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Morphological Substantiation and Technique of Lumbar Surgical Approach for Ovarian and Uterine Extraorganic Nerve Block in Domestic Dogs and Domestic Cats

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Abstract

Despite a great number of newly developed treatment techniques for various diseases, there is an obvious lack of effective surgical approaches to the innervation sources of the internal genital organs in domestic dogs and cats for pathogenetic impact and local anesthesia. This study aims at developing a morphologically substantiated, species-specific lumbar surgical approach for ovarian and uterine extraorganic nerve block in domestic dogs and daomestic cats.

The study has been performed on the bodies of mature mesomorphic domestic dogs and cats that died or were euthanized as a result of noninfectious diseases. A set of morphological study methods has been used, including common and fine dissection after Academician V.P. Vorobyev, classical methods for preparation of light-optical tissue specimens, and morphometry. To develop injection approaches to the innervation sources of genital organs, we applied injections of a colored latex solution with subsequent dissection.

The conducted studies brought understanding of skeleto-, organo- and angiotopic interrelations between the lumbar parts of the right and left gangliated cords, the right and left lumbar splanchnic nerves, the ovarian arterial and venous plexuses, the caudal mesenteric ganglion and the homonymous plexus. A detailed characterization of macro- and microanatomical and histological structure of ovarian and uterinea extraorganic nerves has been provided. The study elucidated histostructural interrelations between innervation sources, ovarian, uterine and vaginal paraorganic nerves and surrounding connective tissue structures in domestic dogs and cats.

The proposed technique of lumbar surgical approach for blocking the lumbar parts of the gangliated cords, the lumbar splanchnic nerves, the ovarian arterial and venous plexus, and the caudal mesenteric plexus provides the coverage of a topographically accurate and anatomically localized area of the ovarian and uterine innervation sources in domestic dogs and domestic cats.

Keywords. Lumbar surgical approach, gangliated cords, lumbar splanchnic nerves, ovarian arterial and venous plexuses, caudal mesenteric nervous plexus, ovaries, uterus, domestic dog, domestic cat.

INTRODUCTION

Despite considerable advances in cynology and felinology, many authors of textbooks on canine and feline diseases recommend using general anesthesia and neuroleptanalgesia for pain control. Local anesthesia techniques, though great in number, are preferred only in rare clinical cases and reduced to regional blocks of somatic nerves in the head and the distal segments of the limbs, infiltration anesthesia mainly in the form of "short" procaine blocks of the cover tissues and the muscle layer of the body, as well as massive intravascular injections of procaine and lidocaine. Anesthetic techniques for the abdomen and the pelvic cavity include only epidural or subarachnoidal approaches for spinal anesthesia, primarily in the form of high or low caudal (or, more rarely, lumbar) anesthesia [1-3, 5, 6, 8, 13, 15]. At the same time, due to the gaps in morphological and topographical knowledge of autonomous nervous structures in canines and felines, as well as the absence of guidelines on their clinical morphology, the techniques of approach to innervation sources of thoracic, abdominal and pelvic organs developed for large ungulates are "by default" transferred to small carnivores by practicing veterinarians [7, 9, 14], thus decreasing clinical efficiency and posing risks to life and health of dogs and cats [10].

Based on the above, the objective of our research has been determined as studying morphological features of ovarian and uterine extraorganic nerves in domestic dogs and domestic cats and developing a species-specific surgical approach for their blocking.

MATERIALS AND METHODS

The study has been performed on the bodies of mature mesomorphic domestic dogs and cats that died or were euthanized as a result of noninfectious diseases not related to the pathologies of the abdominal and pelvic regions of the body and the organs of the abdomen and pelvic cavity. Materials for the study were supplied from the clinic of the Omsk State Agrarian University named after P.A. Stolypin.

A set of the following morphological study methods was used to reach the desired objective: common and fine dissection of ovarian, uterine and vaginal extraorganic nerves (according to the method by Academician V.P. Vorobyev), classical methods for preparation of light-optical tissue specimens of the innervation sources and paraorganic nerves of internal genital organs, and morphometry. The digital material obtained by means of morphometry was processed statistically using the parametric method (Student's t-test). Statistical processing was performed using the application software Microsoft Office Excel 2010 (©Microsoft Corp./primary analysis).

To develop injection approaches to the innervation sources of the genital organs, we applied post-mortem injections of a colored liquid coagulant (latex solution) with subsequent dissection (Table 1).

