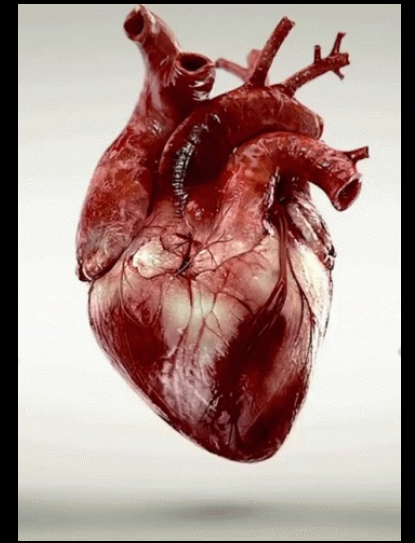




CARDIAC CT IN VETERINARY MEDICINE: TECHNIQUE AND POSSIBILITIES

Edoardo Auriemma
edoardo.auriemma@gmail.com

HUMAN MEDICINE

Eur Radiol. 2012 Dec;22(12):2688-98. doi: 10.1007/s00330-012-2551-x. Epub 2012 Jul 15.

Diagnostic performance of coronary CT angiography for stenosis detection according to calcium score: systematic review and meta-analysis.

den Dekker MA¹, de Smet K, de Bock GH, Tio RA, Oudkerk M, Vliegenthart R.

KEY POINTS: Decisions about performing coronary CT angiography (CCTA) sometimes depend on calcium scoring. CCTA is highly sensitive for coronary stenosis. With 16-MDCT, however, heavy calcification reduces specificity for significant stenosis. For 64-MDCT (and above), CCTA has high specificity, even with severe coronary calcification.

Current Pharmaceutical Design, 2017, 23, 3285-3300

REVIEW ARTICLE



Multimodality Imaging for Interventional Cardiology

Simona Celi^{1,*}, Nicola Martini¹, Luigi Emilio Pastormerlo², Vincenzo Positano¹ and Sergio Berti²

Next-Generation Hardware Advances in CT: Cardiac Applications

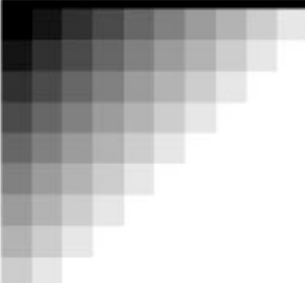
*Alan C. Kwan, MD • Amir Pourmorteza, PhD • Dan Stutman, PhD • David A. Bluemke, MD, PhD •
João A. C. Lima, MD, MBA*

From the Smidt Heart Institute, Cedars-Sinai Medical Center, 127 S San Vicente Blvd, AHSP, Suite A3600, Los Angeles, CA 90048-0750 (A.C.K.); Department of Radiology and Imaging Sciences, Emory University, Atlanta, Ga (A.P.); Winship Cancer Institute, Emory University, Atlanta, Ga (A.P.); Department of Biomedical Engineering, Georgia Institute of Technology-Emory University, Atlanta, Ga (A.P.); Department of Physics and Astronomy, Johns Hopkins University, Baltimore, Md (D.S.); Extreme Light Infrastructure-Nuclear Physics, Bucharest-Magurele, Romania (D.S.); Department of Radiology, University of Wisconsin School of Medicine and Public Health, Madison, Wis (D.A.B.); and Department of Cardiology, The Johns Hopkins Hospital, Baltimore, Md (J.A.C.L.). Received December 23, 2019; revision requested February 7, 2020; revision received August 3; accepted August 18. **Address correspondence to** A.C.K. (e-mail: alan.kwan@cshs.org).

A.C.K. supported by the National Institutes of Health (grant T32HL116273) and Doris Duke Charitable Foundation (grant 2020059). J.A.C.L. supported by Canon Medical Systems, Astra Zeneca, and MedImmune.

Conflicts of interest are listed at the end of this article.

Radiology 2021; 298:3–17 • <https://doi.org/10.1148/radiol.2020192791> • Content codes: **CA** **CT**



AAPM/RSNA Physics Tutorial for Residents

Physics of Cardiac Imaging with Multiple-Row Detector CT¹

Mahadevappa Mahesh, MS, PhD • Dianna D. Cody, PhD

Mahadevappa Mahesh, MS, PhD • Dianna D. Cody, PhD

Cardiac imaging with multiple-row detector computed tomography (CT) has become possible due to rapid advances in CT technologies. Images with high temporal and spatial resolution can be obtained with multiple-row detector CT scanners; however, the radiation dose associated with cardiac imaging is high. Understanding the physics of cardiac imaging with multiple-row detector CT scanners allows optimization of cardiac CT protocols in terms of image quality and radiation dose. Knowledge of the trade-offs between various scan parameters that affect image quality—such as temporal resolution, spatial resolution, and pitch—is the key to optimized cardiac CT protocols, which can minimize the radiation risks associated with these studies. Factors affecting temporal resolution include gantry rotation time, acquisition mode, and reconstruction method; factors affecting spatial resolution include detector size and reconstruction interval. Cardiac CT has the potential to become a reliable tool for noninvasive diagnosis and prevention of cardiac and coronary artery disease.

