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PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIA E SAÚDE ANIMAL

Kath Freire de Vasconcelos

Bases anatômicas para o bloqueio do nervo pudendo em gatos (*Felis catus* Linnaeus, 1758) – estudo cadavérico

Patos/PB
2019

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Tese submetida ao Programa de Pós-Graduação em Ciência e Saúde Animal, da Universidade Federal de Campina Grande, como requisito parcial para obtenção do grau de Doutor em Ciência e Saúde Animal.

Prof. Dr. Pedro Isidro da Nóbrega Neto

Prof. Dr. Gildenor Xavier Medeiros

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Tese submetida ao Programa de Pós-Graduação em Ciência e Saúde Animal da Universidade Federal de Campina Grande, como requisito parcial para obtenção do título de doutora em Ciência e Saúde Animal.

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RESUMO

Estudos demonstraram que o bloqueio do nervo pudendo confere analgesia peniana e uretral tanto para a realização de procedimentos ambulatoriais quanto cirúrgicos. Para a sua realização, no entanto, o conhecimento anatômico é fundamental. Apesar disso as informações anatômicas disponíveis sobre ele não são homogêneas e carecem de dados. Dada sua importância clínica objetivou-se com a realização desta pesquisa analisar os aspectos anatômicos da topografia do nervo pudendo e descrever e avaliar a exequibilidade de duas técnicas de acesso ao nervo pudendo em cadáveres de felinos domésticos. No estudo anatômico utilizaram-se no total 17 cadáveres e para a descrição das duas técnicas de acesso ao nervo pudendo foram empregados, respectivamente, 27 e 16 cadáveres, que foram distribuídos em diferentes fases. No estudo anatômico observou-se que o nervo pudendo se originou do primeiro e segundo nervos sacrais ventrais e que ele apresentou uma curvatura lateral imediatamente caudal ao músculo piriforme e estreitamente relacionada com a espinha isquiática. Na descrição da primeira técnica observou-se que o nervo pudendo poderia ser acessado por meio da introdução, por 27 mm, de uma agulha imediatamente dorsal à tuberosidade isquiática e paralela ao plano transversal. Na descrição da segunda observou-se que o nervo pudendo poderia ser acessado introduzindo-se uma agulha, por 22 mm, entre o ponto cranial e médio de uma reta imaginária ílio-isquiática, formando a agulha um ângulo de 48º com esta reta e de 26º com o plano sagital. Na avaliação da exequibilidade da primeira técnica observou-se que o corante foi depositado dorsalmente à espinha isquiática e que o nervo pudendo foi corado bilateralmente em 67% dos cadáveres. Nas avaliações da segunda observou-se que houve marcação bilateral do nervo pudendo ou de seus fascículos em 100% dos cadáveres. Estes resultados ampliam o conhecimento anatômico sobre o nervo pudendo e demonstram a exequibilidade de seu acesso.

PALAVRAS-CHAVE: Anestesia; Locorregional; Perineural; Felino; Nervo Pudendo.

ABSTRACT

Studies have shown that blocking the pudendal nerve confers analgesia to the perineum and urethra for performing both outpatient and surgical procedures. For this, however, anatomical knowledge is fundamental but the anatomic information available about it is not homogeneous and lacks data. Due to its clinical importance, the objective of the present research was to analyze the anatomic aspects of the pudendal nerve topography and describe and assess the practicality of two techniques to access the pudendal nerve in domestic feline cadavers. A total of 17 cadavers was used in the anatomic study and 27 and 16 corpses were used, respectively, to describe the two access techniques to the pudendal nerve, that were distributed in different phases in the anatomic study. It was observed that the pudendal nerve originated in the first and second ventral sacral nerves and that it presented an immediate lateral caudal curve to the periformis muscle and was directly related with the ischial spine. The description of the first technique showed that the pudendal nerve could be accessed by introducing, for 27 mm, a needle immediately dorsal to the sciatic tuberosity and parallel to the transversal plane. The description of the second technique showed that the pudendal nerve could be accessed by introducing a needle, for 22 mm, between the cranial and midpoint of an imaginary ilio-ischemic straight line, the needle forming a 48° angle with the straight line and a 26° angle with the sagittal plane. The assessment of the practicality of the first technique revealed that the stain was deposited dorsally to the ischial spine and that the pudendal nerve was stained bilaterally in 67% of the cadavers. In the assessment of the second technique it was observed that there was bilateral marking of the pudendal nerve, or of its first sequence, in 100% of the cadavers. These results increase anatomical knowledge on the pudendal nerve and demonstrate the practicality of its access.

KEY-WORDS: Anesthesia; Local regional; Perineural; Feline; Pudendal Nerve.

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SUMÁRIO

INTRODUÇÃO

Em felinos o bloqueio anestésico do nervo pudendo pode conferir analgesia uretral e peniana tanto para a realização de procedimentos ambulatoriais, como a sondagem vesical, quanto cirúrgicos, como a uretrostomia perineal (ADAMI et al., 2014; VASCONCELOS et al., 2018). Seu emprego reveste-se de importância pois felinos submetidos a estes procedimentos geralmente apresentam uma série de alterações metabólicas que, associadas às alterações promovidas pela maioria dos fármacos que compõem o arsenal anestesiológico, podem culminar em morte e as técnicas locorregionais, de maneira geral, podem minimizar este risco (SOUZA, 1998; SKARDA e TRANQUILLI, 2007; O'HEARN e WHIGTH, 2011; MARTIM et al., 2011). Apesar da sua importância, o bloqueio do nervo pudendo em gatos foi descrito pela primeira vez apenas em 2013, por Adami et al. (2013). Atualmente existem três técnicas de bloqueio do nervo pudendo descritas para utilização em gatos: a técnica descrita por Adami et al. (2013, 2014), que bloqueia apenas o ramo sensitivo do nervo pudendo; a técnica descrita por Moraes, Beier e Rosa (2013), que carece de estudos comprobatórios; e a técnica descrita por Vasconcelos et al. (2018), que embora tenha apresentado bons resultados clínicos, não é subsidiada por um estudo anatômico.

Para que a descrição e realização das técnicas de bloqueio do nervo pudendo possam ser realizadas, o conhecimento anatômico acerca deste é fundamental. No entanto, as informações disponíveis até o momento sobre ele, em felinos domésticos, ainda são divergentes. Adami et al. (2013), por exemplo, informam que o nervo pudendo é um nervo multifasciculado que surge da convergência de dois nervos sacrais ventrais (S1 e S2). Dellman e McClure (1975) o descrevem como sendo formado pela congruência dos ramos sacrais ventrais do segundo e terceiro nervos sacrais, e que pode ou não receber um pequeno ramo inconstante do primeiro. Yoo, Woock e Grill (2008) informam que o nervo pudendo se bifurca em dois ramos ao nível da fossa isquiorretal: o ramo sensitivo e o ramo retal-perineal; enquanto Dellman e McClure (1975) informam que ele se subdivide no ramo perineal profundo e no nervo dorsal do pênis. Alguns autores ainda fornecem informações que não foram relatadas por outros, como Adami et al. (2013) que observaram que o ramo retal-perineal tem origem específica do segundo nervo sacral ventral.

Diante da importância do nervo pudendo para o manejo clínico e cirúrgico de algumas patologias e das informações conflitantes acerca da sua anatomia, objetivou-se com a realização desta pesquisa analisar os aspectos anatômicos da topografia do nervo pudendo e descrever e

avaliar a exequibilidade de duas técnicas de acesso anestésico ao nervo pudendo em cadáveres de felinos domésticos.

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CAPÍTULO I:

Anatomic characterization of the pudendal nerve in cats (*Felis catus* Linnaeus, 1758) – a cadaver study

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CAPÍTULO I

Anatomic characterization of the pudendal nerve in cats (*Felis catus* Linnaeus, 1758) – a cadaver study

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Abstract

Objective: Analyze the anatomical aspects of the pudendal nerve topography in domestic cat cadavers.

Methods: Seventeen domestic cat cadavers were used. Seven cadavers (male) were used in the first phase of the research and 10 (eight males and two females) in the second phase. In the first phase the cadavers were dissected to describe the pudendal nerve origin, course and ramification. In the second phase measurements were taken, with and without radiography, taking as references the sciatic tuberosity, ischial spine and the curve made by the pudendal nerve, dorsal to the ischial spine.

Results: The first phase showed that the pudendal nerve was formed by the convergence of the first and second ventral sacral nerves, that it made a lateral curve immediately caudal to the piriformis muscle and that the rectal perineal branch emitted multiple branches and innervated

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different structures. In the second phase there was no difference among the data obtained, except in the comparison of the general means between the distance of the sciatic tuberosity to the curve formed by the pudendal nerve and the distance from the ischial spine to the sciatic tuberosity ($p = 0.0308$).

Conclusion and relevance: The data obtained demonstrated that the pudendal nerve originates from the first two ventral sacral nerves and that it presents an immediate lateral curve caudolateral to the piriformis muscle, that is a close to the ischial spine. This information provides more input than the current literature so that the pudendal nerve can be managed clinically more safety and also increases the information available about it and its branches.

Introduction

The pudendal nerve in cats is formed by the convergence of two ventral sacral nerves (S1 and S2).[1] It divides into two branches at the level of the ischiorectal fossa, the sensitive branch and the rectal perineal branch, that then divide and innervate several structures, including the urethra and the external urethral sphincter and pênis.[2]

Anatomical knowledge of the origin, course and structures innervated by the pudendal nerve is fundamental to perform procedures that involve it, such as surgeries[3] and anesthetic blocks.[1,4-7]

Literature on the anatomy of the domestic cat pudendal nerve, however, is scarce and not standardized. The Nomina Anatomica Veterinaria,[8] for example, does not mention the cat pudendal nerve, citing only anatomical peculiarities for pigs, ruminants, equines and dogs. Dellmann and McClure[9] reported the ramifications of the pudendal nerve and stated that it forks into a profound perineal nerve and dorsal nerve of the penis (males) while other authors[1,2,5,10] reported these structures as being part, respectively, of a rectal-perineal branch and a sensitive branch, which are the branches that originate directly from the pudendal nerve.

Due to the importance of the issue and the lack of more detailed information that could guide clinical management of the pudendal nerve, the anatomical aspects were analyzed of the topography of this nerve in domestic cats.

Material and Methods

The study was carried out after approval from the Committee of Ethics in Institutional Research, under protocol CEP 287/2015.

Cadaver origin and preservation

Seventeen adult crossbred domestic cat cadavers was used in the research, provided by

different public organizations. Seven cadavers (male) were used in the first phase of the research and 10 cadavers (eight males and two females) in the second.

All the cadavers were fixed and preserved in 10% formaldehyde, by intramuscular and intracavitary injection of this solution after thawing the cadavers.

First phase

In this phase the cadavers were dissected to describe the origin, course and ramifications of the pudendal nerve.

To visualize the pudendal nerve, an incision was made close to the perineum, around the base of the tail and on the midline, dorsal to the spinal vertebra processes, from the base of the tail to the cranial medial region of the iliac crest or cranial to this point and the skin was drawn back to the height of the knee (Figure 1). The fat in the ischiorectal fossa was removed to visualize the rectal perineal branch of the pudendal nerve (Figure 2).

Figure 1: Incision and skin removal performed on the domestic cat cadavers.

To better visualize the pudendal nerve, the gluteal fascia was removed and the gluteofemoral, abductor cruris caudalis, superficial gluteal, middle gluteus and piriformis muscles were sectioned and the perineural fat removed until the nerve could be visualized. The middle gluteus, deep gluteus, and cranial twin muscles were also removed to permit sectioning and removal of part of the iliac body and consequent visualization of the ventral sacral nerves.

Figure 3 shows the structures observed after removing the superficial muscles, the deep gluteus muscle and the iliac segment.

The dissections were all performed by the same researcher (K.F.V.).

