It is advisable to administer an enema to empty the rectum, in an attempt to lessen the risk of rectal puncture particularly in constipated patients. If puncture occurs, antibiotic treatment should be provided during 24 hours, with close patient monitoring. As the sacral ventral roots can pass close to the ganglion,73 we must discard the presence of any motor response in the perineal zone before ablation. Performing the technique under computed tomography guidance has also been proposed for accessing the ganglion impar owing to a lesser risk of the aforementioned complications.74

Overall, the complications of thermocoagulation by continuous RF in the management of pain are infrequent and are usually limited to postprocedural pain, sensory alterations, or neuritis of a transient nature. The patients must be awake, imaging techniques are to be used, and stimulation protocols are mandatory to avoid greater complications.

There are still few studies based on sound evidence regarding many of the interventional techniques we use. Although not an objective of the present review, in Europe, where public health care is more consolidated than in the United States, pulsed RF ablation is widely used in application to targets not amenable to continuous RF ablation as a less expensive alternative to stimulation in the treatment of neuropathic pain and without adverse effects.

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