RESULTS

The study has demonstrated that the innervation sources of internal genital organs in female dogs and cats are represented by the lumbar parts of the right and left gangliated cords, the right and left lumbar splanchnic nerves, the ovarian arterial and venous plexus, the caudal mesenteric ganglion, the homonymous plexus with outgoing left and right hypogastric nerves, and the uterine-vesical parts of the pelvic plexus.

The preganglionic branches of the lumbar part of the gangliated cord (neural segments 2 to 5) are combined to form the lumbar splanchnic nerves that follow along the ventrolateral surface of the bodies of the third, fourth and fifth lumbar vertebrae in the ventromedial direction from the ventral muscles of the spine, in the depth of loose areolar connective tissue with a significant content of white fat tissue. At the borderline between the fourth and the fifth lumbar vertebrae, in the cranial direction from the level of the outgoing external iliac arteries, they go to the lateral surface of the abdominal aorta, and then to the craniolateral surface of the caudal mesenteric artery, where (in the projection of the fifth-sixth osseous lumbar segment) they enter the dorsal end of the caudal mesenteric ganglion. Near the base of the ovarian

and cranial uterine arteries and veins, on the ventrolateral surface of the abdominal aorta portion within the third-fourth lumbar vertebral segments, the strongly interconnected lateral and ventral intermesenteric nerves form a thick- or medium-looped plexus of ovarian arteries and veins, which represents the source of formation for nervous plexuses directly in the ovarian hilus (the ovarian paraorganic plexus) and in the cranial third of the uterine horns (the cranial uterine paraorganic plexuses).

All nerves under consideration have a well-marked epineurium which consists mostly of collagen fibers. However, its thickness decreases in the direction from the paravertebral ganglia of the gangliated cord to peripheral nerves until reaching the level at which the latter pass from the ventrolateral surface of the vertebral bodies into loose fibrous perivascular connective tissue of the middle portion of the abdominal aorta, and then increases again, reaching the highest thickness at the caudal mesenteric ganglion and the initial portion of the hypogastric nerve. Epineurium has the lowest thickness in the vertebral portions of the lumbar splanchnic nerves and in the ovarian artery plexus elements located on the lateral surfaces of the abdominal aorta.

Loose fibrous perineural connective tissue is most strongly developed in the paravertebral area, where its ground substance has a higher content of elastic fibers and lipocyte inclusions. In the perivascular region of the above mentioned nervous structures, loose fibrous connective tissue shows a considerable loss of elastic fibers replaced by collagen ones and becomes similar to dense irregular connective tissue. Meanwhile, the amount of fat tissue remains close to that in the paravertebral area.

Anatomotopographically, these structures are located in immediate proximity to each other, at the level of the caudal end of the spinous process of the fourth lumbar vertebra or the lateral end of the transverse process of the fifth lumbar vertebra in the ventral paravertebral region. On the right side of the body, the periaortic region of the lumbar splanchnic nerves and the elements of the ovarian and cranial uterine arterial and venous plexus is laterally overlapped by the portion of the caudal vena cava. In one case, this was observed on the left side of a cat's body.

The dorsal muscles of the back in the area of the third, fourth and fifth lumbar vertebrae form a large number of closed intramuscular and intertendinous spaces containing a small amount of loose fibrous connective tissue. Due to the large amount of muscle tissue, an average ratio between its depth and the width of the lateral vertebral body surface in a domestic dog is 1.9:1. In a domestic cat, this parameter reaches 2.1:1. Intertransverse ligaments of the lumbar vertebrae are located in the medial direction from the muscle layer and, together with multiple tendon ends of the back's dorsal muscles, are fixed to the free ends of the transverse processes; the ligaments have the structure of dense fibrous regular connective tissue similar to aponeuroses in terms of permeability. The spinal ventral muscles of the lumbar region are located in the ventromedial direction from the transverse processes of the lumbar vertebrae, under the ligament-tendon membrane described above. Having a small volume, they contain no complex closed interfascial sheaths, while preperitoneal loose fibrous connective tissue reaches here the depth equal to the width of the lateral surface of the lumbar vertebrae bodies.

The described anatomotopographical and histological features predetermine long-distance free diffusion of the solutions injected under the transverse processes along the ventral surface of the vertebral bodies and the dorsolateral surfaces of the aorta in the region of the third-fifth lumbar segments.