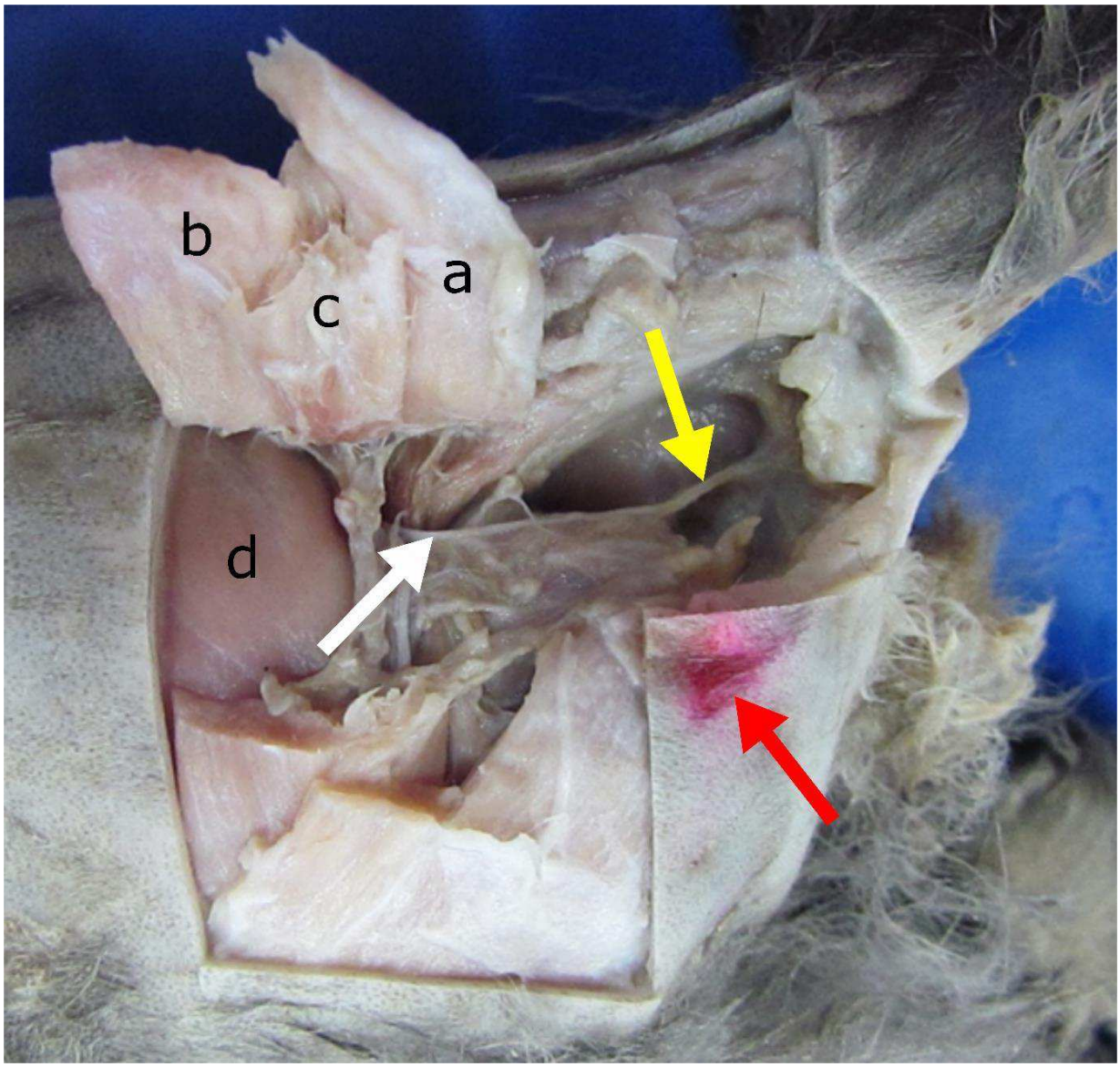

Figure 2: Region of the ischiorectal fossa in domestic cats after removing fat. White arrow – curve of the pudendal nerve; yellow arrow: rectal perineal branch; red arrow – sciatic tuberosity; a – gluteofemoral muscle; b – superficial gluteal muscle; c – piriformis muscle; d – middle gluteal muscle.

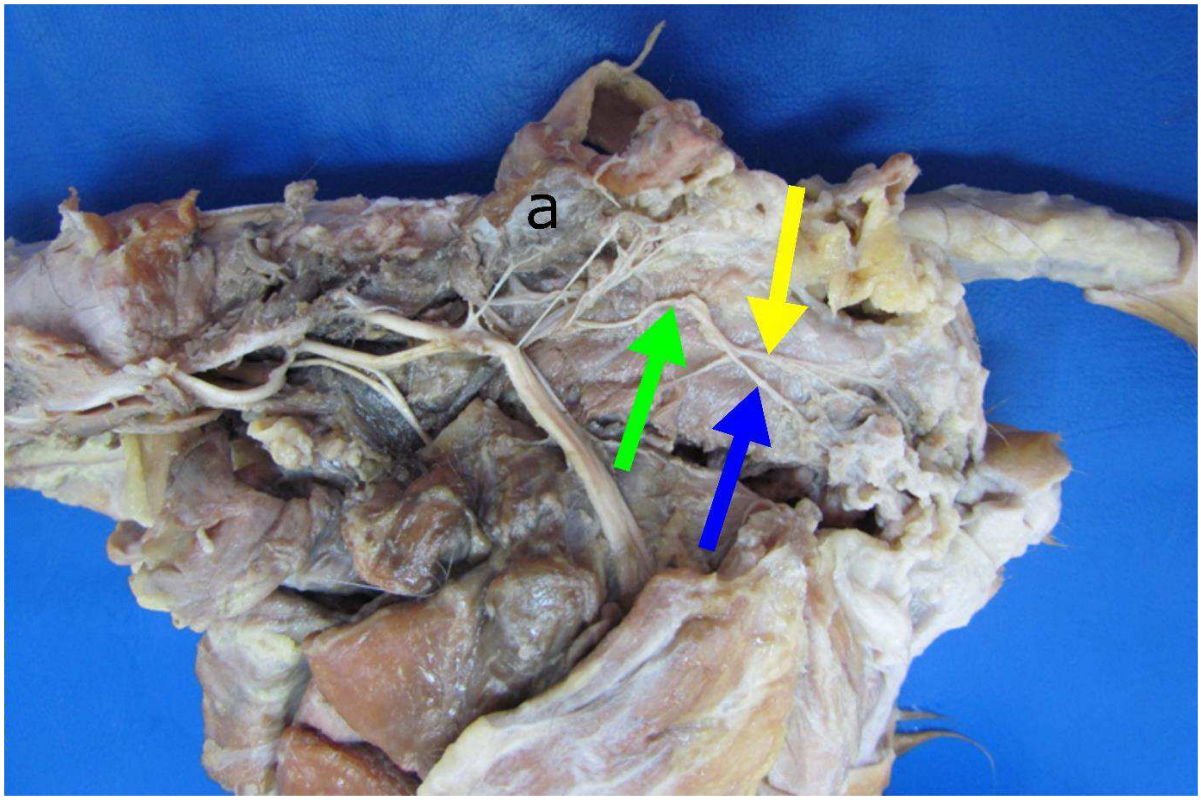

Figure 3: Domestic cat pelvic region after removing the left gluteus muscle and the pelvic bones (ilium, ischium and pubis) of the left antimere. Green arrow – pudendal nerve; yellow arrow – rectal-perineal branch; blue arrow – sensitive branch; joint surface of the wing of the sacrum.

Second phase

In order to verify the relationship of the curve formed by the pudendal nerve, immediately caudolateral to the piriformis muscle, with the ischial spine, measurements were taken, by radiographic projections, of the distance from this curve to the ischial spine. A hypodermic needle was positioned in the most lateral region of the pudendal nerve curve and the measurements taken using a digital pachymeter[1]. Three measurements were taken of the distance between the needle tip and the ischial spine, by latero-lateral and dorso-ventral radiographs, as described below and shown in Figure 4:

- Latero–lateral radiograph: measurement of the distance from the needle tip to the ischial spine, on the sagittal plane.
- Dorso-ventral radiography: measurement of the distance from the needle tip to the ischial spine, perpendicular to the sagittal plane.
- Dorso-ventral radiography: measurement of the distance from the needle tip to the ischial spine, oblique to the sagittal plane.

In addition to these measurements, the following were also registered: the distance from the ischial spine to the sciatic tuberosity by latero-lateral radiography and the distance from the pudendal nerve curve to the skin on the most caudal region of the sciatic tuberosity.

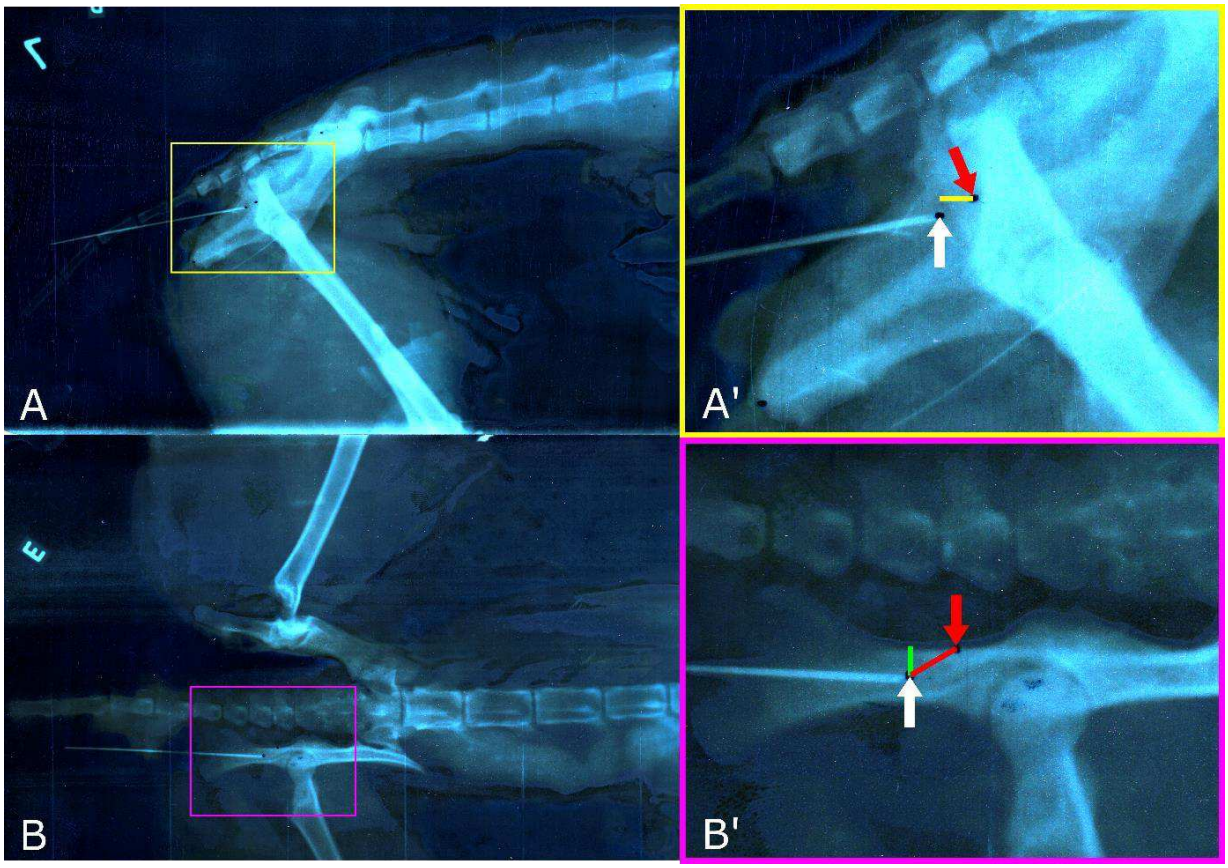

Figure 4: Radiography of the domestic cat pelvis, showing the measurements taken. A. Latero-lateral radiograph. A'. Magnification of the latero-lateral radiograph showing the measurement of the distance from the needle tip (tip of the white arrow) to the ischial spine (tip of the red arrow), on the sagittal plane (yellow line). B. Dorso-ventral radiograph. B'. Magnification of the dorso-ventral radiography showing the measurement of the distance from the needle tip (tip of the white arrow) to the ischial spine (tip of the red arrow), perpendicular (red green line) and oblique (red line) to the sagittal plane.

