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Original scientific paper

Cervical ventral surgical approach to the brachial plexus for resection of an extraskeletal osteosarcoma in a dog

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ABSTRACT

The aim of this report is to describe a new surgical approach to the brachial plexus for resection of an extraskeletal osteosarcoma in a dog. A ventral midline cervical skin incision and blunt dissection of the cervical soft tissue were performed to expose the sternohyoid and sternocephalicus muscles. The trachea, esophagus and recurrent laryngeal nerve were exposed and laterally retracted. A blunt dissection was performed between the external jugular vein and the carotid sheath caudally to the left axillae at the levels of C6, C7, and T1 to expose the mass. Dissection was performed around the mass. The abnormal spinal nerves were transected just ventral to the vertebral body, allowing complete mass removal. The dog was bright and comfortable following surgery. Two weeks later, adjuvant chemotherapy was performed with carboplatin and piroxicam. The dog had a nine-month overall survival from diagnosis to death. The ventral cervical surgical approach to the canine brachial plexus, as described in this report, demonstrated feasibility, and provided satisfactory visualization and access with minimal muscle disruption. This surgical approach may be considered for cases involving neoplasia of the brachial plexus.

Key words: tumor; peripheral nerves; surgical technique; adjuvant chemotherapy

Introduction

The brachial plexus comprises a complex anatomical arrangement, consisting of a network formed by the ventral roots of the C6, C7, C8 and T1 spinal nerves (LAMBERTINI et al., 2023). In certain canine species, it may additionally include branches originating from the nerve roots of C5 and/or T2 (ALLAM et al., 1952; EVANS and DE LAHUNTA, 2013).

Diseases affecting the brachial plexus mainly involve inflammatory, neoplastic, or traumatic lesions, with traumatic lesions being the most fre-

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quent (WHEELER et al., 1986; DE LAHUNTA et al., 2014).

Malignant peripheral nerve sheath tumors (MPNST) are the most common neoplasm that affects the brachial plexus in dogs (TARGETTET al., 1993; SUMMERS et al., 1995; DA COSTA et al., 2008). However, other tumors have also been reported (CARMICHAEL and GRIFFITHS, 1981; TARGETTET al., 1993). The main clinical feature is progressive lameness in one forelimb, with marked muscle atrophy and very obvious but non-localizable pain (CARMICHAEL and GRIFFITHS, 1981). Other clinical signs commonly listed are pain on palpation or manipulation of the limb, hypotonia, hyporeflexia, muscle atrophy, proprioceptive positioning deficits, Horner's syndrome, and abnormalities in the reflex of the cutaneous trunci muscle (MCDONNELL et al., 2001).

The diagnosis of brachial plexus tumor has evolved from survey radiographs, myelography, and surgical exploration of the brachial plexus, to computed tomography (CT) and, more recently, ultrasonography and magnetic resonance imag- ing (WHEELER et al., 1986; MCCARTHY et al., 1993; BREHM et al., 1995; PLATT et al., 1999; RUDICH et al., 2004; ROSE et al., 2005).

The use of ultrasound-guided fine needle aspiration enables the differentiation of brachial plexus neoplasms, critically informing subsequent therapeutic choices and prognostic assessments (DA COSTA et al., 2008).

Optimal treatment for brachial plexus tumors in dogs is not supported by strong evidence, and is also debated in human medicine (PRUDNER et al., 2019; MARSH et al., 2022). Surgery as the sole treatment in dogs has been associated with a poor prognosis due to short times to recurrence and death (BREHM et al., 1995). Where complete resection is not possible, there is some evidence that the use of adjunctive radiotherapy prolongs disease-free and survival times (LACASSAGNE et al., 2018). Radiotherapy as the sole treatment appears to give a similar outcome to surgery alone (DOLERA et al., 2017).

Surgical resection of neoplasms involving the caudal cervical and cranial thoracic spinal nerves and nerve roots presents unique challenges due to the anatomical complexity of the region, including the scapula and vertebral canal involvement, and potentially intra-thoracic extension (MARSH et al., 2022). Different approaches have been reported to facilitate the exploration of the brachial plexus in dogs, including lateral (MOISSONNIER et al., 1998; MARSH et al., 2022) and craniolateral approaches (SHARP, 1988).

