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MORPHOLOGICAL STUDIES ON THE BLOOD VESSELS OF THE ELBOW REGION OF THE DOG

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ABSTRACT

The purpose of this study is to investigate in details the major blood vessels and their branches in the structures of the elbow joint through corrosion, radiography, and computed tomography angiography. The vessels were visualized on 17 canine thoracic limbs. The corrosion cast was obtained after the introduction of Duracryl-Plus dental plastics through the brachial artery, freezing and subsequent tissue lysis. Barium sulfate introduced through the same artery postmortem was used to visualize the vessels by radiography. For the purpose of computed tomography angiography, an arterial catheter was introduced into the brachial artery through which a contrast solution of Ultravist 300 at a rate of 0.5 ml per second was injected using an infusion apparatus. Variations in arterial anastomoses in the elbow region have been identified.

Key words: dog, elbow region, blood supply, radiography, computed tomography angiography.

Introduction

The congenital and acquired pathological conditions in the elbow region are common in dogs. Elbow dysplasia, traumas, systemic diseases, and tumors are some of the conditions that the elbow joint is exposed to (Cook 2001, Fitzpatrick and Yeadon 2009, Lappalainen 2014). The main role in the inflammatory, traumatic, degenerative, and regenerative processes falls on the arterial, venous, and capillary blood supply. Precise specification of the topography of the vessels in this region in dogs using various imaging methods (Georgiev 2020) is important for understanding the diseases of the elbow and for the veterinary practice.

The purpose of this study is to investigate in details the major blood vessels and their branches in the structures of the elbow joint through different methods. The arteries and veins were observed with postmortem methods that include corrosion and radiography, and in vivo methods – radiography and computed tomography angiography, which gave the authors the opportunity to describe the vessels, their anastomoses, and their topographic relations in details.

Materials and methods

Seventeen canine left and right thoracic limbs from middle sized mixed breed dogs were included in this study.

The methods used in the study and the number of limbs examined with each of them are presented in Table 1.

Table 1

	Methods	Limbs
Postmortem	Corrosion cast	6
	Radiography with $BaSO_4$	6
In vivo	Radiography	3
	Computed Tomography	2

For all methods an access to the brachial artery was performed (Troianos et al. 2011, Georgiev 2014, Evans & de Lahunta 2016). The corrosion cast was obtained after the introduction of Duracryl-Plus (SpofaDental, Chezh Republic) dental plastics through the artery with subsequent freezing at -18ºC for 12 hours and tissue lysis in concentrated sulfuric acid diluted with water in a ratio of 1:1, followed by 25% potassium hydroxide. For the postmortem angiography, barium sulfas was introduced through the brachial artery. After ligation of the vessel, radiography was performed in cranioocaudal and lateral projection. The in vivo methods include radiography and computed tomography (CT). Both were conducted under anesthesia with the following anesthetic protocol: atropini sulfas (Sopharma-Bulgaria) – 0.02-0.04 mg/kg SC, followed by Xylazini 2% (Alfasan – The Netherlands) – 0.5–1.5 mg/kg IM and Ketamine 10% (Ketaminol 10%, Intervet – The Netherlands) – 10 mg/ kg IV (Dinev & Aminkov 1999, Thurmon et al. 1996). A Dezile kit (MeritMedical, USA) was used with a 4F arterial catheter. The contrast agent, Ultravist 300 (New Empire Chemists, India), was gradually injected using infusion pumps – 0.5 ml per second. The radiography was performed in lateral view (Sirois et al 2010). The computed tomography was made in sternal recumbency. The scanning stared from the middle of the humerus and ended on the middle of the antebrachial bones (Schwarz et al 2011). The thickness of all sections was 1.5 mm, with an interval of 2 mm, computer software DICOM Viewer® was used.

The patients used in the in vivo methods were handled with care, according all regulations and recovered completely after the intervention.

