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Pudendal nerve neurolysis outcomes for urogenital and rectal disorders in patients suffering from pudendal nerve entrapment: A systematic review

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Purpose: Pudendal neuropathy is an uncommon condition that exhibits several symptoms depending on the site of nerve entrapment. This study aims to evaluate the efficacy of pudendal nerve neurolysis (PNN) in improving lower urinary tract symptoms, anal and/or urinary incontinence, and sexual dysfunctions.

Materials and Methods: A systematic literature search was performed on 20 May 2023 using Scopus, PubMed, and Embase. Only English and adult papers were included. Meeting abstracts and preclinical studies were excluded.

Results: Twenty-one papers were accepted, revealing significant findings in the field. The study identified four primary sites of pudendal nerve entrapment (PNE), with the most prevalent location likely being at the level of the Alcock canal. Voiding symptoms are commonly exhibited in patients with PNE. PNN improved both urgency and voiding symptoms, and urinary and anal incontinence but is less effective in cases of long-standing entrapment. Regarding sexual function, the recovery of the somatic afferent pathway results in an improvement in erectile function early after neurolysis. Complete relief of persistent genital arousal disorder occurs in women, although bilateral PNN is necessary to achieve the efficacy. PNN is associated with low-grade complications.

Conclusions: PNN emerges as a viable option for addressing urinary symptoms, fecal incontinence, erectile dysfunction, and female sexual arousal in patients suffering from PNE with minimal postoperative morbidity.

Keywords: Erectile dysfunction; Lower urinary tract symptoms; Pudendal nerve entrapment; Pudendal nerve neurolysis; Pudendal neuralgia

INTRODUCTION

Pudendal nerve entrapment (PNE) syndrome is a rare condition characterized by chronic perineal pain caused by repetitive microtrauma to the pudendal nerve, resulting in irritation or injury. Patients often describe a burning sensation, but tingling, stabbing, and twitching sensations can also occur. Symptoms typically worsen when sitting and improve when standing or lying down [1]. The incidence of this disease remains unclear due to its poor identification. The

International Pudendal Neuropathy Association suggests a rate of one case per 100,000 individuals in the general population [2]. PNE is a type of tunnel syndrome caused by nerve entrapment, which can occur below the piriformis muscle, at the entrance of the Alcock canal, or along the nerve branches. In most cases, entrapment occurs between the sacrotuberous and sacrospinous ligaments [3]. As a result, various clinical presentations arise depending on the affected area of entrapment. Nociceptive stimuli can affect different regions such as the penis, scrotum, labia, perineum, and anorectal region [4].

Due to the limited success rate of conservative and medical therapies, pudendal nerve neurolysis (PNN) was introduced by Robert et al. [5] in 1993 as a potential treatment. According to the updated European Association of Urology guidelines, nerve decompression through PNN is particularly recommended for carefully selected patients who have failed conservative therapies for chronic pelvic pain associated with PNE [6]. Nerve decompression is the only option that ensures long-term outcomes [7].

Minimally invasive surgery has been introduced for pudendal nerve surgery, offering reduced operative time and a lower risk of postoperative complications. By using the robot-assisted technique, the Numeric Pain Rating Scale showed a reduction from 8 to 4 after 6 months, accompanied by a general "much improved" Patient Global Impression of Change [8]. These benefits also extend to symptoms related to the genitourinary sphere. A recent review demonstrated that most cases of pudendal neuralgia achieved full recovery of potency after PNN, suggesting a potential correlation between pudendal neuralgia and erectile dysfunction (ED) [9]. Aoun et al. [9] also reported that PNE could be a cause of premature ejaculation, and treatments involving the pudendal nerve (nerve block), or its penile dorsal branch (neuromodulation or resection) resulted in a satisfactory increase in intravaginal ejaculatory latency time and sexual satisfaction. As this nerve consists of sensory and motor fibers converging in structures vital for fecal and urinary continence [10], PNE also leads to other urogenital symptoms, such as urgency and voiding symptoms.

We aim to perform a systematic review to assess the effectiveness of PNN on lower urinary tract symptoms (LUTS), anal and/or urinary incontinence, and sexual dysfunctions, while evaluating the most common sites of PNE.

EVIDENCE ACQUISITION

1. Literature search
A broad literature search was performed on May 20, 2023, using PubMed, Scopus, and Embase using the following terms and Boolean operators: (release OR neurolysis OR decompression) AND (pudendal) AND (entrapment OR neuralgia OR nerve OR injury).

