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Pathogenesis and pathomorphology of distraction trauma in the framework of pre-trial investigations of cruelty to animals

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Abstract. The importance of identification and differential diagnosis of spinal injuries, in the case of polytrauma, the ability to distinguish the pathogenesis of various injuries are important and relevant both during clinical and during pathological examination of the animal's body. The purpose of research is to provide veterinary practitioners and lawyers with strategies for identifying the cause (mechanism) of spinal cord injury and to assist triers of fact (decision-makers) in arriving at plausible and reasoned veterinary forensic conclusions. The research was performed using pathological and anatomical dissection and histological studies. It was established that damage to the cervical spinal cord due to traumatic bending of the neck was accompanied by partial or complete rupture of the intervertebral disc and destruction of the ligaments of the vertebrae.



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It was found that the hyperemia of the vessels of the meninges of the brain is the result of blood circulation disorders in the occipital artery and the caudal artery of the meninges, and mechanical damage to the integrity of the intervertebral discs or the destruction of the ligaments of the neck vertebrae led to various disorders of the innervation of various organs and systems of the body and ended the death of animals. It was proved that the distraction injury of the cervical spine led to the swelling of the medulla of the brain, haemorrhages of the caudal-ventral part of the brain substance. It was found that irritation of nervus vagus led to hyperemia of vessels of large (aorta and trunk of pulmonary artery) caliber, cranial mesenteric artery) caudal mesenteric artery and, accordingly, hyperemia of thoracic and abdominal organs. Application of research results will help in differentiation of various types of mechanical injuries of the spine (including differentiation from other pathological conditions of the body), determination of the area of the applied force vector

Keywords: traumatic bending of the neck; distraction injury; cervical vertebrae; spinal cord; swelling; bleeding

INTRODUCTION

The problem of cruelty to animals becomes more urgent every year and is raised both by specialists in law enforcement agencies and doctors of veterinary medicine and by society in general. Without a forensic veterinary examination, a full and comprehensive investigation of offences related to animal cruelty is not possible (Bright *et al.*, 2018; Longobardi & Badenes-Ribera, 2019; Parry & Stoll, 2020). In recent years, there has been a growing awareness of the field of veterinary forensics, involving veterinary professionals in a wide range of investigations, from the assessment of possible injuries to domestic animals to wildlife crimes involving the capture, transport and killing of protected animals and endangered species. In addition, there is increasing recognition of the potential for forensic pathologists to contribute to the field in collaboration with veterinary specialists. One of the tasks of forensic-veterinary research is to establish the method of committing a crime; determination of the instrument (facilities) of committing the crime. All this becomes possible via applying knowledge in the field of veterinary medicine using special research methods (Kazantsev & Yatsenko, 2021).

Studies conducted by Spanish scientists (Rebollada-Merino *et al.*, 2020) indicate that in large cities, the most common cause of death of dogs related to violence is injuries by blunt objects, which accounts for 43.64% of mechanical injuries in general; sharp objects – 1.82%; injuries by firearms – 18.18%, bites by other animals – 1.82%, respectively. In cats, the most common cause of death is blunt force trauma – 21.95%, gunshot wounds – 7.32% and bites – 4.88%.

However, during violence, animals not infrequently receive spinal injuries of varying severity and nature. In many cases, the mechanism of injury (flexing, extensor, flexor-circular and compression) conditions the animal's chance of recovery in the future. The most common cause of damage to the spine is the mechanism of compression along the axis of the spine (for example, falling from a great height, hitting the front part of the head against a hard object at a high speed of the animal, etc.) (Parilovsky & Yatsenko, 2021).

Züger *et al.* (2018) noted, that the most common cause of damage to the cervical spine is mechanical action of a traumatic nature. Vertebral injuries include fractures, dislocations, and subluxations. Vertebral dislocation occurs when the vertebral body is displaced from its normal cranial/caudal synovial joint with adjacent vertebrae. Vertebral subluxation occurs when there is partial displacement of a vertebra from its normal cranial/caudal synovial junction with adjacent vertebrae (Saengthong *et al.*, 2022).

