

Accuracy of Ultrasound-Guided Pudendal Nerve Block in the Ischial Spine and Alcock's Canal Levels: A Cadaveric Study

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Abstract

Background. Blockade of the pudendal nerve (PN) using ultrasound (US) guidance has been described at the levels of the ischial spine and Alcock's canal. However, no study has been conducted to compare anatomical accuracy between different approaches in targeting the PN. **Objective.** To investigate the accuracy of US-guided injection of the PN at the ischial spine and Alcock's canal levels. This study also compared the accuracy of the infiltrations by three sonographers with different levels of experience. **Subjects.** Eight Thiel-embalmed cadavers (16 hemipelvises). **Methods.** Three physiatrists trained in musculoskeletal US imaging with 12 years, five years, and one year of experience performed the injections. Each injected a 0.1-mL bolus of colored dye in both hemipelvises of each cadaver at the ischial spine and Alcock's canal levels under US guidance. Each cadaver received three injections per hemipelvis. The accuracy of the injection was determined following hemipelvis dissection by an anatomist. **Results.** The injections were accurate 33 times out of the total 42 attempts, resulting in 78% accuracy. Sixteen out of 21 injections at the ischial spine level were on target (76% accuracy), while the approach at Alcock's canal level yielded 17 successful injections (81% accuracy). The difference between the approaches was not statistically significant. There was also no significant difference in accuracy between the operators. **Conclusions.** US-guided injection of the PN can be performed accurately at both the ischial spine and Alcock's canal levels. The difference between the approaches was not statistically significant.

Key Words: Pudendal Nerve; Ultrasound-Guided Injection; Cadaveric Study

The pudendal nerve (PN) has been implicated as one of many possible causes of pelvic floor pain [1]. Pudendal neuralgia may cause disabling neuropathic pain in the innervation territory of the PN, as well as other symptoms such as sexual dysfunction [2]. The nerve can be injured via trauma or stretching, such as during childbirth [2, 3]. Another possible cause includes excessive cycling, which can induce recurring mechanical strain [4]. Pudendal neuralgia may also result from pudendal nerve

entrapment (PNE) syndrome. Currently, the diagnosis of pudendal neuralgia remains essentially clinical, with no pathognomonic sign [5], although the Nantes criteria (Table 1) [3] have been defined to aid in its diagnosis.

The pudendal nerve is a mixed motor and sensory nerve that arises from the second, third, and fourth roots of the sacral plexus [6]. It exits the pelvis by the greater sciatic foramen, passes through the infrapiriformis foramen, and crosses the ischial spine over the sacrospinous

ligament and under the sacrotuberous ligament (Figure 1). In this area, the PN is usually medial to the internal pudendal vessels. The PN continues its course

Table 1. Nantes criteria (diagnostic criteria for pudendal neuralgia by pudendal nerve entrapment), adapted from Labat et al. [3]

Essential criteria (all must be present)

- Pain in the territory of the pudendal nerve: from the anus to the penis or clitoris
- Pain is predominantly experienced while sitting
- The pain does not wake the patient at night
- Pain with no objective sensory impairment
- Pain relieved by diagnostic pudendal nerve block

Complementary diagnostic criteria

- Burning, shooting, or stabbing pain, numbness
- Allodynia or hyperpathia
- Rectal or vaginal foreign body sensation (sympathalgia)
- Worsening of pain during the day
- Predominantly unilateral pain
- Pain triggered by defecation
- Presence of exquisite tenderness on palpation of the ischial spine
- Clinical neurophysiology findings in men or nulliparous women

Exclusion criteria

- Exclusively coccygeal, gluteal, pubic, or hypogastric pain
- Pruritus
- Exclusively paroxysmal pain
- Imaging abnormalities able to account for the pain

Associated signs not excluding the diagnosis

- Buttock pain on sitting
- Referred sciatic pain
- Pain referred to the medial aspect of the thigh
- Suprapubic pain
- Urinary frequency and/or pain on a full bladder
- Pain occurring after ejaculation
- Dyspareunia and/or pain after sexual intercourse
- Erectile dysfunction
- Normal clinical neurophysiology

through the lesser sciatic foramen and reaches Alcock's canal, where it then travels in the obturator fascia [7]. It then divides into three main branches: the inferior rectal nerve, the perineal nerve, and the dorsal nerve of the clitoris or penis [8].