All the measurements mentioned above were taken using a digital pachymeter[1] with values given in millimeters (mm) and two decimal points. The measurements obtained by radiography were made by a researcher (I.M.M.G) and the others by another researcher (K.F.V).

Statistical analysis

The normality of the data was verified by the Shapiro-Wilk test. The data was submitted to the Wilcoxon test or to the *t*-test for related samples to verify whether there was difference among the antimeres measured, for the same measurement, and whether the distances were different from the sciatic tuberosity to the ischial spine compared with the sciatic tuberosity to the pudendal nerve curve. Difference between the cadaver weights was verified using the

different phases and data were submitted to the *t*-test for independent samples. All the tests were carried out using the Bioestat 5.0 software at 5% level of significance.

Results

The mean weight of the cadavers used in the first and second phases of the study was 3.35 ± 0.76 kg and 3.29 ± 1.11 kg, respectively, with no statistical difference (p = 0,8882).

First phase

The pudendal nerve was best identified by visualizing the rectal branches at the level of the ischiorectal fossa.

In all the cadavers (7/7) dissected, the pudendal nerve originated from the first and second ventral sacral nerves and presented a lateral curve immediately caudal to the piriformis muscle (Figure 2), that then returned towards the ischiorectal fossa on its lateral surface. Cranially to this curve, in the gluteal region, the pudendal nerve was enveloped in fat and protected dorsally by the piriformis, superficial gluteal and gluteofemoral muscles.

Immediately caudomedial to the curve, on the lateral region of the ischiorectal fossa, the pudendal nerve divided into the sensitive branch and the rectal-perineal branch. The rectal-perineal branch did not originate from any specific sacral nerve, but, in three (3/7) cadavers the sensitive branch originated from the second ventral sacral nerve, unilaterally in two cadavers (2/3) and bilaterally in one cadaver (1/3). The rectal-perineal branch went caudally and branched variably emitting the rectal branches and the deep perineal nerves. Appendix A shows the structures innervated by the perineal branches and the quantity of branches in each cadaver.

The sensitive branch divided into the cranial sensitive branch and the dorsal nerve of the penis dorsal-cranially to the penis curve in all the animals. In six (6/7) cadavers the cranial sensitive branch was inserted in the urethra, and in two (2/6) it was inserted bilaterally in the ventral portion of the urethra, immediately cranial to the penis curve, and in four (4/6) cadavers it followed towards the cranial portion of the urethra in one of the antimeres. One (1/6) cadaver also presented a branch that innerved the rectum and another that was inserted in the dorsal portion of the urethra, immediately cranial to the penis curve. In one (1/7) cadaver the location of the cranial sensitive branch insertion was not observed.

Regarding the dorsal nerve of the penis, in six (6/7) cadavers it went towards the penis, four (4/7) bilaterally and three (3/7) unilaterally. In one (1/7) cadaver the course of the dorsal nerve of the penis was not identified in one of the antimeres and in the other the nerve was not visualized until its insertion in the ischiocavernous muscles.

The ischemic nerve supplied nerve fibers to the pudendal nerve in six (6/7) cadavers, unilaterally in two (2/6) and bilaterally in four (4/6) cadavers.

Second phase

The measurements obtained showed no difference among the antimeres (Table 1). There was significant difference (p = 0.0308) when the general means were compared between the distance from the sciatic tuberosity to the curve formed by the pudendal nerve and the distance from the ischial spine to the sciatic tuberosity.

Table 1 – Anatomic and radiographic data obtained, taking as reference the sciatic tuberosity or the ischial spine, in adult crossbred domestic cat cadavers, fixed in 10% formaldehyde.

Measurement	**Antimere**	**Distances in mm**	**P values among the antimeres**	**General mean or median (*) in mm**
Distance from the sciatic tuberosity to the curve formed by the pudendal nerve	Right	27,52 ± 3,44^{A}	p = 0,3259	27,47 ± 3,16^{A}
	Left	27,41 ± 3,03^{A}		
Distance from the ischial spine to the sciatic tuberosity - latero-lateral radiograph	Right	25,23 ± 4,22^{A}	p = 0,7195	25,29 ± 3,63^{B}
	Left	25,35 ± 3,09^{A}		
Distance from the needle tip to the ischial spine - latero-lateral radiograph	Right	2,07 ± 1,38	p = 0,4682	2,24 ± 1,40
	Left	2,43 ± 1,49		
Distance from the needle tip to the ischial spine, perpendicular to the saggital plane – dorso-ventral radiograph	Right	0,00 ± 0,78*	p = 0,6121$^{\#}$	0,00 ± 1,34*
	Left	0,69 ± 1,64*		
Distance from the needle tip to the ischial spine, oblique to the saggital plane - dorso-ventral radiograph	Right	0,00 ± 1,85*	p = 0,4631$^{\#}$	0,00 ± 2,57*
	Left	1,08±4,3*		

Different superscript letters indicate significant statistical difference (p<0.5) for the same antimere or for the general mean in the comparison of means. *Data presented in mean and interquartílico deviation. $^{\#}$ Data submitted to the Wilcoxon Test.

Discussion

The origin of the pudendal nerve observed in the present study corresponded to that found by Adami et al.[1] and Mariano, Boger and Gustafson[11] but differs from that reported by Dellman and McClure[9] who stated that the pudendal nerve received fibers from the second and

third ventral sacral nerves. Forking in the sensitive and rectal-perineal branches was also observed by Yoo, Woock and Grill.[2] Different to that observed by Adami et al.[1] the rectal-perineal branch did not present specific origin in any sacral nerve. In the present study the rectal-perineal branch presented many perineal branches and there was no homogeneity regarding the number of branches presented by each animal or among the antimeres for the same animal. Due to the multiplicity of perineal branches, the innervated structures also varied, but the bulbouretral gland was the target of innervation in all the animals, either bilaterally (5/7) or unilaterally (2/7), that is in line with observations by Martin, Fletcher and Bradley.[10] Yoo, Woock and Grill[2] and Adami et al.[1] reported that the sensitive branch gave rise to the cranial sensitive branch and the dorsal nerve of the penis and that these went in opposite directions along the urethra, that was also observed in most of the cadavers in the present study. Dellman and McClure[9] reported that the pudendal nerve received a small communicating branch from the sciactic nerve, that was also observed in the present study.

No reports were found in the literature consulted of the curve that the pudendal nerve presents towards the region over the ischial spine in the cat species. Dellman and McClure[9] and Moraes, Beier and da Rosa[6] reported only that in cats the pudendal nerve passes deeply under the piriformis muscle and that it runs caudally, lateral to the coccygeus muscle towards the caudal pelvic opening. Yoo, Woock and Grill[2] studied the anatomical aspects related to the branches of the cat pudendal nerve, describing the initial course in a superficial manner, and only reported that its two initial ramifications occurred at the level of the ischiorectal fossa. In humans, however, there are reports of the pudendal nerve lying close to the ischial spine, and that this proximity may contribute to the development of some pathologies, and reports of the ischial spine as a point of reference for some anesthetic blocks of the pudendal nerve.[12–15] However, apparently, the cat ischial spine is not palpable, as in humans, the knowledge of its relation with the pudendal nerve in the feline species may give more precise identification of a possible site of access, including the performance of perineural anesthesia techniques, thus differentiating and specifying the different sites for blocking the pudendal nerve that that already exist[1,4–6] and possible future ones.

Conclusion

This study showed that the pudendal nerve originates from the two first ventral sacral nerves, that it curves laterally immediately caudolateral to the piriformis muscle and that it presents a close relationship with the ischial spine. It also demonstrated that the rectal-perineal branch gives rise to a variable number of branches and that these innervate several structures.

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.**Conflicts of Interest**

The authors declare that there are no potential conflicts of interest regarding the research, authorship and/or publication of this article.

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CAPÍTULO II:

Description and assessment of the technique to access the pudendal nerve dorsal to the ischial spine in domestic cat – a cadaver study

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Trabalho a ser submetido a Veterinary Anaesthesia and Analgesia

CAPÍTULO II

Description and assessment of the technique to access the pudendal nerve dorsal to the ischial spine in domestic cat – a cadaver study

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Abstract

Objective: Describe and assess the feasibility of access to the pudendal nerve dorsal to the ischial spine in domestic cat cadavers.

Type of study: Experimental prospective cadaver study.

Animals: A total of 27 adult crossbred domestic cat cadavers were used.

Method: After identifying, in a pilot study, anatomical references for access to the pudendal nerve, measurements were taken (first phase), with and without radiography, taking as references the sciatic tuberosity, ischial spine and curve made by the pudendal nerve dorsal to the ischial spine. In the second and third phases of the study, the technique described in the first phase and its modification were simulated, respectively.

Results: In the first phase no difference was observed between the antimeres for the distance

from the curve made by the pudendal nerve to the sciatic tuberosity (p = 0.325) (27.47 ± 3.16mm) and from this to the ischial spine (p = 0.719) (25.29 ± 3.63 mm). In the second phase the nerve was not marked bilaterally by the stain in any cadaver. However, the stain was deposited dorsally to the ischial spine. In the third phase, there was bilateral marking of the stain in four (4/6) cadavers and unilateral staining in one (1/6).

Conclusion and relevance: The data obtained demonstrated that the pudendal nerve can be approached by introducing a needle dorsally to the sciatic tuberosity, and advancing it parallel to the transversal plane towards the iliac crest for 27 mm. The description of this technique increases the range of anesthetic techniques available to anesthetize cats that need procedures involving the penis and urethra.

Introduction

The pudendal nerve block was first described in cats in 2013 by Adami et al. (2013). Although the studies regarding this block in this species are recent and scarce, they are extremely relevant, because they confer urethra and penile analgesia for carrying out both outpatient and surgical procedures (Adami et al. 2014; Vasconcelos et al. 2018).

Although the existing research is relevant, it is pointed out that the studies by Adami et al. (2013, 2014) only blocked the sensitive branch of the pudendal nerve and Vasconcelos et al. (2018) did not show an anatomical study that proved the site regarding the anesthetic deposit. In addition to these two techniques, Moraes et al. (2013) reported a technique to block the pudendal nerve under the piriformis muscle, that, to date, has not been corroborated by an anatomical or clinical study.

Given the importance of this theme and a lack of anesthetic techniques that block the the entire pudendal nerve, the feasibility was described and assessed of accessing the pudendal nerve dorsally to the ischial spine in domestic cat cadavers.

Materials and Methods

The study was carried out after approval by the Committee of Ethics in Institutional Research, protocol CEP 287/2015.

Cadaver origin and conservation

Twenty-seven adult crossbred domestic cat cadavers were used (17 males and 10 females), provided by different public institutions. Ten cadavers were used in the first phase of the research, 11 in the second phase and six in the third phase. Those used in the first and second phases were, after thawing and before any dissection or assessment of the feasibility of the technique, were fixed by intramuscular and intracavity injection of 10% formaldehyde and preserved, by immersion, in the same solution. The cadavers used in the third phase were fixed by intracarotid injection of 10% formaldehyde and preserved immersed in this solution after assessing the feasibility of the technique.

First phase

Prior to this phase, a pilot study identified possible locations for access to the pudendal nerve and their anatomical references. Using these observations and a digital pachymeter[1], bilateral measurements were taken of the distance from the skin on the most cortical region of the sciatic tuberosity, identified by palpation, to the most lateral region of the pudendal nerve curve (immediately caudal lateral to the piriformis muscle), where the nerve passes dorsally to the ischial spine.

In addition, measurements were taken with radiographs to evaluate the relationship of the pudendal nerve with the ischial spine. For this, the distance was measured three times from the needle tip, positioned in the most lateral region of the pudendal nerve curve, to the ischial spine, by latero-lateral radiography and dorso-ventral radiography, as described below and shown in Figure 1:

- Latero–lateral radiograph: measurement of the distance from the needle tip to the ischial spine, on the sagittal plane.
- Dorso-ventral radiography: measurement of the distance from the needle tip to the ischial spine, perpendicular to the sagittal plane.
- Dorso-ventral radiography: measurement of the distance from the needle tip to the ischial spine, oblique to the sagittal plane.

