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Carotid body tumour in a dog: computed tomography and histopathology findings and evaluation of surgical management

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Abstract: A 2.5-kg, eight-year-old, neutered male Yorkshire Terrier was presented for evaluation of a cervical mass that had first been noticed a year earlier. A firm spherical mass located caudal to the left mandible was found on physical examination. Ultrasonography revealed a well-defined, round-shaped mass located medial to the left mandibular salivary gland that was approximately 2.6 cm in height, 2.3 cm in width and 3 cm in length. Volume-rendered images obtained by computed tomography (CT) showed that the left external and internal carotid arteries and internal jugular vein were encased in the mass. A definitive diagnosis of carotid body tumour was made based on histopathology. The tumour and the carotid arteries and internal jugular vein encased in the tumour were resected using CT-based surgical planning. The regional neural structures were preserved by careful blunt dissection. The dog had a mild hacking cough after swallowing and hoarseness that disappeared spontaneously five days and two months, respectively, after surgery. There was no evidence of recurrence or distant metastasis at 18 months postoperatively. This case report describes successful surgical management of a carotid body tumour with ligation and transection of the carotid arteries in a dog. To the authors' knowledge, this is the first report of successful surgical treatment of an advanced carotid body tumour based on CT findings.

Keywords: dog; carotid body tumour; computed tomography; carotid arteries, transection

Chemodectomas, also known as or nonchromaffin paragangliomas, are tumours that arise in the chemoreceptor tissues, which are widely distributed throughout the body. In dogs, these tumours develop mainly in the aortic and carotid bodies. Carotid body tumours are rarer than aortic body tumours but tend to have more malignant potential and have a metastasis rate of 30%. Carotid body tumours are not generally functional but can cause a variety of symptoms because of their steady growth and space-occupying nature (Capen 2002). These tumours can be diagnosed by anatomical location, diagnostic imaging and histopathological evaluation; however, immunohistochemistry is needed to identify the tumour in some cases (Taeymans et al. 2013). The canine carotid body is located near the bifurcation of the common carotid artery and is attached to the origin of the occipital and ascending pharyngeal arteries (Phan et al. 2013). Surgical resection is considered to be the treatment of choice for a carotid body tumour but is difficult because of the tendency of this tumour to progressively surround the carotid artery as it grows (Obradovich et al. 1992). To the best of our knowledge, there are very few reports on surgical removal of carotid body tumours (Sander and

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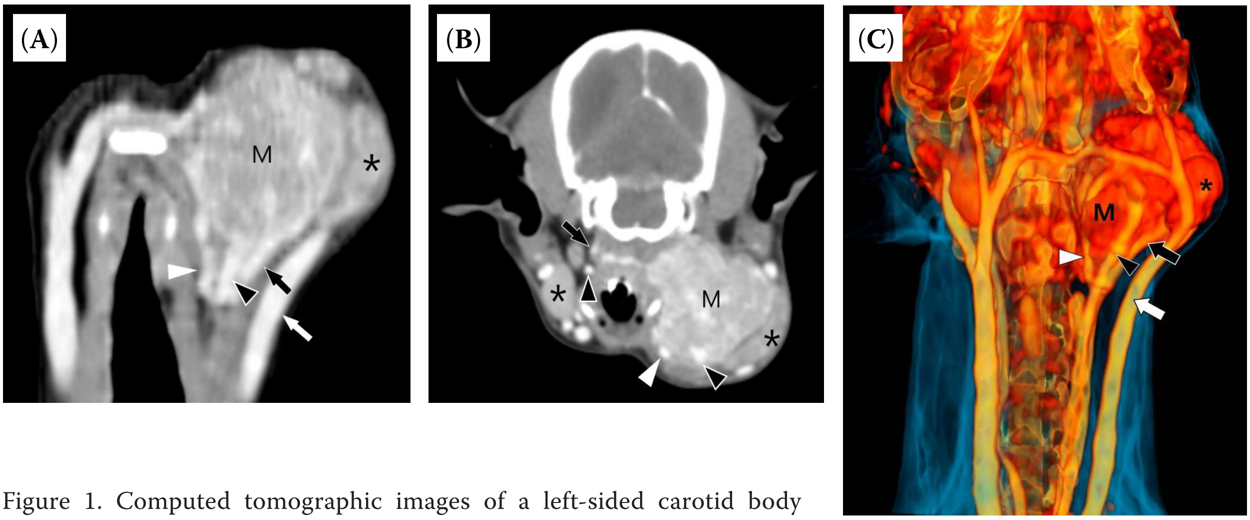
Whitenack 1970; Zakarian et al. 1972; Dean and Strafuss 1975; Phan et al. 2013). Moreover, surgical removal of a carotid body tumour encasing the carotid arteries guided by the appearance of the tumour on computed tomography (CT) has not been described in detail in dogs. This report describes the clinical presentation of such a case, the findings on CT and histopathology and successful surgical management with ligation and transection of the carotid arteries relative to the carotid body tumour without the complication of stroke.