Schmidli *et al.* (2019) declared that isolated vertebral dislocations (without bone fracture) occur in any part of the spine. Therewith, there is a displacement in the intervertebral joints. Dislocations of the cervical vertebrae occur more often with indirect and less often with straight injuries of the spine. In addition, mild forms of subluxations, which are called functional vertebral blocks, can be observed at any level. Vertebral dislocations, as a rule, are accompanied by a violation of the static and dynamic function of the spine. In the event of a fracture of the transverse processes of the lumbar and cervical vertebrae, there are symptoms of the inability to shift the position of the limb and sharp pain in the lumbar region during extension of the pelvic limb bent at the hip joint (Yayla *et al.*, 2023). Parilovsky & Yatsenko (2021) indicated, that damage to the cervical spine can manifest as fractures of the dorsal or ventral arch of the first cervical vertebra, fracture dislocations and fractures of the bodies or arches of the second to seventh cervical vertebrae, fracture of the dentate process of the second cervical vertebra. Not in all cases, trauma to the cervical spine leads to a violation of the integrity and function of the spinal cord. Dislocations and subluxations of the cervical vertebrae can pose a threat to the animal's life. If the injury results in a vertebral fracture, this in turn can cause damage to the spinal cord.

The most dangerous neurological component of damage to the cervical spinal cord is acute respiratory failure, which manifests itself when the C3-C4 vertebrae and C1-C2 vertebrae are damaged (Hansen *et al.*, 2019). In the early stages, after damage at the level of C3-C5, aspiration of gastric masses and a state of shock

can be observed, which will be the cause of death. Neurological symptoms that occur, therewith, can be a manifestation of disorders of the spinal cord or spinal nerves. At the molecular level, immediately after the injury, there is a violation of the ion balance due to the stoppage of membrane ATPase pumps. Violation of membrane integrity leads to the release of glutamate with the subsequent development of excitotoxicity. These processes occur in parallel with the growing damage to the brain tissue due to the increase in active forms of oxygen (Blando *et al.*, 2022).

The purpose of research is to provide veterinary practitioners and lawyers with strategies for identifying the cause (mechanism) of spinal cord injury and to assist triers of fact (decision-makers) in arriving at plausible and reasoned veterinary forensic conclusions.

MATERIALS AND METHODS

Pathomorphological studies were conducted as part of pre-trial investigations on the grounds of a criminal offence provided for in Article 299 of the Criminal Code of Ukraine (2022) based on the educational and scientific laboratory of the Faculty of Veterinary Medicine of Odesa State Agrarian University. The purpose of the research was to determine the causes of death and the nature of injuries of 10 animals (domestic cats) aged 3-5 months that died violently as a result of mechanical damage to the spine in the cervical region. The injuries were caused as a result of the cruel treatment of people towards these animals. Cadavers were dissected by the method of complete evisceration in the generally accepted sequence (Yatsenko & Kazantsev, 2021). A comprehensive patho-anatomical study of the organs and systems of the animal body at the macroscopic level was performed. The production of histological preparations was conducted according to the generally accepted scheme with staining with hematoxylin and eosin and subsequent encapsulation in polystyrene (Horalskyi *et al.*, 2015). A histological examination of the brain and lungs was conducted, pathological changes at the microscopic level were established.

All experimental studies were conducted according to modern methodological approaches and in compliance with the relevant requirements and standards, in particular, they correspond to the requirements of DSTU ISO/IEC 17025:2005 (2006). The animals were kept, and all manipulations were performed according to the provisions of the Procedure for conducting experiments and experiments on animals by scientific institutions (Law of Ukraine No. 249, 2012), the European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes (European convention..., 1986).