PNE has been described at four different locations (Alcock's canal on the medial surface of the obturator internus muscle, sciatic notch, ischial spine, and distal branches of the nerve), but the entrapment location does not significantly alter the presenting symptoms [9, 10]. Depending on the studies, the prevalence of the exact location of the entrapment varies. A prospective study evaluating 200 patients, whose diagnostic criteria were based on history, clinical examination, imaging, and clinical response to magnetic resonance imaging (MRI)-guided selective block, found that in a vast majority of the cases (79.9%), the zone of entrapment was located in Alcock's canal on the medial surface of the obturator internus muscle. Other entrapment locations included the sciatic notch (2%), the ischial spine (4.8%), and the distal branches of the nerve (13%) [9]. The imaging criteria were defined as evidence of nerve edema, and asymmetry of the piriformis and obturator internus muscles were compared with the contralateral side. Notably, the MRI findings reported in this and other studies [11] have yet to prove their clinical correlation with PNE. Furthermore, another study of 100 patients diagnosed with pudendal neuralgia according to the Nantes criteria, including 24 bilateral cases, reported a very different prevalence. In 70% of cases, the locus of entrapment was situated at the ischial spine, while nerve compression in Alcock's canal was demonstrated in 40% of cases.

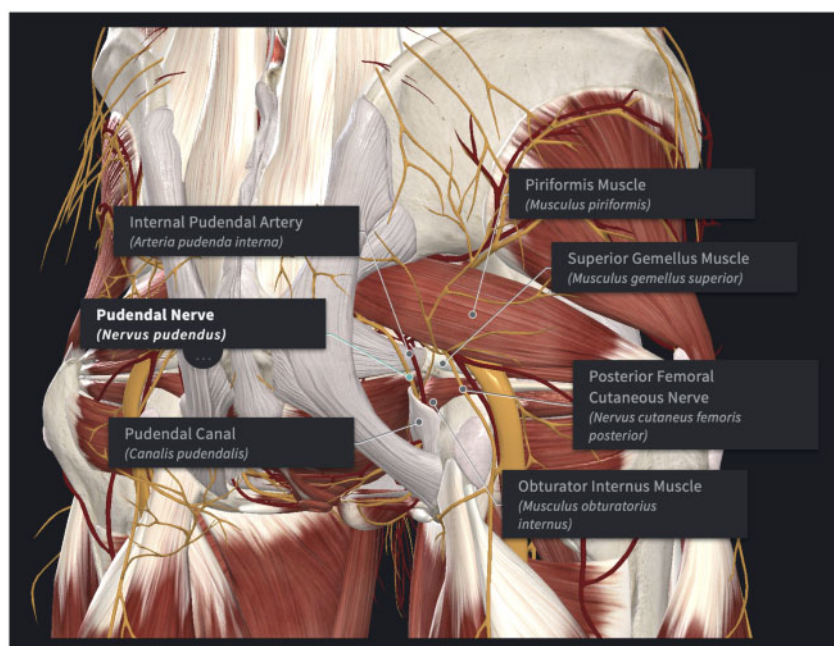


Figure 1. The pudendal nerve is shown, with the key surrounding structures of the right buttock labeled. Image courtesy of Complete Anatomy.

Moreover, several patients suffered entrapment at several locations [10].

Ultrasound imaging of pudendal nerves has been carried out at the level of the ischial spine and Alcock's canal, as well as at the transperineal level [8, 12, 13]. Blockade of the nerve using US guidance has been described at the levels of the ischial spine [14] and Alcock's canal [15]. A successful nerve block points toward a diagnosis of PNE and can contribute to ruling out non-neuropathic causes of perineal pain.

The literature concerning the accuracy of the injections is very scarce. Indeed, there are no cadaveric studies evaluating injection accuracy at the ischial spine and none drawing a comparison between the two locations.

