Can J Anesth/J Can Anesth (2013) 60:1003–1012
DOI 10.1007/s12630-013-0009-5

REVIEW ARTICLE/BRIEF REVIEW

Brief review: Piriformis syndrome: etiology, diagnosis, and management

Article de synthèse court: Le syndrome du muscle piriforme – étiologie, diagnostic et prise en charge

Danilo Jankovic, MD · Philip Peng, MBBS · André van Zundert, MD, PhD

Received: 27 May 2013 / Accepted: 15 July 2013 / Published online: 27 July 2013

Abstract

Purpose *In this narrative review, we aim to provide the pathophysiology and diagnostic criteria of the piriformis syndrome (PS), an underdiagnosed cause of buttock and leg pain that can be difficult to treat. Based on existing evidence, frequencies of clinical features are estimated in patients reported to have PS. In view of the increasing popularity of ultrasound for intervention, the ultrasound-guided technique in the treatment of PS is described in detail.*

Source *A literature search of the MEDLINE® database was performed from January 1980 to December 2012 using the search terms e.g., " piriformis injection", " ultrasound guided piriformis injection", " botulinum toxin", "pain management", and different structures relevant in this review. There was no restriction on language.*

Principal findings *A review of the medical literature pertaining to PS revealed that the existence of this entity remains controversial. There is no definitive proof of its existence despite reported series with large numbers of patients.*

Conclusion *Piriformis syndrome continues to be a controversial diagnosis for sciatic pain. Electrophysiological testing and nerve blocks play important roles when the diagnosis is uncertain. Injection of local anesthetics, steroids, and botulinum toxin into the piriformis muscle can serve both diagnostic and therapeutic purposes. An ultrasound-guided injection technique offers improved accuracy in locating the piriformis muscle. Optimizing the therapeutic approach requires an interdisciplinary evaluation of treatment.*

Résumé

Objectif *Dans ce compte-rendu narratif, notre objectif est de présenter la physiopathologie et les critères diagnostiques du syndrome du muscle piriforme (SMP), une cause sous-diagnostiquée de douleurs aux fesses et aux jambes qui peut être difficile à traiter. En nous fondant sur les données probantes existantes, les fréquences des caractéristiques cliniques sont estimées chez des patients chez lesquels un SMP a été rapporté. Au vu de la popularité croissante de l'échographie pour assister les interventions, la technique échoguidée pour le traitement du SMP est décrite en détail.*

Source *Une recherche de littérature dans la base de données MEDLINE® a été réalisée couvrant la période allant de janvier 1980 à décembre 2012 avec les termes de recherche suivants, par exemple: « piriformis injection » (injection dans le piriforme), « ultrasound guided piriformis injection » (injection échoguidée dans le piriforme), « botulinum toxin » (toxine botulique), « pain management » (prise en charge de la douleur), ainsi que différentes*

Author contributions *Danilo Jankovic*, *Philip Peng*, and *André van Zundert* contributed equally to the design, acquisition of data, drafting, and critical revision of the article.

D. Jankovic, MD (✉)
Regional Pain Management Center DGS, Luxemburger Strasse 323-325, 50354 Cologne-Huerth, Germany
e-mail: danilo@jankovic1.de

P. Peng, MBBS
Department of Anesthesia, Toronto Western Hospital, University Health Network, University of Toronto, Toronto, ON, Canada

A. van Zundert, MD, PhD
Department of Anesthesiology, ICU & Pain Therapy, Catharina Hospital-Brabant Medical School, Eindhoven, The Netherlands

A. van Zundert, MD, PhD
University of Ghent, Ghent, Belgium

A. van Zundert, MD, PhD
University of Maastricht, Maastricht, The Netherlands

structures pertinentes à ce compte-rendu. Aucune restriction de langue n'a été appliquée à la recherche.