RESULTS AND DISCUSSION

Autopsies were conducted and analysed the results of pathomorphological studies of several cases of mass

killing of small animals (cats), the death of which was associated with a primary complex injury of the spine and spinal cord. It was established that pathological anatomical changes had their characteristics depending on the area of the vector of mechanical destructive action directed at the cervical spine, namely:

1) damage to the integrity of the axial skeleton in the neck area (dislocations and fractures with complete or partial rupture of the capsular-ligamentous apparatus) due to traumatic bending of the neck (3 animals);

2) distraction closed mechanical injury of the cervical spinal cord (mechanical injury using opposite pulling forces with stretching of the spinal cord) (7 animals).

All spine injuries were closed and were characterised by the preservation of the integrity of the skin and subcutaneous tissue at the level of the injury. No traces of bites and other mechanical damage (fire, puncture and cut wounds) were found on the body of the animals.

Cervical spinal cord injury due to traumatic neck bending in kittens was accompanied by various combinations of partial or complete rupture of the intervertebral disc and destruction of the vertebral ligaments. Considering the fact that the cervical plexus of nerves is developed by the anterior branches of C1-C4 spinal nerves and is located under m. *Sternocleidomastoidea*, and sensitive, motor and mixed nerves depart from the plexus, which innervate the skin of the lower lateral surface of the head, the lateral and frontal areas of the neck, the auricle, the skin of the back of the head, the diaphragm, the pleura, the peritoneum, the pericardium and, accordingly, mechanical damage to the integrity of the intervertebral discs or the destruction of the ligaments of the vertebrae of the neck led to various disturbances of the innervation of various organs and systems of the body and ended in the death of the animals. All examined cases of damage to the cervical spine were classified as closed unstable injuries. The death of the animals occurred during the period of acute injury (the first period of injury) with the development of primary and secondary signs that were manifested in hemodynamic and lymph circulation disorders, primary traumatic necrosis at the site of application of the traumatic force.

According to a number of authors, the most severe and life-threatening for animals is a complete rupture of the intervertebral disc in combination with the rupture of the ligamentous complex, stretching and compression of the spinal cord, which make up 35-48% of the total number of injuries of the cervical spine, and injuries of the atlanto-occipital sites that range from complete atlanto-occipital or atlanto-axial dislocation to undisplaced occipital condyle fractures (Beauséjour *et al.*, 2022).

Below are the results of the postmortem examination of the corpses of 7 kittens aged 3-5 months due to mechanical trauma, which resulted in dislocations and fractures with partial rupture of the capsular-ligamentous apparatus of the cervical vertebrae, ruptures

between the vertebral discs of the atlanto-occipital and atlanto-axial joints.

The mechanism of dislocation and subluxation of the cervical vertebrae in animals consists in the fact that due to excessive tilting of the head, the left and right caudal articular processes of the cervical vertebra are displaced ventrally behind the facet of the articular surfaces of the left and right cranial articular processes of the cervical vertebra located immediately behind it. Therewith, the capsules of the intervertebral joints (right and left) are torn, and the articular surfaces come in one behind the other, resulting in a bilateral bending (flexor) dislocation. Flexion dislocation of the cervical vertebrae is manifested by the following signs: the head is tilted forward so that the symphysis of the lower jaw hangs almost to the chest; the spiny process of the dislocated vertebra is located more cranially and is palpable with difficulty, and the soft tissues in this area are inflamed; the spinous process of the vertebra located caudal to the dislocated vertebra is clearly contoured under the skin. In cases where a traumatic dislocation is accompanied by a fracture of the articular

end of the bone, then such a condition is diagnosed as fracture (Parilovsky, Yatsenko, 2021).