The purpose of this study was to assess the accuracy of US-guided injections of the pudendal nerve at the ischial spine and Alcock's canal levels. In view of the fact that these are US-guided infiltration techniques with a high level of difficulty, we also compared the accuracy of the infiltrations according to the level of experience of the sonographers.

Methods

This study was approved by the local ethics committee (SCELERA-17-04), and consent was waived because of the retrospective and cadaveric nature of the study.

Subjects

Eight Thiel-embalmed cadavers, for a total of 16 hemipelvises, were used for this study. Exclusion criteria were previous known fracture, tumors, metastases, and surgery at the pelvis or perineum. One cadaver was excluded as two physicians inadvertently used the same latex color, rendering the evaluation impossible. The average age at death, height, and weight (SD) were 68.4 (13.2) years (range = 51–84 years), 1.7 (0.1) m (range = 1.5–1.8 m), and 54.3 (15.3) kg (range = 36–86.1 kg), respectively. All cadavers were obtained from the Willed body program of the Department of Anatomy at UQTR.

Material

For each procedure, one-tenth of a milliliter (0.1 mL) of red, white, or blue laboratory-grade latex (Carolina Biological Supply Company, Burlington, NC, USA) was injected with a 1-mL syringe and a 22-G 90-mm spinal needle. A Samsung US machine (Samsung RS80A) with a linear probe (frequency = 3–12 MHz) was used for imaging during the US-guided injections.

Methodology

Three physiatrists trained in musculoskeletal and peripheral nerve US-guided injection techniques participated in the process. They had 12 years, five years, and one year of experience. Each injected one dose of latex per hemipelvis, for a total of 42 procedures (14 injections per

physician). Each dose contained 0.1 mL of colored latex. For each cadaver, they injected the first side of the pelvis using one of the two approaches (see below); the second approach was used for the contralateral hemipelvis. The side (left or right), order of the sonographers, and the dye color used by each were also randomized by computer sequence to blind the dissecting investigator to the injecting individual.

After each injection, the skin surface was cleaned with a tissue to remove traces of latex. To solidify the latex and minimize its dispersion, the injected area was infused by the last injector with 5 mL of 5% of acetic acid just after the last injection. To determine the location of the latex, a dissection of the gluteal region was carried out by an anatomist with 17 years of experience to access the different sites of injection. A scoring system was established to determine if the injection was successful. If no contact was made with the PN, it was scored as a 0. If the latex was in contact with the surface of the PN, it yielded a score of 1.

Before the injection, each clinician assessed the quality of the nerve visualization, which was scored 0 (no visualization), 1 (partial visualization), 2 (full visualization).

Cadaver Positioning

Before the injections, cadavers were placed in prone position. All injections and dissections were carried out in this position.

Ischial Spine US-Guided Injection Technique

In our opinion, the most feasible and reproducible technique to identify the PN at the ischial spine follows the recommendations set forth and resembles previously published protocols [8]:

The choice of probe should be determined according to the thickness of the subcutaneous tissues and the gluteus maximus muscle. If the spine or the lesser sciatic notch is more than 3 or 4 cm deep, one should use the curvilinear probe 1–7 MHz; if the spine or lesser sciatic notch is more superficial, the linear 3–12 MHz is preferable (Samsung RS80A US machine).

After identification of the ischial tuberosity, one should perform a rostral translation. The convex lesser sciatic notch, as well as the obturator internus muscle on its surface, are visualized. Rostrally, the ischial spine is found as the bony structure flattens and becomes slightly concave in its inner third. Medially to the ischial spine, there are two linear hyperechoic structures: the sacrotuberous (superficially) and sacrospinous (deeper) ligaments. Between the two, one can identify the PN (with its fascicular aspect) and, lateral to the nerve, the internal pudendal and inferior gluteal arteries.

In our study, US-guided injections were done in-plane from a medial to lateral approach, as the pudendal vessels are usually lateral to the PN (Figure 2).