2. Studies identification and selection
The PICOS model (Patient Intervention Comparison Outcome Study type) was used to frame and respond to the clinical question; P: adult patients with PNE; I: transgluteal, transperineal or minimally invasive PNN; C: No intervention or none; O: Site of pudendal nerve compression, and resolution or improvements in LUTS, anal or urinary incontinence, and sexual dysfunction; S: observational studies. We included only adult studies that were published in English. Preclinical and animal studies were excluded, as were review articles, letters to the editor, and meeting abstracts. Two independent authors screened all retrieved studies using Covidence Systematic Review Management® (Veritas Health Innovation). A third author resolved conflicts.

EVIDENCE SYNTHESIS

1. Literature screening
The initial literature search yielded a total of 723 papers. After removing 360 duplicates, we screened the remaining 363 papers based on titles and abstracts. Among these, 293 papers were found irrelevant to the purpose of this review and were excluded. Finally, 70 full-text papers underwent further screening for appropriateness, leading to the exclusion of 49 additional papers. Finally, 21 papers met the inclusion criteria and were included [11-31]. Fig. 1 shows the flow diagram of the literature screening.

2. Study characteristics
Among the included studies, 7 were retrospective [12,14,19,23,24,27,31], 8 were prospective [11,13,15,16,20,21,25,29], and 6 were case reports [17,18,22,26,28,30]. No randomized trials were identified. The surgical techniques employed varied, with 8 studies utilizing minimally invasive surgery [12,15,18-20,23,29,30], while the remaining ones used transgluteal or transperineal open PNN [11,13,14,16,17,21,22,24-28,31]. Six studies assessed the specific site of PNE [11-16]. LUTS was evaluated in 5 studies [15,17-20], anal or urinary incontinence in 6 studies [13,19,21-24], and sexual dysfunction in 11 studies [16,17,19,22,25-31]. Table 1 shows the characteristics of the included papers.
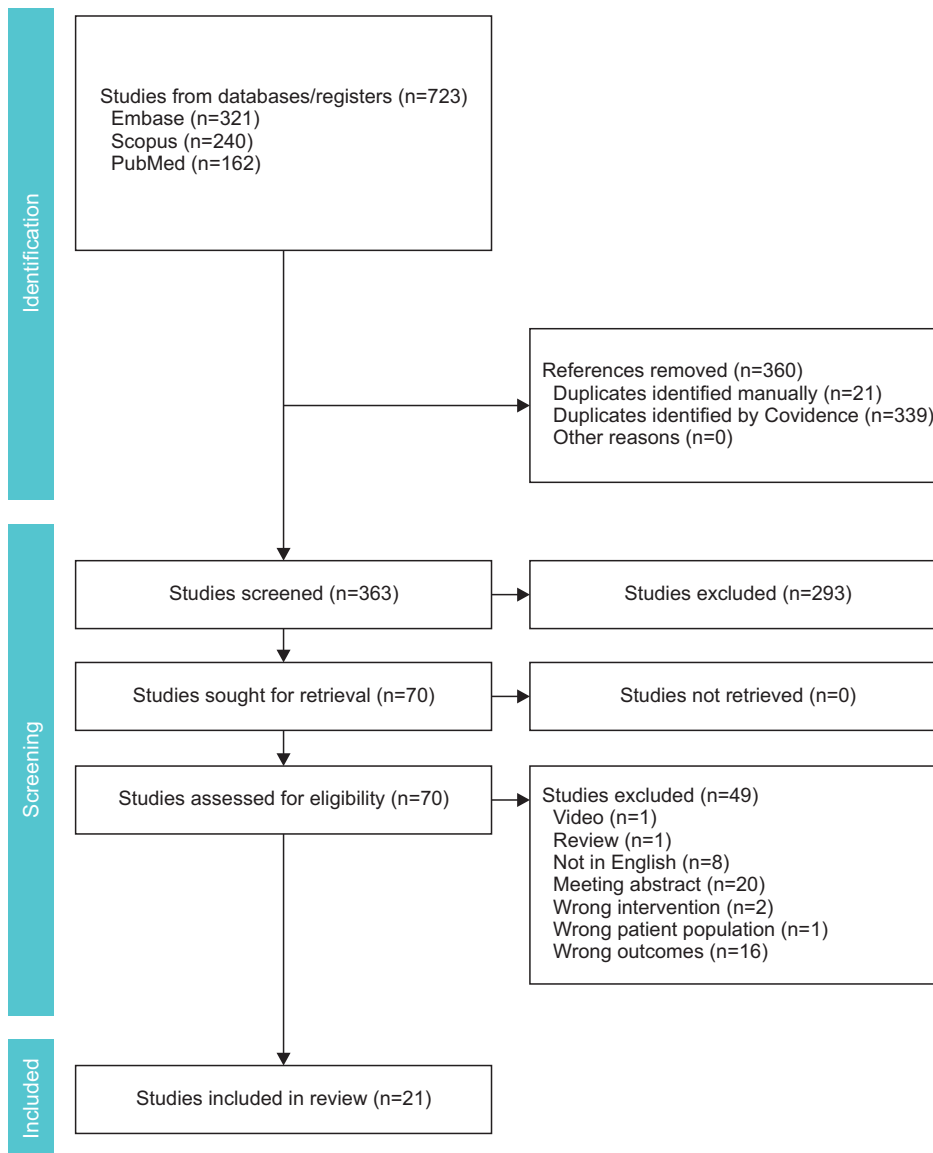
DISCUSSION