In addition to these measurements, the distance from the ischial spine to the sciatic tuberosity was also recorded by latero-lateral radiography.

All the measurements were taken by the same researcher (K.F.V) using a digital pachymeter and presented in millimeters.

Second phase

After taking the measurements reported above, a technique was described to access the pudendal nerve dorsally to the ischial spine, by introducing a needle for approximately 27 mm, immediately dorsal to the sciatic tuberosity parallel to the lesser sciatic notch towards the iliac crest (Fig. 2).

The feasibility of this technique was assessed using 11 (nine males and two females) domestic cat cadavers previously fixed in 10% formaldehyde. The pudendal nerve was accessed, following the description obtained in phase 1, using a Tuohy[2] 18G 3½ needle with the bevel placed dorsally at the moment of introduction. Yellow enamel[3] was used as stain at the volume of $0.1 mL kg^{-1}$ (frozen weight) $nerve^{-1}$ and administered to all the cadavers on the same day.

Only the bilateral marking of the pudendal nerve by the stain was considered as effective.

Stain dispersion was also assessed using a digital pachymeter[1] to verify whether the stain was deposited dorsally on the ischial spine measuring the distance from the sciatic tuberosity to the most cortical region marked by the stain, and its craniocaudal dispersion.

Third phase

Six domestic cat cadavers (female) were used in this phase, in which the technique proposed in the previous phase of the study was modified, advancing the needle towards the iliac crest parallel to the transversal plane (Fig. 3).

A Tuohy[2] 18 G 3½ needle was used with the bevel placed dorsally at the moment of introduction. Yellow enamel diluted in acetone at $1_{stain}:3_{acetone}$ was used as stain, and this solution was administered at 0.1 $mL kg^{-1} nerve^{-1}$ volume. The cadavers were dissected to visualize the enamel dispersion on a different day than the enamel administration and bilateral marking of the pudendal nerve by the stain was considered effective.

All the techniques described and dissections were carried out by the same researcher (K.F.V).

Statistical analysis

The normality of the data was verified by the Shapiro-Wilk Test. To verify whether there was difference among the antimeres measured, for the same measurement, the data were submitted to the Wilcoxon Test or the *t*-test for related samples. To verify whether the

measurements for stain distribution corresponded to the location of the ischial spine, the data were submitted to the *t*-test for independent samples or the Mann-Whitney test. To verify whether there was difference between the cadaver weights among the different phases of the study, analysis of variance (ANOVA) was carried out of one criterion, followed by the Tukey test. All the tests were made using the Bioestat 5.0 software at 5% level of significance.

Results

The mean weight of the cadavers used at each one of the phases was 3.35 ± 0.76kg (first phase), 2,55 ± 1.03 kg (second phase) and 1.7 ± 0.41 kg (third phase). There was significant difference only among the weights of the cadavers used in the first and third phases ($p < 0.01$).

First phase

There was no difference between the antimeres for any of the measurements (Table 1).

The data also demonstrated that the location selected to deposit the stain was very close to the ischial spine, and there was no statistical difference between the antimeres for the distance from the sciatic tuberosity to the curve formed by the pudendal nerve and for the distance from the ischial spine to the sciatic tuberosity {$p = 0.1604$ [right antimere (AD)], $p = 0.1098$ [left antimere (AE)]}. For this comparison there was difference only in the global comparison of the data ($p = 0.0308$) (Table 1).

The pudendal nerve could be accessed by introducing the needle immediately dorsal to the sciatic tuberosity, the closest possible to the dorsal edge of the ischium body, advancing towards the iliac crest parallel to the lesser sciatic notch, for approximately 27 mm (Fig. 2).

Second phase

Stain distribution in the gluteus region was generally heterogeneous (Appendix A) (Fig. 4).

There was no bilateral marking of the pudendal nerve in any of the cadavers. One cadaver (1/11) showed unilateral marking of the pudendal nerve and in five cadavers (5/11) the stain remained located close to the pudendal nerve in one of the antimeres, in four of which (4/5) the stain was located over the artery and the caudal gluteus nerve and on the adjacent fat. In one cadaver (1/5) the stain was separated from the pudendal nerve only by the fat.

There was no difference among the antimeres for the distance measured from the caudal region of the stain to the sciatic tuberosity (p = 0.0683). The means of these range from 23.34 ± 6.89 mm (AD), 19.76 ± 7.25 mm (AE) and 21.55 ± 7.14 mm [general mean ($\bar{x}_G$)]. There was no difference among the antimere regarding cranial caudal distribution of the stain (p=0.9379) and the means were 24.71 ± 6.84 mm (AD), 24.91 ± 6.88 mm (AE) and 24.81 ± 6.69 mm ($\bar{x}_G$).

There was no difference in the comparison between the data of each antimere, between the distance from the ischial spine to the sciatic tuberosity and the distance from the caudal region of the stain to the sciatic tuberosity [p = 0.4618 (AD), p = 0.0627 (AE)], but there was difference in the global comparison of the data (p = 0.0414), and the caudal region of the stain was closer to the sciatic tuberosity than the ischial spine ($p_{unilateral}$ = 0.0207), as demonstrated by the means reported above (Table 1) and by the means obtained (mean of the distance from the ischial spine to the sciatic tuberosity = 24.95 ± 4.74; mean of the distance from the caudal region of the stain to the sciatic tuberosity = 18.65 ± 9.74).

Comparison of the cranial extension of the stain to the distance of the ischial spine to the sciatic tuberosity showed there was difference between the distances from the cranial region of the stain to the sciatic tuberosity and from the ischial spine to the sciatic tuberosity [p = 0.0001 (AD), p = 0.0002 (AE) and p < 0.0001 (general comparison) and that the distance from the cranial region of the stain to the sciatic tuberosity {40.01 ± 8.68 mm [mean (AD)], 44.67 ± 8.81 mm [mean (AE)], 46.34 ± 8.70 mm ($\bar{x}_G$); 46.85 ± 7.35 mm [mean (AD) ($\bar{x}_{AD}$)], 44.46 ± 10.59 mm [mean (AE) ($\bar{x}_{AE}$)], 46.41 ± 10.08 mm [general mean ($\bar{x}_G$)]} was bigger than the distance from the ischial spine to the sciatic tuberosity (Table 1) [25.48 ± 4.05 mm ($\bar{x}_{AD}$), 24.95 ± 5.15 mm ($\bar{x}_{AE}$)].

Third phase

The technique was modified due to the results obtained in the second phase of the study to permit better approximation of the needle tip to the pudendal nerve, advancing the needle parallel to the transverse plane (Fig. 3), towards the iliac crest.

There was bilateral marking of the pudendal nerve in four cadavers (4/6) and unilateral marking in one cadaver (1/6) (Fig.5). In this cadaver the stain did not come into direct contact with the pudendal nerve of the non-stained antimere, but was separated from it by a 1 mm thick layer of fat, and was distributed dorsally to the pudendal nerve for 4 mm. In the pudendal nerves where there was direct marking by the stain this was distributed over or under the nerves for 9.67 ± 3.39 mm average distance. In the cadaver where the marking was not effective in any of

the nerves, the stain was deposited on the middle gluteus muscle and on the piriformis muscle (right antimere) and lateral to the iliac body, under the middle gluteus muscle and ventral to the sciatic nerve (left antimere) with a distance from the caudal region of the stain to the sciatic tuberosity of respectively, 35.19 mm and 32,41 mm. Also in this case, although the technique proposed was not effective, the curve formed by the pudendal nerve dorsally to the ischial spine was approximately 27 mm distant from the sciatic tuberosity.

The stain also marked the sciatic nerve bilaterally in four (4/6) cadavers and unilaterally in one cadaver (1/6). The sciatic nerve was also not stained in the cadaver where the pudendal nerve was not marked. Figure 5 shows the stain distribution in different cadavers and its relation with the pudendal nerve and sciatic nerves. In the sciatic nerves marked by the stain, the stain was distributed on or under the nerve for an average distance of 11.44 ± 4.65 mm.

Discussion

The pudendal nerve curve was chosen as the point to deposit the stain because of its location dorsal to the ischium, and it was thus possible to access it by introducing the needle on the sciatic tuberosity towards the iliac crest, thus following the natural anatomical conformation of the animal.

The data obtained the second phase of the study showed that although the pudendal nerve curve is not exactly dorsal to the ischial spine, it is very close, distant only about 2 mm, that was also proven by the measurement of the distance from the needle tip to the ischial spine, obtained by the latero-lateral radiographs.

No reference was found in the literature consulted regarding the curve that the pudendal nerve presents towards the region over the ischial spine in the feline species.. Dellman e McClure (1975) e Moraes et al. (2013) reported only that the pudendal nerve, in cats, passes deeply under the piriformis muscle and runs caudally, lateral to the coccygeus muscle, towards the caudal pelvic opening. Yoo et al. (2008) studied anatomical aspects related to the branches of the feline pudendal nerve, describing the initial course of the nerve superficially, reporting only that its two first ramifications occurred at the level of the ischiorectal fossa. In humans, however, there are reports of the pudendal nerve running close to the ischial spine, and that this proximity can contribute to the development of some pathologies, and there are reports of the ischial spine as a point of reference to carry out some anesthetic blocks of the pudendal nerve (Antolak et al. 2002; Roche et al. 2009; Romanzi 2010; Bendtsen et al. 2016). Although the feline ischial spine is not apparently palpable, as it is in humans, the knowledge of its

relationship with the pudendal nerve in that species may allow more precise identification of the location to deposit anesthetic, differentiating and specifying the different locations for pudendal nerve block that already exist (Adami et al. 2013; Morais et al. 2013; Adami et al. 2014; Vasconcelos et al. 2018) and future ones.

Although the data obtained in the second phase study did not show that the pudendal nerve curve is exactly dorsal to the ischial spine, but only close, the third phase showed that the stain was distributed from the region immediately caudal to the ischial spine up until about 21 mm cranial to this, demonstrating that the stain deposit was in fact dorsal to the ischial spine. In spite of this finding, in this phase, the pudendal nerve was not stained bilaterally in any cadaver. In contrast, in the last phase of the study, after modifying the technique, the pudendal nerve was stained bilaterally in most of the cadavers. In the cadaver where there was no staining of any of the pudendal nerves, the distance was measured from the stain deposit location (pudendal nerve curve) to the sciatic tuberosity and this measurement corresponded to the depth of the introduction of the needle (27 mm) given in the description of the technique, that demonstrated that the technique described was correct.

Although the stain of choice is methylene blue for anatomical studies applied to anesthesia, using cadavers, its use is more common in fresh or refrigerated cadavers (Hofmeister et al. 2007; Campoy et al. 2008; Carvalho 2008; Prat-Pradal et al. 2009; Adami et al. 2013; Desmet et al. 2015) but it could not be used in the present study because the cadavers used in the second and third phases were injected with formaldehyde and maintained in 10% formaldehyde solution. This conservation method was chosen because of the impossibility of carrying out stain deposit and dissection immediately after the death of the animals or after thawing, because the cadaver would probably not remain viable for the time needed for stain deposition and dissection of the pudendal nerve, as its dissection is complex and requires time for careful execution, especially when dealing with a bilateral procedure.

Therefore enamel was chosen as stain, that also optimized cadaver use, because a further two approaches to the pudendal nerve were tested, but not described here, thus permitting visualization of the dispersion of all the techniques, as three different colored enamels were used (yellow, red and blue).

Although using enamel as stain is not common, its use was reported by Martins et al. (2014) to simulate brachial plexus block in *Sapajus libidinosus* cadavers, and it was sufficient to simulate the techniques proposed and confirm their effectiveness. In the present experiment, the enamel was restricted to the deposition location and did not diffuse through the tissues, especially in the third phase of the study. This may limit its use because, although indicating

the exact point of stain deposition, the enamel as stain did not show diffusion through the tissues similar to local anesthetics.