During the lifetime of all studied animals, there was a violent excessive bending of the body (in the ventral direction and to the side in relation to the axial skeleton) in the cervical spine, which led to damage to the ligamentous apparatus of the atlanto-occipital and atlanto-axial joints, the spinal canal between 1 and 2, 2 and 3, 3 and 4 cervical vertebrae. Excessive (violent) bending of the body in the neck area led to cervical damage to the ligamentous apparatus and joints of the cervical vertebrae, spinal canal, and rupture of the spinal cord membranes. cervical vertebrae. After the skin resection, it was established that the muscles of the neck, in the area of increased mobility of the cervical vertebrae, have a more saturated red color, compared to the general color of the muscles of other areas of the neck. There was hyperemia and haemorrhages in the muscles of the skin around the mechanical injury. In most animals, pronounced blood filling of the lingual veins and sublingual venous arch was established (Fig. 1).



Figure 1. Marked blood filling of lingual veins and sublingual venous arch (B)

In one animal, excessive bending of the head led to a fracture of the tooth-like process of the second cervical vertebra (epistrophe). Another animal had separation of the body of the second cervical vertebra from its arch (animal no. 1-2). Sharp tilts of the head to the side led to stretching and rupture of intervertebral ligaments, ruptures of intervertebral arteries and fracture of the transverse processes of the vertebrae. There was a violation of the integrity of the ligamentous apparatus of the joints of the axial and 3rd cervical vertebrae, stretching and rupture of the spine and spinal canal in the axial plane at the level of the 2 and 3rd cervical vertebrae, the membranes of the spinal cord (animal No. 3); violation of the integrity of the ligamentous apparatus of the joints of the axial and 3rd cervical vertebrae, damage to the

membranes of the spinal cord (animal No. 4). In animal No. 5, the injury was accompanied by a violation of the integrity of the ligamentous apparatus of the joint of the 3rd cervical vertebra, damage to the membranes of the spinal cord; joints 2 and 3 of the cervical vertebrae in animal No. 6. Violent excessive bending of the body in the cervical part of the spine to the right in relation to the axial skeleton led to cervical damage to the ligamentous apparatus of the joints of the 4 and 5th cervical vertebrae, the spinal canal, rupture of the membranes of the spinal cord 1-5 cervical (animal No. 7). Vertebral and other vertebral openings (intervertebral and wing, transverse, lateral) of 1-5th cervical vertebrae contain blood. The surface of the pits (articular, wing) is red (Fig. 2). Spinal cord around the area of damage, uneven light red color.



Figure 2. The vertebral and intervertebral openings of the cervical vertebrae contain blood. Blood vessels of the spinal cord with signs of hyperemia

After resection of the skin, it was established that the bluish color of the brain can be traced through the bones of the skull. In most animals, the brain membrane has a diffuse to focal dark red color, the brain substance has an

uneven light to dark pink color, which is more intense in the ventral part. In many animals, the brain membrane in the medulla oblongata has a saturated, uneven red color, and the blood vessels are above the average blood level (Fig. 3).



Figure 3. General view of the skull (top view) after skin resection (A). Hyperemia of the brain (more pronounced in the rhomboid brain)

Considering the fact that the vertebral artery anastomoses with the occipital artery, accordingly, hyperemia of vessels of the meninges of the brain is a consequence of impaired blood circulation in the occipital artery and caudal artery of the meninges. According to the above, as a result of the injury, there was a violation of hemodynamics of the brain. Spinal cord injury, in all cases, led to a violation of the blood-brain barrier, and to bleeding and swelling, which in turn disrupted blood circulation and led to ischemia due to damage to blood vessels and increased pressure inside the dura mater.

Bleeding in the lumen of the vertebral openings in the zone of mechanical damage, moderate hyperemia and haemorrhages in the muscles around the mechanical injury of the axial skeleton indicate the fact that the injuries were inflicted during the life of the animals. There was a violation of hemodynamics, which was manifested by hyperemia of the cervical spinal cord and brain.

