Surg Radiol Anat (2009) 31:769–773
DOI 10.1007/s00276-009-0518-7

ORIGINAL ARTICLE

Surgical anatomy of the extrapelvic part of the pudendal nerve and its applications for clinical practice

Nicolas Pirro · Igor Sielezneff · Thomas Le Corroller · Mehdi Ouaissi · Bernard Sastre · Pierre Champsaur

Received: 19 December 2008 / Accepted: 16 May 2009 / Published online: 3 June 2009

Abstract
Purpose This study aims to report the topography of the extrapelvic part of the pudendal nerve (EPPN) and its relationship with the sacrospinous ligament and the pudendal artery.
Methods The pudendal nerve (PN) was dissected by a gluteal approach in 40 cases. The morphology of the EPPN, its topography and the relationship between the PN on the one hand, and the pudendal artery and the tip of the ischial spine on the other hand were reported.
Results The length and the diameter of the EPPN were identical on the right and on the left side. The PN was a single trunk in 3/4 of cases. The PN was medial to the pudendal artery in 32 cases and crossed the sacrospinous ligament in 32 cases and the ischial spine in 6 cases.
Conclusions The topographic variations of the EPPN are large and complicate its surgical and radiological approach.

Keywords Anatomic variations · Anatomy · Perineal innervation · Pudendal nerve · Transgluteal approach

Introduction

The pudendal nerve (PN) is a motor and sensory nerve innervating the urethral and anal sphincters and contributes to anal and urinary continence. The PN also innervates the perineal musculature and the perineal skin. The course of this nerve is complex, initially intrapelvic then extrapelvic in the gluteal area and further on in the perineal area. Along this path, the PN may be compressed especially in this extrapelvic part between the sacrotuberal and sacrospinous ligaments, resulting in persistent pain [16, 24].

Several reports have described the anatomy of the pudendal nerve. The course and topographic relationship have been variably reported. The purpose of this study was to report the topography of the pudendal nerve especially in this extrapelvic part, and to indicate its relationship with the sacrospinous ligament and the pudendal artery.

Materials and methods

Twenty unselected human adult cadavers (11 males), preserved in formalin ($n = 10$) or in Winckler's liquid ($n = 10$), were explored bilaterally. The mean age and mean weight of the cadavers were 84.51 ± 8.45 years (range 72–100) and 72.5 ± 10.6 kg (range 55–88). The pudendal nerve was dissected using a gluteal approach as described by Robert [16]. A skin incision was made parallel and 2 cm lateral to the lateral border of the sacrum, exposing the gluteus maximus muscle by reflecting an adipocutaneous flap. The gluteus maximus muscle was split in the line of its muscle fibers without being divided. The sacrotuberal ligament was stripped free of its muscular attachment and transected transversely at the level of the ischial spine, exposing the neurovascular pudendal bundle. The length of the extrapelvic portion of the pudendal nerve was measured between the inferior border of the pyramidal muscle and the pudendal canal. The number of trunks or branches at the level of the sacrospinous ligament was reported. The extrapelvic

N. Pirro (✉) · I. Sielezneff · M. Ouaissi · B. Sastre
Department of Digestive Surgery, Hôpital La Timone,
264 rue Saint-Pierre, 13385 Marseille Cedex 05, France
e-mail: nicolas.pirro@ap-hm.fr

N. Pirro · T. Le Corroller · M. Ouaissi · P. Champsaur
Department of Anatomy, Faculté de Médecine de Marseille,
Secteur Timone, 27 Bd Jean Moulin,
13385 Marseille Cedex 05, France

pudendal nerve was classified into three types: type I, where the nerve was a single common trunk; type II, where there were two separate trunks; and type III, where all three roots of the pudendal nerve were separate.

The morphology of the PN at the level of the ischial spine was noted as being either round or ribbonlike in configuration. The width (the long axis in the case of a non-circular cross section) of the pudendal nerve was measured at the level of the ischial spine. The relationship between the PN, the pudendal artery and the tip of the ischial spine was determined.

