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Analysis of surgical correction of atlanto-axial instability in dogs

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Abstract. Effectiveness of ventral surgical approach in correction of atlanto-axial instability in dogs of «toy» breeds was analyzed in the research. 135 clinical cases of surgical correction, the general concept of surgical access and implant placement, which minimize risks of iatrogenic complications, were studied. Ventral stabilization was carried out by forming an arthrodesis between atlas and epistropheus by inserting screws or spokes through articular structures and vertebral bodies from ventral surface and then fixing them with bone cement. In the studied method, there are also complications in form of failure of metal structures or damage to recurrent laryngeal nerve, but, according to statistics, the incidence of these complications in world practice does not exceed 20 %. Among the possible complications during the operation are death of animal because of sudden respiratory arrest associated with spinal cord injury, migration or breakage of implants, inadequate alignment of spine. In addition, implants may not be placed correctly causing chronic pain or damage to the spinal cord. As a result of the operation, 104 dogs fully recovered, partial preservation of neurological deficit was observed in 13 animals, 18 animals died in the early postoperative period. Complications that did not lead to a deterioration in neurological status and quality of life occurred in 17 animals. Analyzing the work done, the method of ventral stabilization in the treatment of atlanto-axial instability can be recommended as the most reliable and optimal method, since it is technically simple and has good long-term results. Statistical data showed good results, the method is effective and allows to fully return the animal to a quality life in more than 86 % of cases.

Keywords: surgery, postoperative complications, spinal column, ventral stabilization

Conflicts of interest. The authors declare no conflicts of interest.

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Introduction

Atlanto-axial instability (AAI) is a common pathology of cranio-vertebral zone of spine in «toy» breeds of dogs, and to date, extensive experience has been accumulated in the use of various methods for treatment of this disease. Long-term studies have demonstrated various approaches to solving the problems of surgical practice in AAI. Thus, a number of authors announced the use of the dorsal method [1], which is considered to be the most acceptable and has positive results. At the same time, it is stated in [2] that dorsal decompression provides some relief, but it does not relieve pressure on the ventral surface of the spinal cord. Meanwhile, the dorsal technique, (with rigid fixation by inserting Kirschner wires through the spinous process of the epistropheus into atlas wings or fixing the vertebrae with a cerclage wire) has been used in practice for a long time and definitely had a positive role [3–7].

Nowadays, ventral techniques provide access to atlanto-axial joints, and debridement of joints performed in such cases causes arthrodesis and associated permanent stability. Access to ventral surface of vertebrae is carried out along the midline between the right sternocephalic and sternothyroid muscles [8]. Its use has the advantage of avoiding complications and reducing the risk of iatrogenic spinal cord injury during screw placement due to its position and direction [9–11].

Clinical experience shows that ventral techniques include cross-pinning, transarticular screws, combination of pins or bone-cemented screws, and various sizes of vertebral fixation plates. The authors in [12–14] used cortical screws inserted into the joints at an angle in bilateral direction, thereby reducing the possibility of iatrogenic spinal cord injury. In [15], scientists used Kirschner wires, which were inserted bilaterally from epistropheus through synovial joints into atlas body. Thus, a large number of options for surgical techniques indicate the ongoing search for the most optimal surgical approach to the treatment of AAI. So far, there is no consensus on what the most preferable method is — method of ventral stabilization with a plate, Kirschner wires or transarticular cortical screws using bone marrow cement [16–19]. Therefore, the question of the advantages of a particular method remains open.

The purpose of the study was to analyze effectiveness of surgical method of ventral stabilization of atlas and epistropheus.

Materials and methods

In the period from 2015 to 2023, the records of patients with neurological deficits were analyzed, of which 9657 animals underwent visual diagnostics on MRI and CT. Only 2860 (29.6 %) animals of the total number of dogs and cats had pathologies in the cervical spine. And only 135 animals were found to have AAI, which is only 1.4 % of the total number of animals suffering from neurological disorders.

Each animal underwent a primary neurological examination, the stage of neurological deficit was identified, and a visual examination, radiography, MRI of cervical region on a Siemens impakt 1Tl tomograph, 32-slice CT scan of cervical region on a Siemens Somatom Go. Now apparatus were performed. All animals in the group showed ventral compression of spinal cord at the level of atlas and epistropheus [19]. Moreover, in AAI group, concomitant diseases were detected: Chiari-like malformation, herniated cerebellum, Dewey's depression, syringomyelia. Epistropheal tooth hypoplasia was detected in 9 dogs, epistropheal tooth aplasia — in 3 dogs, tooth deviation — in 1 dog, 30 dogs were admitted with atlas fracture and 5 dogs — with epistropheal tooth fracture.

All animals underwent surgical treatment by ventral stabilization with screws in bilateral direction using polymethyl methacrylate.