Constatations principales *Un examen de la littérature médicale concernant le SMP a révélé que l'existence d'un tel syndrome demeure controversée. Il n'existe pas de preuve absolue de son existence, malgré des séries de cas rapportées comportant un nombre élevé de patients.*

Conclusion *Le syndrome du muscle piriforme demeure un diagnostic controversé de douleur sciatique. Les tests électrophysiologiques et les blocs nerveux jouent des rôles importants lorsque le diagnostic est incertain. L'injection d'anesthésiques locaux, de corticostéroïdes, et de toxine botulique dans le muscle piriforme peut servir à des fins diagnostiques aussi bien que thérapeutiques. Une technique d'injection échoguidée permet de gagner en précision lors de la localisation du muscle piriforme. L'optimisation de l'approche thérapeutique nécessite une évaluation interdisciplinaire du traitement.*

In this narrative review, we aim to provide a brief update regarding the pathophysiology and diagnostic criteria of the piriformis syndrome (PS), an underdiagnosed cause of buttock and leg pain that can be difficult to treat. Based on existing evidence, frequencies of clinical features are estimated in patients reported to have PS. In view of the increasing popularity of ultrasound for intervention, the ultrasound-guided technique in the treatment of PS is described in detail.

Piriformis syndrome is caused by prolonged or excessive contraction of the piriformis muscle (PM). Because of the close proximity to the sciatic nerve, PS is associated with pain in the buttocks, hips, and lower limbs.[1-10] Yeoman (1928) was the first to describe pain in the sciatic distribution to PS.[11] Beginning with Mixter and Barr's classic article (1934),[12] the cause of sciatica and buttock pain was increasingly attributed to the lumbar spine. With a few exceptions, the literature on PS includes only isolated case reports.[13-16] Many synonyms for the condition are used in the literature, such as "deep gluteal syndrome" and "pelvic outlet syndrome".[17] Analogous to other entrapment neuropathies, such as carpal tunnel syndrome, this clinical picture can also be correctly termed "infrapiriform foramen syndrome".[18]

It has been suggested that PS is responsible for 5-6% of cases of sciatica.[6,18-20] Taking a conservative estimate of new cases of low back pain and sciatica at 40 million annually,[A] the incidence of PS would be 2.4 million per year.[A,21] In the majority of cases, PS occurs in middle-aged patients (mean age 38 yr).[22] The ratio of female to male patients with PS has been reported as 6:1.[4]

Anatomy

The PM is the only muscle that courses transversely through the greater sciatic notch, and it is the key landmark to all the important nerves and vessels that pass from the pelvis to the gluteal region (Figs. 1, 3A).

The innervation of the PM is usually derived from the first and second sacral nerves. There are six routes by which portions of the sciatic nerve may exit the pelvis, and these are illustrated in Fig. 2A-F.[7,13,23-28]

Pathophysiology and etiology

There are two components contributing to the clinical presentation, namely, somatic and neuropathic. The *somatic component* underlying PS is a myofascial pain syndrome of the PM.[2,7,14,29,30] The symptomatology of the PS can also be contributed from a few muscles in the

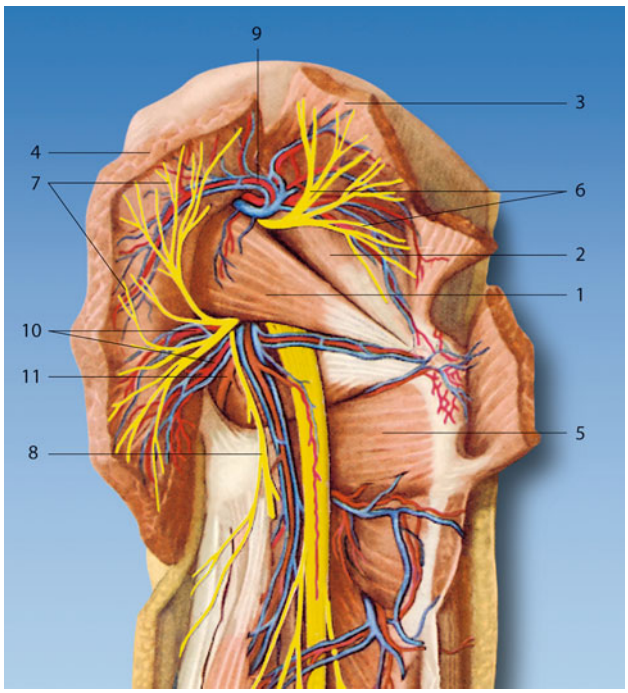

Fig. 1 The piriformis muscle (1) and neighboring muscles, nerves, and vessels: 2, gluteus minimus; 3, gluteus medius; 4, gluteus maximus; 5, quadratus femoris; 6, superior gluteal nerve; 7, inferior gluteal nerve; 8, posterior cutaneous femoral nerve; 9, superior gluteal artery; 10, inferior gluteal artery and vein; 11, internal pudendal artery[91] (reproduced with permission from Danilo Jankovic.)