1. The evaluation of the site of PNE

Compression, transection, or stretching of the pudendal nerve are commonly reported and can occur through entrapment in Alcock's canal [32]. The pudendal nerve can be entrapped at various anatomical levels, causing chronic pain in the perineum, genitals, and anorectal region. The pudendal nerve originates from the sacral spinal nerves at S2–S4 level, exits the pelvis through the greater sciatic foramen, and then turns around the sacrospinous ligament to enter the perineum through the lesser sciatic foramen. It passes through the Alcock canal, along with the pudendal vein and artery [33]. Using physical examination maneuvers and diagnostic imaging such as magnetic resonance (MR) neurography and open MR image-guided injections, Filler [11]

identified four main locations of entrapment during the pudendal pathway, that reflect the four principal types of the pudendal neuralgia.

- Type I: Entrapment below the piriformis muscle as the pudendal nerve exits the greater sciatic notch.
- Type II: Entrapment between sacrospinous and sacrotuberous ligaments.
- Type III: Entrapment in the Alcock canal, medially to the internal obturator muscle. This category is divided into 2 subtypes: Type IIIa when it is involved only the internal obturator or IIIb when both the internal obturator and piriform muscles are involved.
- Type IV: Entrapment of terminal branches of pudendal nerve.

Among these sites, the authors identified type III entrapment in the Alcock canal as the most common cause of PNE

Table 1. Studies concerning the specific site of pudendal nerve entrapment (PNE) or the impact of pudendal nerve neurolysis (PNN) on functional outcomes