Compression squeezing of the chest during fixation of the animals during the infliction of injuries led to a fracture of 3 to 5 ribs on both the right and left side of the body, in one animal there was a violation of the integrity of the right lung by a fragment of a rib. In most animals, along the ribs on the medial side, there are striped haemorrhages, located parallel to the ribs, bruises of a rounded shape (formed by the pressure of human fingers), located

on the right and left sides of the body, clearly visible from the lateral surface (superficial muscles).

The physiological role of the vagus nerve is very large, the zone of its innervation covers the head, neck, thoracic and abdominal cavities, and therefore regulates the activity of the heart. *Irritation (damage)* vagus nerve and (or) depression of the respiratory center due to mechanical injury of the cervical spinal cord and compression pressure on the chest led to pathological changes in the lungs. In all animals, the lungs acquired an uneven color, on the side of the pleura and in the thickness of the organ, there were areas from light to dark red with a purple tint. On the section, the tissue is dry and somewhat sunken in relation to the general surface. The lumen of the alveoli is empty. Areas protruding above the general surface, pink in color, contain air, when pressed on them - crepitate. Focal foci of lung atelectasis can be attributed to the so-called "reflex atelectasis". Alveolar emphysema is a manifestation of compensatory and adaptive processes to reduce the functional capabilities of the lungs and indicates the vital capacity of the body for some time after the spinal cord injury.

There is a direct causal relationship between mechanical damage to the cervical vertebrae and the death of kittens, the injuries were assessed as fatal. Distraction closed mechanical injury of the cervical spinal

cord (mechanical injury with the use of opposite pulling forces with stretching of the spinal cord). Distraction is a strong stretching of the parenchyma of the spinal cord in the axial plane. All cases of damage to the cervical spine explored by the author were classified as closed unstable injuries. According to Beauséjour *et al.* (2022) both discs and facet joints are damaged in neck sprains. A common disc injury is a “rim lesion” or transverse tear near the front edge of the vertebra. It is caused by distraction and shear when suddenly stretched. Both the back of the disc and the facets are compressed, causing disc bruising or herniation, facet hemarthroses, bruising around the C2 nerve, or articular process fractures (Beauséjour *et al.*, 2022).

Immediately after the injury, the animals developed spinal shock, and as a result – a critical drop in arterial blood pressure, a decrease in heart rate, and a decrease in body temperature. Bradycardia, resulting from an increase in the parasympathetic tone of the vagus nerve, with a simultaneous decrease in the sympathetic tone

(which is provided by the last cervical and first thoracic segments of the spinal cord) led to an increase in arterial hypotension, and, accordingly, a deterioration in the level of blood supply to the heart muscle. As a result of the above-mentioned processes, there was a decrease in the force of heart contractions and a decrease in stroke volume with further progression of arterial hypotension.

In the animals, foci of hyperemia of the mucous membrane of the palate (clearly defined rectangular area of dark red color) and the ventral part of the tongue – spotted (Fig. 4) were found. The mucous membrane of the gums and the buccal part of the oral cavity (more pronounced in animal No. 2) has an uneven to diffuse dark red color, the integrity of the mucous membrane of the oral cavity is not disturbed. The soft tissues around the oral cavity are unevenly colored and contain haemorrhages (more pronounced in animal No. 2). The conjunctiva had a dull red color; the skin of the lateral edge of the ears is light red.



Figure 4. Hyperemia of the mucous membrane of the palate; spotted hyperemia of the ventral part of the tongue

Focal hyperemia and spotty haemorrhages of soft tissues were registered in the neck area, there are symmetrically located areas of red color in the form of a strip of 0.1 cm similar in shape to a crescent (haemorrhages in the places of fixation of animals with fingers). Damage to tissue integrity was not detected. Large (aorta and pulmonary artery trunk) and medium-caliber vessels (vessels of the middle cranial mesenteric artery,

pancreatoduodenal anastomosis, caudal mesenteric artery (rectum) were above the average blood volume (Fig. 5). The above-mentioned violation of blood circulation is not characteristic of the death of animals due to mechanical trauma by a blunt object to the occipital region of the head and mechanical trauma resulting in dislocations and fractures with partial rupture of the capsular-ligamentous apparatus of the cervical vertebrae.



