INTRODUCTION

Compressive pudendal neuropathy is a frequent condition that is often ignored. Its incidence is approximately 1% in the general population and the condition probably affects women more than men. Because healthcare professionals lack an adequate method to diagnose accurately pudendal neuropathy, the affected individuals often embark on an endless quest for effective relief with serious physical and psychological consequences.

There are several possibilities of a treatment to diminish pain. The first line is conservative followed by infiltrations and, ultimately by surgical procedures. It is therefore important to identify precisely the site where the nerve is compressed. The classical approach consists of measuring pudendal nerve terminal motor latencies. Normal latencies, reported in the literature, vary from 2 to 5.35 msec. The measurement of the sacral reflex allows to narrow down the location of nerve compression. Electrophysiological data was obtained from 59 patients by measuring the healthy side and the pain-side (Fig. 1A). The stimulus may be delivered through an endo-vaginal insertion. In both cases, the examination consists of measuring the latency, i.e. the time elapsed between the moment of impulse delivery and the recorded potentials. When a nerve is compressed, its vascularization is compromised and consequently the nerve suffers. Nerve suffering has several consequences, including a decrease in nerve conduction velocity that affects both the motor fraction of the sacral reflex and the sensory transmission owing to the evoked somesthesic potentials. This decrease can be recorded as a prolonged latency period between the stimulus and the record points. In a pudendal nerve terminal motor latency measurement, the stimulation electrode is placed over the ischial spine usually by endo-rectal insertion. An impulse is delivered and a recording is made using a surface electrode placed on the perineal muscle, usually at the level of the anal sphincter (Fig. 1A). The stimulus may also be delivered through an endo-vaginal insertion. In both cases, the examination consists of measuring the latency, i.e. the time elapsed between the moment of impulse delivery and the record of the electric potential in the target region. By comparing the recorded latencies to normal values, it is possible to estimate the intraneural transmission capacity of the nerve.

Key words: Anatomy; Compressive neuropathy; Electrophysiology; External anal sphincter innervation; Pudendal nerve.
in the sacral plexus and runs above the levator ani muscle (on top of the pelvic floor) on the pelvic side and then innervates the iliococcygeus and pubococcygeus muscles as well as the upper part of the puborectalis.18-20 The pudendal nerve circumvents or perforates the sacrospinous ligament (formerly called small sacro-sciatic ligament) and enters between sacrospinous and sacrotuberous ligaments (formerly also called great sacro-sciatic ligament) into the perineum, also called “ligament clamp” as it constitutes a site for potential pudendal nerve compression. Nerve and blood vessels run within the ischiorectal fossa towards the anterior perineum and vascular-nervous elements enter the pudendal canal (also termed Alcock’s canal), that is constituted by duplication of the fascia of the internal obturator muscle, thus may also cause a nerve compression. The inferior rectal nerve classically innervates all parts of the anal sphincter, and separates from the pudendal nerve at the beginning of the pudendal canal and runs across the ischiorectal fossa towards the anal sphincter. In the middle of the pudendal canal, the pudendal nerve divides into two branches: the dorsal nerve of the clitoris and the perineal nerve, with both nerves traversing the pudendal canal in its entirety. The perineal nerves give off the sensory branches to the perineum as well as the motor branches for the perineal muscles and for the external anal sphincter. The dorsal nerve of the clitoris is a terminal sensory branch of the pudendal nerve.

Here, we confirm that the anterior and posterior quadrants of the anal sphincter are innervated by different branches and by different trajectories and provide several possible entrapments of parts of the nerves and consequently pudendal neuropathy. Because the afferent path of the dorsal nerve of the clitoris is always the same, it is theoretically possible to locate the site of compression with some precision by examining the different efferent paths. To confirm the validity of this assertion, we carried out an anatomical study aimed at determining:

i) the systematic presence of a nerve in the levator ani (pubococcygeus) muscles;
ii) the location of the dorsal nerve of the clitoris starting point relative to the main trunk;
iii) the presence of a starting point of the inferior rectal nerve that would be more proximal than what is described in the literature;
iv) to identify differences in the innervation of the anterior and posterior anal sphincter quadrants.

MATERIALS AND METHODS

We relied on 27 consecutive male and 49 female patients suffering from unilateral or bi-lateral pudendal neuropathy. The diagnosis was ascertained because symptoms disappeared after conservative treatment or surgery. We hypothesize that the absence of symptoms on the contralateral part was the guaranty of an intact pudendal anatomy. Also for ethical reasons we decided to use each patient as his own comparative and the healthy side as control value. Each patient had 3 measurements on each side meaning 6 values at all. The first record was the reference for the pubo-rectal muscle, the second was taken at the superior quadrant of the external anal sphincter and the third at the inferior quadrant of the external anal sphincter. The obtained values show that nerves may be affected differentially and exhibiting significantly higher electrophysiological values on the affected side than on the normal side. To ascertain that our hypothesis was correct, we decided to confirm the anatomical situation on cadavers. The seven corpses used in this study were obtained by the donation program to the Department of Cellular Biology and Morphology. All donors gave previously a written consent. The cadavers were perfused through the femoral artery with a mixture of 0.9 L of formaldehyde (38%), 0.5 L of phenol (85%), 1.0 L of glycerol (85%), 4.0 L of ethanol (94%) and 10.6 L of water. The cadavers, were stored at 8 °C until dissected by second year medical students as part of their training. Half pelvises that had not been dissected in the course were used to study the trajectories of the anal, pudendal and perineal nerves described in this work.