Here, we describe the clinical presentation, imaging findings, and cervical ventral surgical approach, developed to provide improved access to an extraskeletal osteosarcoma involving the brachi- al plexus of the dog.

Materials and methods

Signalment and clinical presentation. A 6-year-old, neutered female was admitted, weighing 26.6 kg, and with a 1-week history of progressive left thoracic limb lameness. The dog enrolled had written informed consent obtained from the owner for its participation. Examination revealed non-weight-bearing lameness of the left thoracic limb, severe pain on orthopedic and neurological examination, and moderate muscle atrophy. Neurological examination revealed mild proprioceptive deficits in the left thoracic limb and poor hopping movement. No other neurological deficits were noted. Hematology and biochemistry profiles were unremarkable. No mass was palpable in the left axilla. Despite a 3-day course of carprofen (2.2 mg/kg/12h), tramadol (2 mg/kg/12h), and dipyrone (25 mg/kg/12h), the clinical signs did not improve.

Imaging. Radiographs of the thorax and cervical spine were normal, with narrowing of the T11–T12 intervertebral disc space, lumbarization of T13, disc-space narrowing on lumbar, sclerosis of the vertebral surface and spondylosis of the ven- tral spine at L7-S1. The left thoracic limb showed humeroradioulnar incongruity, an increased humeroradial radiographic interline, diffuse subchondral bone sclerosis and osteophytes on the cranial margin of the radius, sclerosis of the medial coronoid process of the ulna and medial humeral epicondyle. The left scapulohumeral relationships were normal, with a minimal osteochondral fragment at the cau-

dal margin of the glenoid cavity, and a minimal osteophyte on the caudal aspect of the humeral head.

Ultrasonography of the left scapula showed discrete periarticular osteophytes, irregularity in the subchondral bone, and anechoic scapulohumeral joint effusion. The spine of the scapula, supraspinatus muscle and infraspinatus muscle were normal. There was irregularity of the biceps tendon insertion, where the tendon sheath had a normal appearance.

Computed tomography of the neck and thorax demonstrated a well-defined soft tissue mass, with mineralized foci and heterogeneous enhancement after contrast administration, measuring 0.9 cm x 2.4 cm x 1.7 cm (width x height x length) in the left axilla, extending from C6-C7 (cervicothoracic transition) (Fig. 1). In the dorsal plane reconstruction, the axillary lymph node was enlarged. Additionally, there was no indication of pulmonary metastatic disease.

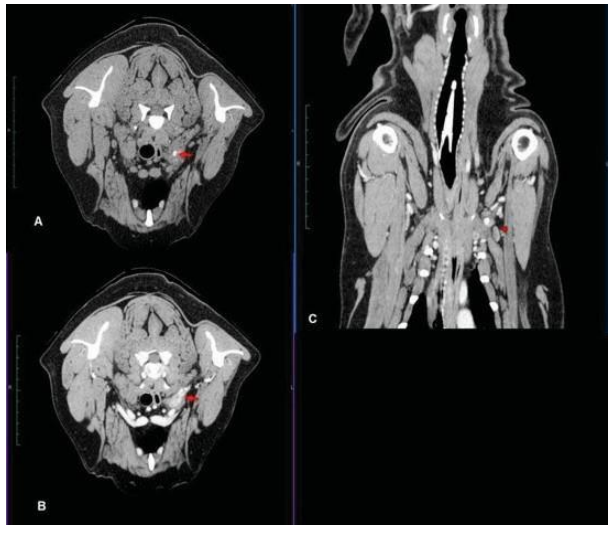

Fig. 1. Computed tomographic of the axillary cervical region
Pre- (A) and post-contrast (B) show the tumor with mineralized areas and post-contrast enhancement (arrows). In the dorsal plane reconstruction (C) the axillary lymph node is enlarged (arrowhead)

Pre- (A) and post-contrast (B) show the tumor with mineralized areas and post-contrast enhancement (arrows). In the dorsal plane reconstruction (C) the axillary lymph node is enlarged (arrowhead)

Surgical procedure. Before surgery, the dog was sedated with a combination of acepromazine (0.03 mg/kg) and methadone (0.2 mg/kg). Anesthesia was induced by an intravenous (IV) injection of propofol at 5.0 mg/kg plus ketamine at 0.5 mg/ kg and maintained with isoflurane at 100% oxygen (1-2 l/min). Anesthesia was monitored by a pulse oximeter for the duration of the procedure.