Conclusion

This study showed that the pudendal nerve lies dorsal to the ischial spine and that it can be accessed by introducing a needle immediately dorsal to the sciatic tuberosity, as close as possible to the dorsal edge of the ischium body, advancing in the same direction to the iliac crest, parallel to the transverse plane, for approximately 27 mm.

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Contribuição dos autores

KFV: cadaver acquisition and preparation, study design, data collection, data management and interpretation, and manuscript preparation. JRSS: cadaver preparation and study design. ASSF: cadaver preparation and data collection. AFM: cadaver preparation and data collection. CRAL: data management and interpretation. IMMG: data collection. TRS: cadaver preparation and data collection. DSP: cadaver acquisition and manuscript preparation. GXM: study design and manuscript preparation. PINN: cadaver acquisition, study design, Aquisição dos cadáveres, delineamento experimental and interpretation, and manuscript preparation.

Conflicts of Interest

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3 Esmalte Bella & Chick Sun Sol, Indústria e comércio de Cosméticos LTDA, Itajuípe, Bahia, Brazil.

Refereces

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Table 1 – Anatomic and radiographic data obtained, taking as reference the sciatic tuberosity or the ischial spine, in adult crossbred domestic cat cadavers, fixed in 10% formaldehyde.

Measurement	**Antimere**	**Distances in mm**	**P values among the antimeres**	**General mean or median (*) in mm**
Distance from the sciatic tuberosity to the curve formed by the pudendal nerve	Right	27,52 ± 3,44^{A}	p = 0,3259	27,47 ± 3,16^{A}
	Left	27,41 ± 3,03^{A}		
Distance from the ischial spine to the sciatic tuberosity - latero-lateral radiograph	Right	25,23 ± 4,22^{A}	p = 0,7195	25,29 ± 3,63^{B}
	Left	25,35 ± 3,09^{A}		
Distance from the needle tip to the ischial spine - latero-lateral radiograph	Right	2,07 ± 1,38	p = 0,4682	2,24 ± 1,40
	Left	2,43 ± 1,49		
Distance from the needle tip to the ischial spine, perpendicular to the saggital plane – dorso-ventral radiograph	Right	0,00 ± 0,78*	p = 0,6121$^{\#}$	0,00 ± 1,34*
	Left	0,69 ± 1,64*		
Distance from the needle tip to the ischial spine, oblique to the saggital plane - dorso-ventral radiograph	Right	0,00 ± 1,85*	p = 0,4631$^{\#}$	0,00 ± 2,57*
	Left	1,08 ± 4,3*		

Different superscript letters indicate significant statistical difference ($p < 0.5$) for the same antimere or for the general mean in the comparison of means. *Data presented in mean and interquartílico deviation. $^{\#}$ Data submitted to the Wilcoxon Test.

Figure 1

Radiography of the pelvis of a domestic cat showing the measurements taken. A. Latero-lateral radiography. A'. Magnification of the latero-lateral radiograph showing the measurement of the distance from the needle tip (tip of the white arrow) to the ischial spine (tip of red arrow), on the sagittal plane (yellow line). B. Dorso-ventral radiography. B'. Magnification of the dorso-ventral radiograph showing the measurement of the distance from the needle tip (tip of the white arrow) to the ischial spine (tip of the red arrow) perpendicular (green line) and oblique (red line) to the sagittal plane.

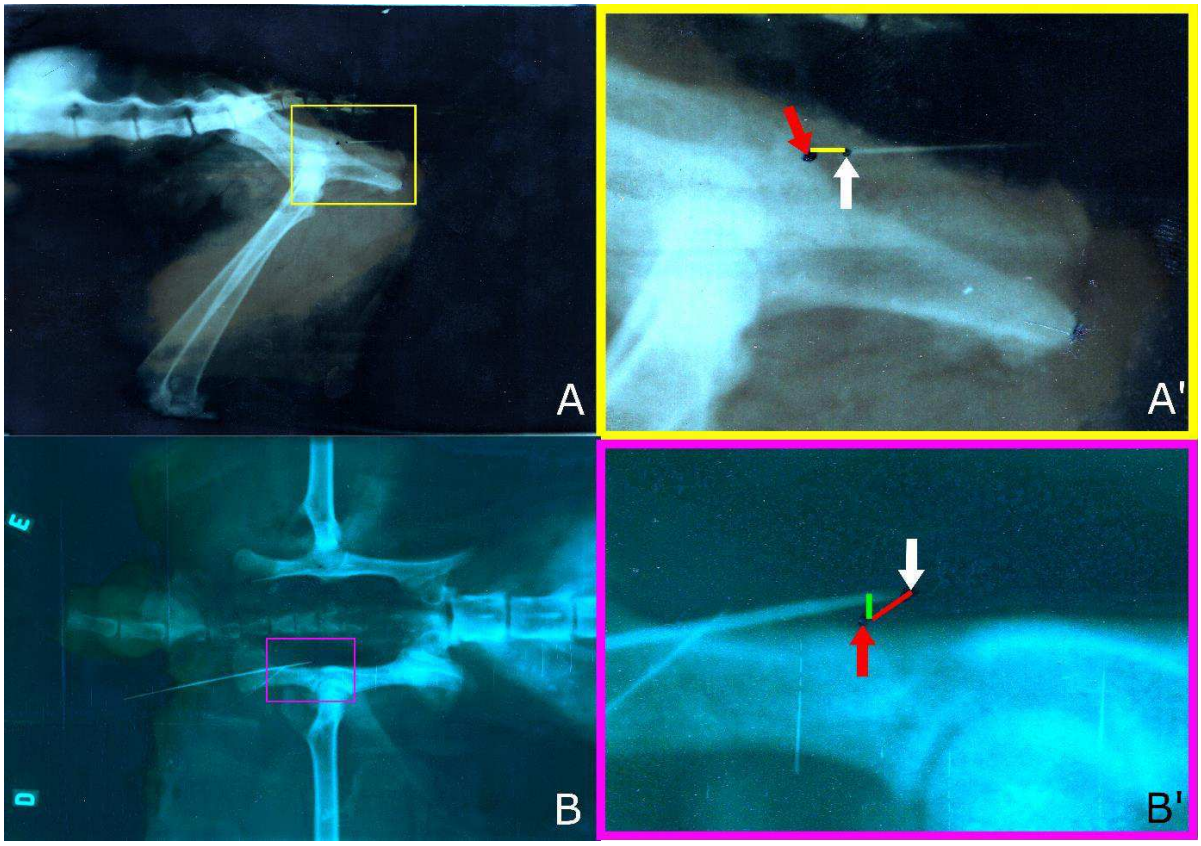


Figure 2

Access technique to the pudendal nerve dorsally to the ischial spine in domestic cats used in the second phase of the study. A – Step 1: Identify the palpable bone protuberances (yellow – iliac crest; green – sciatic tuberosity); B – Step 2: Position the needle immediately dorsal to the sciatic tuberosity and parallel to the lesser sciatic notch; C – Step 3: Position the needle towards the iliac crest; D – Step 4: Introduce the needle 27 mm and deposit the anesthetic.

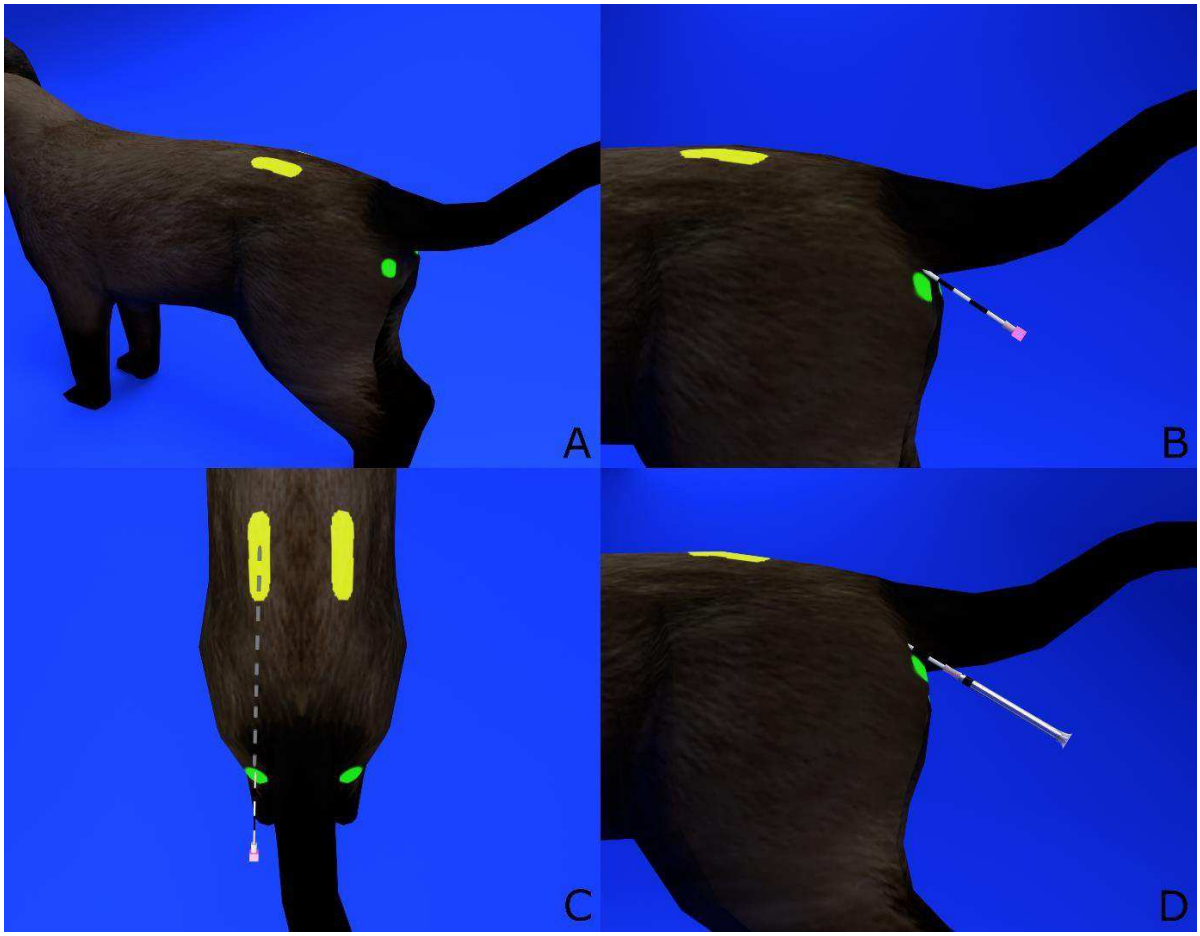


Figure 3

Access technique to the pudendal nerve dorsally to the ischial spine in domestic cats used in the third phase of the study. A – Step one: Identify the palpable bone protuberances (yellow – iliac crest; green – sciatic tuberosity); B – Step 2: Position the needle immediately dorsal to the sciatic tuberosity and parallel to the transverse plane; C – Step 3: Position the needle towards the iliac crest; D – Step four: Introduce the needle 27 mm and deposit the anesthetic.