Results

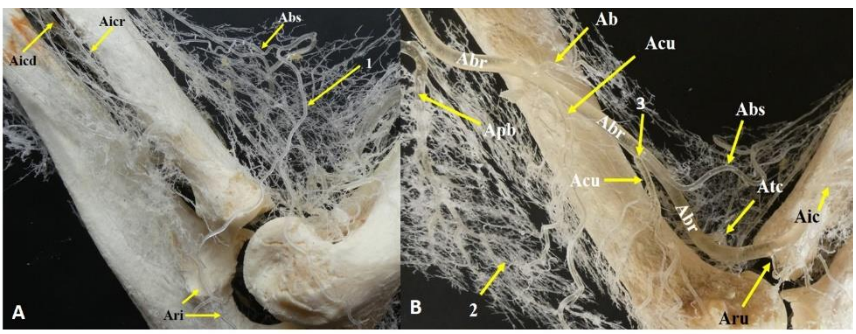

Figure 1: A Corrosion cast of the arteries, lateral view - Abs – a. brachialis superficialis, Aic – a. interossea communis, Aicd – a. interossea caudalis, Aicr – a. interossea cranialis, Ari – a. recirrens interossea, 1 – connection between a. recurrens interossea and a. brachialis superficialis; B Corrosion cast of the arteries, medial view - Abr – a. brachialis, Apb – a. profumda brachii, Ab – a. bicipitalis, Acu – a. collateralis ulnaris, Abs – a. brachialis superficialis, Atc – a. transversa cubiti, Aru – a. recurrens ulnaris, Aic – a. interossea communis, 2 – connection between a. profunda brachii and a. collateralis ulnaris 3 – common trunk for a. collateralis ulnaris and a. brachialis superficialis.

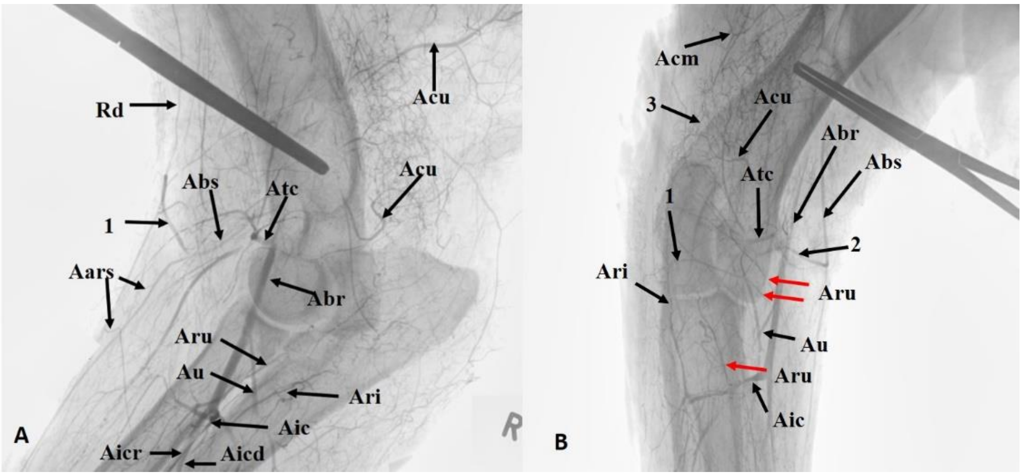

Figure 2: A Postmortem radiography in mediolateral view - Abr – a. brachialis, Rd – r. deltoideus, Aars – aa. radiales superficiales, Acu – a. collateralis ulnaris, Abs – a. brachialis superficialis, Atc – a. transversa cubiti, Aru – a. recurrens ulnaris, Au – a. ulnaris, Ari – a. recurrens interossea, Aic – a. interossea communis, Aicr – a. interossea cranialis, Aicd – a. interossea caudalis, 1 – connection between r. deltoideus and a. brachialis superficialis; B Postmortem radiography in craniocaudal view Acm – a. collateralis media, Abs – a. brachialis superficialis, Atc – a. transversa cubiti, Acu – a. collateralis ulnaris, Aru – a. recurrens ulnaris, Au – a. ulnaris, Ari – a. recurrens interossea, Aic – a. interossea communis, 1 – connection between a. recurrens ulnaris and a. recurrens interossea, 2 - connection between a. brachialis superficialis and a. recurrens ulnaris, 3 – connection between a. collateralis media and a. collateralis ulnaris.