Study	Country	Type of study	No. of patients	Type of disorder	Bilateral cases, n (%)	Approach technique	Postoperative complications	Follow-up (mo)	Final considerations
Filler [11] (2009)	USA	Prospective	200	Disruption of sensation or function in the perineum, genitalia, or rectum	-	Open transgluteal	Re-surgery for hemostasis: 1	12	The identification of the specific site of PNE and the tailored surgical approach result in improved postoperative functional outcomes.
Lemos et al. [12] (2021)	Brazil	Retrospective	63	-	-	Laparoscopic	PN transection: 1 (1.5%); ON tear: 1 (1.5%); ureteral injury: 1 (1.5%); GF neuropathy: 2 (3.0%); incisional hernia: 1 (1.5%); rectovaginal fistula: 1 (1.5%); piriformis muscle adhesion to the sciatic nerve requiring a transgluteal neurolysis: 1 (1.5%)	12	Laparoscopic PNN is an effective and reproducible PNE and a tempestive surgery is required to increase the success rate.
Mauillon et al. [13] (1999)	France	Prospective	12	Anal, genital pain, or both	7 (58)	Open transgluteal	-	21	The transgluteal PNN is effective. Improvement pudendal neuralgia.
Ploteau et al. [14] (2017)	France	Retrospective	100	-	45 (45)	Open transgluteal	-	-	The transgluteal approach is considered the most effective method as it successfully addresses PNE in over 70% of cases, primarily located between the sacrospinous and sacrotuberous ligaments.
Possover and Forman [15] (2015)	Switzerland	Prospective	97	Urogenital pain	-	Laparoscopic	None	24	Minimally invasive surgery guarantees a high success rate, minimizing the morbidities.
Dellon et al. [16] (2015)	USA	Prospective	55	PGAD, rectal or iatrogenic pain	-	Open transgluteal in case of rectal pain; open transperineal in absence of rectal pain	-	14	Site-specific surgical approach determines a long-term improvement of functional outcomes.
Armstrong and Vancaillie [17] (2016)	Australia	Case report	1	LUTS, PGAD, constipation	1	Open+sacral neuromodulation	-	6	The combination of the two techniques improves the chronic pudendal symptoms.
Kale et al. [18] (2021)	Türkiye	Case report	1	LUTS, dyspareunia	1	Laparoscopic	None	6	Laparoscopic PNN completely resolved the urogenital disorders.
Bollens et al. [19] (2021)	Belgium	Retrospective	235	LUTS, rectal symptoms, erectile dysfunction	-	Laparoscopic	Genital numbness: 36 (15.3%); urinary retention: 1 (0.4%); transient anal incontinence: 2 (0.9%); lymphocele: 1 (0.4%)	24	Laparoscopic approach determined an improvement in pain, ED, constipation, and dysuria. However, no difference in storage symptoms and SUI was noted.
Aoun et al. [20] (2021)	Belgium	Prospective	5	LUTS	-	Laparoscopic	-	3	Laparoscopic PNN in male patients with refractory LUTS determined an amelioration of IPSS and urinary flow, determining an improvement in overall quality of life.
Shafik [21] (1994)	Egypt	Prospective	12	SUI	-	Open transperineal	None	18	In almost all patients who underwent PNN, an improvement in SUI was reported, as evidenced by electromyography, along with the resolution of genital paresthesia.
Ayık et al. [22] (2021)	Türkiye	Case report	1	Urinary incontinence, ED	1	Open transgluteal+open transperineal	-	12	Selective debridement of the branches of the pudendal nerve has been associated with an improvement in functional outcomes.
Shafik [23] (1997)	Egypt	Retrospective	9	Anal and urinary incontinence	9	Laparoscopic	None	21	Laparoscopic PNN is a safe procedure, loosening efficacy in long-term symptoms.
Beco et al. [24] (2004)	Belgium	Retrospective	74	Anal and/or urinary incontinence	74	Open transgluteal	Anemia: 1 (1.3%)	12	After surgery, the anal, stress urinary and urge incontinence were resolved or improved in most cases.
Shafik [25] (1994)	Egypt	Prospective	7	ED	7	Open transperineal	None	20	The transperineal approach determined a resolution or an improvement of ED, with reduction in bulbocavernosus reflex latency and pudendal nerve terminal motor latency.

Table 1. Continued

Study	Country	Type of study	No. of patients	Type of disorder	Bilateral cases, n (%)	Approach technique	Postoperative complications	Follow-up (mo)	Final considerations
Seckin et al. [26] (2005)	Türkiye	Case report	1	Erectile dysfunction and anal incontinence	-	Open transgluteal	-	24	The open PNN improved functional outcomes, particularly in sexual function rather than in the recovery of the anal sphincter.
Klifto and Dellon [27] (2020)	USA	Retrospective	7	ED and genital numbness	5 (71)	Open transperineal	Numbness: 1 (14.3%)	12	Neurolysis of the dorsal nerve to the penis led to the resolution of ED and loss of genital sensation.
Luther and Castellanos [28] (2019)	USA	Case report	1	ED and genital numbness	1	Open transgluteal in two times	None	24	Bilateral transgluteal PNN resolved long-term sexual dysfunction with no supplementary medical therapy.
Aoun et al. [29] (2021)	Belgium	Prospective	5	ED	-	Laparoscopic	Numbness: 1 (20.0%)	3	Laparoscopic PNN ensures prompt resolution of ED with a safe profile.
Maggi et al. [30] (2020)	Belgium	Case report	1	ED and genital numbness	-	Laparoscopic	None	24	Laparoscopic PNN determined a fast reprise of ED, with a complete PA revascularization.
Klifto and Dellon [31] (2020)	USA	Retrospective	8	PGAD	7 (87)	Open transperineal	None	7	Bilateral PNN resolved PGAD in most cases, unlike the unilateral approach.