Figure 5. Spotted haemorrhages in the muscles and subcutaneous base of the cranial part of the neck, blood filling of the vessels of the cranial part of the neck (jugular veins, common carotid artery)

Spinal cord injury results in interference with the autonomic nervous system, which ultimately affects various systems, including respiratory, cardiovascular, genitourinary, gastrointestinal, and sexual function (Corcos *et al.*, 2020). In all animals, the injury of the cervical spine was accompanied by a respiratory syndrome, the essence of which is the exclusion of the intercostal muscles from the act of breathing, which ultimately leads to critical hypoxemia, further hypoxia of organs and tissues. In addition, the detected violation of the function of external breathing in the case of spinal cord injury can be caused by neurogenic pulmonary edema. This condition is caused by significant sympathetic hyperactivity, which leads to the stimulation of some parts of the hypothalamus or is caused by an increase in intracranial pressure (Mattucci *et al.*, 2021; Pascoal *et al.*, 2022).

The wall of the trachea and esophagus is within normal limits: its integrity is not disturbed, the mucous membrane is light to dark pink in color, moderately moistened. In the work of the respiratory system, and in the work of the cardiovascular system, there is an activation of the tone of the parasympathetic system against the background of a decrease in the tone of the sympathetic system. The expansion of the cavity of the right ventricle of the heart was registered, the blood was semi-liquid, dark red in color. In animal No. 3, the membrane of the wall of the right ventricle (epimyocardium) has a diffuse dark red color. Lungs in all animals have an uneven red-pink color, on the cut surface

there is a small amount of straw-like transparent liquid (transudate).

The spleen has a uniform dark red color, is elastic, the edges are pointed, the parenchyma is moderately moistened. The pancreas is unevenly red in color. Focal hyperemia of the serous membrane of the intestine was registered. Hyperemia of the thoracic and abdominal organs is a consequence of irritation of the vagus nerve.

The meninges of the brain are of an uneven red color, the vessels are filled with blood. Brain substance of uneven color (milky, pink, red of different saturation in different animals) due to blood filling of medium and small caliber vessels, white matter of uneven color with areas of milky and red color, changes are more pronounced in the caudal-ventral way, there are small haemorrhages.

There were no signs of blunt trauma, vertebral fracture, disc extrusion, or injection puncture in the surrounding soft tissues. The vertebral foramina of the cervical vertebrae and the surface of the articular fossae contain blood. Changes in the spinal cord were accompanied by haemorrhages as a result of rupture of blood vessels. The spinal cord in the cervical and thoracic regions is of an uneven milky-red color. Hyperemia of the vessels of the meninges of the brain is a consequence of impaired blood circulation in the occipital artery and caudal artery of the meninges. Bleeding into the lumen of the vertebral openings in the zone of mechanical damage indicates the fact that the injuries were inflicted during the life of the animals (Fig. 6).



Figure 6. General view of the skull (top view) after skin resection (A); hyperemia of the dura mater (top view) (B); the vertebral openings of the cervical vertebrae and the surface of the articular fossae contain blood (C)

According to the results of histological studies of the spinal cord taken from animals that died as a result of traumatic bending of the neck, pronounced blood filling of the lingual veins and sublingual venous arch was established; for distraction injuries of the cervical vertebrae and spinal cord – bleeding into the lumen of the spinal canal, haemorrhages in the tissues of the spinal cord. The lesion was accompanied by damage to the integrity of the vessel wall, swelling of the spinal cord with the development of extracellular and intracellular edema. The above-mentioned changes led to a

