



Morphofunctional Substantiation of Intraoperative Block of the Pelvic Plexus During Ovariohysterectomy in Domestic Dogs and Cats

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Abstract | The anatomically and topographically inaccurate and functionally unsubstantiated surgical approaches result in a decreased efficiency of the block as a treatment method and high probability of excessive injury to the animal. This paper is aimed at developing a morphologically substantiated and clinically efficient surgical approach for performing intraoperative block of the pelvic plexus in domestic dogs and cats. The work was performed at the morphological laboratory and the university clinic of the Omsk State Agricultural University using light-optic and histological methods, macro- and micro-slicing according to V. P. Vorobyov, by clinical study and determination of general and biochemical parameters of the blood in the animals from the experimental and reference groups before surgery and 14 days after it. As a result of the studies, it has been found that manual and visual monitoring of needle position, direction, and depth of puncturing at any moment of injection ensures the utmost noninvasiveness of the surgical approach proposed for making the block during a surgical approach. This ensures punctate unilateral effect immediately on the nerves in the rectal and the urocytic-reproductive departments of the pelvic plexus for anesthetization and pathogenetic treatment of the rectum, the bladder, the caudal part of the uterine horns, uterine body, and uterine neck, thus increasing the mobility of the organs in the pelvic cavity during their evacuation into the incision lumen. Thus, the clinical result of the proposed block lies in increasing the anatomic nature, the pathogenic effect, the noninvasive nature of the method, and in reducing the toxicity during surgery.

Keywords | Operational access, Intraoperative block, Pelvic plexus, Rectum, Uterine, Urinary bladder, Anesthesia, Pathogenetic treatment, Domestic dog, Domestic cat

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INTRODUCTION

For local anesthesia of the organs in the pelvic cavity and for pathogenetic effect on their autonomous nerves in domestic animals, many blocks performed by various trans-somatic surgical approaches have been developed (Ermolaev et al., 2007; Shakurov et al., 2007; Bailard et al., 2014; Steagall et al., 2013). At the same time, on the background of the successful use of blocks for the autonomic nervous system in case of acute noncontagious diseases and surgical pathologies in large ungulates, their use is limited in veterinary clinics for small

domestic animals. This circumstance is due to insufficient information about the morphology of the peripheral part of the sympathetic and parasympathetic nervous system in dogs and cats. Most works devoted to this problem describe the structure of the sources for the formation of the autonomous nerve plexuses, or the histological structure of the intramural nerves (Korotkovskaya, 2009; Teltsov et al., 2011). There have been few studies of the anatomical and topographic and histological and topographical features of the nerve structures and tissues adjacent to the organs in various Carnivora representatives. The existing gap in neuromorphology leads to the shortage of surgical

approach methods adapted for small carnivores, which makes practitioners apply to dogs and cats the methods of pelvic pathogenetic blocks developed and recommended for ungulates (Pulniashenko, 2000; Gurney and Leece, 2014; Lemke, 2000). The morphologically and functionally unsubstantiated manipulations result in deterioration and even loss of efficiency of the block as a method of treatment. No less dangerous are anatomically and topographically inaccurate surgical approaches that are used for injections, given the high likelihood of excessive injury to the animal.

This paper is aimed at developing a morphologically substantiated surgical approach for performing clinically efficient intraoperative blocks of the pelvic plexus in domestic dogs and cats.

Objectives are as follows:

- Finding out the features of skeletotomy, organotomy, and angiopathy of the nerves in the pelvic plexus in domestic dogs and cats.
- Studying the histological structure of the neural and epineural tissues of the extra-organic nerves in the rectum, the caudal part of the uterine horns, uterine body and uterine neck, and in the bladder.
- developing a method of an intraoperative surgical approach for blocking the pelvic nerve plexus in domestic dogs and cats, which ensures safe anesthesia or the pathogenic effect on the organs in the pelvic cavity of domestic dogs and cats with the use of a small dosage of the anesthetic drug.
- assessing the effect of blocking the nerves in the pelvic plexus by intraoperative injection of anesthetic on the changes in some vegetative functions, hematologic indicators, and the postoperative course in domestic dogs and cats.

MATERIALS AND METHODS

The work was performed from 2012 to 2018 at the morphological laboratory of the Institute of Veterinary Medicine and Biotechnology and at the university clinic of the Omsk State Agricultural University. To study the anatomical and topographic features of the nerves in the pelvic plexus, and to develop methods of surgical approach for making intraoperative block, the macro- and micro-slicing methods according to V.P. Vorobyov were used, as well as posthumous introduction of a solution of latex stained with black ink into the loose fibrous connective tissues adjacent to organs in the peritoneal and extraperitoneal parts of the pelvic cavity. For the histostructural studies, staining of histological slices with hematoxylin and eosin according to Mallory, Weigert, Van Gieson, and Nissl, as well as impregnation according to Bielschowsky-Gros were used (Semchenko et al., 2003). The total of 390 morphological slices were made.