The pudendal nerve was dissected distally in the pudendal canal after incision of the overlying fascia in order to identify its terminal branches: the inferior rectal nerve, the dorsal genital nerve and the perineal nerve. The collateral branches of the PN in this extrapelvic part were systematically sought.

Diameter of PN was measured with a caliper square and length was measured with a measuring tape. The data obtained were subjected to statistical analysis (SPSS® version 8.0 software, SPSS Inc, Chigago, IL) by calculation of mean, standard deviation, range and *P* value using paired *t* tests for differences between the sides of the body and an unpaired *t* test for gender differences. *P* values less than or equal to an alpha level of 0.05 were considered statistically significant.

Results

Pudendal nerve dissection was hindered by the presence of a venous plexus, which was particularly well developed on three occasions (bilaterally for one subject). Reflection of the sacrotuberous ligament revealed a pudendal nerve trunk with a mean length of 38.6 ± 8.4 (range 22–55) mm on the right and 36.8 ± 7.8 (range 18–51) mm on the left-hand side ($P > 0.05$) before its division into 2–4 terminal branches. Type I was the most frequent ($n = 29$, 72.5%) (Fig. 1), type III being found on only a single occasion (Fig. 2). The mean diameter of the PN at the level of the ischial spine level was 3.4 ± 1.0 (range 2–6) mm on the right and 3.8 ± 1.4 (range 2–6) mm on the left side ($P > 0.05$). The pudendal nerve was ribbonlike in 17 cases (42.5%). Its configuration (round or ribbonlike) was found bilaterally in each cadaver with a single exception.

The PN was medial to the pudendal artery in 32 cases (80%) and lateral to the artery in 4 cases (10%). The artery was located between the 2 trunks of the PN in 1 case. In 3 cases (7.5%) the PN was crossed by the artery.

The PN crossed the sacrospinous in 32 cases (80%) and the ischial spine ligament in 6 cases (15%). In the remaining 2 cases, a multiple-trunked pudendal nerve crossed both the ischial spine and the sacrospinous ligament. No difference was noted between sides ($P > 0.05$). In 2 cases (5%) one trunk of the pudendal nerve pierced through the sacrotuberal ligament. The PN was accompanied along the whole of this extrapelvic path by a collateral branch in 3 cases (7.5%) (Fig. 3). The inferior rectal nerve arose from the extrapelvic part of the pudendal nerve in 5 cases (12.5%) either on the right ($n = 2$) or left ($n = 3$) hand side. In 2 cases the origin of the inferior rectal nerve was at the same level on the right- and left-hand sides. In no case did the other terminal branches of the pudendal nerve originate from its extrapelvic part.

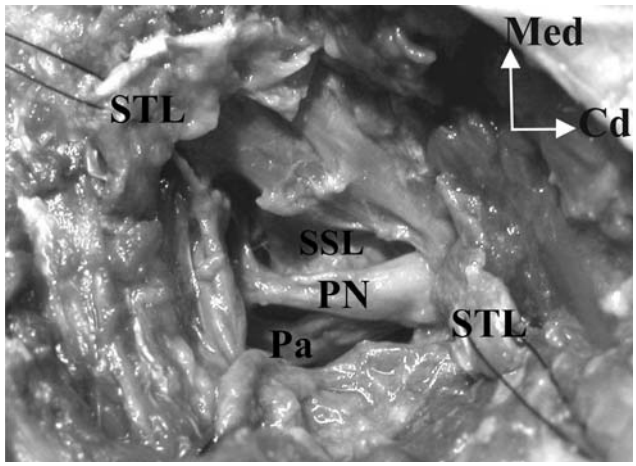

Fig. 1 Pudendal nerve type I posterior view, left side. *STL* sacrotuberous ligament transected and reclined, *PN* pudendal nerve, *Pa* pudendal artery, *SSL* sacrospinous ligament