Results and discussion

Our own clinical experience, as well as the analysis of scientific literature data [2, 16, 17], indicated the presence of many complications in surgical correction by means of dorsal fixation of the AAI. Thus, studies have demonstrated many complications, manifested in the long term by the failure of metal structures and relapses in the operating area, characterized by subluxation of the vertebrae. In the postoperative period, additional external fixation of craniovertebral zone of animal and long periods of rehabilitation, and often reoperations, are required. Therefore, the preferred method of treatment today is ventral stabilization of atlas and epistropheus with screws or wires using bone cement (polymethyl methacrylate). This method is the most reliable, it allows for arthrodesis, which in turn, ensures viability of the metal structure to a greater extent.

The ventral correction method was performed by inserting screws with fixation using bone cement. In the procedure [19, 20] for performing this operation, the authors noted: "Surgical access was performed from ventral surface of neck to arch of atlas and epistropheus body by dissection of sternothyroid and sternohyoid muscles, as well as by isolating atlanto-axial joint from soft tissues. A surgical cutter was used to abrade the articular surfaces C1–C2 to create arthrodesis of articular surfaces. Two screws were inserted intra-articularly into ventral arch of atlas with a lateral displacement of the conduction angle up to 35°, and two screws were inserted into ventral surface of cranial articular facets with a lateral deviation of the screw conduction angle of 40...45°. One screw was inserted monocortically into the thickest part of epistropheus body from its caudal part in the lateral direction at an angle of 55...65°, which allowed the tooth to be distracted and bone cement was placed at the time of tooth abduction. Control was carried out until the cement was completely cured". The surgical wound is closed with a monofilament thread layer by layer. It should be noted that the operation is based on reducing pressure on spinal cord and stabilizing the joint (Fig. 1–6). The pressure is usually relieved by bringing vertebrae into their normal anatomical position. If epistropheus tooth is deformed and displaced towards spinal cord, it must be removed to relieve pressure on ventral surface of

spinal cord. In summary, it can be noted that atlanto-axial joint is stabilized using the ventral technique, since approaches from the dorsal side usually do not lead to stable fixation of the two surfaces of vertebrae, and long-term stability is ensured by strength of metal structure.



Fig. 1. Radiography in lateral projection. Spinal stenosis is determined due to ventral compression of the dens

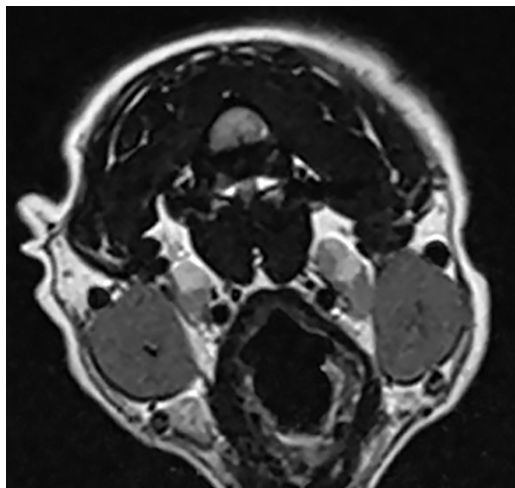


Fig. 2. MRI in sagittal projection. Compression of the spinal cord at the level of C1–C2 is determined



Fig. 3. Postoperative scan in dorso-ventral projection. Creation of arthrodesis of articular surfaces with 7 screws



Fig. 4. Postoperative scan in latero-lateral projection. The safety and volume of the spinal cord after surgery is determined. Fixation with screws and bone cement

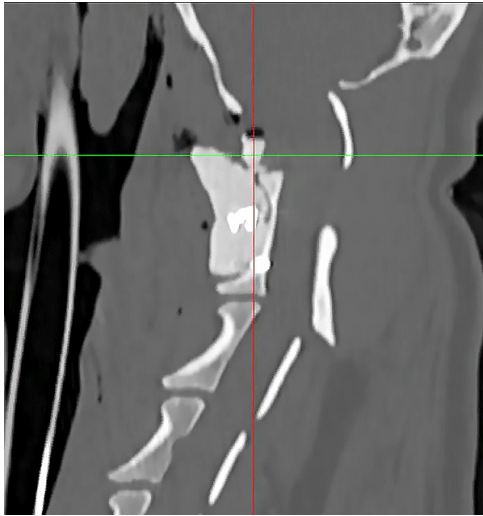


Fig. 5. Postoperative CT scan in sagittal direction. Preservation and volume of the spinal cord after surgery is determined

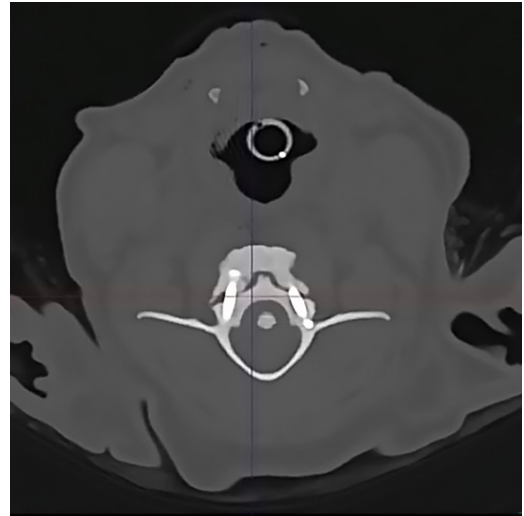


Fig. 6. CT scan in axial projection. Preservation and volume of the spinal cord after surgery is determined

Source: made by the authors

Analysis of the method showed the presence of complications in the form of structural failure or damage to the recurrent laryngeal nerve, however, according to statistics, the incidence of these complications in the world does not exceed 20 %.

