Research in Veterinary Science 102 (2015) 15–21

Contents lists available at ScienceDirect

Research in Veterinary Science

journal homepage: www.elsevier.com/locate/yrvsc

Epinephrine-enhanced computed tomographic arthrography of the canine shoulder

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ARTICLE INFO

Article history:
Received 8 January 2014
Received in revised form 6 May 2015
Accepted 21 June 2015

Keywords:
Canine
Shoulder
Computed tomography
Arthrography
Epinephrine

ABSTRACT

The aim of this study was to investigate the effect of epinephrine-enhanced computed tomographic arthrography (CTA) on the image sharpness of the lateral and medial glenohumeral ligaments (LGHL and MGHL, respectively), biceps tendon (BT) and joint cartilage (JC) in the canine shoulder.
The shoulders of eight normal dogs were examined using a 4-slice helical CT scanner. The right shoulders were injected with Iohexol and the left shoulders with a mixture of Iohexol and epinephrine. CTA images were obtained after 1, 3, 5, 9, 13, 20 and 30 min and the image sharpness of the intra-articular structures in both shoulders was graded for visibility. The attenuation values were measured to examine the persistence of contrast appearance. Admixture of epinephrine and Iohexol significantly improved the image sharpness of the LGHL and the BT, especially on delayed CTA images. The use of epinephrine did not negatively affect post-CTA recovery.

1. Introduction

In human medicine, CTA of the shoulder is widely used to evaluate rotator cuff tears, and labral or capsular abnormalities, and to assess cartilage pathology (Rafii et al., 1986; Yang et al., 1987; De Maeseneer et al., 2000; Charousset et al., 2005; Lecouvet et al., 2007; Lecouvet et al., 2008; Omoumi et al., 2011). In veterinary medicine, CTA of the canine shoulder performed with a 4-slice helical CT-device, is used to evaluate the joint cartilage and intra-articular structures such as the glenohumeral ligaments and the BT (De Rycke et al., 2015).

In general, the accuracy and usefulness of arthrography depend on the contrast medium providing a sharp outline of the intra-articular structures. Once the concentration of iodinated contrast material is injected into the joint, it decreases within minutes through diffusion into the cartilage and the highly vascular synovium, resorption, and fluid influx into the joint. Rapid deterioration of the image quality may follow, making the intra-capsular structures indiscernible because of the lack of detail (Spataro et al., 1978; Oberman and Kieft, 1987; Obermann et al., 1989; Van Bree, 1989; Wellings et al., 1994). In animals where inflammatory changes and synovial hyperemia occur, even more rapid resorption of the contrast medium can be expected (Katzberg et al., 1976; Spataro et al., 1978; Wellings et al., 1994). The CTA examination must therefore be performed quickly after intra-articular injection of the contrast medium to minimize the absorption of contrast solution (Wellings et al., 1994). Also, it is best to use a contrast medium that resorbs slowly (Wellings et al., 1994; Blum et al., 2000). Human studies have shown that non-ionic dimeric contrast agents likely will undergo fewer dilution and resorption processes than non-ionic monomeric contrast agents, and provide a better contrast in delayed CT scans (Ingram and Stoker, 1986; Oberman and Kieft, 1987; Obermann et al., 1989; Wellings et al., 1994; Blum et al., 2000). However, for delayed CTA examinations, adding epinephrine to non-ionic monomeric contrast agents can produce a significant improvement in CT density that surpasses the density provided when the dimeric contrast agent is used alone (Wellings et al., 1994). Epinephrine has a vasoconstrictive effect on the synovial membrane, which temporarily reduces the fluid movement across the membrane (Hall, 1974; Spataro et al., 1978; Ng et al., 1989; Wellings et al., 1994; Jacobsen et al., 2003; Mutschler et al., 2003). This may be important, depending on the interval between the time of injection into the joint and the CT imaging (Jacobsen et al., 2003). The initial sharpness of the image can be improved and image degradation delayed by the greater persistence of the contrast medium in the joint, as well in cases with hyperemic synovia (Wellings et al., 1994).