Case description

A 2.5 kg, eight-year-old, neutered male Yorkshire Terrier was presented for evaluation of a cervical mass. The owner mentioned that a progressive swelling has been present in the neck region for a year. There were no other clinical signs accompanying this space-occupying lesion, so the owner had not sought a veterinary consultation. Physical examination revealed a painless, firm, spherical mass located caudal to the left mandible. Routine ultrasonographic examination was performed (Prosound F75, ALOKA, Tokyo, Japan) with linear-array (10–13 MHz) and curvilinear-array (6–8 MHz) probes. The mass was seen to be located medial to the left mandibular salivary gland and to be well-defined, round-shaped and well-marginated. The mass was approximately 2.6 cm in height, 2.3 cm in width and 3 cm in length and had a heterogeneous echotexture. Colour Doppler sonography showed increased vascularity within the mass. A complete blood count and serum biochemistry profile were unremarkable. Fine needle aspiration of the cervical mass revealed cells with an appearance of moderate anisokaryosis, and free nuclei were seen in



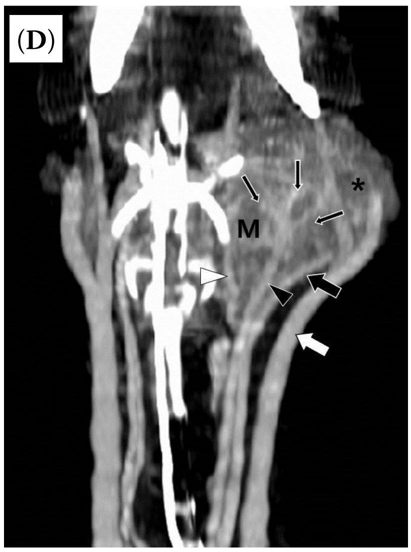


Figure 1. Computed tomographic images of a left-sided carotid body tumour. The patient's right side is on the left in all images. (**A**) A post-contrast transverse image shows a well-marginated, isoattenuating mass with strong contrast enhancement. The left external and internal carotid arteries and the left mandibular salivary gland are displaced ventrolaterally by the mass. (**B**) A dorsal reconstruction image shows a large mass cranial to the level of the bifurcation of the left common carotid artery. (**C**, **D**) Dorsal reconstructed maximal intensity projection and volume-rendered images show that the left external and internal carotid arteries and left internal jugular vein are encased in the mass and the left external and internal carotid arteries are obliterated because they run rostrally. The bifurcation of the left common carotid artery is displaced caudally when compared with the bifurcation of the right common carotid artery

Asterisk = mandibular salivary gland; black arrow = internal jugular vein; black arrowhead = external carotid artery; M = mass (in all panels); narrow black arrow = obliterated carotid arteries; white arrow = external jugular vein; white arrowhead = internal carotid artery

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a background of lightly basophilic cytoplasm. CT was performed to determine if the mass was encroaching on any of the surrounding structures. CT scans were acquired in ventral recumbency using a 4-multi-detector-row machine (Lightspeed, GE Medical Systems, Milwaukee, USA). The imaging protocols were 120 kVp and 200 mAs with a slice thickness of 1.25 mm. For contrast-enhanced CT examination, iohexol (Omnihexol 300, Korea United Pharmaceutical, Seoul, Republic of Korea) at 600 mg iodine/kg was injected manually into the cephalic vein. Post-contrast transverse images showed a large, well-marginated attenuating soft tissue mass with strong and heterogeneous contrast enhancement. The left external and internal carotid arteries and the left mandibular salivary gland were displaced and compressed ventrolaterally by the mass (Figure 1A). On dorsal reconstruction images, the mass was located cranial to the level of the bifurcation of the left common carotid artery (Figure 1B). On dorsal reconstructed maximal intensity projection and volume-rendered images, the left external and internal carotid arteries and the internal jugular vein were encased in the mass and the left external and internal carotid arteries were obliterated because they ran rostrally (Figures 1C and 1D). The bifurcation of the left common carotid artery was displaced caudally when compared with the bifurcation of the right common carotid artery (Figure 1C).