RESULTS

The nerve fibers for levator ani (pubococcygeus) muscle run directly from the sacral plexus, above the pelvic floor on the side of the levator ani and follow a different direction from the pudendal nerve (Figs. 2A and 2B). The pudendal nerve traverses the ligament clamp located between the sacrospinal and the sacrotuberal ligament in the lateral space of the ischiorectal fossa where nerves and vessels are surrounded by the fascia of the internal obturator muscle and form the pudendal canal. In one of the seven dissections performed, the pudendal nerve actually perforates the sacrospinal ligament. In five cases, the pudendal nerve divides into the dorsal nerve of the clitoris and perineal nerves after passing underneath the sacrospinous ligament but before entering the pudendal canal (Fig. 2C). The same anatomical section also shows that the dorsal nerve of the clitoris runs parallel to the pudendal canal. The neurovascular bundle within the pudendal canal gives rise to multiple perineal branches that branch off either at the point of entry into the ischiorectal...
fossa, inside the pudendal canal in the direction of the anal canal (sphincter) or the anterior perineum. In all of the dissections, the inferior rectal nerve originates prior to the entry into the ischiorectal fossa and runs straight towards the back of the anal canal, through the ligament clamp but not through the pudendal canal (Figure 2D).

The electrophysiological measurements of the staged sacral reflexes show a significant higher latency time of the ventral quadrant of external anal sphincter innervation, while the posterior or caudal quadrant was just slightly prolonged and levator ani innervation was unaffected (Fig. 3A-C).

DISCUSSION

Historically, the pudendal nerve has been investigated using terminal motor latency, a technique which is not very reliable. Indeed, because of the distance between the stimulation point and the nerve (approximately 1 cm), it is possible that the electrical impulse delivered at the point of contact with the ischial spine does not merely travel along the nerve but diffuses in the entire perineal region. Several investigators have made different contributions to the available tests. The levator ani nerve appears to be recognized as a distinct entity by all authors. Our work has shown that the levator ani is innervated by a nerve that originates in the sacral plexus. This nerve runs above the sacrospinal ligament and terminates in the pubococcygeus, the iliococcygeus, and the puborectalis muscles. This finding is supported by investigations carried out by Hallner who failed to find any pudendal nerve innervation of these muscles in 200 dissections. At the same time, it should be noted that a few authors have nevertheless proposed possible pudendal nerve innervation of the levator ani muscle. In most cases, these opinions are based on experiments in which this nerve was anesthetized at the level of the ischial spine, resulting in the paralysis of the levator ani muscle. The methodology of such experiments is however questionable: the anesthetic could have easily diffused towards the levator ani nerve, located less than 1 cm away from the anesthetic injection point. The dorsal nerve of the clitoris is classically described as a terminal branch of the pudendal nerve. However, in our dissections it often appears as a branch that is parallel to the pudendal nerve and that does not run through the pudendal canal. If this observation is correct, then the dorsal nerve of the clitoris can hardly be compressed, which explains the interest in using this nerve as an afferent branch in sacral reflex studies. An even bigger controversy surrounds the inferior rectal nerve. Certain authors believe that it originates at the beginning point of the pudendal canal, with some variations. Thus, its origin may be independent with or without an anastomotic branch from the perineal nerve. Moreover, the inferior rectal nerve may perforate the sacrospinal ligament in its middle portion at an approximate distance of 1 cm from the ischial spine, extending to a distance of up to 1.5 cm. Other investigators estimate that 60% of
Interventions.

More precisely, infiltration treatments or to start surgical treatments. Staged sacral reflexes is introduced and should lead to apply physiological examinations of the three zones. The concept of muscular innervations of the anterior and posterior parts of the external anal sphincter muscle as well as for the pubococcygeus muscle. It may be possible to better identify the site of innervation are important from both the clinical and electromyographical points of view. Indeed, one branch is the inferior rectal nerve that branches off very early (proximally) and runs parallel to the nerve, but is not located in the pudendal canal and no longer at risk for compression. This nerve terminates in the posterior hemi-sphincter. A second branch that innervates the anterior hemisphincter appears to originate from a more distal region, i.e. the perineal branch of the pudendal nerve. It is thus subject to compression at the level of the ligament clamp and the pudendal canal or the falciform process. In other words, we believe that it is anatomically correct to postulate that the anterior and posterior anal sphincter quadrants as well as the pubococcygeus muscle all have separate and distinct innervations that may explain the differences with the classical descriptions in literature. The first innervation network originates from the inferior rectal nerve itself, while the second network is generated by the pudendal nerve via perineal branches. We believe that the multiple origins of innervation are important from both the clinical and electromyographical points of view (Fig. 3A-C).

CONCLUSION

Our anatomical study confirms the existence of separate innervations of the anterior and posterior parts of the external anal sphincter muscle as well as for the pubococcygeus muscle. It may be possible to better identify the site of compression of the pudendal nerve by separate electrophysiological examinations of the three zones. The concept of staged sacral reflexes is introduced and should lead to apply more precisely infiltration treatments or to start surgical interventions.

ABBREVIATIONS

LAN: levator ani nerve; PNA: pudendal nerve afferents; PNE: pudendal nerve efferents; MT: medullar transfer; SC: spinal cord.

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