Among the possible complications of surgical intervention are death of animal as a result of sudden respiratory arrest due to spinal cord injury during surgery, migration or breakage of implants, and inadequate alignment of the spine. In addition, implants may be placed incorrectly, causing chronic pain or spinal cord injury, and require removal. Improper placement can be a problem due to the small area of bone available to engage pins or screws. Thus, in [1], 28 surgical interventions were performed on dogs with AAI. The authors indicated that dorsal stabilization in seven dogs resulted in two recoveries and five misfixation failures. Ventral decompression and stabilization in 18 dogs resulted in eight recoveries and four failures.

Considering the experience of working with complications, special attention should be paid to the pathogenesis of this disease. A review of the scientific literature shows that in case of epistrophe tooth pathology, in 24 % of cases — it is aplasia, in 32 % — hypoplasia, and only in 26 % of cases — an anomaly of ligamentous apparatus [21–23], which definitely increases the need to search for the optimal method. Moreover, there are postoperative complications affecting the function of the upper respiratory tract (for example, cough, gagging, paralysis of the larynx). Aspiration pneumonia is also a potential postoperative complication that may be associated with dysfunction of the upper airways (eg, larynx) and/or pharynx. In general, reported perioperative mortality rates for surgical treatment of dogs with AAI range from 0 to 30 %, with the most recent review reports reporting rates of 5 to 10 %. Due to the proximity of atlantoaxial region to centers of brainstem responsible for cardiac and respiratory cycles, intraoperative death is explained by inadvertent damage to these brain areas [23–25].

The analysis of the performed operations showed positive results. According to observations, out of 135 operated animals, 104 animals recovered, 13 animals showed partial preservation of neurological deficit, 18 animals died in the early postoperative period. Complications that did not lead to a deterioration in neurological status and quality of life occurred in 17 animals (Table).

Postoperative parameters for ventral correction of atlanto-axial instability in dogs

Type of surgical operation	Total number of animals	Full and partial recovery, maintaining a good quality of life	Complete gait recovery	Partial recovery, preservation of mild neurological deficit	Death	Complications without worsening clinical symptoms
Ventral stabilization	135	117	104	13	18	17
Share,%	100	86.6	77	9.6	13.3	12.6

Conclusion

Based on the results of the research performed, we can recommend the method of ventral stabilization in treatment of AAI as the most reliable and optimal method, since it is technically simple and has good long-term results. Statistical data show good results, the method is effective and allows the animal to fully return to a quality life in more than 86 % of cases.

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Анализ оперативной коррекции атланта-аксиальной нестабильности у собак

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Аннотация. Проведен анализ эффективности вентрального оперативного доступа при коррекции атлантаксиальной нестабильности у собак «игрушечных» пород. Рассмотрены 135 клинических случаев хирургической коррекции, общая концепция хирургического доступа и проведения имплантации, позволяющая минимизировать риски ятрогенных осложнений. Вентральную стабилизацию осуществляли путем формирования артродеза между атлантом и эпистрофеем посредством введения винтов или спиц сквозь суставные структуры и тела позвонков с вентральной поверхности и последующей их фиксацией костным цементом. Исследованный метод может сопровождаться осложнениями в виде несостоятельности металлоконструкций или повреждения возвратно-гортанного нерва, но, согласно статистике, встречаемость данных осложнений в мировой практике не превышает 20 %. Среди возможных осложнений во время операции выделяют гибель животного в результате внезапной остановки дыхания, связанной с травмой спинного мозга, миграцию или поломку имплантатов, неадекватное выравнивание позвоночника. Кроме того, имплантаты могут быть установлены некорректно, вызывая хроническую боль или поражение спинного мозга. В результате операции полностью выздоровели 104 собаки, частичное сохранение неврологического дефицита наблюдалось у 13 животных, 18 животных погибли в ранний послеоперационный период. Осложнения, которые не повлекли за собой ухудшение неврологического статуса и качества жизни, возникли у 17 животных. Анализируя проведенную работу, мы можем рекомендовать метод вентральной стабилизации при лечении атлантаксиальной нестабильности как наиболее надежный и оптимальный, поскольку он технически несложен и имеет хорошие отдаленные результаты.

Статистические данные показали хорошие результаты, метод эффективен и позволяет полностью вернуть животное к качественной жизни в более чем 86 % случаев.

Ключевые слова: хирургическая операция, послеоперационные осложнения, позвоночный столб, вентральная стабилизация

Заявление о конфликте интересов. Автор заявляет об отсутствии конфликта интересов.

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