[A] *Bigos S, Bowyer O, Braen G, et al*. Acute Low Back Problems in Adults. Rockville, MD: Agency for Health Care Policy and Research, Public Health Service, U.S. Department of Health and Human Services, 1994. (Clinical Practice Guideline No. 14. AHCPR Publication No. 95-0642.)

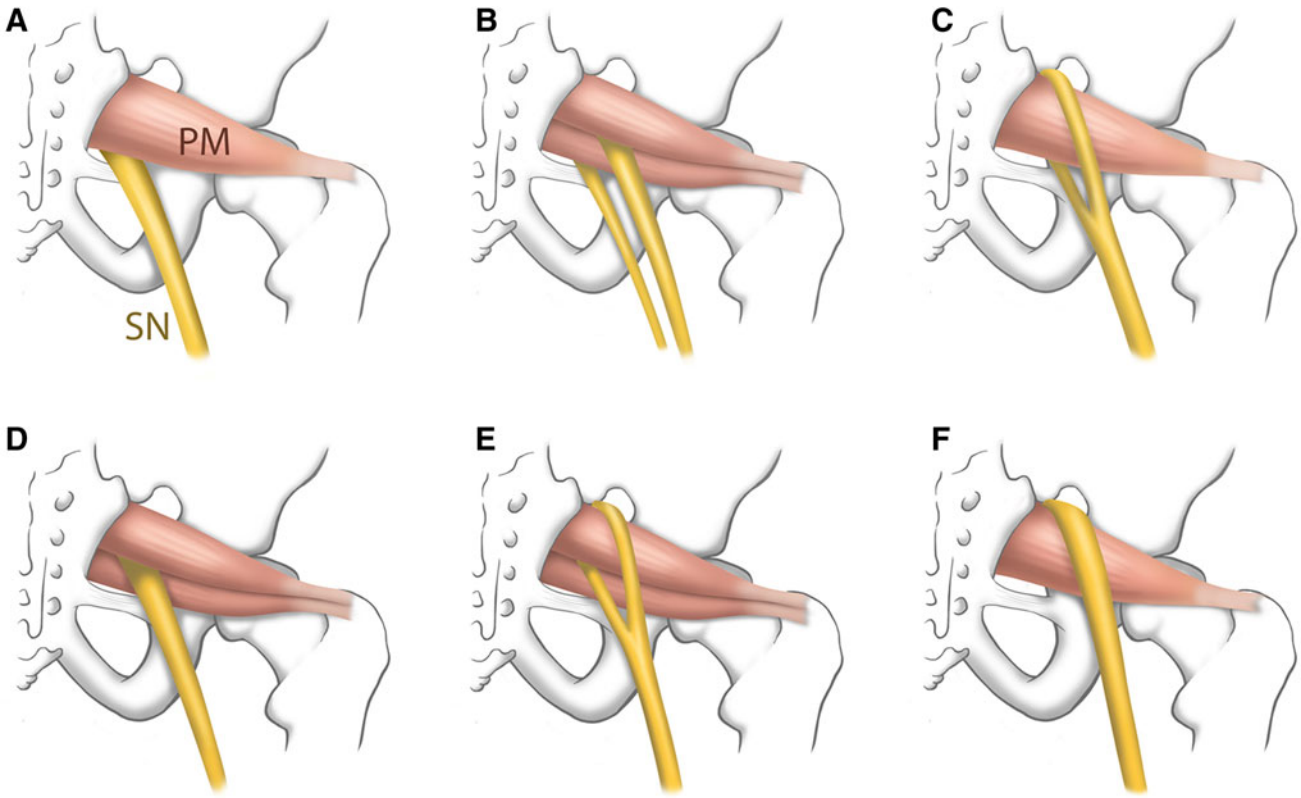

Fig. 2 The six routes by which portions of the sciatic nerve may exit the pelvis.[28] (Reproduced with permission from Philip Peng Educational series.)

vicinity. They are the small external rotators of the hip (obturator internus, in particular, because it is partly an intrapelvic muscle and partly a hip muscle)[7,31] and the hamstring muscles (through activation and perpetuation of trigger points).[7,32] The *neuropathic component* refers to the compression or irritation of the sciatic nerve as it courses through the infrapiriform foramen.[5,9,14,20,33-37] In addition, irritation and compression of the neighbouring nerves and vessels (Figs. 1, 3A, 3D) can give rise to pain with a classic distribution pattern.[7]

A number of etiological factors that may account for the presence of PS have been described (Table 1).[3-5,7,13-15,18,20,22,33,38-59] In most patients, there is no identifiable cause.