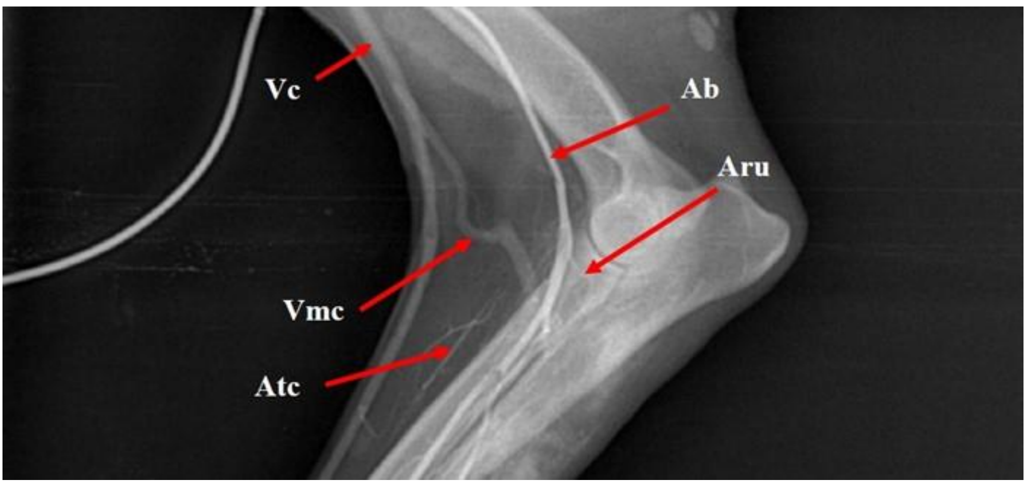

Figure 3: In vivo radiography in medio-lateral view - Ab – a. brachialis, Aru – a. recurrens ulnaris, Atc – a. transversa cubiti, Vc – v. cephalica, Vmc – v. mediana cubiti.