In veterinary medicine, studies have confirmed that image sharpness is improved when epinephrine is added to an ionic contrast medium (diatrizoate meglumine, urografin) with conventional arthrography of the canine shoulder and knee (Hall, 1974; Spataro et al., 1978; Van Bree, 1989). Intra-articular injection of Iohexol is now the method of choice for veterinary arthrography (Hong et al., 2010), including at our

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http://dx.doi.org/10.1016/j.rvsc.2015.06.009
0034-5288/

clinic, where arthrographic examinations of the canine shoulder are routinely performed using Iohexol, a non-ionic, monomeric contrast agent. Except for one experimental study on CTA of the canine shoulder (De Rycke et al., 2015), nothing has been published about the use of CTA in veterinary practice. The CTA procedure can be more time-consuming than conventional arthrography, so the need for admixture of epinephrine and Iohexol (Omnipaque) is desirable, but as yet of undetermined efficacy.

In this CTA study, the effect of admixture of epinephrine and Omnipaque on the image sharpness of the LGHL, MGHL, BT and JC in the canine shoulder was studied on CTA images taken 1, 3, 5, 9, 13, 20 and 30 min after injection. The persistence of the contrast medium on delayed CTA images was also investigated by measuring the attenuation values Hounsfield Units (HU) in the caudal pouch of the glenohumeral joint.

2. Materials and methods

2.1. Animals

CTA was performed on both shoulders of eight clinically normal, 3- to 6-year-old dogs (two foxhounds and six beagles). The dogs were maintained and the procedures performed, in accordance with the Ethical Committee of the Faculty of Veterinary Medicine, Ghent University. None of the dogs had a history of shoulder disease and no abnormalities were detected during physical and radiographic examinations. Two standard radiographs (mediolateral and craniocaudal) were obtained for each shoulder. All shoulder regions were clipped before the scanning procedure.

2.2. CTA

The dogs were sedated with medetomidine hydrochloride[1] (30–50 ug/kg of body weight, IM), anesthesia was induced with propofol[2] (bolus of 1–2 mg/kg of body weight, IV given to effect) and the dogs were intubated. Anesthesia was maintained with isoflurane[3] in oxygen. The dogs were positioned in ventral recumbency with both forelimbs extended cranially on the table of a 4-slice helical CT device.[4] Lateral and dorsoventral scout views were taken with an extension angle of 120–150° maintained between the spine of the scapula and the long axis of the humerus. Native, transverse, 1.3-mm thick slices with a 0.7-mm interval of both shoulders also were obtained from the mid-scapula to the mid-humerus regions and perpendicular to the long axis of the spine of the scapula. Settings for the CT imaging, calculated using a bone algorithm, were 120 kV and 140 mA. Image matrix size was 512 × 512 and field of view was 25 cm. All the images were taken in approximately 4 min.

During the arthrographic CT scan, each dog was studied using contrast medium[5] alone in the right shoulder and a mixture of contrast medium and epinephrine[6] in the left shoulder. The dogs were positioned in left lateral recumbency, and 4–6 ml of contrast medium (Omnipaque 240: 4 ml for the beagles, 6 ml for the foxhounds) diluted to 100 mg/ml with sterile saline (0.9% NaCl) was injected into the right shoulder. Immediately after the injection, the dogs were turned to right lateral recumbency and their left shoulders were injected with the same amount of contrast medium mixed with 0.2 mg (0.25 ml) of epinephrine[6]. This injection time was noted as time zero. Next, the dogs were positioned in ventral recumbency with both forelimbs extended cranially and CT images of both shoulders were obtained 1, 3, 5, 9, 13, 20 and 30 min after the intra-articular injection using the same settings. The reconstructed CT images that were acquired in dorsal and sagittal planes using CT reconstruction imaging software[7] were high quality because of their 1.3-mm thickness.