The dog was placed in a dorsal recumbent position with its head located at the superior region of the examination table (Fig. 2). A longitudinal incision was made along the ventral midline of the cervical skin, extending from the manubrium sterni to the hyoid bone (Fig. 3). Careful blunt dissection of the cervical soft tissues revealed the sternohyoid and sternocephalicus muscles.

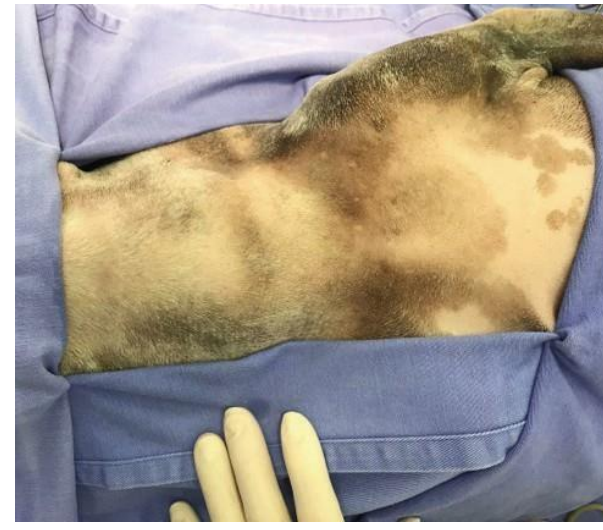

Fig. 2. Dog positioned in dorsal recumbency for the cervical ventral surgical approach to the brachial plexus

The fascia covering the paired sternohyoids was divided along the midline, exposing the trachea. The trachea, esophagus, and recurrent laryngeal nerve were retracted laterally to the right to reveal the paratracheal neurovascular bundle, which was subsequently retracted laterally to the right. Blunt dissection was performed in the space between the external jugular vein and the carotid sheath, extending caudally to the left axilla at the levels of C6, C7, and T1, where the mass could be readily palpated.

Dissection using swabs was performed around the mass. The nerves intimately involved with the

tumor were isolated and infiltrated with lidocaine. The abnormal spinal nerves were transected just ventral to the vertebral body, allowing complete removal of the mass (Fig. 3). The sternohyoid muscles were closed with 3/0 poliglecaprone (Monocryl) in a simple-continuous pattern, with elimination of the dead space by approximating the subcutaneous tissues with 3/0 poliglecaprone (Monocryl) in a continuous intradermal pattern. The skin was closed with a simple interrupted suture pattern using 3/0 nylon suture material.

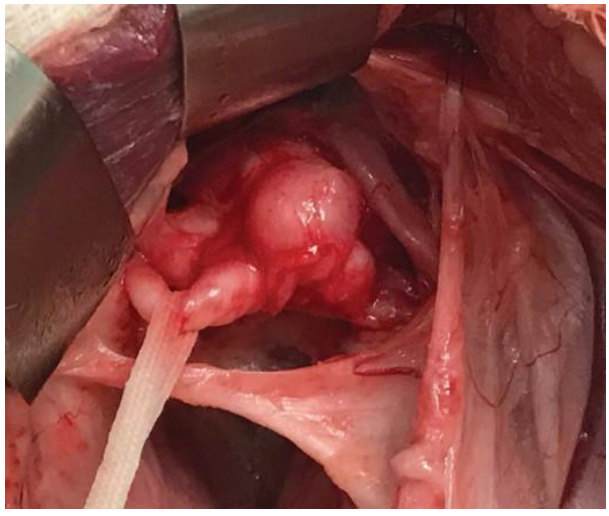

Fig. 3. Dissection and exposition of the mass in the left axillae at the levels of C6, C7, and T1

An intraoperative frozen section was undertaken to establish a tissue diagnosis. The result of the frozen sections was suggestive of extraskeletal osteosarcoma. During surgery, gross macroscopic changes extending to the C8-T1 nerve roots were observed, anticipating the need for limb amputation. At the end of the procedure, the specimen was embedded in formalin for a standard histological examination.