Preoperative histopathological analysis reported the cervical mass to be a carotid body tumour. The tumour was surrounded by a fibrous capsule with branching trabeculae extending into the tumour tissue. The tumour cells were round to polyhedral in shape with vacuolated cytoplasm, and the nuclei were large with anisokaryosis (Figure 2A). Immunohistochemistry was positive for cytoplasmic expression of chromogranin A, confirming that the tumour had a neuroendocrine origin (Figure 2B).

The dog was premedicated for surgery with atropine sulphate (0.02 mg/kg subcutaneously; Atropine sulfate inj®, Je Il Pharm. Co., Ltd., Seoul, Republic of Korea) followed by induction of anaesthesia with propofol (6 mg/kg intravenously; Provive 1%®, Myungmoon Pharm. Co., Ltd., Seoul, Republic of Korea). The dog was then intubated and anaesthesia was maintained with isoflurane (Isoflurane®, Choongwae. Co., Ltd., Seoul, Republic of Korea) and oxygen. Lactated Ringer's solution

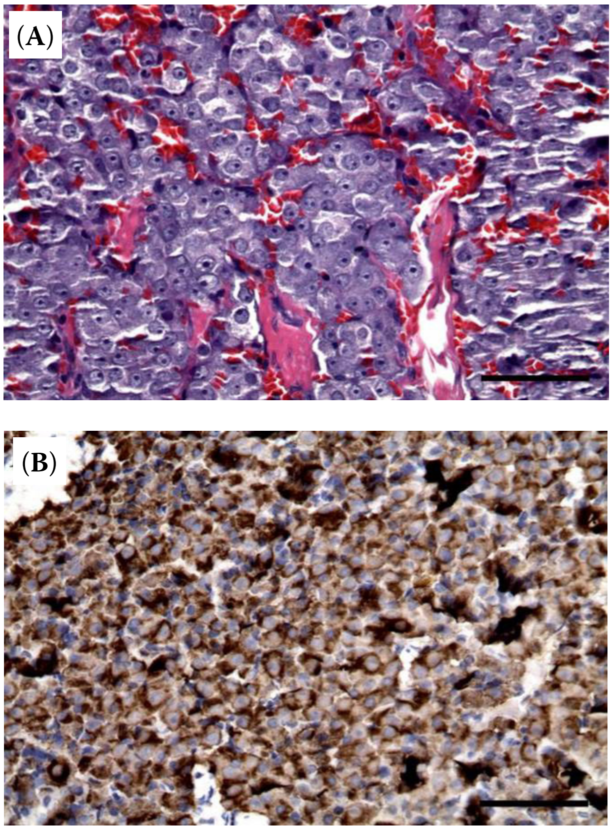

Figure 2. Preoperative histopathological findings of a carotid body tumour. (**A**) The tumour cells are round to polyhedral with vacuolated cytoplasm and the nuclei are large with anisokaryosis. (**B**) On immunohistochemistry, the tumour cells are positive for chromogranin A. Bar = 50 µm

was administered intravenously at a rate of 5 ml/kg/h until completion of the surgical procedure. The dog was positioned in right lateral recumbency under general anaesthesia. Incisions of the skin, subcutaneous tissue and platysma muscle were made from caudal to the left mandible to caudal to the bifurcation of the external jugular vein. A firm, dark red-coloured tumour was identified and noted to be attached to the salivary glands. The sublingual and mandibular salivary glands were separated from the tumour by blunt dissection and removed because of their proximity and mild attachment to the tumour (Figure 3A). The mandibular lymph nodes were identified and removed for histopathological examination. On gross examination, the tumour was highly vascularised and partially pseudo-encapsulated. The external and internal carotid arteries were closely adjacent to the tumour cranial to the bifurcation of the com-