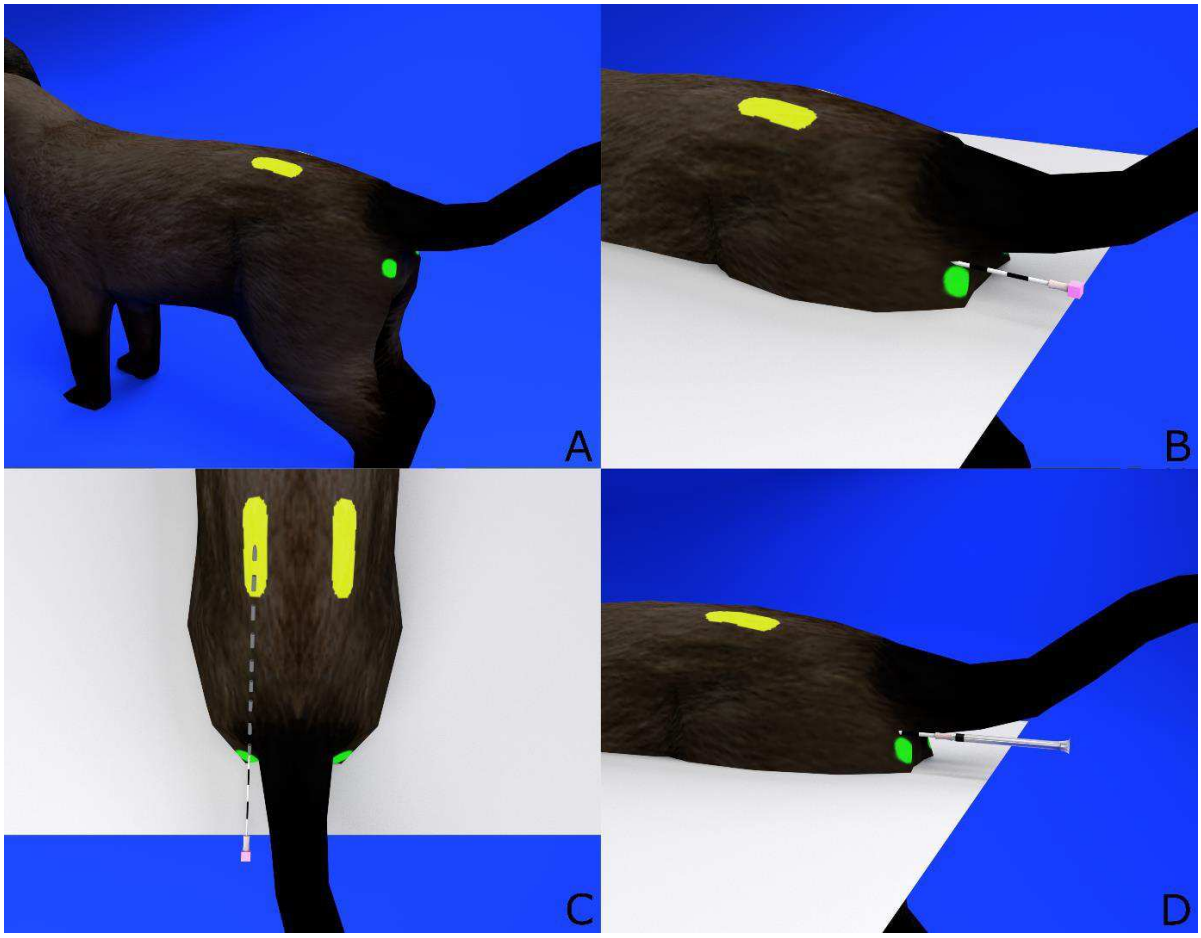


Figure 4

Stain dispersion in different domestic cat cadavers. A – Pudendal nerve curve (tip of the white arrow); B and C – Stain dispersion over the gluteal fascia; D and E – Stain dispersion under the gluteal fascia; F – Stain dispersion over the sciatic nerve; G to J – Stain dispersion under the gluteofemoral (*) and superficial gluteal (#) muscles; K and L – Relation of the stain with the pudendal nerve; white arrow – pudendal nerve; green arrow - sensitive branch of the pudendal nerve; blue arrow – rectal-perineal branch of the pudendal nerve; red arrow – sciatic nerve.

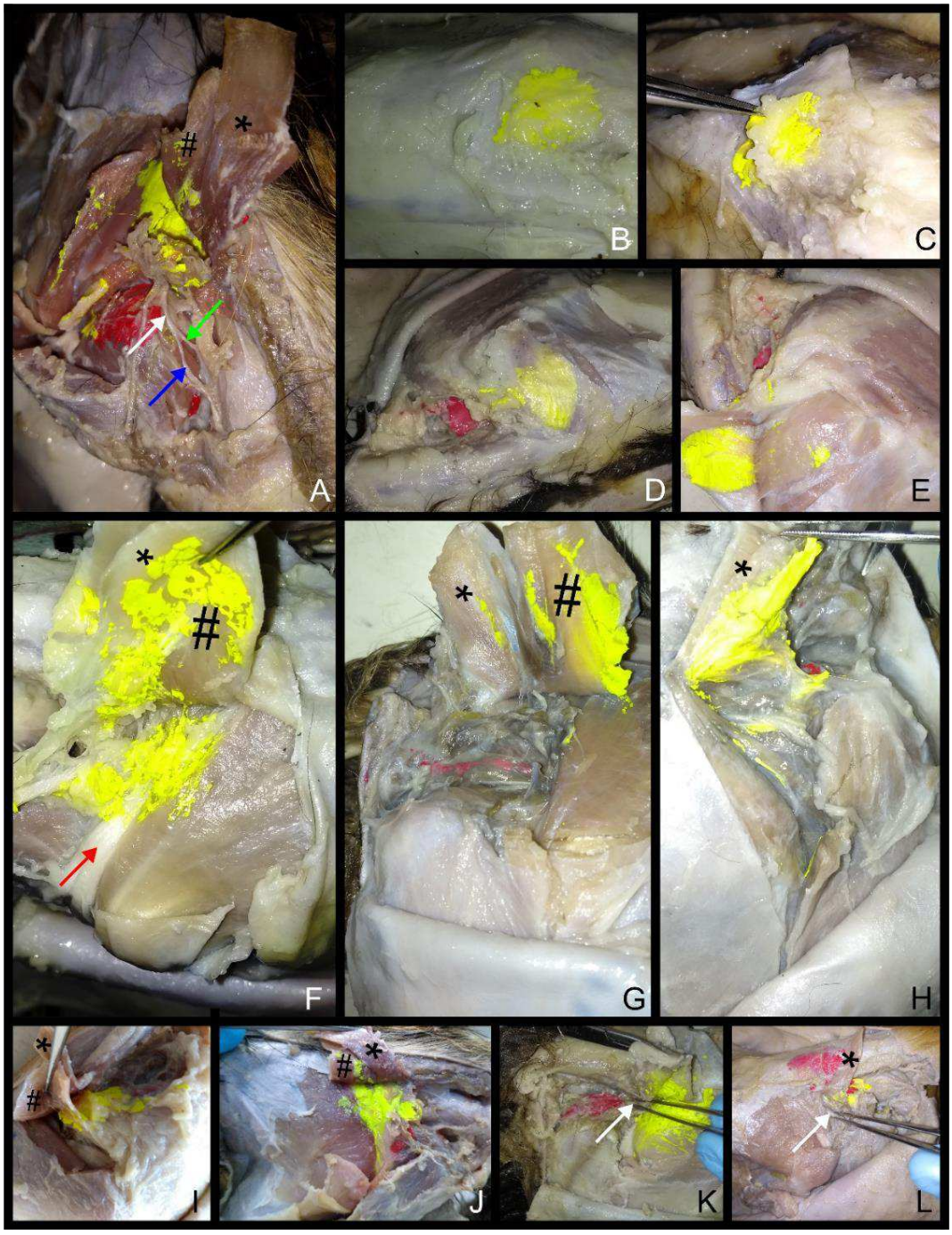
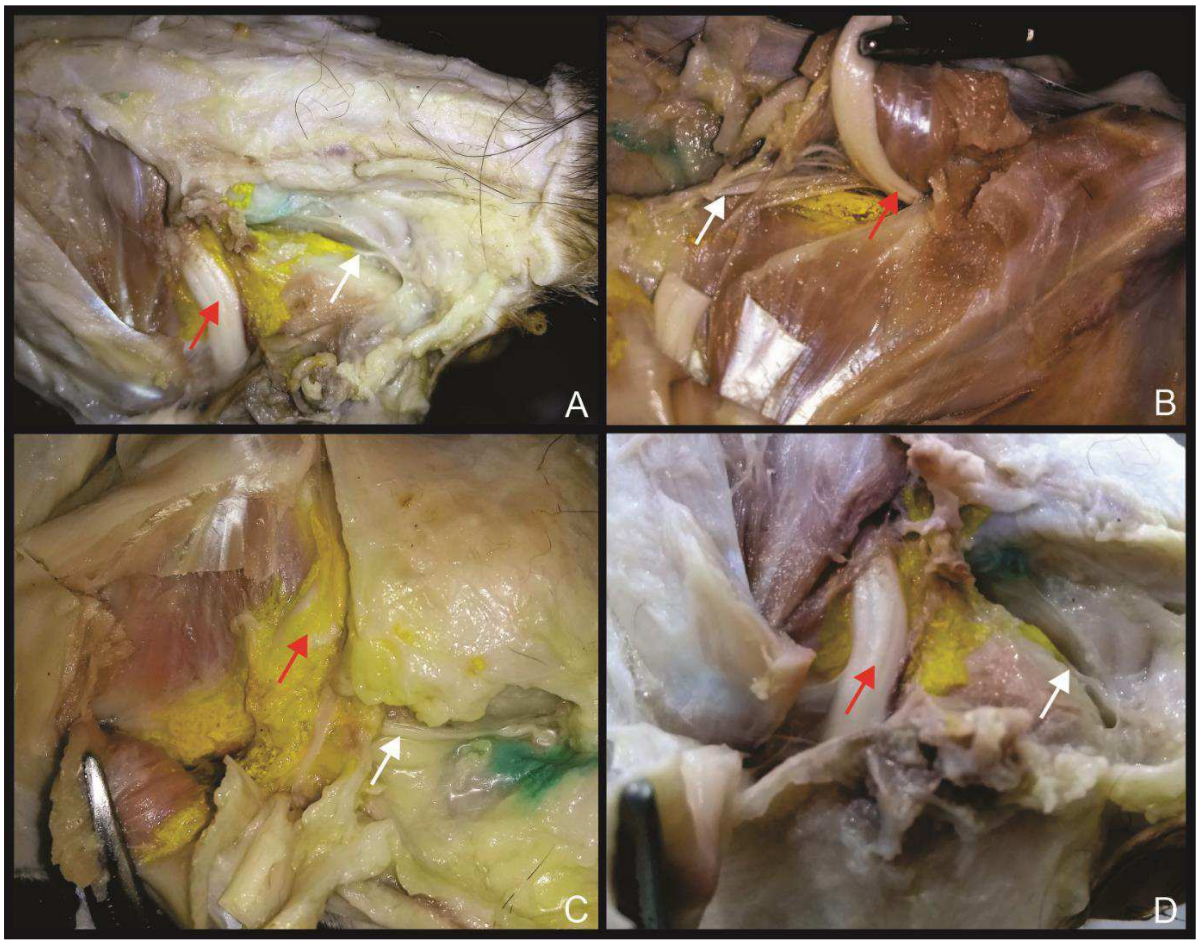


Figure 5

A, B, C and D - Stain dispersion in different domestic cat cadavers. White arrow – pudendal nerve; red arrow – sciatic nerve.



CAPÍTULO III:

Description and assessment of the cranial access technique to the pudendal nerve in cats – a cadaver study

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CAPÍTULO III

Description and assessment of the cranial access technique to the pudendal nerve in cats – a cadaver study

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Abstract

Objective: Describe and assess the feasibility of cranial access to the pudendal nerve, concomitant to it and the pelvic nerve, in domestic cat cadavers.

Methods: Ten cadavers were used in the first phase of the study and six cadavers in the second. In the first phase measurements were made taking as reference the needle tip in relation to the pudendal nerve and/or pelvic nerve. In the second phase the feasibility was assessed of the techniques described in the first phase, considering as effective the bilateral staining of the pudendal nerve or of the fascicle that originated it.