compression syndrome of the tissue of the spinal cord and brain (the caudal part of the trunk), the spinal canal. Focal ischemia of the spinal cord, formation of microthrombi, and microeffusions were recorded. haemorrhages are surrounded by edema with necrosis of neurocytes, edema and destruction of axons, endothelial cells of capillary walls are registered. The swelling of the axons indicates that at least 30 minutes passed from the injury to the death of the animals. The absence of neutrophils on histological preparations indicates the fact that the life expectancy of animals after trau-

matisation was less than 6 hours. In most animals, the swelling of the spinal cord spread to the brain stem and led to the disruption of the vital functions of the body and to the death of the animals. The death of the animals occurred during the period of acute injury (the first period of injury) with the development of primary and secondary signs that were manifested in hemodynamic and lymph circulation disorders, primary traumatic necrosis at the site of application of the traumatic force.

According to the results of studies (Beauséjour *et al.*, 2022) of spinal cord injuries after flexion-distraction injuries of the cervical spine, white matter compression is determined as the main post-traumatic mechanism. The results of this research confirm the fact of the development of compression syndrome of the tissue of the spinal cord and brain (the caudal part of the trunk) in the case of cervical spine injuries. In most animals, the swelling of the spinal cord spread to the brain stem, which led to a violation of the vital functions of the body and to death. The established signs of hemodynamic disturbances (haemorrhages, edema, microthrombi and ischemia of brain tissues), dystrophic changes and necrosis of neurocytes coincide with the features of the manifestation of secondary damage due to mechanical trauma of the cervical spine, which were described in scientific works Corcos *et al.* (2020), Blando *et al.* (2022), Thomas *et al.* (2022).

Thus, according to Corcos *et al.* (2020), during the first 3 hours after the injury, degeneration of the white matter of the spinal cord occurs, damage to the myelin of axons, which leads to spinal shock. Scientists have indicated that the primary injury in spinal cord injury is the initial mechanical trauma that can compromise the physiology of the spinal cord by disrupting neural transmission. Secondary damage is caused by vascular and biochemical effects. Secondary damage mechanisms are manifested in the form of vascular and biochemical disturbances that lead to an imbalance of the physiology of the microenvironment and are accompanied by hypoxia, hypoperfusion, inflammation, edema, microhaemorrhages and thrombosis (Blando *et al.*, 2022; Thomas *et al.*, 2022).

In the available scientific literature, the author was unable to find data on hemodynamic disturbances (hyperemia, haemorrhages) of the brain, blood filling of lingual veins and sublingual venous arch, blood filling of vessels of the cranial neck (jugular veins, common carotid artery), no data on chest hyperemia and abdominal cavity for flexion-distraction injuries of the cervical spine in animals of any species.

In scientific sources there is information about respiratory complications as the main cause of morbidity and mortality after spinal cord injury; about the dependence of the degree of respiratory dysfunction on the neurological level of damage, however, these data are given from the practice of humane medicine and refer to the period of stabilisation of the patient in the

conditions of a medical institution (Pascoal *et al.*, 2022; Gee *et al.*, 2022). Pathological changes in the lungs of animals established during the pathomorphological examination and described in this work as “reflex atelectasis” and pulmonary edema, the corresponding profile was not found in scientific works.

Therefore, according to the results of the pathomorphological studies, the primary injury of the cervical spine and brain stem was established as the cause of the death of the animals as a result of human cruelty to them. The results of the conducted studies demonstrate that even as an isolated injury, an injury to the cervical spine can cause death, due to such complications as: paralysis of the respiratory muscles, neurogenic shock, spinal shock.

CONCLUSIONS

One of the objective signs of cruelty to animals (method of committing a crime) established under Art. 299 of the Criminal Code of Ukraine was examined, namely: infliction of mechanical injuries with violation of the integrity of the axial skeleton in the neck area as a result of traumatic bending of the neck and distracting mechanical injury to the cervical spinal cord, which caused pain, suffering and led to their death.