Previous gluteal trauma can cause sciatica-like pain.[22,33] This is probably the most common cause of PS.[13,22,33] Certain anatomic variants, such as double piriformis and course variants of the sciatic nerve, posterior cutaneous femoral nerve, inferior gluteal nerve, and superior gluteal nerve[4,5,7,14,15,26,27,40,41,60,61] can predispose to PS.[7,26,34,44]

The presence of PS is frequently overlooked; the differential diagnosis is presented in Table 2.[3,4,7,9,14,18,41,45,51,62-67]

Clinical evaluation

Clinical presentation

Three specific conditions may contribute to PS: 1) myofascial referred pain from trigger points in the PM; 2) adjacent muscles, nerve and vascular entrapment by the PM at the greater sciatic foramen; and 3) dysfunction of the sacroiliac joint.[9,63,64]

Myofascial pain syndrome in the PM is well recognized.[7,20,38,39,50,64,68,69] Gluteal pain is reported to be observed in 97.9% of cases,[70] pain (and paresthesias) in the back, groin, perineum, buttocks, hip, back of the thigh (81.9%),[70] calf (59%),[70] foot, in the rectum (during defecation), and in the area of the coccyx. Low back pain is reported to be observed in 18.1% of cases.[43,70] Some authors have suspected that contraction of the PM is an often overlooked cause of coccygodynia.[13,24,41] Swelling in the affected leg and disturbances of sexual function are observed (dyspareunia in women, 13-100%,[71] and disturbances of potency in men are very often present as accompanying symptoms).[4,7,71] Intense pain will occur when the patient sits or squats (39-95%).[71]