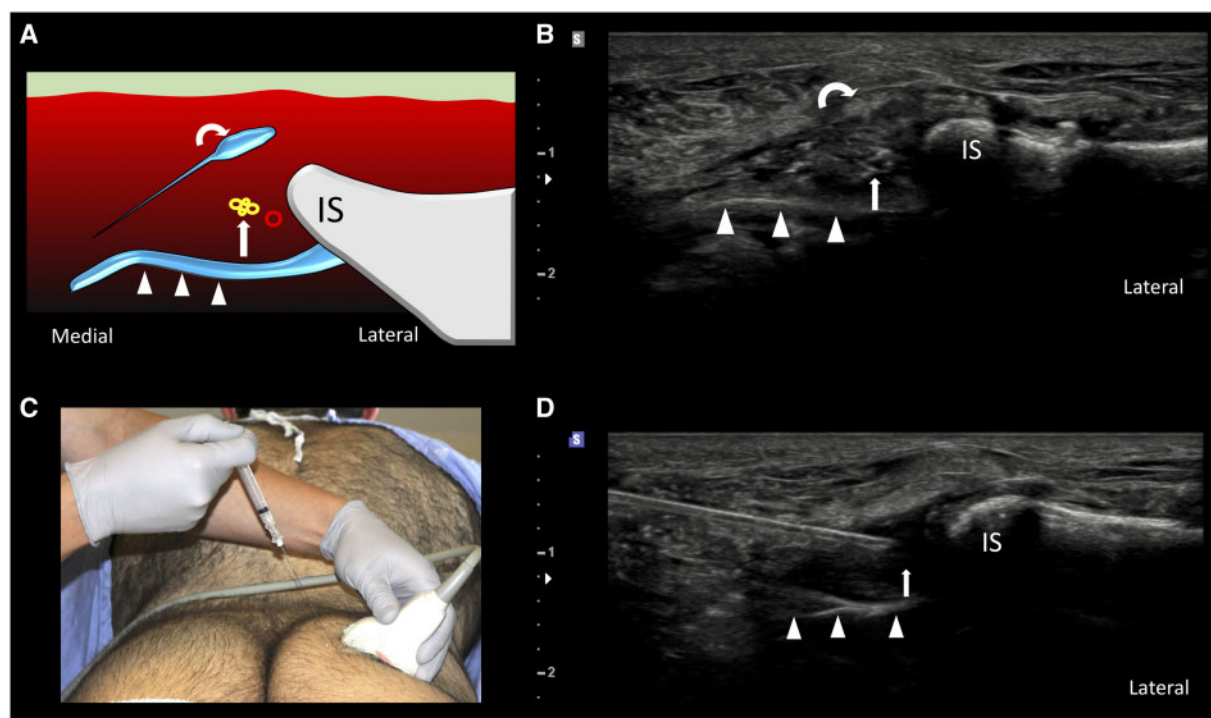


Figure 2. US images and US-guided injection technique of the PN at the level of the ischial spine. A) Schematic drawing of a transverse view of the PN. B) Short-axis US image of the PN. C) US-guided technique for PN injection: Subject is lying in prone position, and the probe is positioned at the level of the ischial spine. D) Corresponding US image for PN injection. Pudendal nerve: arrow; sacrotuberous ligament: curved arrow; sacrospinous ligament: arrowheads. IS = ischial spine; PN = pudendal nerve; US = ultrasound.

Alcock's Canal US-Guided Injection Technique

For the obturator internus, the transducer was displaced caudally from the ischial spine to the lesser sciatic notch.

At this level, the pudendal nerve is usually superficial and medial to the obturator internus muscle (which is also superficial and medial to the lesser sciatic notch), under the coccygeus muscle (which is under the sacrotuberous ligament), and lateral to the levator ani muscle. As the pudendal nerve is more superficial at Alcock's canal, only the linear transducer was used.

After optimal US visualization was established, US-guided injections were done in-plane using a lateral-to-medial approach (Figure 3).

Latex Diffusion

As some diffusion was observed along the trajectory of the nerve even with only 0.1 mL of latex (Figure 4), one cadaver was used to assess the diffusion of the injectate: 3 mL of blue latex was injected at the level of the obturator internus once, and the amount of diffusion was observed (Figure 5).

Results

The injected dye made contact with the PN 33 times out of the total 42 attempts (both approaches), resulting in 78.5% accuracy.