The material for the morphological studies were the bodies of outbred female dogs and cats of the mesomorphic type that had died or had been subjected to euthanasia for the reasons not related to diseases and injuries in the pelvis. Euthanasia of the animals was performed in accordance with the European Convention for the Protection of Vertebrate Animals Used for Scientific Purposes (2003). The material for the research was delivered from Specialized Motor Fleet No. 1 of Omsk and the Clinic of the Institute of Veterinary Medicine and Biotechnology of the Omsk State Agrarian University.

The material for the clinical and physiological studies were 40 clinically healthy outbred dogs at the age of 3 – 6 years, and 50 healthy outbred mesomorphic cats subjected to ovariohysterectomy for economic reasons. The animals were divided into the experimental and the reference groups (20 dogs and 25 cats in each group). The surgery was made using the same methodology with surgical approach along the white line on the abdomen in the area behind the navel on the ventral abdominal wall. Three minutes before the surgical approach, the animals in the experimental group had intraoperative block of the pelvic plexus. Clinical observations, overall and biochemical blood parameters were examined before surgery and 14 days after it. Blood for the biochemical analysis was taken from the saphenous vein, for general analysis from the auricular vein three to four hours before feeding. The level of hemoglobin, ESR, the erythrocytes and leukocytes count in the blood, the leucoformula were determined using the Vetscan HM2 hemoanalyzer. The biochemical blood parameters were studied using the ScreenMasterTouch biochemical analyzer.

Results in domestic dogs and cats, the pelvic plexus is divided into the cranial, the loosely glomerular, and the more compact caudal sections. Each of these sections of the pelvic plexus is in turn subdivided into the dorsal rectal plexus and the uterovesical plexus placed ventrally against it. The cranial section of the pelvic plexus is located in the abdominal section of the pelvic cavity at the level from the middle of the dorsal edge of the iliac wing to the middle of its body. Segmentally, it corresponds to the first bone segment of the hindquarters. Organotopically, the ventral uterovesical part of the cranial section of the pelvic plexus is localized on the laterodorsal surface of the uterus body and the dorsolateral surface of the caudal third of the body, and the initial segment of the bladder neck. The cranial border of the plexus is the segmentary plane at the level of the uterine body transition into horns and rectum transition into the segmented intestine. The caudal border is the segmentary plane at the level of the beginning of the ampulla-like widening of the rectum, uterus body transition into the uterus neck, and the cranial third of the bladder neck. The caudal border of the plexus coincides with the edge of the visceral layer of the pelvic fascia. Thus,

the uterovesical plexus is located in the peritoneal and the extraperitoneal sections of the pelvis and is laterally covered with the pelvic fascia, which limits the ease of surgical approach for blocking from the side of the lateral surface of the pelvic cavity.

The two-layer spatial organization of the cranial section of the uterovesical plexus has a connective tissue skeleton that consists of the loose fibrous connective tissue, the main substance of which contains many interweaving collagen and elastic fibers, and bulky inclusions of the adipose tissue, which make up to 2/3 of the volume of connective tissue layer. Insulation with the adipose tissue requires injecting anesthetic drugs directly into the right and the left halves of the cranial uterine-vesical parts of the pelvic plexus. In addition, the neural ganglion of this part of the plexus, as well as the caudal uterine nerve coming out if it, which serve as sources for formation of the caudal uterine plexus adjacent to organs, are surrounded by expressed connective tissue capsule, the thickness of which is $95.4 \pm 11.5 \mu\text{m}$ and $91.5 \pm 10.2 \mu\text{m}$, respectively, consisting of collagen fibers connected to the surrounding loose fibrous connective tissue. A large amount of adipose tissue was also found around them. In the area of the capsule, the nerve fibers interwove with collagen and elastic fibers. The minimum thickness of the epineurium that surrounds individual nerve bundles of the uterovesical plexus was $64.6 \pm 7.2 \mu\text{m}$. The developed nature of the fibrous connective tissue structures around the main elements of the uterovesical part of the pelvic plexus, as well as their isolation with the adipose tissues require the targeted delivery of anesthetic solutions to the nerves of the plexus, and considerable volumes of these solutions. This circumstance is not an obstacle since there are many elastic fibers in the loose fibrous connective tissue around the plexus.