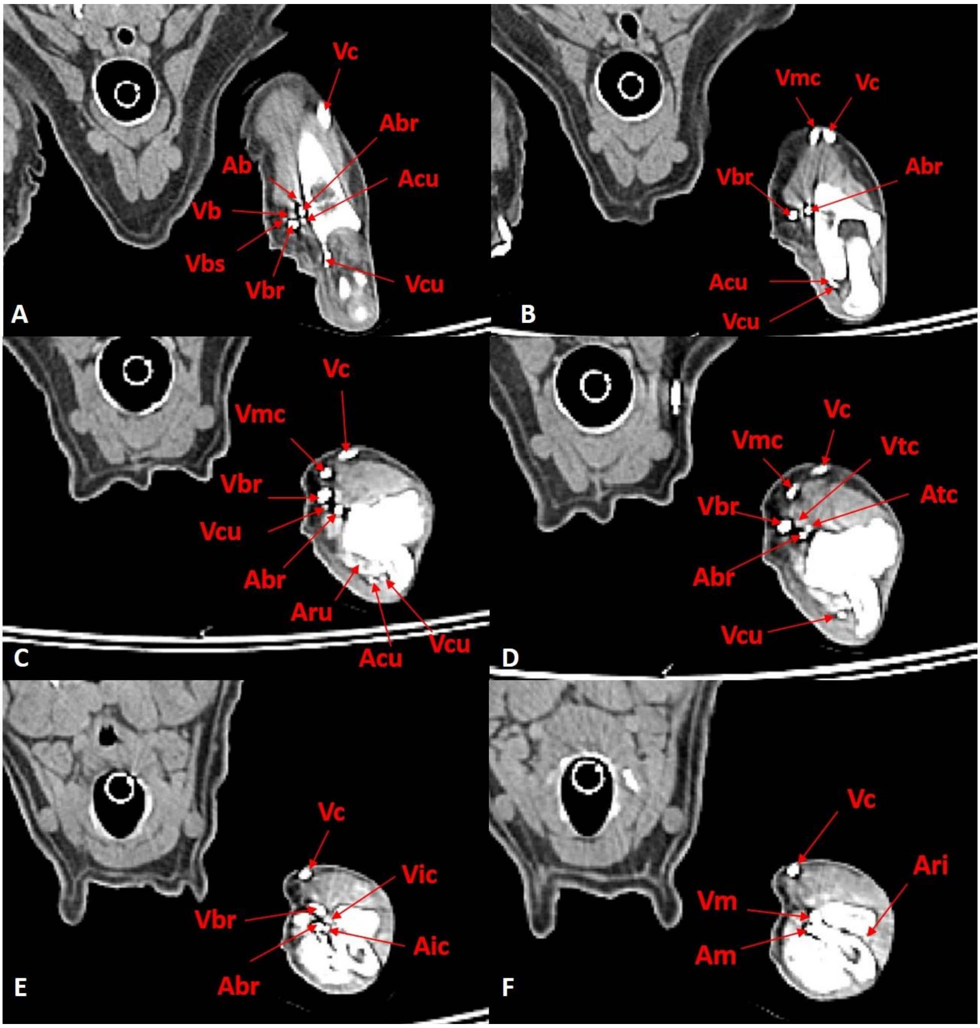

Figure 4: A - CT scan at the level tuber olecranii- Abr – a. brachialis, Vbr – v. brachialis, Vc – v. cephalica, Acu – a. collateralis ulnaris, Vcu – v. collateralis ulnaris, Vbs – v. brachialis superficialis, Ab – a. bicipitalis, Vb – v. bicipitalis; B - CT scan at the level of condylus humeri Abr – a. brachialis, Vbr – v. brachialis, Vc – v. cephalica, Acu – a. collateralis ulnaris, Vcu – v. collateralis ulnaris, Vmc – v. mediana cubiti; C, D - CT scan at the level of trochlea and capitulum humeri - Abr – a. brachialis, Vbr – v. brachialis, Vc – v. cephalica, Vmc – v. mediana cubiti, Aru – a. recurrens ulnaris, Acu – a. collateralis ulnaris, Vcu – v. collateralis ulnaris, Atc – a. transversa cubiti. Vtc – v. transversa cubiti; E, F - CT scan, proximal third of the antebrachium Am – a. mediana, Vm – v. mediana, Vc – v. cephalica, Ari – a. recurrens interossea, Abr – a. brachialis, Vbr – v. brachialis, Aic – a. interossea communis, Vic – v. interossea communis.

The arterial vessels at the elbow region are branches of the brachial artery which was established by all methods in this study (Fig. 1B, 2A, 3, 4). Single *a. profunda brachii*, detaching from the caudal surface of the brachial artery, was observed on the corrosion cast (Fig. 1B.). Distal branch from this artery connects with the collateral ulnar artery (Fig. 1B). The bicipital artery was visualized on the corrosion cast (Fig. 1B) and together with the bicipital vein on the CT scan at the level of *tuber olecranii* on the medial side of the humerus, cranially from the brachial artery (Fig. 4A). Two collateral ulnar arteries were established on the corrosion cast (Fig. 1B) and on the postmortem x-ray images (Fig. 2A). The beginning of the distal collateral ulnar artery was together with *a. brachialis superficialis* (Fig. 1B). Anastomosis between *a. collateralis ulnaris* and *a. collateralis media* was observed (Fig. 2B). On the CT scan at the level of tuber olecranii *a. collateralis ulnaris* was placed on the medial side of the bone, caudally of the brachial artery and laterally of the brachial vein Fig. (4A). The collateral ulnar vein at the same level was found more caudally, behind caudomedial margin of the bone (Fig. 4A). Distally, at the level of the condyles of the humerus the artery was visualized craniomedially from the vein (Fig. 4B). On the CT scans through trochlea and capitulum humeri the collateral ulnar vessels were placed caudomedially of the bone (Fig. 4C, 4D). The superficial brachial artery was established on the corrosion cast and with the postmortem x-ray (Fig. 1, 2). Its branches, *aa. radiales superficiales*, were also found on the radiographic image (Fig. 2A). Three anastomoses between *a. brachialis superficialis* with other vessels in this region were established. Two of them were visualized on the postmortem radiographic picture – the first one was with *a. recurrens ulnaris* and the second one with *ramus deltoideus* of the superficial cervical artery (Fig. 2). On the corrosion cast was presented the third anastomosis, which was between *a. brachialis superficialis* and *a. recurrens interossea* (Fig. 1A). The superficial brachial vein was observed on CT scans at the level of tuber olecranii medially of the bicipital vein and craniomedially of the brachial vein (Fig. 4A). *A. transversa cubiti* was observed by all methods of this study. On the corrosion cast and postmortem x-ray image the artery was visualized craniomedially, in the angle of the elbow joint (Fig. 1B, 2). On Figure 3 representing the in vivo radiography *a. transversa cubiti* was presented cranially of the radius. On the CT scans through trochlea and capitulum humeri the transverse cubital artery and vein were found medially of *trochlea humeri*, where the artery was observed laterally of *a. brachialis* and the vein laterally of *v. brachialis* (Fig. 4D). On the postmortem radiographic image in craniocaudal view were visualized three recurrent ulnar arteries (Fig. 2B). The first twodetach from the brachial artery in the level of trochlea humeri, and the third was given by *a. interossea communis* at the proximal end of the radius. The most distal recurrent ulnar artery was also observed in lateral view (Fig. 2A). On the corrosion cast and in vivo radigraphy *a. recurrens ulnaris* was presented as a single artery (Fig. 1B, 3). An anastomosis between the recurrent ulnar artery and *a. recurrens interossea* was reported (Fig. 2B). *A. recurrens ulnaris* was also established on the CT scans through trochlea and capitulum humeri on the caudomedial side of the bone, cranially from the collateral ulnar artery and vein (Fig. 4C). On the corrosion cast and postmortem radiography in each projection was observed *a. interossea communis* (Fig. 1B, 2). Its branch, *a. ulnaris* (Fig. 2) and the terminal bifurcation branches – the cranial and the caudal interosseal arteries (Fig. 1A, 2A) were also established. At the level between the proximal and middle quarter of the antebrachial bones via CT *a. interossea communis* was visualized laterally of the brachial artery, and v. interossea communis was located laterally of the brachial vein (Fig. 4E). The median artery and vein were presented medially of the radius and the ulna, where the vein was placed cranially of the artery (Fig. 4F). *V. mediana cubiti* was observed on the in vivo x-ray image in the angle of the elbow joint (Fig. 3) and with computed tomography Fig. 4B, 4C, 4D). On the level of trochlea humeri the vein was presented craniomedially of the bone (Fig. 4B) and at the level of the distal part of the humerus the median cubital vein was more cranially of the bone and medially of the cephalic vein (Fig.4C, 4D). The cephalic vein, observed with radiography angiography, is presented on Figure 3. On the CT scans the same vein was established craniomedially of the radius at the distal level of the elbow region (Fig. 4B, 4C, 4D, 4E). Proximocranially at the flexor surface of the elbow joint the cephalic vein was visualized craniolaterally of the distal epiphysis of the humerus (Fig. 4A).