Ischial Spine vs Alcock's Canal Injection

Sixteen out of 21 injections at the ischial spine level were on target (76.2% accuracy), while the approach at the level of the obturator internus yielded 17 successful injections (80.9% accuracy) (Table 2). A chi-square test with Yates correction was performed to compare the performance of the two approaches. There were no significant differences between the two approaches ($P = 0.999$).

Effect of Physician Experience

Physician experience was also taken into account for data analysis. The sonographer with one year of experience managed nine successful injections, resulting in 64% accuracy. The two others, with five and 12 years of experience, had an accuracy of 93% (13 successful injections) and 79% (11 successful injections), respectively (Table 2). Although the sonographer's experience seemed to have an influence on the accuracy of the infiltrations, there were no statistically significant differences between any of the injectors, regardless of the infiltration approach ($P = 0.564$ to 0.606).

We performed an additional PN US-guided injection on a test cadaver with 3 mL of blue latex at the level of the obturator internus. We observed a rostral diffusion of at least 3 cm, exceeding the level of the ischial spine (Figure 5).

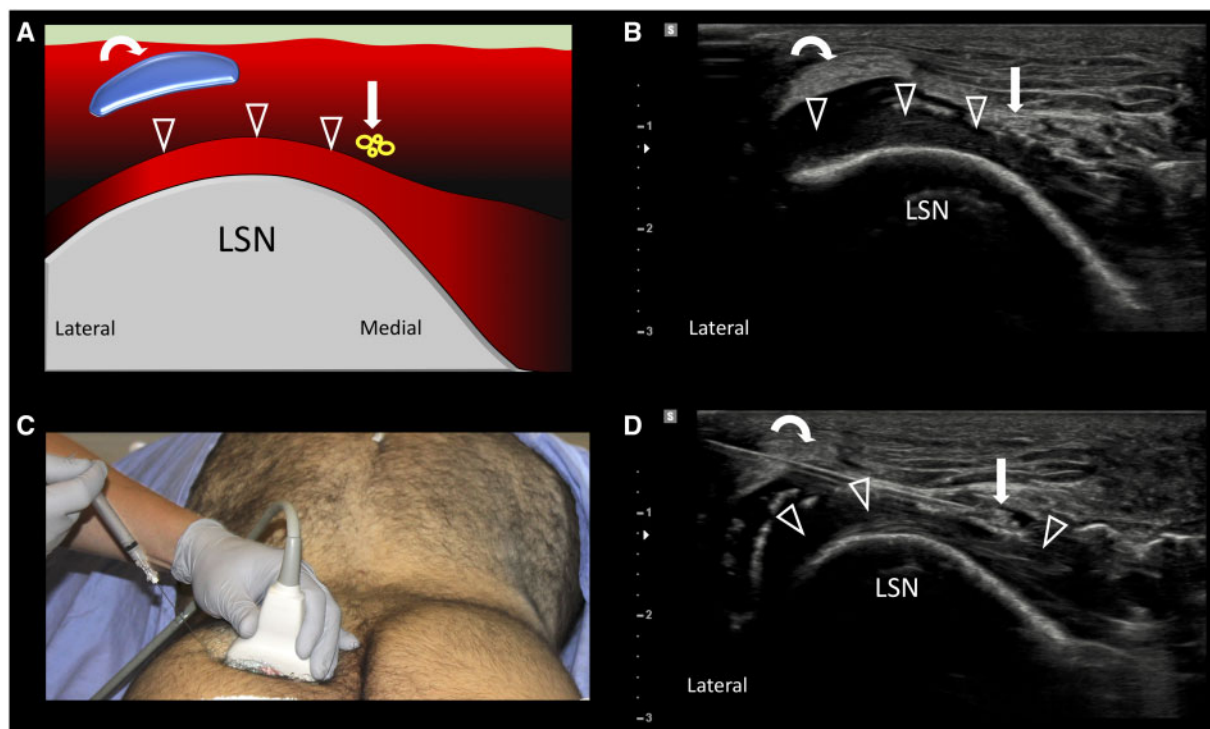


Figure 3. US images and US-guided injection technique of the PN at the level of Alcock's canal. A) Schematic drawing of a transverse view of the PN. B) Short-axis US image of the PN. C) US-guided technique for PN injection: Subject is lying in prone position, and the probe is positioned at the level of the lesser sciatic notch. D) Corresponding US image for PN injection. Pudendal nerve: arrow; sacrotuberous ligament: curved arrow; obturator internus muscle: void arrowheads. LSN = lesser sciatic notch; PN = pudendal nerve; US = ultrasound.