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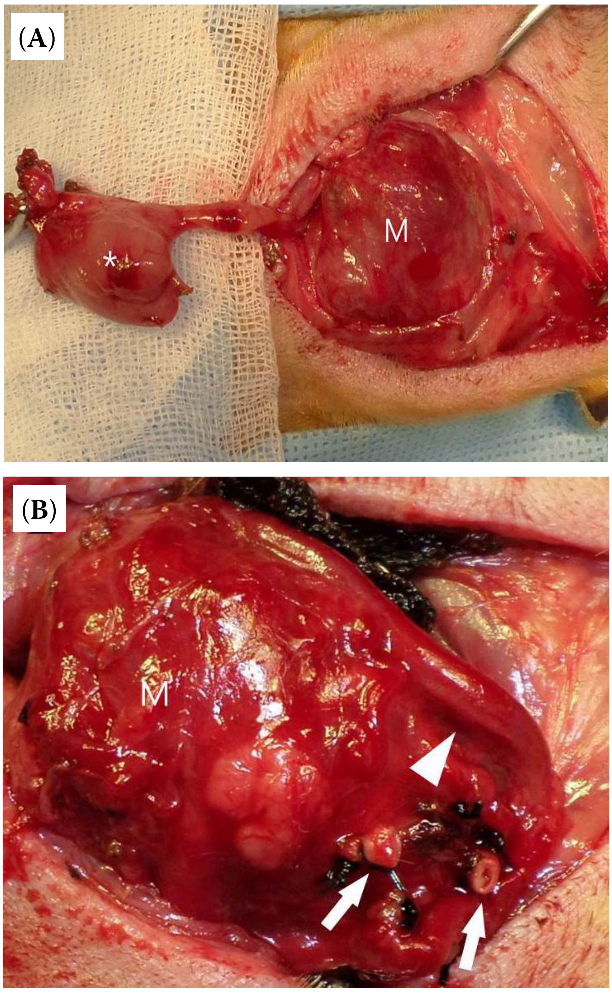

Figure 3. Intraoperative photographs. (**A**) A firm, dark red-coloured tumour was identified and noted to be attached to the salivary glands. The sublingual and mandibular salivary glands were separated from the tumour by blunt dissection. (**B**) The external and internal carotid arteries, internal jugular vein and small blood vessels associated with the tumour were ligated and transected. The cranial portion of the transected external carotid artery was fully surrounded by the tumour and the internal jugular vein was partially surrounded by the dorsolateral portion of the tumour

Asterisk = mandibular salivary gland; M = mass; white arrow = transected external carotid artery; white arrowhead = internal jugular vein

mon carotid artery. Cranial to this level, the tumour encased the external and internal carotid arteries completely and the internal jugular vein was partially surrounded by the dorsolateral portion of the tumour. The external and internal carotid arteries, internal jugular vein and small blood vessels associated with the tumour were ligated and transected because of the difficulty of dissection (Figure 3B). After transection of the vessels, the tumour was removed from the adjacent structures with careful dissection to preserve the hypoglossal nerve and vagosympathetic trunk. A Penrose drain (All Silicone Penrose Drain Tube®, Yushin Medical, Gyeonggi-do, Republic of Korea) was inserted from the surgical area to the ventral midline of the skin. The subcutaneous tissue and skin were routinely closed. The Penrose drain was removed three days postoperatively. The mandibular lymph nodes were submitted postoperatively for histopathology, and the diagnosis was reactive lymphadenopathy. The dog had a mild hacking cough after swallowing and hoarseness that disappeared spontaneously five days and two months, respectively, after surgery. There was no evidence of local recurrence or metastasis at 18 months after surgery.

DISCUSSION AND CONCLUSIONS

Canine carotid body tumours were first described in the 1950s (Jubb and Kennedy 1957). This tumour commonly presents as an asymptomatic slow-growing cervical mass that causes difficulty in swallowing, respiratory distress and entrapment of the carotid arteries (Phan et al. 2013). Surgical resection is the treatment of choice, and aggressive surgical removal should be considered for potential cure and long-term survival. However, complete removal of a carotid body tumour without causing damage to critical adjacent structures, such as nerves and major blood vessels, is a surgical challenge (Evans and de Lahunta 2013; Phan et al. 2013). In humans, carotid body tumours are traditionally graded by the Shamblin classification, which is based on the relationship of the tumour to the internal and external carotid arteries (Shamblin et al. 1971). Using this system, a grade I tumour is small, well-localized and easily resectable, a grade II tumour is adherent to the surrounding vessels or partially encloses them and a grade III tumour is large and difficult to excise and incarcerates the carotid arteries. This grading system is useful for determining the extent of resection needed for a carotid body tumour and associated structures, including the carotid arteries. In Shamblin grade III cases, curative surgical management remains challenging and is associated with major adverse