Discussion

At the proximal border if the elbow region the brachial artery positioned craniolaterally of the brachial vein in distal direction passes laterally, then caudolaterally and at the distal border of the elbow region is placed caudally of the brachial vein (Done 2009, Evans & de Lahunta 2013), confirmed by this study on CT angiography. Many authors describe the collateral ulnar artery as a double vessel (Davis 1941, Konig & Leibich 2004, Budras et al 2007, Schaller 2007, Dyce et al 2010, Evans & de Lahunta 2013,), while in this study we observed a common trunk between the beginning of the distal collateral ulnar artery and *a. brachialis superficialis*, which is not described in the available literature. Three undescribed in the literature to our knowledge anastomoses of the superficial brachial artery were established by the authors – with *a. recurrens ulnaris*, with *ramus deltoideus* (from *a. cervicalis superficialis*) and with *a. recurrens interossea*. Evans & de Lahunta 2013 describe the transverse cubital artery as a vessel similar in size with *a. brachialis superficialis*, which was confirmed by our findings.

In the present study three recurrent ulnar artery were observed, which is different from that described in literature (Schaller 2007, Evans & de Lahunta 2013), where it is marked as a single vessel, and from Davis (1941) statement, who reports it as a double, giving its origin from *a. brachialis*, from *a. interossea communis* or both at the same time. Connections of *a. recurrens ulnaris* with the collateral ulnar artery and with the deep antebrachial artery (Evans & de Lahunta 2013) was not observed in our research. An anastomosis of the recurrent ulnar artery with *a. recurrens interossea* was established with this study, for which no data were found in the available literature. In a previous work, Georgiev (2020) observed and described the exact location of *V. mediana cubiti* and *v. cephalica* in distal and proximal of the elbow joint regions, while in the present study these vessels were established in the elbow region with CT and radiography.

Conclusion

To our knowledge this is the first time the vessels of the elbow joint of the dog were described with computed tomography angiography. Undescribed in the available literature arterial anastomoses, were detected, together with different beginning of some branches of the artery and quantity variations. The precise specification of the blood vessel topography, their branches and their possible variations allows better understanding of the blood supply to the structures in the elbow area, relevant to the development of various pathological processes, inflammations, dysplasia, etc.

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