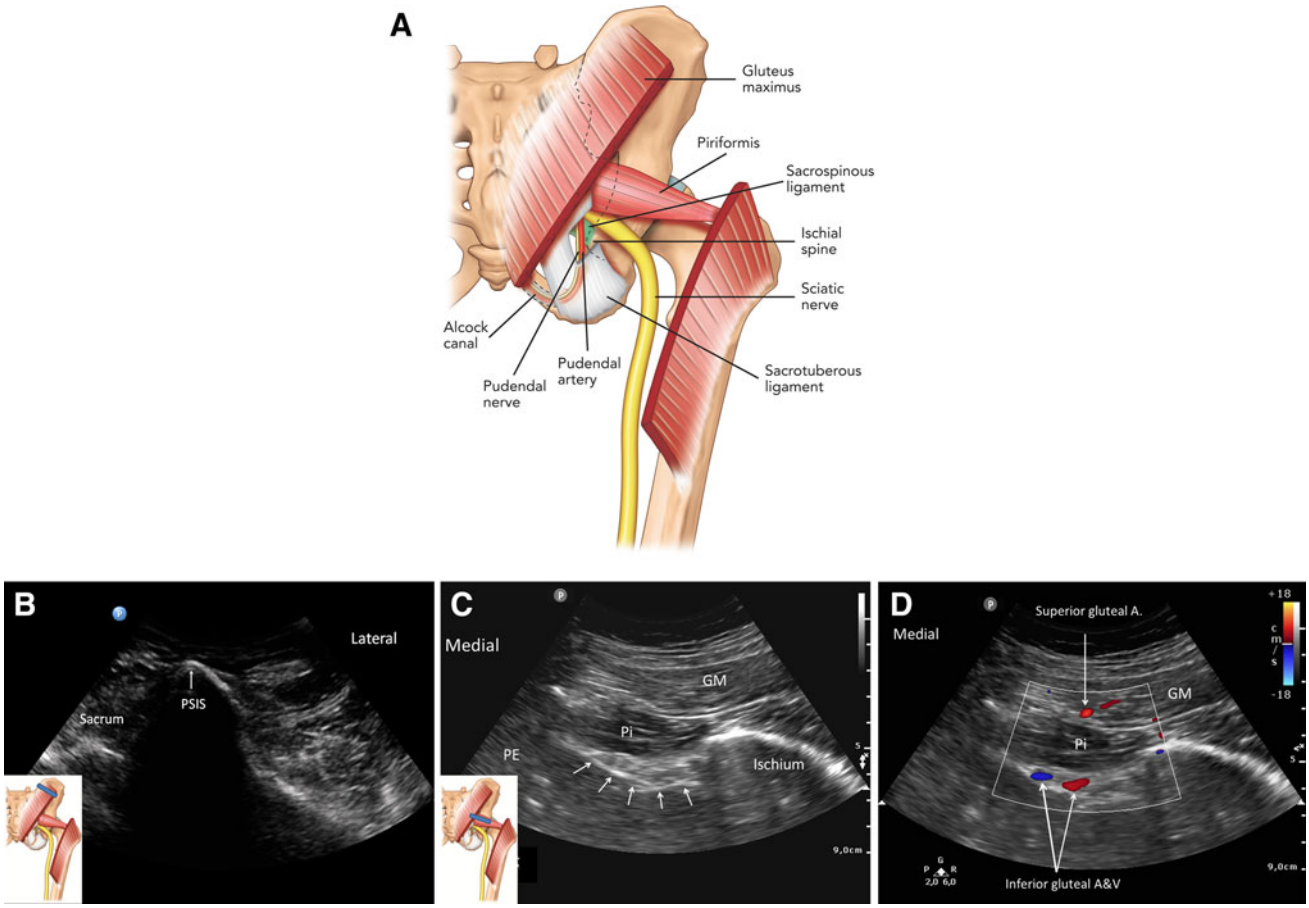

Fig. 3 Images reproduced with permission from Ultrasound for Regional Anesthesia, Toronto Western Hospital, Toronto, Canada[28] (www.usra.ca). (A) Posterior view of the pelvis showing the piriformis muscle and surrounding structures. The gluteus maximus muscle has been transected to show the deeper structures. It should be pointed out that the sciatic nerve typically emerges caudal to the piriformis muscle in the greater sciatic notch. (B) Ultrasonography of the ilium cephalad to the greater sciatic notch. The position of the ultrasound probe (dark rectangle) is indicated in the insert. The ilium appears as a hyperechoic line. PSIS = posterior superior iliac spine. (C) Ultrasound of the greater sciatic notch, with the position of the ultrasound probe indicated in the insert (dark rectangle). The sciatic nerve is seen as a structure deep to the piriformis muscle, indicated by the arrows. GM = gluteus maximus muscle; PE = peritoneum; Pi = piriformis muscle. (D) Ultrasonography of the sciatic notch as in C, with Doppler imaging. The inferior gluteal artery is seen adjacent to the sciatic nerve, and the superior gluteal artery is located between the gluteus maximus (GM) and piriformis muscle (Pi). A = artery; V = vein

Table 1 Etiology of piriformis syndrome

- Gluteal trauma in the sacroiliac or gluteal areas (possibly several years previously)[13,22,33]
- Predisposing anatomic variants[4,5,7,14,15,40,41]
- Myofascial trigger points[7,20,38,39,42]
- Hypertrophy and spasm of the piriformis muscle[14,18,43-45]
- Secondary to laminectomy[13,38,39,43,46-50]
- Abscess,[51] hematoma,[52,53] myositis,[54] bursitis of the piriformis muscle,[55] neoplasms in the area of the infrapiriform foramen,[56] colorectal carcinoma,[57] neurinoma of the sciatic nerve,[18] episacroiliac lipoma[50]
- Intragluteal injection[58]
- Femoral nailing[18]
- Myositis ossificans of the piriformis muscle[3,59]
- Klippel-Trénaunay syndrome[18]

Table 2 Differential diagnosis of piriformis syndrome

- Dysfunction, lesion, and inflammation of sacroiliac joint[3,7,9,63,64]
- Pseudoaneurysm in the inferior gluteal artery following gynecologic surgery[4,65]
- Thrombosis of the iliac vein[18,51,65]
- Painful vascular compression syndrome of the sciatic nerve, caused by gluteal varicosities[6]
- Herniated intervertebral disc[67]
- Post-laminectomy syndrome or coccygodinia[18,41]
- Pseudoradicular S1 syndrome[45]
- Posterior facet syndrome at L4-5 or L5-S16[3]
- Unrecognized pelvic fractures[14]
- Lumbar osteochondrosis[7,62]
- Undiagnosed renal stones[14]