The ventral cervical approach (Fig. 4) was not relevant to the amputation, therefore the limb was pre-prepared and then the patient was positioned laterally, allowing an adaptable position throughout the new approach. The amputation was performed following previously described techniques (TOBIAS and JOHNSTON, 2012).

Fig. 4. Post-surgical view showing the place of ventral midline cervical skin incision (arrow red) after removal of tumor

Results

Recovery and follow-up. Postoperatively, the dog appeared cheerful and relaxed; its appetite was robust, and it could stand without assistance. Two weeks after the surgery, adjuvant chemotherapy was administered, featuring four cycles of carboplatin (300 mg/m²) administered intravenously at three-week intervals, supplemented by oral piroxicam at a dosage of 0.3 mg/kg once daily throughout the protocol's duration. From the time of diagnosis, until it passed away, the dog survived for a total of nine months.

Histopathology. Histopathological examination of the mass revealed a moderately cellular lesion composed of mesenchymal cells arranged in an intersecting pattern and supported by a mineralized extracellular matrix (ECM). Moderate pleomorphism with moderate anisocytosis and anisokaryosis was noted. The tumor cells exhibited eosinophilic cytoplasm with indistinct cytoplasmic borders. The nuclei were oval, and vesicular, possessing prominent nucleoli. Frequent mitotic figures, with 1-3 mitotic figures per 10 400× fields, were observed. Examination of the axillary lymph node revealed no evidence of metastatic disease. These findings are consistent with a diagnosis of extraskeletal osteosarcoma.

Discussion

This report presents evidence supporting the feasibility of a novel cervical ventral approach to the brachial plexus for resection of extraskeletal osteosarcomas in canine subjects, particularly those with tumors extending from C6 to C7. This cervical ventral approach provided more direct access to the plexus, thereby facilitating complete tumor removal.

Osteosarcoma stands as the most prevalent primary bone tumor diagnosed in dogs, with the potential to manifest in both the appendicular and axial skeletons. A retrospective study of 216 dogs diagnosed with osteosarcoma revealed that 16.7% were diagnosed with extraskeletal osteosarcoma, with most cases involving the mammary glands. Considering the location of the extraskeletal osteosarcoma, in most of the studies evaluated, none reported involvement of the brachial plexus nerves (PATNAIK, 1990; LANGENBACH et al., 1998; GUIM et al., 2019).

The diagnosis of brachial plexus tumor has evolved from survey radiographs, myelography, and surgical exploration of the brachial plexus, to computed tomography (CT) and, more recently, ultrasonography and magnetic resonance imag- ing (WHEELER et al., 1986; MCCARTHY et al., 1993; BREHM et al., 1995; PLATT et al., 1999; RUDICH et al. 2004; ROSE et al., 2005). Although selected radiographic examinations were not diagnostic in this report, radiographic examination is a vital tool in the diagnosis of lameness not associated with trauma. MRI is superior to CT for detecting brachial plexus tumors, due to its excellent contrast resolution, the ability to distinguish nerve bundles from vessels, and primary multiplanar imaging (BRADLEY et al., 1982; RETTENBACHER et al., 2003; TODD et al., 2004). In this report, computed tomography was the first choice because of other benefits, such as speed, cost, availability, and the capacity for detailed assessment of the thorax in the same procedure. Additionally, computed tomography imaging provided a three-dimensional reconstruction, improving surgical planning and playing a vital role in the decision-making of this approach.

The usual finding is chronic progressive lameness, unresponsive to medical therapy(WHEELER et al., 1986) with marked muscle atrophy (CARMICHAEL and GRIFFITHS, 1981). The case reported here had left thoracic limb lameness and evidence of a neurological deficit, indicated by evaluation of moderate muscle atrophy, corresponding closely with cases reported in the literature. Axillary palpation may aid in the diagnosis of tumors involving the brachial plexus (WHEELER et al., 1986). BRADLEY et al. (1982) reported the presence of a palpable mass in their cases, and pain. Digital pressure will often lead to a change in the respiratory pattern, indicating pain (WHEELER et al., 1986). In this dog, the mass could not be so readily palpated in the dog while conscious, although palpation and/or manipulation of the limb elicited a marked pain response.