[1] Domitor, Orion Corp, Espoo, Finland.
[2] Rapinovet, Schering-Plough, Comazzo, Italy.
[3] IsoFlo, Abbott Laboratories, Abbott Park, IL.
[4] CT-scanner, LightSpeed, GE Medical Systems, Milwaukee, WI.
[5] Omnipaque 240, GE Healthcare Ireland, Cork, Ireland.
[6] Epinephrine HLC (adrenaline 0.8 mg/mL) Sterop, Brussels, Belgium.
[7] OsiriX 32-bit, advanced open source PACS workstation, DICOM viewer.

The use of epinephrine did not negatively affect post-CTA recovery.

After completion of the study, the CTA images of each dog, both with and without epinephrine injection, were evaluated, compared and scored by blinded radiologists. Three experienced radiologists, who had no knowledge about the time when the CT was performed or which side received the epinephrine injection, interpreted the arthrograms. The radiologists agreed by consensus about the image sharpness of the intra-articular structures with medium-coated contrast and the persistence of the contrast medium when they evaluated the images.

The persistence of contrast medium was determined by measuring the attenuation value (HU) at the caudal pouch of the glenohumeral joint. For each specific set of arthrograms (performed at a certain time) an average HU score was calculated for the eight dogs, with separate calculations made for the shoulders injected with epinephrine and those without.

The MGHL, LGHL, and BT at the height of the intertubercular sulcus and the joint JC on the CTA images with and without epinephrine were graded for visibility on a scale from 3 to 0 (3 = excellent visibility, 2 = moderate, 1 = poor, 0 = not visible). The CTA images performed at 1, 3, 5, 9, 13, 20 and 30 min after the intra-articular injection were graded separately. For each structure, an average score was calculated for each time period for the eight dogs.

A mixed model was fitted to HU, the score of the three different structures separately and the average score as response variables, including dog as random effect, and time (continuous), epinephrine (categorical) and their interaction as fixed effects. To assess the effect of epinephrine, we test the hypothesis whether the slopes with and without epinephrine, corresponding to the reduction of score or HU over time, differ significantly from each other using a F-test at the 5% significance level.

3. Results

The decrease of HU was not significantly faster (P = 0.50) in shoulders without epinephrine (slope = −13.2 (se = 2.24)) compared with the shoulders with epinephrine (slope = −9.7 (se = 2.24)) (Fig. 1).

For the BT, the visibility score decreased significantly faster in the shoulders without epinephrine (slope = −0.048 (se = 0.007)) compared with those with epinephrine (slope = −0.024 (se = 0.007)) (P = 0.0037) (Fig. 2). CTA images of both shoulders of one dog, 1 and 30 min after injection showed that the visibility score for the BT decreased from 2 to 0 in the shoulder without epinephrine and from 3 to 1 with epinephrine (Fig. 3).

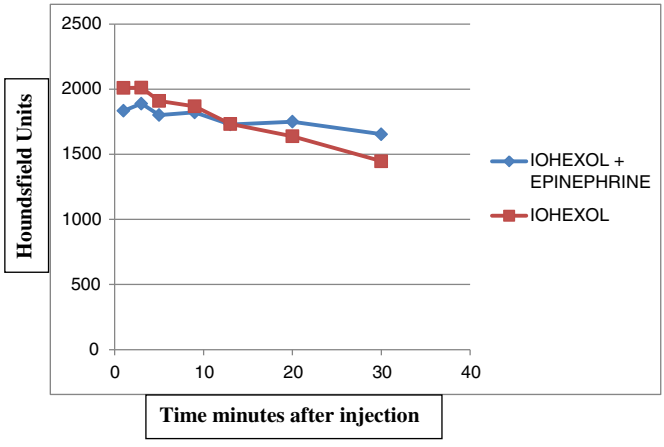

Fig. 1. Mean Hounsfield Units (HU) in the caudal pouch of the shoulder joint versus time comparing shoulders with Iohexol alone and with Iohexol and epinephrine.