PN, pudendal nerve; ON, obturatory nerve; GF, genitofemoral; PGAD, persistent genital arousal disease; LUTS, lower urinary tract symptoms; ED, erectile dysfunction; SUI, stress urinary incontinence; IPSS, International Prostate Symptom Score; PA, pudendal artery.

in their series (80%), with obturator internus spasm playing a significant role.

However, other authors have reported different incidences regarding the entrapment site. For example, Lemos et al. [12] found the most frequent site of entrapment was proximal to the S2–S3–S4 nerve roots (35% of cases), followed by the lateral sciatic/lumbosacral trunk (25% of cases), with only 8% of patients experiencing compression in the Alcock canal. These different results indicate the multiplicity and sometimes atypical clinical presentations of PNE.

Multiple sites of entrapment may be interested in determining variable clinical manifestations. Ploteau et al. [14] demonstrated that some patients may have bilateral entrapment sites, with the most common combination being compression at the ischial spine and the Alcock canal. A combination of all three major sites of entrapment can be present (i.e., intrapiriform foramen+ischial spine+Alcock canal), although this is an uncommon finding [14]. Moreover, pudendal neuralgia differs from other peripheral neuropathies since bilateral disease occurs in more than half of patients. Therefore, a same-sitting surgical treatment may need to be performed bilaterally as well in some patients [11,13,14].

The relationship between symptoms and the site of entrapment plays a role in choosing the appropriate surgical approach [11,15,16]. Filler [11] proposed four different minimally invasive procedures, each one targeting a specific site of entrapment, ranging from type I to type IV entrapment. Regarding the transgluteal approach, rectal symptoms assessment is fundamental to planning the appropriate surgical method, such as a "posterior transgluteal" approach in the presence of rectal symptoms or an "anterior inferior pubic ramus" approach [16]. On the other hand, a laparoscopic transperitoneal approach can be proposed for the diagnosis and management of intrapelvic causes of pudendal entrapment, from the sacral root to the Alcock canal [12,15]. The latter is considerably the best technique for exploring the pelvis and sacral plexus extensively and identifying all possible causes of pudendal neuralgia, including less common ones such as retroperitoneal disease or sacral nerve root S2 entrapment.

2. The role of PNN on LUTS

LUTS encompass a broad range of clinical presentations that are distinguished based on the phase of micturition involved, including both the filling and voiding phases. Micturition follows a complex mechanism influenced by various factors, regulated by the nervous control of the lumbosacral plexus, which includes the pudendal nerve. Indeed, the pudendal nerve becomes excited, as the bladder fills,

with subsequent external urethral sphincter contraction [34]. Therefore, it is not surprising to consider that pudendal neuropathy can also impair the micturition [35]. Diagnostic criteria have been introduced to help physicians in diagnosis of PNE, namely the Nantes diagnostic criteria [36]. The five essential criteria are (1) pain in the anatomical distribution territory of the pudendal nerve; (2) worsening pain by sitting; (3) the patient is not woken at night by the pain; (4) no objective sensory loss on clinical examination; (5) positive anesthetic pudendal nerve block. When certain symptoms fail to meet the Nantes diagnostic criteria, the potential for confusion arises, leading to delays and possible misdiagnosing of the neuropathy. Hence, it is essential to carefully evaluate and consider all related symptoms and their variations to ensure an appropriate and precise diagnosis.

Two case reports by Armstrong and Vancaillie [17] and Kale et al. [18] provide detailed information on specific types of LUTS. Both patients experienced urinary symptoms worsened by prolonged sitting or standing, including urgency and nocturia. The former patient underwent laparoscopic pudendal neurolysis, resulting in significant reduction of pain and cutaneous hyperesthesia and resolution of urinary frequency and nocturia after six months [17]. In the second case, bilateral surgical release of the pudendal nerve with neuromodulator insertion led to an improvement in LUTS, with only a slight persistence of urgency six months after surgery [18].

The role of compression sites in the manifestation of symptoms is of notable importance. Possover ane Forman [15] investigated the compression sites in 97 patients suspected of experiencing PNE. Patients underwent neurolysis and were examined using magnetic resonance imaging and Doppler ultrasound. The study identified three primary compression sites. Interestingly, not all patients exhibited LUTS. Out of the 97 patients with compression localized to the distal portion of the lumbosacral trunk between the terminal line and enlarged varicose veins, or the sciatic nerve just before entering the large sciatic notch, 86 experienced LUTS, with 24 cases of PNE at the lesser sciatic notch. Among them, 24% displayed symptoms of a urinary urgency. However, despite the reported high rate of improvement in neuralgia, the outcomes regarding the effect of PNN on LUTS were not described.