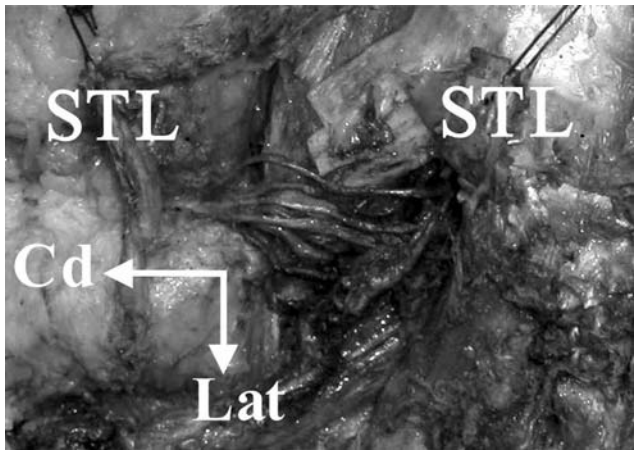

Fig. 2 Pudendal nerve type III posterior view, left side. *STL* sacrotuberous ligament transected and reclined

Discussion

Knowledge of the anatomy of the PN is of great importance in pelvic and perineal surgery. A good understanding of the course, branching pattern and variations of the PN is

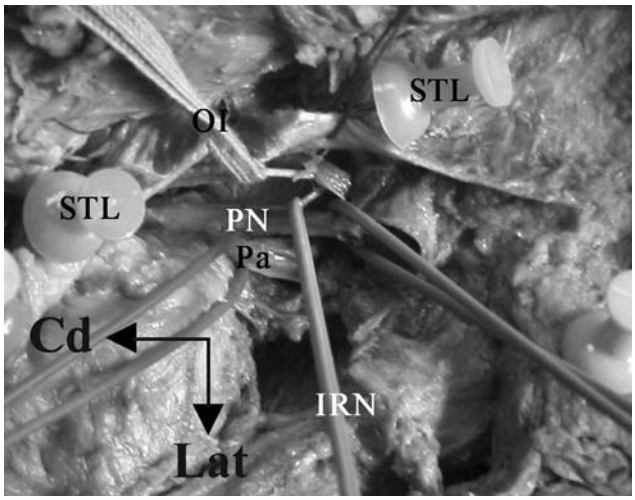

Fig. 3 Collateral branch of the PN in this extrapelvic part. *OI* landmark on the nerve to obturator internus muscle, *STL* sacrotuberous ligament transected and reclined, *PN* pudendal nerve, *Pa* pudendal artery, *IRN* landmark on the inferior rectal nerve

helpful in all procedures performed in the gluteal area or using the PN.

The pudendal nerve forms anteriorly to the lower part of piriformis muscle from the ventral divisions of sacral nerves S2, S3 and S4. It leaves the pelvic cavity through the greater sciatic foramen, inferior to the piriformis muscle, and enters the gluteal region. The pudendal nerve is posterior to the ischial spine and under the sacrotuberous ligament. It is medial to the pudendal vessels [4] and lateral to the rectal superior nerve. It passes around the sacrospinous ligament or ischial spine and into the perineum through the lesser sciatic foramen. As it enters the perineum, it lies on the lateral wall of the ischio-anal fossa in a compartment of fascia of the obturator internus muscle, the pudendal canal. The pudendal nerve has three major terminal branches: the inferior rectal nerve, the perineal nerve and the dorsal nerve of the penis or clitoris. The inferior rectal nerve continues medially across the ischio-anal fossa to innervate the external anal sphincter and related regions of the levator ani muscles. The nerve is also sensory for the skin of the anal area. In our study, we reported 25% of type II and 2.5% of type III. The dissection of the PN was performed by transgluteal approach and was made as much as possible towards the proximal part of the nerve. This approach does not allow to differentiate a very proximal origin of the rectal inferior nerve and a real type II/III. It may be a limit of this study.

Knowledge of the path and arrangement of the extrapelvic part of the pudendal nerve has many clinical applications. Infiltrations of the pudendal nerve and its branches using steroid or anesthetics are performed to treat certain chronic pelvic pains [20] and to carry out pudendal nerve blocks [27]. Neurolysis of the pudendal nerve may be performed in the setting of a nerve entrapment [10, 17]. Neuromodulation of either the pudendal nerve or its root or branches may be used to treat anal or urethral insufficiency [3, 8, 26, 28]. Recently, several studies reported procedures of sphincter reconstruction using the gluteus maximus muscle [21, 22] or gracilis muscle [12, 13] reinnervated by pudendal nerve anastomosis. Entrapment of the PN and injury of the neurovascular pudendal bundle are among the main dangers involved in the surgical procedures correcting post-hysterectomy vaginal vault prolapse by suspension to the sacrospinous ligament [1]. In each of these clinical settings a thorough knowledge of pudendal nerve variation is necessary for a satisfactory outcome.