Nevertheless, true neurologic findings are not usually present in PS, and sensory deficits may be completely absent.[3,5,14,38,39,64] There is no gold standard in diagnosing PS. The physical examination may reveal several of the following well-described signs.[13,70] External palpation of the *piriformis line* can be used to elicit trigger-point tenderness through a relaxed gluteus maximus muscle. The patient is placed in the Sims position. The piriformis line overlies the superior border of the PM and extends from immediately above the greater trochanter to the cephalic border of the greater sciatic foramen at the sacrum. The line is divided into equal thirds. The fully rendered thumb presses on the point of maximum trigger-point tenderness, which is usually found just lateral to the junction of the middle and last thirds of the line. A positive test is reported to be observed in 59-92% of the patients.[13,70,71] The *piriformis sign,* (which presents as tonic external rotation of the affected lower extremity) is reported to be observed in 38.5% of the patients.[13] The medial end of the PM should be palpated within the pelvis by *rectal or vaginal examination* (this test is positive in almost 100% of the patients).[7,13,41,72,73] Rectal or pelvic examination may reveal a tender palpable sausage-shaped mass along the lateral pelvic wall. *Freiberg's sign*[13,14,19,67] involves pain on passive forced internal rotation of the hip in the supine position, thought to result from passive stretching of the PM and pressure on the sciatic nerve at the sacrospinous ligament. This test is positive in 56.2% of the patients (32-63%).[70,71] *Pace's sign*[13,38,39] consists of pain and weakness on resisted abduction and external rotation of the thigh in a sitting position . A positive test is reported to occur in 46.5% of the patients (30-74%).[70,71] *Lasègue's sign*[74] involves pain on the affected side on voluntary adduction, flexion, and internal rotation. *Beatty's maneuver*[1,35] is an active test that involves elevation of the flexed leg on the painful side while the patient lies on the asymptomatic side. Abducting the thigh to raise the knee off the table elicits deep buttock pain in patients with PS but back and leg pain in those with lumbar disk disease. The *Hughes test*[75] (external isometric rotation of the affected lower extremity following maximal internal rotation) may also be positive in PS. *Gluteal atrophy* may be present[13,33,38,45] as well as *shortening of the limb on the affected side.*[7,45,72] *Sacroiliac tenderness* is reported to be observed in 38.5% of the patients.[13]

Electrophysiological tests

The role of unprovoked electrophysiological tests (in an anatomical position) is minimal. Nevertheless, the diagnostic value of such tests can be improved by stressing the muscle in *flexion, adduction,* and *internal rotation* (the FAIR test).[14,15,19,70,76,77] The test compares posterior tibial and peroneal H reflexes elicited in the anatomic position with H reflexes obtained in flexion, adduction, and internal rotation [normal mean (SD) prolongation: 0.01 (0.62) msec]. A prolongation of 1.86 msec in the FAIR test is an electrophysiological criterion for diagnosing PS.[14,78] The test correlates well with estimates of pain on a visual analogue scale.[14,15,19,70,76,77] Somatosensory-evoked cortical potentials are also reported to objectify sensory abnormalities of innervation.[14,79]

Imaging modalities

Plain pelvic radiography can identify calcification of the PM or its tendon only in exceptional circumstances.[14,42] Involvement of the PM in sciatic neuropathy has been supported by evidence from computed tomography (CT), magnetic resonance imaging (MRI),[62,68,80-84] scintigraphy,[85] and ultrasound.[36] Even so, if PS is suspected, a CT examination of the pelvis should certainly be conducted in order to detect side-to-side differences in the PM or other causes of the narrowing of the infrapiriform foramen.[26,86,87] If uncertainties remain, an MRI examination of the sciatic nerve and its vicinity — particularly with regard to structural changes in the PM — is indicated.[88] When the newly introduced neuroradiological technique of magnetic resonance neurography has been used alongside established imaging methods, such as MRI, for evaluating unexplained chronic sciatica, it has led to the identification of various changes relating to the PM and sciatic nerve which have been further shown with surgical exploration.[26]

Diagnostic injection with local anesthetics and steroids

Although PM injection has not been compared with other diagnostic tests, it is a widely used method of establishing the diagnosis after initial evaluation.[13,38,39]