Different approaches have been reported to facilitate the exploration of the brachial plexus in dogs, including lateral (MOISSONNIER et al., 1998; MARSH et al., 2022) and craniolateral approaches (SHARP, 1988). Previous approaches described involved transection and disinsertion of several anatomic structures to access the brachial plexus. Contrary to these reports, we performed a blunt dissection of the cervical soft tissue, and the cervical structures were retracted laterally, enabling easy access to the mass. This approach provided optimal access for efficacious tumor removal.

Surgical resection of tumors involving the brachial plexus is challenging due to its complexity, and may affect the nerves responsible for movement. Compartmental excision can lead to good limb function, and should therefore be considered as an alternative to limb amputation (STEE et al., 2017). This surgical approach was feasible, to achieve resection of the whole tumor. Despite computed tomography showing a mass extending from C6-C7, intraoperative findings revealed gross macroscopic changes extending to the C8-T1 nerve roots. The ulnar, median, and radial nerves originate from C8 and T1 ventral rami (SHARP and WHEELER, 2005). Transection of these nerves could lead to limb dysfunction, justifying amputation. The adjuvant chemotherapy was intended to eliminate microscopic disease, reducing the likelihood of local spread or widespread metastasis.

Conclusions

The cervical ventral surgical approach to the canine brachial plexus reported here was feasible and provides good visualization and access, with minimal damage to muscles. This surgical approach can be considered in cases of tumors involving the brachial plexus.

Author contributions

Julia Maria Matera DVM, PhD[1] and Paulo Vinícius Tertuliano Marinho DVM, PhD[2]: Contributed to experimental design, data collection, surgical procedure and manuscript preparation. Carla Aparecida Batista Lorigados DVM, PhD[3]: Contributed with diagnostic imaging, e view of CT images. Genilson Fernandes de Queiroz DVM, PhD[4]: Contributed to manuscript preparation. All authors read and approved the final version of the manuscript.

Declaration of competing interests

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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MATERA, J. M., P. V. T. MARINHO, C. A. BATISTA LORIGADOS, G. F. DE QUEIROZ: Vratno ventralni kirurški pristup brahijalnom pleksusu za resekciju izvankoštanog osteosarkoma u psa. Vet. arhiv 95, 449-456, 2025.

SAŽETAK

Cilj rada bio je opisati novi kirurški pristup brahijalnom pleksusu za resekciju izvankoštanog osteosarkoma u psa. Provedena je ventralna incizija po medijalnoj liniji i tupa resekcija mekog tkiva vrata kako bi se pristupilo sternohioidnom i sternocefaličnom mišiću. Dušnik, jednjak i rekurentni laringealni živac su izloženi i uvučeni lateralno. Tupa resekcija izvedena je između vanjske jugularne vene i karotidne ovojnice kaudalno prema lijevoj aksili na razini C6, C7 i T1 kako bi se došlo do tvorbe. Resekcija je izvedena oko tvorbe. Učinjena je transekcija promijenjenih spinalnih živaca ventralno prema kralježnici, što je omogućilo da se ukloni cijela tumorska tvorba. Postoperacijski tijek bio je uredan. Dva tjedna poslije, provedena je adjuvantna kemoterapija karboplatinom i piroksikamom. Pas je imao devetomjesečno preživljenje od dijagnoze do smrti. Vratno ventralni kirurški pristup brahijalnom pleksusu u psa, kao što je ovdje opisano, pokazao se izvedivim te je pružio zadovoljavajući prikaz tvorbe i pristup tvorbi uz minimalno oštećenje mišića. Stoga bi se navedeni kirurški pristup mogao uzeti u obzir u slučajevima neoplazija brahijalnog pleksusa.

Ključne riječi: tumor; periferni živci; kirurški zahvat; adjuvantna kemoterapija