In a retrospective study by Bollens et al. [19], 235 patients underwent laparoscopic PNN, and 32 of them were followed up to 24 months after the intervention. The mean surgical time per side was 33.9 minutes, and minor postoperative complications were noted in 18.7% of patients. Complications included 36 cases (15.3%) of genital numbness, 1 urinary

retention (0.4%), 1 lymphocele (0.4%), and 2 transient anal incontinence (AI) (0.9%). Assessing LUTS related to bladder filling and voiding, a significant decrease from 4.2 to 1.9 in the Urgency Perception Scale was noted. Since no major complication occurred, the authors concluded that laparoscopic PNN is a safe and effective procedure for treating PNE.

Aoun et al. [20] prospectively examined LUTS refractory to medical therapy in young males who presented with some of the Nantes diagnostic criteria. The most commonly reported symptoms in this group were frequency, urgency, nocturia, and a sensation of incomplete emptying. At the 3-month follow-up after laparoscopic transperitoneal PNN, the median International Prostate Symptom Score decreased from 18 to 8, and the maximum urinary flow rate increased from 12 to 18 mL/s. However, there were no significant differences observed in median voided volume and post-void residual of urine before and after the procedure.

PNE should be considered a potential underlying cause in patients with LUTS refractory to medical therapy. Both transperitoneal and transgluteal surgeries seem to offer a safe and highly effective therapeutic option for patients experiencing debilitating pain and intractable LUTS that significantly impact their quality of life.

3. The role of pudendal neurolysis on urinary and AI

In pudendal canal syndrome, urinary and AI can be accompanied by various symptoms depending on the affected nerve branches. Compression of the inferior rectal nerve, which originates in the pudendal canal and supplies the external anal sphincter and levator ani muscle, leads to AI [37]. The inferior rectal nerve originates in the pudendal canal, emerging behind the ischial spine and then dividing into two terminal branches. The muscular branch of the perineal nerve provides innervation to the external urethral sphincter. Since the anal and urethral sphincters receive bilateral innervation, nerve decompression for the treatment of urinary and AI should be performed on both sides.

Two articles investigated the efficacy of pudendal neurolysis in isolated stress urinary incontinence (SUI). Initially, Shafik [21] reported a case series of 12 female patients who underwent transgluteal surgery for SUI. The mean operative time was 22.2 minutes for each side, and no postoperative complications were encountered. At 3–5 months follow-up, half of the patients achieved complete dryness, while the remaining experienced significant improvement. Only one case had persistent SUI. Additionally, an improvement in labia majora sensation and motor manifestations was observed

after 4 and 5 months, respectively.

In another case series by Bollens et al. [19], laparoscopic PNN was performed on 235 patients, four of whom had concomitant SUI. Although the surgery was successful in all patients, no significant differences were observed in the Urogenital Distress Inventory score for SUI and overactive bladder.

Regarding AI, Mauillon et al. [13] reported the outcomes of 12 patients who underwent transgluteal PNN. Among them, eight cases exhibited weakness in voluntary anal contraction, and three had AI. Surgery was unilateral in five and bilateral in seven patients. With a mean follow-up of 21 months, the success rate of PNN decreased from 58% to 33%. The authors suggested that the complete disappearance of pain for at least two weeks after two repeated nerve blocks before surgery might be the best criterion for predicting treatment success.

In some cases, PNE, SUI, and AI may coexist. Ayik et al. [22] reported a case with bilateral PNE following a pelvis fracture 27 years before. Proximal transgluteal PNN relieved rectal pain and resolved AI. A second surgery using a transperineal approach resulted in improved urinary continence.

In a case series by Shafik [23], nine patients with AI were treated; four of whom also had concomitant SUI. AI resolved in seven patients after a mean period of three months, while SUI resolved in two of them, occurring approximately two weeks earlier than the improvement in AI. Improved perianal sensation accompanied the restoration of fecal control, along with an improvement in electromyography activity. The two patients who did not show functional improvement presumably had advanced pudendal neuropathy. Nonetheless, in this series most of the patients achieved significant fecal control, which may be attributed to the laparoscopic technique providing improved exposure and easier management of the nerve in the ischiorectal fossa.