The extrapelvic part of the pudendal nerve is generally a single trunk [4, 7, 14, 25] ranging, however, as low as from 29 [15] to 75% [14] (Table 1). The difference between sides expressed in left versus right ratios ranging from 1.2 [15] to 2.5 [14] is not reported in other studies [21–23]. None proposed any explanation for differences between sides [4, 15, 25]. Although multiple trunks may be combined using fibrin glue [2, 11] and anastomosed to the pudendal nerve, the existence of double or triple trunks of the PN may still be an obstacle to sphincter reconstruction by means of pudendal nerve anastomosis; epineuro-perineural suture remains the best method for peripheral nerve reconstruction [19].

The variation in the distribution of collateral branches of the pudendal nerve is also large. The inferior rectal nerve may arise directly from the pudendal plexus and have a course parallel to the pudendal trunk as reported by Robert [16], who does not state the frequency of such a variation. It may also arise from the pudendal trunk in this extrapelvic part [16]. Any comparison between studies is difficult because the definition of the same structure can differ from one study to another [16, 23].

The length of the extrapelvic part of the PN was in this study was 37.7 ± 8.1 mm (range 18–55) and is consistent with the PN length below the sacrotuberous ligament reported by O'Bichere [14] and Sato [21] (mean 24 and 29.5 mm). One branch of the PN may pierce through the sacrotuberous ligament [4] or through the sacrospinous ligament [4, 9, 18] with a frequency ranging from 11 [9] to 20% [18].

The tip of the ischial spine is an important landmark which may be used for infiltrations and surgical procedures. For Gruber [4] the PN was found both medial and lateral to the tip, within a range of 13.4 mm medial and 7.4 mm lateral to the tip of ischial spine; in a majority of cases it crossed the sacrospinous ligament medial to the tip (median, 2 mm). This is in contrast to Shafik et al. [24] who never observed the PN crossing the ischial spine in 20 newborn and adult cadavers. The different ages of the subjects in the studied groups might be an explanation for the

Table 1 Morphology of the extrapelvic part of the pudendal nerve

Author, year (type of study)	Number of cases (PN)	Type I (%)	Type II (%)	Type III (%)	Mean diameter ± SD (mm)	Mean length of the extrapelvic part of the PN ± SD (mm)
Mahakkanukrauh, 2005 [9] (A)	73	56.2	31.5	12.3	4.67[a] ± 1.17	25.14 ± 10.3
Gruber, 2001 [4] (A)	116	59.5	34.5	6	3.6[a] ± 1.1	
O'Bichere, 2001 [14] (A)	28	75	NR	NR	Right side 5.25 Left side 4.96	23.9 24.2
Schraffordt, 2004 [23] (A)	56	96	4	0	NR	NR
Gustafson, 2005 [5] (A)	12	75	25	0	3.2 ± 0.56	NR
Sikorski, 1987 [25] (A)	200	35	45.5	19.5	NR	NR
Olszewski, 1982 [15] (A)	NR	29	NR	NR	NR	NR
Kovacs, 2001 [7] (R)	106 (53 investigated by 2 examiners)	NR	NR	NR	5.5 ± 0.8	NR

A anatomical study, *R* in vivo radiological study using ultrasound (nerve only detected >3.5 mm), *NR* not reported, *SD* standard deviation

[a] Main trunk

absence of similarity between the studies. The use of ultrasound in order to detect the PN or the pudendal artery and the ischial spine directly may improve therapeutic access to the PN [4, 7]. In our study the PN crossed the sacrospinous in 80% of cases. This relationship can guide the approach for the infiltrations or blocks of the PN even if the injected drugs spreads within 2–3 cm from the injection point. A medial approach with regard to the top of the ischial spine must be preferred in case of "normal" ischiatic spine, while a more lateral approach must be preferred when the ischial spine is long. To decrease the risk of pudendal nerve entrapment during colposuspension type Richter's procedure, the sutures must be done medially in the sacrospinal ligament. A hypoaesthesia or pain in the territory of the pudendal nerve after colposuspension can indicate a transgluteal approach to release the wires and make the nerve free.