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effects such as cerebrovascular complications, which are caused by common carotid artery ligation (Patetsios et al. 2002; Makeieff et al. 2008). Therefore, careful reconstructive vascular surgery is recommended for excision of higher-grade carotid body tumours in human medicine (Patetsios et al. 2002; Makeieff et al. 2008). However, cerebrovascular complications associated with occlusion of the carotid artery are believed to be insignificant in dogs in light of a report by Clendenin and Conrad (1979a; Clendenin and Conrad 1979b) showing that tissue perfusion to the head is maintained by development of a collateral circulation after resection of the common carotid artery. According to that report, there were no neurological or ischaemic deficits in experimental canine models of common carotid artery occlusion either unilaterally or bilaterally. In the case reported here, the carotid body tumour was Shamblin grade III and complete resection was possible by vascular sacrifice without evidence of a major surgical complication, such as brain ischaemia. The uneventful postoperative recovery in this dog suggests that complications related to cerebral ischaemia need not be anticipated in cases of surgical management using ligation and transection of the carotid arteries.

Although CT alone is not sufficient to make a definitive diagnosis, it can be helpful for treatment planning because it can provide the anatomical details needed for assessment of the extent of a carotid body tumour and the degree of invasion into the surrounding tissues (Mai et al. 2015). The typical CT characteristics of a carotid body tumour include a mass centred at the carotid bifurcation with strong enhancement and displacement and entrapment of the carotid arteries (Mai et al. 2015). Carotid body tumours often invade adjacent structures, including the basilar portion of the skull, carotid arteries, jugular veins, maxillary vein, linguo-facial vein, thyroid cartilage, adjacent hyoid bone and surrounding muscles (Mai et al. 2015). In the case reported here, volume-rendered and maximum intensity projection images revealed that the left external and internal carotid arteries and the left jugular vein were encased by the strongly heterogeneous contrast-enhanced tumour and the left external and internal carotid arteries were obliterated because the carotid arteries ran rostrally. A post-contrast transverse image showed that the left mandibular salivary gland was compressed ventrolaterally by the mass. These preoperative CT findings were helpful for staging based on the vascular involvement, planning surgical removal of the salivary gland and tumour including the vessels and predicting the potential complications following surgery.

Anatomical consideration of nerves may increase the likelihood of successful resection of a carotid body tumour with minimal risk of neurological complications. The vagosympathetic trunk lies dorsal to the common carotid artery (Budras et al. 2007). The hypoglossal nerve courses ventrorostrally lateral to the external carotid artery and passes medial to the mandibular salivary gland (Evans and de Lahunta 2013). Given their anatomical location, these nerves would be vulnerable to injury during excision of a carotid body tumour. In a previous report, about 71% of dogs with a Shamblin grade III tumour had postoperative neurological deficits caused by invasion or surgical resection of the tumour (Obradovich et al. 1992). The most common complication in that report was Horner's syndrome, followed by laryngeal paralysis. In humans, the incidence of cranial nerve injury after resection of a carotid body tumour has been reported to be between 7% and 49% (Luna-Ortiz et al. 2005; Sajid et al. 2007; Makeieff et al. 2008). This neurological deficit is considered to be related to dissection of a tumour that is in close proximity to the glossopharyngeal, hypoglossal, spinal and vagal nerves (Makeieff et al. 2008). In the case reported here, the hypoglossal nerve and vagosympathetic trunk were adherent to the tumour, so the tumour was dissected meticulously to preserve these nerves. Transient neurological signs developed but resolved without treatment. A detailed understanding of neuroanatomy can aid careful intraoperative handling, preservation of nerves and minimize postoperative neurological complications in patients with higher-grade carotid body tumours.

To the authors' knowledge, surgical management of a carotid body tumour with ligation and transection of the carotid arteries encased in the tumour based on CT findings has not been described in detail in dogs. Our dog recovered without stroke and there was no evidence of further complications related to ischaemic encephalopathy. Therefore, complete resection of the carotid arteries should be considered for surgical management of higher-grade carotid body tumours, and complications related to brain ischaemia need not be anticipated.

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A large case series study is needed to better determine the overall success and complication rates of surgical management of carotid body tumours with ligation and transection of the carotid arteries in dogs.

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