Results: In the first phase, only for the angles formed between the needle and the imaginary ilio-ischemic line were statistically different when the locations for placing the needle close to the pelvic nerve and close to the pudendal nerve were compared for both the antimeres [right antimere ($p < 0.01$); left antimere ($p < 0.05$)], and in general ($p < 0.01$); and between the angle formed between the needle and the imaginary ilio-ischemic line when the needle positioning locations close to the pudendal nerve and close to the pelvic nerve-pudendal nerve mid-point were compared, for the right antimere ($p < 0.05$) and in general ($p < 0.01$). In the secondphase

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there was bilateral marking of the pudendal nerve or its fascicles in all the cadavers.
Conclusion and relevance: The data obtained demonstrated that, in female cats, description of an access technique concomitant to the pelvic and pudendal nerves was not possible, but that the cranial access to the pudendal nerve was feasible. The description of this technique increases the range of anesthetic techniques available to anesthetize cats needing procedures involving the penis or urethra.

Introduction

In domestic cats, the pudendal nerve anesthetic block confers analgesia to perform outpatient and surgical procedures that involve the penis and the feline urethra, because it innervates several structures, including the urethra, external urethra sphincter and pênis.[1-3] The patients that need these procedures usually present hemodynamic and metabolic alterations, that associated to alterations caused by general and/or dissociative anesthetics, can lead the animal´s death. Thus, the use of locoregional techniques can minimize this risk.[4-6]

Currently three pudendal nerve block techniques have been described.[2,7,8] Not all, however, present anatomical studies that supply the basis for the description of the techniques presented, for example the report by Vasconcelos et al.[2] that in spite of this lack, presented promising clinical results. In addition to pudendal nerve block, these authors also reported block of the pelvic nerve in approximately half the patients, that, although not fundamental to allow vesical catheter passage, is desirable, since the pelvic nerve innervates the urethra.[9,10]

Given the possibility of concomitant pelvic and pudendal nerve block, the need to improve the technique described by Vasconcelos et al.[2] and the clinical importance of the pudendal nerve block, the aim of the present research was to describe and assess the feasibility of an access to the pudendal nerve, or concomitant to it and the pelvic nerve, in domestic cat cadavers.

Material and Methods

The study was carried out after approval by the Committee of Ethics in Institutional Research (protocol CEP 287/2015).

Cadaver origin and preservation

Sixteen adult crossbred domestic cat cadavers were used (eight males and eight females), provided by different public institutions. The cadavers used in the first phase of the study (eight males and two females) were thawed and fixed by intramuscular and intracavity injection of 10% formaldehyde and preserved by immersion in this solution. The cadavers used in the second phase (six females) were dissected fresh immediately after anesthetic simulation.

First phase

This phase was preceded by a pilot study where possible locations were identified for access to the pudendal nerve and their anatomical references.

The needle to take the measurements was introduced at the union of the cranial and mid-section of the imaginary ilio-ischemic line, that was divided into three equal segments, shown in Figure 1 B and according to Portela et al.[11]

The following measurements were taken using a digital pachymeter:

- Mean of the distance from the skin to the pudendal nerve
- Mean of the distance from the skin to the pelvic nerve
- Mean of the distance from the skin to an intermediate point (mid) between the pudendal and pelvic nerves.
- Measurement of the angles formed between the needle and the imaginary ilio-ischemic line in each needle tip position (the closest possible to the pelvic nerve, to the pudendal nerve and to the mid-point between these two nerves).
- Measurement of the angles formed between the needle and the sagittal plane, in each needle tip position (the closest possible to the pelvic nerve, to the pudendal nerve and to the mid-point between these two nerves).

In addition, the distance was measured from the skin to the pelvic cavity. The needle was introduced in the skin at an angle of 90° to the imaginary line traced between the iliac crest and sciatic tuberosity and at 45° to the sagittal plane, as described by Vasconcelos et al.[2]

The values obtained using the digital pachymeter[1] were given in millimeters (mm) and two decimal points. The means referring to the angles were obtained using a cardboard square marked with the respective angles, and the angles were read with a protractor. All the measurements were taken by the same researcher (K.F.V).

After taking the above measurements, an access technique to the pudendal nerve was described, taking as reference for introducing the needle in the skin the point between the cranial third and middle of an imaginary line traced between the iliac crest and the sciatic tuberosity.

Second phase

The access to the pudendal nerve described in the previous phase was assessed, using a was described needle with the bevel placed cranially. Methylene blue (powder) was used as stain diluted in 2% lidocaine until the stain reached 1% concentration. The volume used of this solution was 0.1 mL/kg/nerve.

The procedure was only considered effective when the pudendal nerve or the fascicle

that gave origin to it were marked bilaterally by the stain.

All the simulations were carried out by the same researcher (K.F.V.) and the dissections were made by two researchers (T.F.S. and K.F.V). The rectal-penial branch was identified by the first researcher and the stained structures were dissected by the second group.

Statistical analysis

The normality of the data was verified by the Shapiro-Wilk Test. The data were submitted to the Wilcoxon Test or *t*-Test for related samples to verify whether there was difference among the antimeres measured, for the same measurement. The data were submitted to the *t*-test for independent samples or the Mann-Whitney test to verify whether the measurements for stain distribution corresponded to the location of the ischial spine. Difference between the cadaver weights among the different phases of the study was verified by one criterion analysis of variance (ANOVA), followed by the Tukey test. All the tests were made using the Bioestat 5.0 software at 5% level of significance.

Results

The mean weight of the cadavers used in the first and second phases of the study was 3.35 ± 0.76 kg and 2.94 ± 0.25 kg, respectively, and there was no statistical difference ($p = 0.0965$).

First phase

The distances from the skin to the anesthetic deposit site and between the angles formed between the needle and the sagittal plane were not statistically different in any needle tip position, either for the antimeres or the needle positioning locations. Similarly, no difference was found between the angles formed between the needle and the imaginary ilio-ischemic line, in the comparisons between the needle positioning locations close to the pelvic nerve and close to the pelvic nerve-pudendal nerve mid-point; and between the needle positioning location close to the pudendal nerve and close to the pelvic nerve-pudendal nerve mid-point for the left antimere (Table 1).

Only the angles formed between the needle and the imaginary ilio-ischemic line were statistically different in the comparison between the needle positioning locations close to the pelvic nerve and close to the pudendal nerve, for both the antimeres [right antimere ($p < 0.01$); left antimere ($p < 0.05$)], and in general ($p < 0.01$); and between the angle formed between the needle and the imaginary ilio-ischemic line, when the needle position locations close to the pudendal nerve were compared to those close to the pelvic nerve – pudendal nerve mid-point for the right antimere ($p < 0.05$) and in general ($p < 0.01$) (Table 1).

Table 1 – Measurements obtained of the pelvic nerve, or pudendal nerve, or of an intermediate point between these two as far as the skin, in adult crossbred cats cadavers fixed in 10% formaldehyde.

Measurement	Needle tip positioning site	Antimere	Mean per antimere	General mean	p values between the antimere antímeros
Distance from the skin to the anesthetic deposit site (in millimeters)	Pelvic Nerve	Right	21,80 ± 4,6^{A}	21,67 ± 3,76^{A}	p = 0,6716
		Left	21,52 ± 2,83^{A}		
	Pudendal Nerve	Right	21,60 ± 3,32^{A}	21,47 ± 2,74^{A}	p = 0,3873
		Left	21,33 ± 2,12^{A}		
	Pelvic nerve-pudendal nerve mid-point	Right	20,11 ± 3.26^{A}	20,88 ± 3^{A}	p = 0,1525
		Left	21,73 ± 2,59^{A}		
Angle formed between the needle and the imaginary line between the iliac crest and the sciatic tuberosity	Pelvic Nerve	Right	70 ± 11^{A}	72 ± 10^{A}	p = 0,6114
		Left	74 ± 7^{A*}		
	Pudendal Nerve	Right	49 ± 11^{B}	48 ± 14^{B}	p = 0,5408
		Left	46 ± 16^{B*}		
	Pelvic nerve-pudendal nerve mid- point	Right	65 ± 14^{A}	67 ± 11^{A}	p = 0,5726
		Left	68 ± 5^{AB*}		
Angle formed between the needle and the sagittal plane (in degrees)	Pelvic Nerve	Right	32 ± 15 ^{A}	35 ± 14 ^{A}	p = 0,2095
		Left	38 ± 13 ^{A}		
	Pudendal Nerve	Right	28 ± 18 ^{A}	26 ± 16 ^{A}	p = 0,4722
		Left	24 ± 13 ^{A}		
	Pelvic nerve-pudendal nerve mid- point	Right	34 ± 12 ^{A}	36 ± 14 ^{A}	p = 0,5675
		Left	37 ± 16 ^{A}		

Except indication to the contrary, the data are presented in mean and standard deviation and the statistical test used was ANOVA with one criterion. Different Superscript letters indicate statistical significance statistical difference ($p < 0.05$) among the locations of needle tip positioning, for the same antimere or general means of the same measurement * Kruskal-Wallis Test.

There was no statistical difference among the antimeres for the distance from the skin to the pelvic cavity (p = 0.2613), general measurement 26.24 ± 4.13 mm (right antimere: 25.21 ± 4.69 mm; left antimere: 27.39 ± 3.28 mm).

With these results it was chosen to assess the access technique to the pudendal nerve, supporting the needle on the skin at an angle of approximately 48° with the ilio-ischemic line and then moving the needle laterally to an angle of approximately 26° with the sagittal plane. After this positioning, the needle was introduced into the skin for 22 mm (Figure 1).

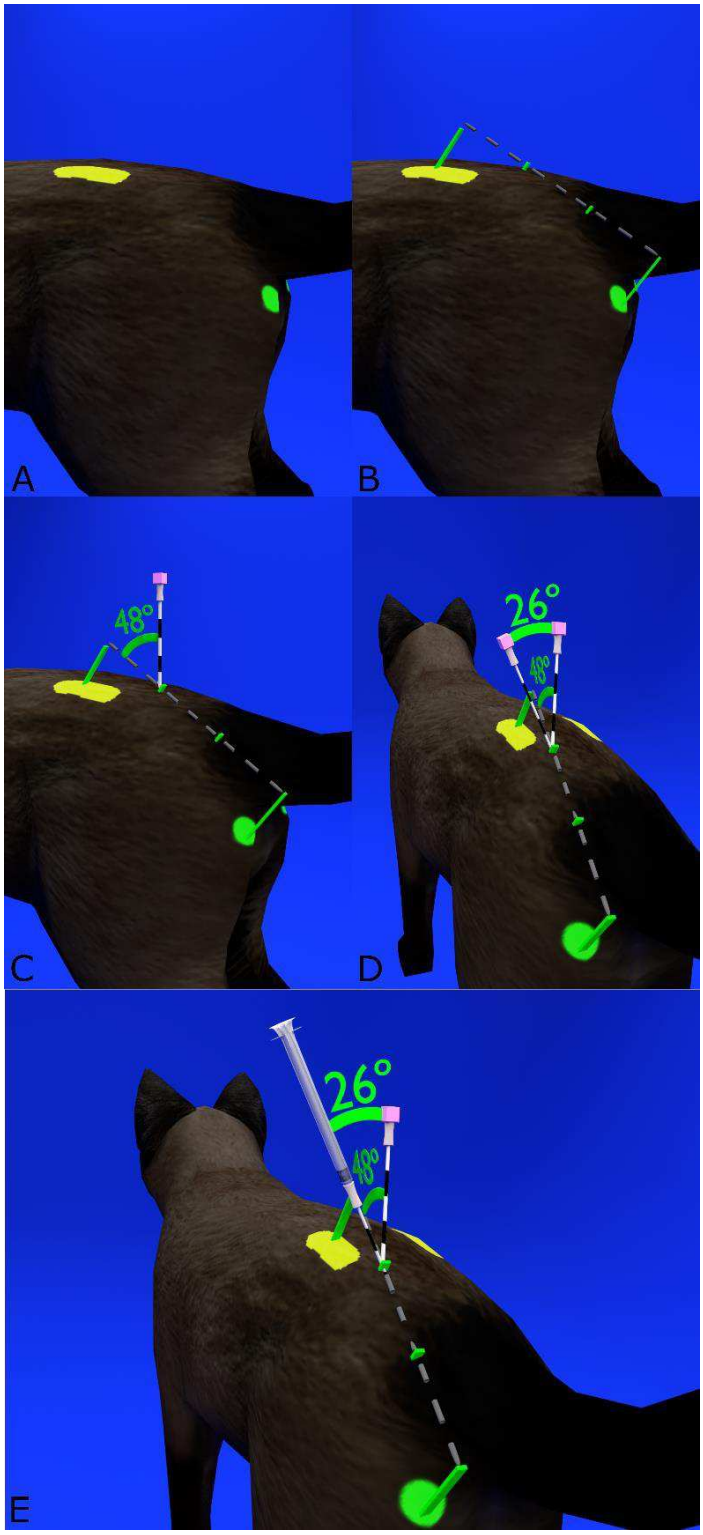

Figura 1: Steps to carry out the cranial access technique to the pudendal nerve in domestic cats. A – Step 1: Identify the palpable bony protuberances (yellow – iliac crest; green – sciatic tuberosity); B – Step 2: Trace an imaginary line linking the dorsal region of the iliac crest to the caudal region of the sciatic tuberosity and divided into three equal segments; C – Step three: Place the needle at the point of union between the cranial segment and the middle segment of the line created in step 2. forming a 48°angle; D – Step 4: Move the needle laterally, forming an angle of 26° the sagittal plane; E – Step 5: Introduce the needle for 22.