Given the anatomotopographic and histostructural features of the pelvic plexus, the authors suggest a technique of surgical approach for intraoperative block of the pelvic plexus in domestic dogs and cats. After peritoneotomy in the abdominal area behind the navel, the entire organ set in the caudal half of the abdominal cavity was laterally shifted with spatulas or fingers to expose the loose connective tissue that filled the pelvic protrusion of the peritoneum, and the gaps between the rectum, the bladder neck, the uterine body and the uterine neck. After that, in the loose connective tissue, in the vicinity of the walls of the rectum, the uterus body and the uterine neck, and the bladder neck, the needle of a syringe with its hub connected to a PVC tube adapter or to the hub of the syringe is inserted at the angle of 15–20 degrees to the medial surface of the visceral layer of the pelvic fascia. The needle is slowly pushed into the loose connective tissue between the visceral layer of the pelvic fascia and the walls of the ampulla-like widening of the rectum, the uterine body, the uterine neck, and the

bladder neck to the depth of 3 to 4 cm for cats, and up to 10 cm for dogs, introducing the solution in advance of the needle. The amount of the stained latex solution is 3 to 10 ml on each side of the body. In using the proposed method of surgical approach in the experiment, the stained latex solution coagulated in the entire area of the pelvic plexus localization, soaking the loose fibrous connective tissue adjacent to organs throughout the entire volume, at the level from the middle of the seventh lumbar vertebra to the second tail vertebra. In the projection of these segments, the solution was spreading in the area of the body adjacent to organs, uterine neck and the vagina, as well as the caudal third of the bladder body and bladder neck, soaking the loose fibrous connective tissue in the area of the nerve nodes in both parts of the plexus, of the nerves exiting from them, and of the individual nerve conductors that formed the extraorganic plexuses of the organs in the pelvic cavity.

The intraoperative block of the pelvic plexus involves the introduction of local anesthetics using the method described above before a surgical approach. The 0.5 % solution of novocaine is injected for the pathogenetic purpose, and for local anesthesia. The dosage is 3 ml for cats and small dogs, and up to 10 ml of the anesthetic solution for large dogs on each side of the body. The same manipulation is performed on the opposite side immediately after the first one. The waiting period before the onset of anesthesia is three to four minutes.

The post-surgery care was limited to the treatment of the dermic suture with the Teramycin antiseptic once in two days and protecting it with a special purpose bandage made of cotton fabric. The state of all animals was monitored by daily clinical examination, and by analyzing the morphological and biochemical composition of the blood, ESR and hemoglobin levels immediately after surgery, and three times after every 48 hours.

As a result of the research, it was found that the main clinical parameters in the animals from the experimental group had normalized within the first 24 hours after surgery. It was only in six cats and four dogs that the main indicators returned to the norm by the middle of the second day after surgery. Throughout the entire subsequent observation period (10 days), these indicators also remained within the physiological norm. With that, in all animals in the experimental groups, appetite and locomotor activity were observed as soon as in the early post-surgery period during the first 48 hours. Attempts of licking the dermic sutures were noted in 14 dogs and in 17 cats. They were not systematic and did not result in suture destruction or inflammation of the adjacent tissues. In all animals in the experimental groups, surgical wounds healed up without complications in course of primary healing. Dermal sutures were removed seven days after surgery.

The morphological picture of the blood and the dynamics of its changes also show the positive effect of the block on the post-surgery state of the animals in the experimental groups. ESR, which initially exceeded the norm 1.5 times, normalized on day 3 after surgery. The hemoglobin level remained moderately high throughout the entire observation period, and reached 140–150 g/l on the background of insignificant erythremia (up to 10 million/ μ l) due to absolute erythrocytosis, with the predominance of normochromatic and hyperchromatic erythrocytes, as well as reticulocytes. In all animals in the experimental groups, regenerative leucocytosis with a slight left neutrophilic shift, appearance of young cells on the background of eosinophilia (up to 12 %) and lymphocytosis (up to 50 %) were observed, as well as increased total blood serum protein mainly due to gamma globulins.

In the reference groups, the first signs of animals' state normalization were noted on days three to four of the post-surgery period, and in three cats and two dogs on day 10 of the observation after the antibiotic therapy used. All animals in the reference groups had no appetite during the first two days after surgery; weakness and involuntary movements and postures were observed. In four cats and two dogs from the reference group, purulent-ligature fistula and deep serous dermatitis developed around the dermal suture. Perverted appetite, troubled and painful movements in these animals were observed even outside the official observations period of 14 days. In all reference animals, regular attempts of licking and chacking dermal sutures had been noted, which in two cats and one dog resulted in secondary healing of the skin wounds with the formation of scars. Dermal sutures in the reference groups were removed on days 7–12 of the post-surgery period.