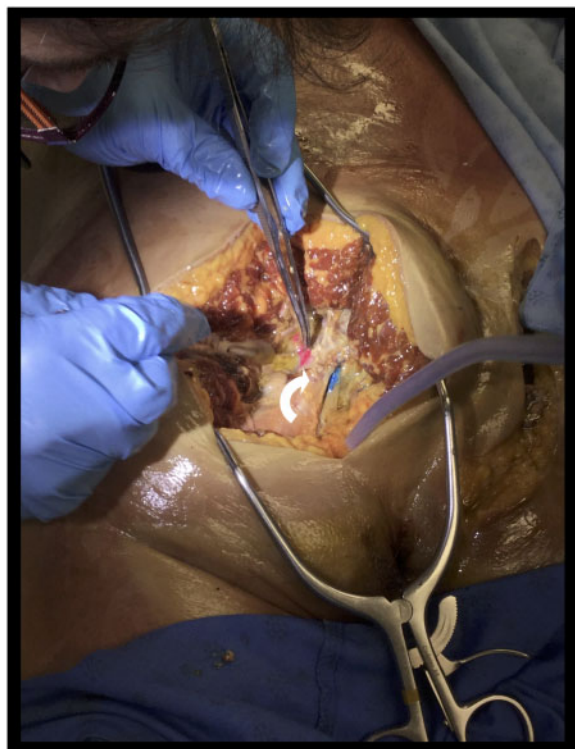


Figure 4. Cadaveric dissection after US-guided injection of the pudendal nerve with the ischial spine approach and Alcock's canal approach. PN at the level of the ischial spine: red; PN at the level of Alcock's canal: blue; sacrotuberous ligament: curved arrow.

Discussion

In this study, the pudendal nerve injections were accurate on 76% of the attempts at the ischial spine level and on 81% of the attempts at Alcock's canal level. The difference between the approaches was not statistically significant, and there was no significant difference in accuracy between the operators, even though experience did seem to have an influence.

Although injections were considered failures if the latex was not in direct contact with the PN, the injectate was within 2 mm of the target in all of these occurrences. In a clinical setting, as well as in some other studies, the injected volume is much greater (0.1 mL vs usually 3 mL, even up to 10 mL [15]), and the injectate (steroids, lidocaine, or saline) is less viscous, which should also favor diffusion. We observed a rostral diffusion of at least 3 cm, exceeding the level of the ischial spine, for a single injection of 3 mL of blue latex at the level of the obturator internus. We could therefore estimate that the injection would probably prove successful despite not being specifically on the nerve, rendering the technique effective despite a technically inaccurate injection.

Notwithstanding the probable underestimation of the accuracy of the technique, it remains that the nerve was missed in a significant number of attempts. Therefore, when using US-guided injection as a diagnostic criterion for pudendal neuropathy [16], the clinician has to consider the possibility of false negatives.

In our study, there were no statistically significant differences between the sonographers, regardless of their experience, despite success rates ranging from 64% to 93%. A larger sample of clinicians and cadavers might have found a statistically significant difference related to the experience of the sonographers.