The PN diameters observed are consistent with those reported in literature (Table 1). A difference may be partly due to the measurement of either the major axis or the minor axis when the cross section of the nerve is not circular. Therefore, the mean diameter reported by Kovacs [7] using an ultrasound approach is greater than the mean diameter reported by anatomical studies [4, 5, 9, 14, 15, 23, 25]. This difference can constitute a limit of ultrasound approach. For O'Bichere [14] the mean pudendal nerve diameter was greater on the right than on the left. On the contrary for Gustafson [5] the mean pudendal nerve diameter was greater on the left than on the right. This might be explained by the dominance of one limb over the other in life but was not confirmed. The differences of size between the right and the left sides are common for all the peripheral nerve trunks. Further studies are required in order to investigate whether there is a correlation between the side on the one hand, and the diameter and number of trunks of the PN on the other hand, as this may condition the selection of possible reconstructive procedures.

The pudendal nerve was located medial to the pudendal artery and vein in all specimens in this study as well as in others [5]. However, Gruber [4] reported 8.6% of trunks positioned laterally to the artery, and 15.5% where a multiple-trunked pudendal nerve accompanied the artery on both sides. The pudendal artery may be a satisfactory landmark to approach the PN [6] which is located more often than not medially to the artery.

The variability in number and the variability in topography of the pudendal veins surrounding the extrapelvic part of the PN is important. For this reason we did not study the relationship between veins and PN. However, sometimes a venous plexus surrounds the pudendal nerve and complicates a gluteal approach [16]. In our study, a venous plexus which was particularly developed was reported in three cases without other venous dilatation in the pelvic or gluteal areas. Such huge veins surrounding the PN can reflect a chronic conflict.

Conclusion

Appropriate knowledge of the anatomy of the pudendal nerve in this extrapelvic part is critical to allow accurate approach and exposure to recognize potential variations, and to avoid damage during surgical procedures. Knowledge of the topographic relationship of the PN to the ischial spine and to the pudendal artery is also essential to approach this region and ensure the integrity of the PN and its branches, which contribute to perineal sensory, normal erectile and ejaculatory functions as well as urinary and anal continence.