Finally, Beco et al. [24] retrospectively analyzed 74 females who underwent bilateral transgluteal PNN. Of these patients, 46 had AI, and 55 had SUI. Among those with AI, only 36 had a postoperative follow-up longer than one year, and among them, 23 (63.9%) were cured, while 7 (19.4%) showed an improvement in voluntary anal contraction. Concerning SUI, 37 patients had a postoperative follow-up longer than one year: 26 (70.0%) were completely cured, and 7 (18.9%) showed an improvement in continence. PNN resulted in resolution in 17 (62.9%) and improvement in 6 (22.2%) with urge incontinence.

4. The role of PNN on sexual dysfunction

The pudendal nerve plays a crucial role in penile erection. The somatic afferent pathway of the pudendal nerve innervates the glans and penile skin through both the peripheral and central components of the dorsal nerve pathway [38]. The somatic efferent pathway innervates the ischio- and bulbocavernosus muscles that surround the corporal bodies, while the autonomic efferent pathway innervates the smooth muscles surrounding the helicine arterioles and lacunar spaces, forming the pelvicavernous nerve pathway.

Historically, the open approach was performed to treat sexual disorders due to PNE.

In a study by Shafik [25], 323 patients who complained of ED were analyzed, and PNE was considered its cause in 7 men. These patients underwent bilateral surgical decompression of the pudendal nerves. Improvement in erectile function was observed in 3 patients within 2 to 3 months after the operation and in another 3 patients after 4 to 6 months. Within 12 months post-surgery, there was a significant reduction in bulbocavernosus reflex latency and pudendal nerve terminal motor latency in patients who showed improvement in erectile function; however, only 3 patients achieved normalized latencies.

Dellon et al. [16] conducted a prospective study to evaluate different surgical approaches for treating PNE in 55 patients. The selection of a transperineal or transgluteal surgical approach was based on the involvement of specific branches of the pudendal nerve. The posterior approach was chosen when rectal pain occurred, while the anterior approach in the absence of pain. A relationship between improvement in symptoms and the change in female sexual function and male penile function index was reported. The satisfaction score for the patients was excellent in 42% and good in 7% of cases. Failure occurred in 37% of patients. No differences were observed in outcomes between men and women, anterior and posterior approaches. Interestingly, the authors showed that untreated anxiety or depression was identified as a predictor of surgical failure in their series.

ED due to PNE can also be caused by traumatic events. Ayik et al. [22] reported a case of a bilateral crushed pudendal nerve in a patient with a pelvic fracture. The patient presented with painful erections. After open PNN, erectile function improved according to the International Index of Erectile Function (IIEF-5) score (from 9 to 22 points). The patient's general and sexual satisfaction scores improved as well. Similarly, in a case report of a gunshot injury [26], PNE was associated with pudendal artery entrapment. Immediately after the transgluteal PNN, angiography revealed

a restoration of normal vascularization in the pudendal artery. Although perineal hypoesthesia persisted for 3 months after surgery, erectile function was restored and maintained during the 2-year follow-up period. Klifto and Dellon [27] conducted a retrospective analysis of transperineal PNN in men who presented with loss of penile sensation, penile pain, and ED following a trauma of the dorsal branch of the pudendal nerve. Among the six men complaining of loss of penile sensation, complete recovery was observed in five patients according to the IIEF-5 score, while the remaining one experienced partial recovery. Two out of three patients with ED regained normal erections. Three out of six patients achieved complete pain relief, while the remaining ones showed a partial response. The median time for symptom improvement after surgery was six weeks. One patient experienced residual numbness as a complication.

Luther and Castellanos [28] presented a case report of a 39-year-old man who suffered from penile and perineal numbness (with no pain) and ED. The patient underwent unilateral left transgluteal PNN. After the sensory recovery in the left pelvic region six months after surgery, the patient underwent contralateral PNN. During the follow-up, the patient recovered sexual function and achieved resolution of AI and urinary frequency.

In the study by Bollens et al. [19] laparoscopic PNN demonstrated a significant improvement in erectile function with an increase of IIEF-5 score (from 15.2 to 19.3, p=0.036) after surgery in men suffering from ED.