Also, despite the greater viscosity of the injected latex compared with the solution normally used, significant diffusion was observed along the trajectory of the nerve even with only 0.1 mL. When 3 mL of latex was injected at the level of the obturator internus muscle, it easily spread to the ischial spine and above. The different techniques seem hardly specific, and one may question the pertinence of testing different areas within the same patient to locate the precise location of the entrapment,

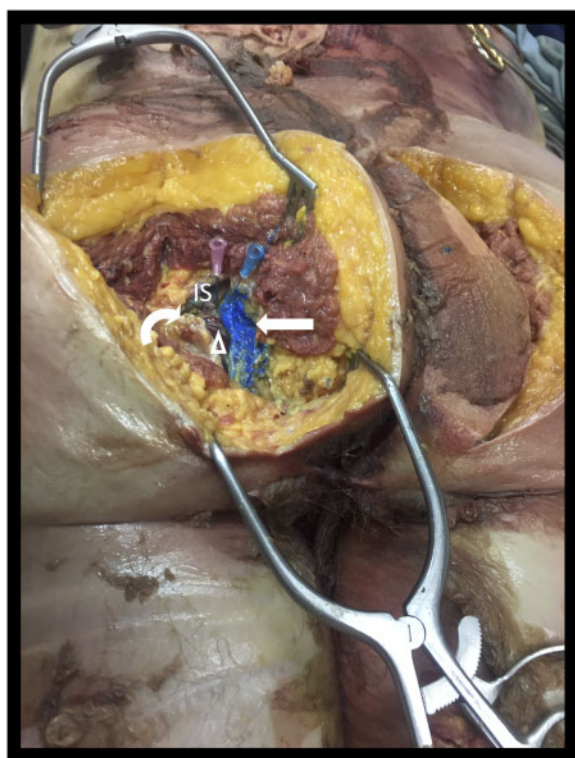


Figure 5. Dissection after injection with 3 mL of blue latex at Alcock's canal. When 3 mL of latex were injected at the level of the obturator internus, it easily spread to the ischial spine and above. PN: blue needle and arrow; ischial spine: pink needle; sacrotuberous ligament: sectioned, curved arrow; obturator internus muscle: void arrowhead. IS = ischial spine; PN = pudendal nerve.

especially considering the volumes of up to 10–12 mL injected in certain studies described below [9, 17].

Bellingham [14] compared the clinical response between US- and fluoroscopy-guided injections at the ischial spine (4 mL of bupivacaine vs 40 mg of methylprednisolone); there were no significant differences. Moreover, in about 20% of cases, no nerve block was achieved, with a significant proportion considering the large volume of anesthetics. Bendtsen [15] tested the clinical response, as defined by anesthesia in the territory of the pudendal nerve, in three patients with US-guided injections of 10 mL of ropivacaine at Alcock's canal, with a 100% success rate; they also used the same technique to inject dye in two cadavers (four nerves), with the same results. Both studies were done by experienced clinicians.

Limitations

The number of available cadavers was limited, and one was excluded from the study. Also, with an average body mass index of 18.8, the cadavers were thinner than our usual patient population. This is one reason why we were able to use only the linear 3–12-MHz probe, as opposed to the curvilinear probe that is mostly used in the clinical setting. Moreover, differences in the course [10] and size [2] of the nerve have been described, and hence only a subset of possible variations was addressed. However, we found that the number of procedures performed was adequate to assess the precision of the technique.

Using cadavers as models entails many advantages, such as the possibility of dissection after injection, but also involves underlying limitations from tissue deterioration, as well as absence of muscle and vascular tone. However, Thiel-embalmed cadavers maintain a very realistic tissue consistency, allowing for US imaging that is very similar to imaging obtained on fresh cadavers. Therefore, such bodies are deemed adequate for the purpose of these studies.

Conclusions

US-guided injection of the PN can be performed accurately at both the ischial spine and Alcock's canal levels. Furthermore, it appears that professionals with varying levels of experience can perform the procedure. However, the accuracy of US-guided PN injection is not

Table 2. Injection accuracy by clinician and by approach

Location	Successful Injections		Mean Success (Clinician; N = 14), %
	Alcock's Canal (N = 7)	Ischial Spine (N = 7)	
Clinician 1 (12 y of experience), No. (%)	5 (71.4)	6 (85.7)	79
Clinician 2 (5 y of experience), No. (%)	7 (100)	6 (85.7)	93
Clinician 3 (1 y of experience), No. (%)	5 (71.4)	4 (57.1)	64
Mean success (technique), %	81	76	78

perfect and creates a possibility of false negatives, and this might be even more important with less experienced sonographers.

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