All examined cases of mechanical damage to the cervical spine were classified as closed unstable injuries. Moderate hyperemia and haemorrhages in the muscles, bleeding in the lumen of the vertebral openings in the area of mechanical damage, indicate that the injuries were inflicted during the life of the animals. Hyperemia of the vessels of the meninges of the brain is a consequence of impaired blood circulation in the occipital artery and caudal artery of the meninges. In the case of a traumatic neck bend, pronounced blood filling of the lingual veins and sublingual venous arch was established, in the case of a distraction injury – blood filling of the vessels of the cranial neck area (jugular veins, common carotid artery).

As a result of a mechanical injury due to a traumatic bending of the neck, the integrity of the axial skeleton in the neck area was damaged (dislocations and fractures with complete or partial rupture of the capsular-ligamentous apparatus), hyperemia and haemorrhages occurred in the tissue of the spinal cord, bleeding in the lumen of the vertebral openings in the area mechanical damage. The development of “reflex atelectasis” is a consequence of suppression of the respiratory centre or damage (irritation) of the vagus nerve due to injuries, compressive pressure on the chest; alveolar emphysema is a manifestation of compensatory and adaptive processes.

Distraction injury of the cervical spine led to swelling of the brain's medullary substance, haemorrhages of the caudal-ventral part of the brain's substance. The pathological process was accompanied by a respiratory syndrome with the development of hypoxia and

neurogenic pulmonary edema with subsequent asphyxia of the animals. Hyperemia of the thoracic and abdominal organs is a consequence of nervus vagus irritation and, accordingly, hyperemia of large vessels (aorta and trunk of the pulmonary artery), cranial mesenteric artery (pancreatoduodenal anastomosis), caudal mesenteric artery (rectum). Massive haemorrhage in the tissues of the spinal cord led to compression syndrome. Prospects for further research: analysis of pathomorphological changes in the body of domestic animals (dogs, cats) due to mechanical trauma of the lumbar and sacral spine.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Патогенез та патоморфологія дистракційної травми в рамках досудового розслідування жорстокого поводження з тваринами

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Анотація. Важливість ідентифікації та диференціальної діагностики ушкоджень хребта, у разі політравми, вміння розрізняти патогенез різних ушкоджень є важливими та актуальними як під час клінічного, так і під час патологоанатомічного дослідження організму тварини. Мета дослідження – надати практикуючим ветеринарним лікарям та юристам стратегії ідентифікації причини (механізму) пошкодження спинного мозку та допомогти судовим експертам (особам, які приймають рішення) у формулюванні правдоподібних та обґрунтованих висновків ветеринарно-медичної експертизи. Дослідження проводили з використанням патолого-анатомічного розтину та гістологічних досліджень. Встановлено, що пошкодження шийного відділу спинного мозку внаслідок травматичного згинання шиї супроводжувалося частковим або повним розривом міжхребцевого диска та руйнуванням зв'язок хребців. Встановлено, що гіперемія судин мозкових оболонок головного мозку є наслідком порушення кровообігу в потиличній артерії та каудальній артерії мозкових оболонок, а механічне пошкодження цілісності міжхребцевих дисків або руйнування зв'язок шийних хребців призводило до різних порушень іннервації різних органів і систем організму та закінчувалося загибеллю тварин. Доведено, що дистракційна травма шийного відділу хребта призводила до набряку головного мозку, крововиливів у каудально-вентральну частину речовини мозку. Встановлено, що подразнення блукаючого нерва призводило до гіперемії судин великого (аорта і стовбур легеневої артерії) калібру, каудальної брижової артерії і, відповідно, гіперемії органів грудної та черевної порожнини. Застосування результатів дослідження допоможе в диференціації різних видів механічних пошкоджень хребта (в тому числі диференціації з іншими патологічними станами організму), визначенні зони дії вектора прикладеної сили

Ключові слова: травматичне згинання шиї; дистракційна травма; шийні хребці; спинний мозок; набряк; кровотеча