Aoun et al. [29] performed laparoscopic PNN in 10 young men with ED resulting from PNE. Patients had a preoperative IIEF-5 score ≤16 and an erectile hardness score (EHS) ≤2. They were refractory to phosphodiesterase-5 inhibitors but maintained libido and exhibited an absent nocturnal penile tumescence. Five patients with ED from other causes were excluded. The mean duration of refractory ED in the remaining patients was 5 years. Significant differences were observed in mean IIEF-5 scores before and 3 months after treatment (13.0 vs. 18.8; p=0.017), as well as in mean EHS scores (2.0 vs. 3.4; p=0.046). Patients noticed an improvement in erectile function as early as 1-month post-surgery. No major postoperative complications were reported.

Maggi et al. [30] reported a case report of a patient with ED unresponsive to medical therapy secondary to PNE. The patient had an IIEF-5 score of 5 and underwent laparoscopic PNN. At 1-month postoperative follow-up, the patient reported improvement in erectile function, and tadalafil was discontinued. During the 2-year follow-up after surgery, there was a full recovery of sexual function.

Persistent genital arousal disorder (PGAD) is also associated with PNE, which is characterized by the perception in women of persistent and unrelated sexual arousal remaining after orgasm. Klifto and Dellon [31] described 8 women who underwent bilateral PNN of the dorsal branch. The most common location of nerve entrapment was found to be distal to the exit of Alcock's canal. Complete relief of symptoms for 7 patients occurred, while the other one experienced partial relief.

In a case report by Armstrong and Vancaillie [17], a 35-year-old woman presented with urinary, sexual, and gastrointestinal dysfunction associated with pain. The selected treatment was PNN along with the implantation of a combined sacral and pudendal nerve neuromodulator device. At 6-month follow-up, the patient was free from all pelvic pain except after intense physical activity, experienced complete relief of arousal sensations, and had only mild ongoing urinary urgency and frequency. Therefore, PGAD should be thoroughly investigated, and a diagnosis of PNE should be suspected, as it can cause significant stress in everyday life, leading to feelings of anxiety or guilt in affected women.

5. Take-home messages

Our review provides a succinct yet sound message to urologists managing patients with urinary or sexual disorders stemming from PNE. Given the prevailing evidence in the literature, four critical points have risen to prominence:

(1) Four primary sites of PNE have been identified, with the Alcock canal level being the most frequent location, although entrapment can coexist at various points.

(2) Patients with PNE frequently encounter voiding symptoms, and surgical intervention leads to an improvement in urgency perception and voiding symptoms.

(3) PNN plays a pivotal role in attaining dryness by resolving SUI and reinstating external anal sphincter functionality. Nevertheless, in the latter two effects, surgery seems to have reduced effectiveness in cases of long-standing disorders.

(4) Concerning sexual function, the recovery of the somatic afferent pathway culminates in an improvement in erectile function within the early months post-surgery.

6. Limits

There are limitations linked to the considered studies. Only a limited number of studies have evaluated the specific PNE site, and the most suitable technique based on the site has not been assessed. Furthermore, no comparative

studies have been conducted among the various available approaches concerning the resolution or enhancement of the various disorders associated with PNE. Finally, there is no randomized trials that assess disparities in functional outcomes in comparison to surgery and established standards of care.

CONCLUSIONS

The present systematic review analyzed the outcomes of surgical neurolysis in patients suffering from PNE. We found that PNN is a viable option for addressing LUTS, ED, AI, SUI, and female sexual arousal related to PNE. Minimally invasive surgery, such as laparoscopic or robotic-assisted neurolysis, demonstrated to be safe with minimal perioperative morbidity and should be offered in patients suffering from PNE refractory to conservative treatments. However, a meticulously designed randomized controlled trial is essential to determine the efficacy and safety of PNN on urogenital symptoms, thereby ensuring the robustness and reliability of our findings.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

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None.

AUTHORS' CONTRIBUTIONS

Research conception and design: Carlo Giulioni. Data acquisition: Lucia Pitoni, Demetra Fuligni, Virgilio De Stefano, and Daniele Castellani. Drafting of the manuscript: Carlo Giulioni, Lucia Pitoni, Demetra Fuligni, Mattia Beltrami, Valeria Passarella, Vanessa Palantrani, and Virgilio De Stefano. Critical revision of the manuscript: Carlo Giulioni and Daniele Castellani. Administrative, technical, or material support: Daniele Castellani. Supervision: Andrea Benedetto Galosi. Approval of the final manuscript: all authors.

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