Based on the above, we propose the following technique of lumbar surgical approach for blocking the gangliated cords, the lumbar splanchnic nerves, the ovarian arterial and venous plexus, the caudal mesenteric ganglion, the caudal mesenteric plexus and the hypogastric nerves in domestic dogs and domestic cats. A needle is introduced in the horizontal plane into the intersection of two conventional lines: a horizontal one, which represents the lower edge of the back's dorsal muscles and the transverse processes of the lumbar vertebrae, palpable as a single anatomo-topographical orientation point, and a vertical one drawn perpendicular to the first line at the level of the spinous process of the fourth lumbar vertebra. If the spinous processes in well-nourished animals are poorly palpable, the vertical line is drawn at the level of the lateral edge of the fifth lumbar vertebra's transverse process. The needle moves along the ventral surface of the base of the fourth lumbar vertebra's transverse process against stop toward the vertebral body. The injection depth is 5 to 10 centimeters for adult mesomorphic medium-nourished dogs, and 2 to 4 centimeters for cats. After touching the vertebral body, the needle is retracted by 2-3 millimeters, a syringe is attached to its hub, and, upon an inspection, 10-15 ml of a colored latex solutiaon are injected from both sides of the body for dogs, and 5-7 ml - for cats. If during the inspection the solution requires force to be injected, the needle is retracted by another 1-2 mm to remove its end from the subperiosteal space or from the depth of the lumbar muscles into paravertebral and periaortic loose fibrous connective tissue.

When the proposed surgical approach was used in the experiment, the colored latex solution coagulated around the gangliated cords and their branches going from lumbar sympathetic ganglia to the lateral and ventral intermesenteric nerves and their connections at the level from the caudal end of the second lumbar vertebra's body to the cranial end of the sixth one. In the projection of the same lumbar segments, the solution diffused ventrally in the paravertebral and periaortic regions, impregnating loose fibrous connective tissue in the area of localization of the lumbar splanchnic nerves, the ovarian arterial and venous plexuses, the caudal mesenteric ganglion, as well as the dorsal part of the homonymous plexus with the hypogastric nerves.

A modification of the above described technique was used as a lumbar approach option to specifically address the cranial lumbar splanchnic nerves and the ovarian arterial and venous plexus, or the caudal lumbar splanchnic nerves, the caudal mesenteric ganglion, the homonymous plexus, and the hypogastric nerves. Instead of being introduced perpendicularly to the longitudinal axis of the body, the needle was introduced at the same point in the horizontal plane at the angle of 35-40° either in the craniomedial direction (the depth of introduction against the third lumbar vertebra's body increased by 2-3 cm in dogs and by 1-1.5 cm in cats, respectively) or in the caudomedial direction (the needle stopped against the body of the fifth lumbar vertebra). In both cases, the solution is injected while the needle is removed from tissues. During craniomedial injections, the ink-colored latex solution injected in the experiment coagulated primarily around the cranial lumbar splanchnic nerves, the ovarian arterial and venous plexus, and the gangliated cords at the level of the second-fourth lumbar segments. When the needle was introduced in the caudomedial direction, the coagulating colored solution was localized around the caudal lumbar splanchnic nerves, the caudal mesenteric ganglion, the homonymous plexus, the cranial portions of the hypogastric nerves, and the gangliated cords at the level of the fourth-sixth lumbar vertebrae.

Table 1 – Study materials and methods

Study methods		Animal species		Total
		Domestic dog	Domestic cat	
Common and fine dissection		10	10	20
Histological study (staining)	Hematoxylin and eosin	5	5	10
	Weigert–Van Gieson	5	5	10
	Mallory	5	5	10
	Bielschowsky–Gross	5	5	10
	Nissl	5	5	10
	Methylene blue	5	5	10
Injection of a colored liquid coagulant followed by dissection with the purpose of developing injection approaches		5	5	10
			Total:	**90**