The results of the laboratory studies of the blood of the animals in the reference groups were consistent with the clinical observations. The ESR and hemoglobin levels were normalized by the time of the last study, on day 6 after surgery, and their decrease was not gradual, lytic, and was accompanied by mild anisochromia and erythrocytes anisocytosis (single hypochromic micro- and megalocytes) on the background of overall erythropenia up to 4.3 million/ μ l. The leukogram on the background of high leukocytosis (25–35 thousand/l) also indicated a complicated post-surgery period in most reference animals. The leukocyte profile was distinguished by neutrophilia with abrupt regenerative (degenerative in 11 animals) nuclear left shift: up to 80 % of segmented neutrophils and up to 15 % of banded neutrophils, among which some degenerative forms were found (in 6 animals – up to 10 %).

In five dogs and six cats, lymphocytosis of up to 60 % was observed on the background of agranulocytosis.

The disadvantages of this method of irrigating the mesentery, the myometrium, and the mesovarian ligament irrigation (Reshetnyak, 2000) are the low anatomical and pathogenic effect due to nondelivery of anesthetic solutions to the sources of innervation of the organs in the pelvic cavity, and high toxicity, since the method involves the use of high concentrations of anesthetics in large dosages.

Parasacral blocks according to I.A. Kalashnik affect branches of the pudendal and hemorrhoid nerves and are recommended for anesthesia and pathogenetic treatment of the perineum, the anus, the ampulla-like widening of the rectum, the sphincter of the uterine neck, and the external genitalia (Shakurov et al., 2007). They do not involve the nerves in the pelvic plexus that serve as the main source of autonomous innervation of the pelvic organs in predators (Sitdikov et al., 2014; Shvedov, 2004). As a result, the anesthetic and pathogenic effects do not involve the bladder, the uterine neck, body, and horns. In addition, insertion of needles into the connective tissues space between the rump bone and the rectum without visual monitoring of needle movement in the tissues presents a high risk of injuring the wall of the latter, or the middle rump artery and vein (Sapozhnikov et al., 2011; Gurney and Leece, 2014).

In 4 % of the cases in the reference animals, lymphocytosis was noted on the background of agranulocytosis, which, in combination with sharp degenerative neutrophilic left shift, indicated severe inflammation, as well as reduced phagocytic activity due to depletion of hematopoiesis. The leukogram on the background of high leukocytosis also indicated more complicated post-surgery period in most reference animals (Reshetnyak, 2002; O'Hearn and Wright, 2011).

Early normalization of the main clinical indicators of the state of the organism of the animals subjected to surgery in the experimental group, as well as the leukogram (regenerative leukocytosis due to increasing the segmented cells with insignificant neutrophilic left shift on the background of eosinophilia (up to 11 %) and lymphocytosis (up to 52 %)) and increasing the level of total blood serum protein mainly due to gamma globulins confirm high resistance of the organisms of the experimental animals, and rapid post-trauma recovery on the background of hematopoiesis and cellular immunity. The most strikingly, these changes are manifested in the early post-surgery period, in the first three to four days. Moreover, during subsequent rehabilitation, observations also revealed the strengthening of the immunological reactions of the organisms of the animals in the experimental group. In the

absence of additional serious treatment, this effect could only be achieved by intraoperative block of the pelvic plexus (Smirnov et al., 2000; Bailard et al., 2014).

CONCLUSION

The clinical result of the proposed block lies in increasing the anatomic nature, the pathogenic effect, the noninvasive nature of the method, and in reducing the toxicity during surgery. This ensures punctate unilateral effect immediately on the nerves in the rectal and the urocytic-reproductive departments of the pelvic plexus for anesthetization and pathogenetic treatment of the rectum, the bladder, the caudal part of the uterine horns, the uterine body, and the uterine neck, i.e., the analgesic and pathogenetic effects increase. In addition, this increases the mobility of the rectum, the bladder neck, the uterine body and neck, when they are evacuated into the incision lumen due to reduced pain during manipulations, and to relaxation of the muscular elements of the ligaments of the bladder and the mesorectum in the places of their attachment to the abdominal wall, as well as of the smooth muscles of the uterus, its ligaments, and mesentery, which are sedentary in dogs and cats due to the weak development of loose connective tissues in the caudal half of the pelvic cavity. The most veracious manual and visual monitoring of needle position, direction and depth of puncturing at any moment of injection ensures the utmost noninvasiveness of the surgical approach proposed for making the block during the surgical approach.

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AUTHORS CONTRIBUTION

All authors contributed equally.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

ETHICAL CLERANCE

Ethical permission was obtained from the Ethics Committee at the Department of Diagnostics, Internal

Noncontagious Diseases, Pharmacology, Surgery and Obstetrics of the Omsk State Agrarian University.

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