Second phase

The pudendal nerve was marked bilaterally in four cadavers (4/6). In two cadavers (2/6) the pudendal nerve had unilateral staining and in the contralateral antimere, the fascicles that formed it were stained. Figure 2 shows the stain distribution in different cadavers. In the pudendal nerves marked by the stain, the stain extended for 12.1 ± 1.63 mm (right antimere) and 16.7 ± 6.19 mm (left antimere). The fascicles of the cadavers with unilateral marking of the pudendal nerve were stained for 13.6 mm (right antimere of cadaver 5) and 18.27 mm (left antimere of cadaver 3). In addition to the two cadavers reported above, the fascicles of one cadaver (1/6) were stained bilaterally and unilaterally in two cadavers (2/6). All the ventral sacral roots were marked by the stain bilaterally in one cadaver (1/6) and unilaterally in two cadavers (2/6). In one cadaver the first and second ventral sacral roots were stained in one antimere and only the second ventral sacral root was stained in the other.

The sciatic nerve was also marked bilaterally in four cadavers (4/6) and complete unilateral marking was shown in two cadavers (2/6), in which (2/6) there was only partial marking of the sciatic nerve in the incompletely stained antimere. The stain that marked the sciatic nerves extended for 18.9 ± 6.03 mm (right antimere) and 19.4 ± 7.47 mm (left antimere).

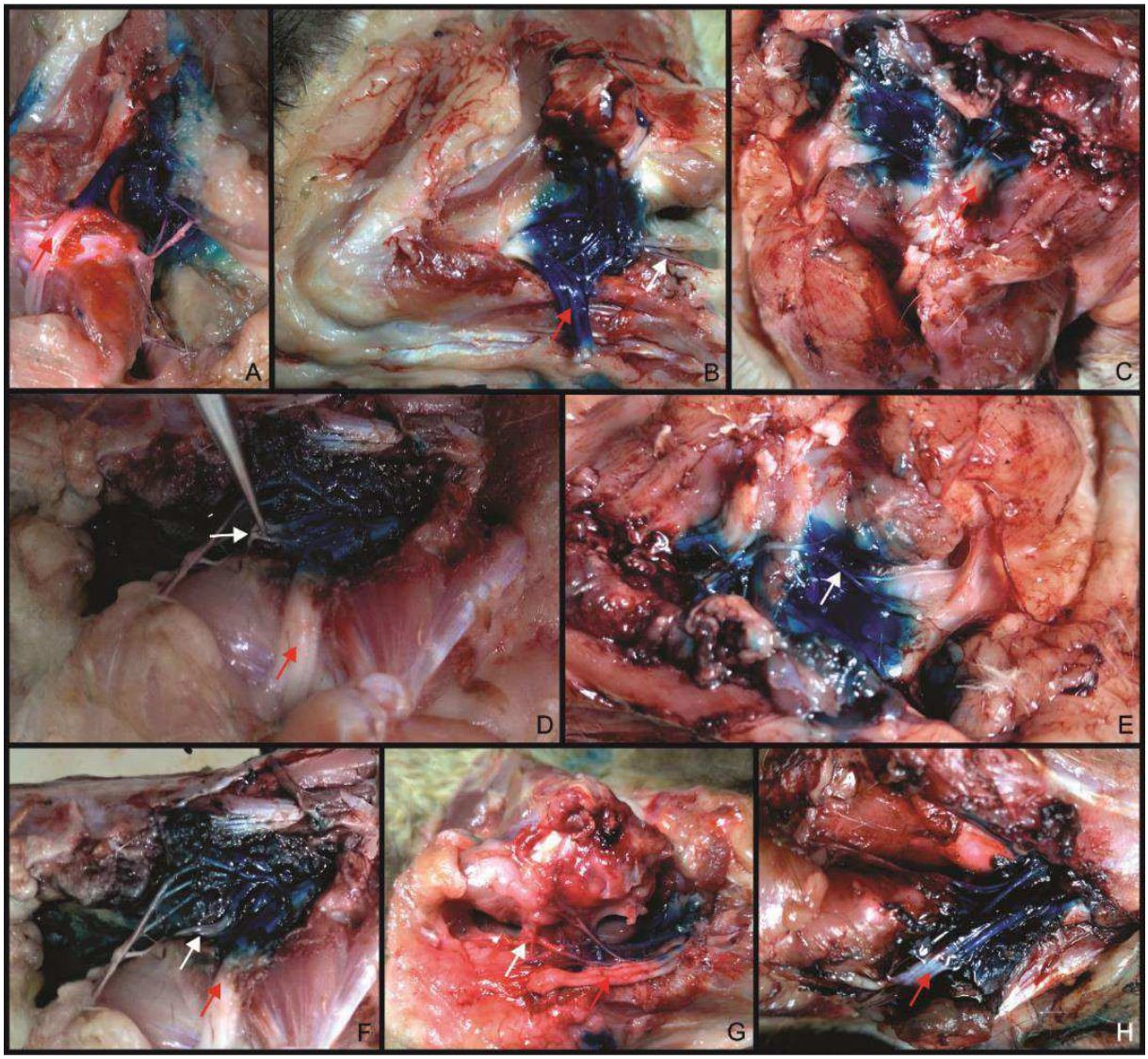

Figura 2: Stain dispersion in different domestic cat cadavers. A-H - Methylene blue dispersion over the region of the fascicles that give rise to the pudendal nerve; A,B,D,F,H - marking of the sciatic nerve by the stain; E and F – Marking of the pudendal nerve by the stain; White arrow – pudendal nerve; red arrow – sciatic nerve.

Discussion

Although the original objective of the present research was to describe a technique that could promote access concomitantly to the pelvic and pudendal nerves, it was chosen to describe the one that focused mainly on the pudendal nerve because of the statistical differences presented between the angles formed with the ilio-ischemic line, in the comparison between the needle positioning locations. A different option for stain deposit would probably make access to the pudendal nerve impossible, that is the primary object of anesthesia block because it accounts specifically for the innervation of the urethra, the external urethra sphincter and the pênis.[3]

The technique described in the present study is similar to those described by Vasconcelos et al.[2] and Portela et al.[11] In the first study the differences are in the angulation with the ilio-ischemic line and the sagittal plane, that were approximately twice those described in the present study. In the second case the objective diverged because the authors intended to perform the sciatic nerve anesthetic block so that the angulations with the line and the sagittal plane were also different.

When assessing access to the pudendal nerve, marking was observed of the pudendal nerve or of its fascicles in all the cadavers. These results demonstrated that this technique is feasible, that is similar to the results obtained by Vasconcelos et al.[2] who achieved bilateral block of the pudendal nerve in 14 of the 16 animals studied.

Vasconcelos et al.[2] further observed sciatic nerve block in three patients (3/16) that was also observed in the present study by the marking of this nerve by the stain. Adami et al.[6] when developing an ultrasonography-guided technique for pudendal nerve block, rejected one of the techniques described due to the risk of blocking the sciatic nerve and consequent probable motor block *in vivo*. However, as reported by Vasconcelos et al.[2] clinically the anesthesia of the sciatic nerve would not be relevant as after blocking with local anesthetics the patients (cats with urethra obstruction) remained under fluid therapy and, therefore, with restricted movement. This argument makes sense for the patients in question and, furthermore, there are local anesthetics that are more selective for the sensitive block than the motor, that could be used to minimize the probable motor block of the sciatic nerve, in the cases where a longer duration of the anesthetic is desired.

Conclusion

This study demonstrated that, in domestic cats, concomitant access to the pelvic and pudendal nerves was not possible, but that the cranial access to the pudendal nerve was feasible and effective. There should be future studies to assess the effectiveness and applicability of this technique in clinical practice.

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Conflicts of Interest

The authors declare that there are no potential conflicts of interest regarding the research, authorship and/or publication of this article.

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CONCLUSÃO GERAL

Esta pesquisa demonstrou aspectos anatômicos do nervo pudendo que não foram relatados por outros autores, como a curvatura que ele apresenta e sua relação com a espinha isquiática e demonstrou que é possível acessar o nervo pudendo em diferentes locais tomando-se como referência diferentes estruturas anatômicas, fornecendo, desta forma, subsídios para que elas sejam, futuramente, testadas clinicamente e ampliando o arsenal de técnicas disponíveis para serem empregadas na anestesia de felinos que necessitem de procedimentos que envolvam o pênis e a uretra.

APÊNDICE

Appendix A: Distribution of the perineal nerves and structures innervated by the perineal branches of the pudendal nerve.

Cadaver	**Animal A**				**Animal B**								**Animal C**						**Animal D**							**Animal E**			**Animal F**						**Animal G**								
Antimere	**D**		**E**		**D**				**E**				**D**		**E**				**D**			**E**				**D**	**E***	**D**				**E**			**D**			**E**					
Perineal nerve	**1**	**2***	**1**	**2**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**1**	**2**	**3***	**4***	**1**	**2**	**1**	**1**	**2**	**3**	**1**	**2**	**3***	**1**	**2**	**3***	**1**	**2**	**3**	**4**	**5**	**6**
Bulbourethral gland	x					x					x			x			x			x			x			x					x		x			x			x	x			
Follows dorso-caudally to the bulbourethral gland							x	x																																				
Follows caudal-ventrally to the bulbourethral gland																																									x			
Ischiocavernous muscle									x	x											x	x															x							
Penis curve												x	x			x			x							x																		
Prostate			x																																								
Urethra					x#				x						x#														x	x														
External anal sphincter																		x+																							x	x		
Rectum																															x												

* Innervation location could not be identified; # cranial portion; + ventral third.

Appendix B – Stain distribution per cadaver.

Stain distribution		Animal																					
		1		2		3		4		5		6		7		8		9		10		11	
		D	E	D	E	D	E	D	E	D	E	D	E	D	E	D	E	D	E	D	E	D	E
Pudendal nerve marked by the stain																				X			
Stain close to the pudendal nerve	Stain over the artery and caudal gluteal nerve and over the adjacent fat				X	X							X						X				
	Stain over a think fat layer that involves the pudendal nerve							X															
Stain over the superficial gluteus fascia		X		X						X	X				X			X					X
Stain over the superficial gluteus fascicle			X			X	X					X						X		X		X	
Stain under the superficial gluteus fascia					X		X								X	X	X					X	
Stain over the gluteofemoral muscle								X							X									
Stain over the superficial gluteus muscle			X		X	X		X	X				X	X					X	X	X		
Stain under the gluteofemoral muscle						X			X				X										
Stain under the superficial gluteus muscle						X			X												X		
Stain over the caudal edge of the middle gluteus muscle									X														
Caudal to the gluteofemoral muscle over the fat over the internal																				X			

obturator muscle																					
On the caudal third of the piriformis muscle				**X**																	
Lateral to the rectum																			**X**		
Under and on the abductor cruris caudalis muscle													**X**								
Under the fat under the gluteofemoral muscle																			**X**		
Sciatic nerve marked by the stain					X							X									