RESULTS AND DISCUSSION

A paranephric block technique developed in 1951 by I.Ya. Tikhonin for horses and later proposed for other animals [7, 9, 14] shows low specificity and suggests the injection of procaine solution into the paranephric adipose capsule, the borders of which vary both among different species of animals and among different periods of life in a particular animal. In the meantime, it offers an inaccurate surgical approach, poorly oriented in terms of depth and direction (5-10 cm for ungulates and 1.5-3 cm for all canines), thus requiring a long period of individual training for each operator to develop a nontransferable personal experience of orientation in the corresponding tissues of particular species and even breeds of animals. This technique may easily result in a 5-7-mm inaccuracy in the needle introduction depth and location, which is of low significance for large animals having a developed paranephric fat body. However, in small breed dogs and especially in domestic cats, this may at best cause the anesthetic solution to "fall" into the abdomen without any effect from the manipulation, and at worst lead to abdominal injuries and unreasonable intoxication of the entire body. In addition, the diffusion area of the solution injected by means of the proposed techniques covers primarily the renal plexus, only partially reaching the neural components of the ovarian arterial and venous plexus. The above-mentioned disadvantages clearly demonstrate that the surgical approach used for the block after I.Ya. Tikhonin cannot be an absolute indication for the block of the ovarian and cranial uterine arterial plexuses in domestic dogs and domestic cats.

A translumbar block of the lumbar splanchnic nerves and a group of other nerve guides in this region (B.A. Bashkirov, 1955) was also initially intended for use only in large ungulates. This technique implying the needle introduction at the angle of 55–60° tangentially to the body of the third or fourth lumbar vertebra to the different depths, depending on the animal's species and nutritional status, was later extended to carnivores [7, 9, 14]. However, a needle can be introduced "tangentially" to the vertebral body only in large animals whose lumbar vertebrae bodies have a significant lateral surface area, while the thoracolumbar region of the spine has a relatively low mobility (ungulates, pigs, some "gigantic" breed dogs). Small carnivores (furbearers, cats, small and medium-size breed dogs) are characterized by a significant mobility and small sizes of the thoracolumbar region components. In addition, the ratio between the vertebra body width and the thickness of the back's soft tissues to be pierced by a needle before touching the vertebra, is 1:1.9-2.1 in canines and felines, in contrast to the most cloven-hoofed animals, in which it is 1:1.2-1.3 at a low mobility of the body's lumbar region. A needle is very hard to be introduced permanently at an acute angle to the vertebra body and at a high amplitude of mobile tissues. Diffusion of the solutions injected through dorsal muscles may be also stopped by intertransverse ligaments of the lumbar vertebrae, located in the medial direction from the muscle layer and having the structure of dense fibrous regular connective tissue similar to aponeuroses in terms of permeability [4, 10-12]. The above mentioned morphofunctional features of small carnivores hamper the objective control of the anesthetic solution's direct delivery to the autonomous innervation sources of the ovaries and the uterus, providing conditions for its diffusion mainly in the back's dorsal muscles of the lumbar region of the body or in the abdomen. In addition, there is a risk of damaging the aorta and cavernous organs due to the possibility to lose control over the depth and direction of the needle.

We propose a technique of lumbar approach for blocking the lumbar splanchnic nerves, the ovarian arterial and venous plexus, and the caudal mesenteric plexus in domestic dogs and domestic cats at a higher accuracy and safety compared to the previously used techniques. As the injection is targeted, a lesser quantity of the anesthetic may be used, covering a topographically accurate and anatomically localized area of the ovarian and uterine innervation sources. The spinal ventral muscles of this area have small volume and contain no complex closed fascial sheaths, their preperitoneal loose fibrous connective tissue is always well-developed, while the epineurium is much thinner compared to that of the nerves in the adjacent areas. The described approach techniques and morphofunctional features of the application area predetermine free diffusion of the injected solutions along the ventral surface of the lumbar vertebrae bodies and the abdominal aorta, surrounded by the plexuses of autonomous nerves. This is particularly relevant for extensive diagnostic and treatment laparotomies, long and complex operations on the abdominal genital organs, as well as for acute inflammatory processes in the ovaries, the oviducts, and the uterus. A different geometry and objective control of a needle's introduction depth (a needle always stops against the body of the fourth lumbar vertebra) provides minimization of injection injuries and eliminates the risk of the abdominal wall perforation and organ damage. This technique is convenient for management of small carnivores characterized by a high degree of locomotion in the thoracolumbar region of the body. It holds open the possibility of atraumatic and effective manipulations on manually fixed animals without preliminary relaxation and sedation.

CONCLUSION

The conducted study led to the development of the technique of surgical approach to the autonomous nervous system structures responsible for innervation of the ovaries and the uterus in domestic dogs and domestic cats. The developed lumbar surgical approach enables blocking of the lumbar parts of the gangliated cords, the lumbar splanchnic nerves, the ovarian arterial and venous plexus, the caudal mesenteric plexus and ganglion, and the hypogastric nerves, taking into account the anatomotopographical and histological features of the internal genital organs, their neural components and perineural tissues.

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