Management of PS

General

Piriformis syndrome causing sciatica usually responds to conservative treatments, including physical therapy, lifestyle modification, pharmacological agents (non-steroidal anti-inflammatory agents, muscle relaxants, and neuropathic pain medication),[89] and psychotherapy. When patients fail to respond to simple conservative therapy, interventional modalities are considered. In rare circumstances, surgical release of the PM has been described for difficult cases of PS. There is a paucity of controlled trials critically examining the effectiveness of the noninvasive management modalities. Notwithstanding the lack of critical evaluation, the use of

physical therapy methods are well supported in the literature.[4,5,7,19-21,40,41,43,64,73,90] In general, physical therapy is performed only as part of multimodal therapy. Since PM injection is the main reason for the referral of this group of patients to an anesthesiologist/pain specialist, most of the discussion will focus on the technique.

Piriformis muscle injection

Piriformis muscle injection is usually offered to patients as part of multimodal therapy. The muscle can be targeted by a landmark-based technique, with or without the assistance of electrophysiological stimulation or image-guided techniques.

Limitation of the current techniques

Given the proximity of the PM to the pelvic cavity, sciatic nerve, and inferior gluteal artery (Figs. 1, 3A, 3D), landmark-based infiltration is not recommended.

Frequently, the landmark-based technique is accompanied with an electrophysiological stimulation method, such as the use of a nerve stimulator[47,91] or electromyography;[90] however, there are limitations with localization methods that use electrophysiological techniques. The premise in these techniques is that the close proximity of the needle to the muscle or nerve will reliably produce a brisk motor unit action potential or muscle contraction. Although this concept has *not* been validated for the electromyography-guided technique, the needle-to-nerve proximity relationship in nerve stimulation has been examined.[92] Several studies using *in vivo* models have shown that the minimum stimulating current may not reliably reflect the distance of the needle tip from the nerve.[93-96] Furthermore, the nerve stimulation technique cannot reliably differentiate whether the needle tip is within the muscle or lying in a plane between muscles (an important consideration when botulinum toxin is being injected). Both electrophysiological approaches neither allow direct visualization of the muscle nor ensure accurate positioning of the needle within the PM.[97]

Localization of the PM using the fluoroscopy-assisted contrast injection technique has also been examined. A cadaver study showed that the accuracy of this method was only 30%, with most of the needle tip being positioned in the gluteus maximus muscle.[98] This is not surprising given the fact that the fluoroscopy technique does not allow direct visualization of the soft tissue. Ultrasound and computer tomography (CT) have the advantage of allowing direct visualization of the PM. The reliability of the ultrasound-guided method has been confirmed in a cadaver study.[98] Compared with a CT-guided technique, ultrasound is much more affordable and accessible. The ultrasound-guided technique also offers the additional advantages of avoiding radiation exposure and allowing real-time injection.[97] In the experience of one of the present authors (P.P.), it is not uncommon for the patient to react when the practitioner injects the medication into the muscle. The pressure sensation on injection may elicit gluteus muscle contraction, which can displace the needle tip from the PM. This is particularly the case if the patient has developed piriformis atrophy with repeated injections of botulinum toxin. Real-time surveillance of the spread of the injectate can ensure that the needle is positioned within the muscle through the injection procedure. Because of the emerging popularity of the ultrasound-guided technique, details will be described below.

Ultrasound-guided injection

The accuracy of needle placement with ultrasound was recently validated in a cadaver study, suggesting an accuracy of 95%.[98] There have been many reports of ultrasound-guided PM injection that describe similar techniques with minor variation.[36,80,98-100] The technique described below is the author's preferred technique.[28]

Sonoanatomy[97,100]

The key for locating the PM is the greater sciatic notch (Fig. 3A). The patient is placed in the prone position, and the ultrasound probe is placed just lateral to the posterior superior iliac spine (PSIS), revealing a hyperechoic bone shadow from the ilium (Fig. 3B). The ultrasound probe is then moved in the caudal direction toward the sciatic notch. At this level, the hyperechoic shadow of the bone will disappear from the medial aspect and two muscle layers will be visible — the gluteus maximus and the piriformis. The PM muscle can be better visualized by rotating the hip externally and internally with the knee flexed. This movement allows gliding of the PM in real time and helps the practitioner distinguish the PM from the gluteus muscle (Fig. 3C). The ultrasound scan should also show the presence of the sciatic nerve, inferior gluteal artery, and pelvic cavity, which are deep to the PM muscle (Figs. 3C, 3D).