References

1. Alevizon SJ, Finan MA (1996) Sacrospinous colpopexy: management of postoperative PN entrapment. Obstet Gynecol 88:713–715
2. Becker CM, Gueuning CO, Graff GL (1985) Sutures of fibrin glue for divided rat nerves: Schwann cell and muscle metabolism. Microsurgery 6:1–10
3. Groen J, Amiel C, Bosch JL (2005) Chronic pudendal nerve neuromodulation in women with idiopathic refractory detrusor overactivity incontinence: results of a pilot study with a novel minimally invasive implantable mini-stimulator. Neurourol Urodyn 24:226–230
4. Gruber H, Kovacs P, Piegger J, Brenner E (2001) New, simple, ultrasound-guided infiltration of the pudendal nerve: topographic basics. Dis Colon Rectum 44:1376–1380
5. Gustafson KJ, Zelkovic PF, Feng AH, Draper CE, Bodner DR, Grill WM (2005) Fascicular anatomy and surgical access of the human pudendal nerve. World J Urol 23:411–418
6. Juenemann KP, Lue TF, Schmidt RA, Tanagho EA (1988) Clinical significance of sacral and pudendal nerve anatomy. J Urol 139:74–80
7. Kovacs P, Gruber H, Piegger J, Bodner G (2001) New, simple, ultrasound-guided infiltration of the pudendal nerve: ultrasonographic technique. Dis Colon Rectum 44:1381–1385
8. Leroi AM, Parc Y, Lehur PA, Mion F, Barth X, Rullier E et al (2005) Efficacy of sacral nerve stimulation for fecal incontinence: results of a multicenter double-blind crossover study. Ann Surg 242:662–669
9. Mahakkanukrauh P, Surin P, Vaidhayakarn P (2005) Anatomical study of the pudendal nerve adjacent to the sacrospinous ligament. Clin Anat 18:200–205
10. Mauillon J, Thoumas D, Leroi AM, Freger P, Michot F, Denis P (1999) Results of pudendal nerve neurolysis-transposition in twelve patients suffering from pudendal neuralgia. Dis Colon Rectum 42:186–192
11. Palazzi S, Vila-Torres J, Lorenzo JC (1995) Fibrin glue is a sealant and not a nerve barrier. J Reconstruct Microsurg 11:135–139
12. Pirro N, Konate I, Sielezneff I, Di Marino V, Sastre B (2005) Anatomic bases of graciloplasty using end-to-side nerve pudendal anastomosis. Surg Radiol Anat 27:409–413
13. Pirro N, Sielezneff I, Malouf A, Ouaissi M, Di Marino V, Sastre B (2005) Anal sphincter reconstruction using a transposed gracilis muscle with a pudendal nerve anastomosis: a preliminary anatomic study. Dis Colon Rectum 48:2085–2089
14. O'Bichere A, Green C, Phillips RK (2000) New, simple approach for maximal pudendal nerve exposure: anomalies and prospects for functional reconstruction. Dis Colon Rectum 43:956–960
15. Olszewski J (1982) Variations of the pudendal nerve in man. Folia Morphol (Warsz) 41:245–252
16. Robert R, Prat-Pradal D, Labat JJ, Bensignor M, Raoul S, Rebai R et al (1998) Anatomic basis of chronic perineal pain: role of the pudendal nerve. Surg Radiol Anat 20:93–98
17. Robert R, Labat JJ, Bensignor M, Glemain P, Deschamps C, Raoul S et al (2005) Decompression and transposition of the pudendal nerve in pudendal neuralgia: a randomized controlled trial and long-term evaluation. Eur Urol 47:403–408
18. Roberts WH, Taylor WH (1973) Inferior rectal nerve variations as it relates to pudendal block. Anat Rec 177:461–463
19. Sames M, Blahos J, Rokyta R, Benes V (1997) Comparison of microsurgical suture with fibrin glue connection of the sciatic nerve in rabbits. Physiol Res 46:303–306
20. Sato T, Nagai H (2002) Sacral magnetic stimulation for pain relief from pudendal neuralgia and sciatica. Dis Colon Rectum 45:280–282
21. Sato T, Konishi F, Kanazawa K (1997) Anal sphincter reconstruction with a pudendal nerve anastomosis following abdominoperineal resection: report of a case. Dis Colon Rectum 40:1497–1502
22. Sato T, Konishi F, Kanazawa K (1997) Functional perineal colostomy with pudendal nerve anastomosis following anorectal resection: a cadaver operation study on a new procedure. Surgery 121:569–574
23. Schraffordt SE, Tjandra JJ, Eizenberg N, Dwyer PL (2004) Anatomy of the pudendal nerve and its terminal branches: a cadaver study. ANZ J Surg 74:23–26
24. Shafik A, el-Sherif M, Youssef A, Olfat ES (1995) Surgical anatomy of the pudendal nerve and its clinical implications. Clin Anat 8:110–115
25. Sikorski A, Olszewski J, Miekos E (1987) Anatomical considerations of selective pudendal neurectomy. Int Urol Nephrol 19:159–163
26. Spinelli M, Malaguti S, Giardiello G, Lazzeri M, Tarantola J, Van Den Hombergh U (2005) A new minimally invasive procedure for pudendal nerve stimulation to treat neurogenic bladder: description of the method and preliminary data. Neurourol Urodyn 24:305–309
27. Thoumas D, Leroi AM, Mauillon J, Muller JM, Benozio M, Denis P et al (1999) Pudendal neuralgia: CT-guided pudendal nerve block technique. Abdom Imaging 24:309–312
28. Uludag O, Morren GL, Dejong CH, Baeten CG (2005) Effect of sacral neuromodulation on the rectum. Br J Surg 92:1017–1023