Injection technique

The needle is inserted from medial to lateral using an in-plane technique. Due to anatomic anomalies of the sciatic nerve within and below the PM, a practitioner with limited experience with ultrasound-guided injection is advised to perform the needle insertion with the nerve stimulator to prevent unintentional injection in the vicinity of the sciatic nerve. The stimulating current is usually set at 1 mA. Either

a 3.5-in 22G spinal needle or an 80-mm insulated needle is usually sufficient, but a longer needle is required for patients with a high body mass index. A very small amount of normal saline (< 0.5 mL) is injected to confirm the intramuscular location of the needle (hydrolocation).The author usually chooses a small volume (1-1.5 mL) of injectate, whether it is botulinum toxin or a mixture of local anesthetic with steroid.

Injection solution

Mixing the local anesthetic solution with 20-40 mg of a long-acting corticosteroid (e.g., long-acting methylprednisolone) is also recommended.[101] Experience shows that long-acting local anesthetics do not provide any substantial advantages over short-acting agents.[7,13,91]

Response to injections

The response to injections can be immediate but may be of short duration. Recent reports have focused on botulinum toxin injections.

Botulinum toxin injections in PS[14,21,29,35,48,84,87,90,102-104]

Botulinum toxin type A is one of seven immunologically distinct serotypes (A-G) of neurotoxin produced by *Clostridium botulinum.* Botulinum toxin type A can be administered with fluoroscopic, electromyelographic, CT, or MRI guidance. The recommended dose of botulinum toxin type A in PS is usually 100-200 units diluted in small volumes (1-1.5 mL) of normal saline.[2,14,21,35,102]

In summary, the indications, techniques, dosages, and monitoring vary significantly. This variability limits any comparison of studies and treatment groups. There is a lack of double-blind randomized controlled trials. More controlled studies are needed in order to determine the number of nerve blocks required in chronic pain therapy and to establish selection criteria for patients who are suitable for nerve blocks in pain therapy. The efficacy of nerve blocks depends on the stage of development of chronic pain.

Surgical treatment

Surgical intervention should be considered only when nonsurgical treatment has failed and the symptoms are becoming intractable and disabling, as the outcome is often disappointing. There is a lack of literature on surgical treatment for PS.

Classic indications for surgical treatment include abscess, neoplasms, hematoma,[5,22,33,45,46,49] and painful vascular compression of the sciatic nerve caused by gluteal varicosities, etc.[66] Since the introduction of botulinum toxin therapy, however, surgical interventions have rarely been necessary in patients with PS. The technical details of surgical treatment are beyond the scope of this review.

Conclusions

Piriformis syndrome continues to be a controversial diagnosis for sciatic pain. Given the fact that nerves and blood vessels accompany the PM, contracture of the latter can have widespread effects. Clinically, PS presents itself with pain (and paresthesias) in the buttocks, hips, and lower limbs. Electrophysiological testing and nerve blocks play important roles when the diagnosis is uncertain. Clinicians should be aware that many etiological factors are involved, which may be possible to modify or treat. Most patients respond to conservative measures, including nerve blocks, whereas surgical treatment is seldom necessary and often disappointing. Anesthesiologists are commonly involved in the management of PS due to their expertise in pain management and in carrying out nerve blocks. Injections of local anesthetics, steroids, and botulinum toxin into the PM muscle can serve both diagnostic and therapeutic purposes. The practitioner should be familiar with variations in the anatomy and the limitations of landmark-based techniques. An ultrasound-guided injection technique has recently been described, which offers improved accuracy in the nerve blockade. This technique has been shown to have both diagnostic and therapeutic value in the treatment of PS. Optimizing the therapeutic approach requires an interdisciplinary evaluation and treatment.

Sources of funding None. No financial sources were received to support this work.

Conflict of interest None declared. None of the authors have any association with pharmaceutical or medical manufacturing companies; none are consultants of any company. Dr. Philip Peng received equipment support from SonoSite Canada. He is a faculty member of Ultrasound for Regional Anesthesia (USRA) and publisher of the Philip Peng Educational Series.

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