©RSNA, 2007

Applications in human medicine

Coronary arteries assessment

Congenital and acquired cardiac disease

Cardiac neoplasia

Pre and post surgical assesment

VETERINARY MEDICINE

Coronary arteries?

J Vet Intern Med 2003;17:489–494

Association between Diabetes Mellitus, Hypothyroidism or Hyperadrenocorticism, and Atherosclerosis in Dogs

Rebecka S. Hess, Philip H. Kass, and Thomas J. Van Winkle

Atherosclerosis associated with vasculopathic lesions in a golden retriever with hypercholesterolemia

Nicole A. Boynosky, Laura Stokking

pentoxifylline, omega-3 fatty acids, and chloramphenicol were discontinued. The patient continued to decompensate and expired at the owners' home about 9 wk after the initial presentation.

The cause of death was determined to be myocardial infarction. Postmortem histopathology revealed atherosclerosis in coronary arteries. Foamy macrophages with cholesterol clefts infiltrated the subintima and tunica media. Atherosclerotic plaques obscured vascular lumina and arteries on the pericardial sac; plaques were observed in the lungs, kidneys, and submucosal and medial arteries of the small intestine. Areas of infarction

[J Vet Cardiol](#). 2016 Dec;18(4):418-426. doi: 10.1016/j.jvc.2016.08.003. Epub 2016 Sep 29. [ajvr.22.05.0085](#). doi: 10.2460/ajvr.22.05.0085.

Use of ECG-gated computed tomography, echocardiography and selective angiography in five

ve size as measured by computed

> [BMC Vet Res](#). 2011 Sep 23;7:57. doi: 10.1186/1746-6148-7-57.

Multidetector-row computed tomography of aortic anomalies in dogs and cats: patent ductus arteriosus and

Christiane R Henjes¹, I

Electrocardiogram-gated tomographic angiography in dogs

> [Vet Rec](#). 2018 Oct 20;183(15):473. doi: 10.1136

[Vet Radiol Ultrasound](#). Author manuscript; available in PMC 2012 Mar 21. [ena Montin¹](#), [Christopher P Ober²](#), [Jessi L Corvell³](#).

[Vet Radiol Ultrasound](#). 2011 Sep-Oct; 52(5): 507-515.

Published in final edited form as:

[Vet Radiol Ultrasound](#). 2011 Sep-Oct; 52(5): 507-515.

Published online 2011 Apr 26. doi: [10.1111/j.1740-8261.2011.01826.x](#)

PMCID: PMC3309425

NIHMSID: NIHMS356535

PMID: [21521398](#)

64-MULTIDETECTOR COMPUTED TOMOGRAPHIC ANGIOGRAPHY OF THE CANINE CORONARY ARTERIES

[Randi Drees](#), [Alex Frydrychowicz](#), [Scott B. Reeder](#), [Marie E. Pinkerton](#), and [Rebecca Johnson](#)

> [Front Vet Sci](#). 2022 Aug 3;9:952412. doi: 10.3389/fvets.2022.952412. eCollection 2022.

Non-electrocardiography- and electrocardiography-gated computed tomography and evaluation of feline coronary anomalies

Junyoung Kim^{1,2}, I

Case Reports > [J Vet Cardiol](#)

Epub 2021 Oct 14.

Non-electrocardiographic-gated computed tomographic angiography can be used to diagnose coronary artery anomalies in Bulldogs with pulmonary valve stenosis

[Catherine T. Gunther-Harrington](#)✉, [Kathryn L. Phillips](#), [Lance C. Visser](#), [Samantha L. Fousse](#), [Joshua A. Stern](#)

Computed tomography diagnosis of a caval azygos communication in a dog with cor triatriatum dexter

[V Phillips¹](#), [J Neves¹](#), [B Pedro¹](#), [C Linney¹](#), [S Griffin²](#)

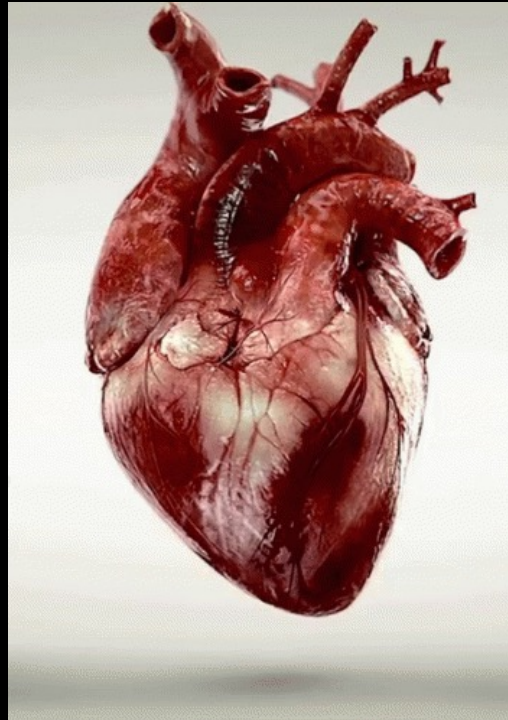
Applications in veterinary medicine

Coronary arteries assessment (pre-surgical)

Complex cardiac pathologies

Cardiac neoplasia

DIFFICULTIES



Temporal resolution





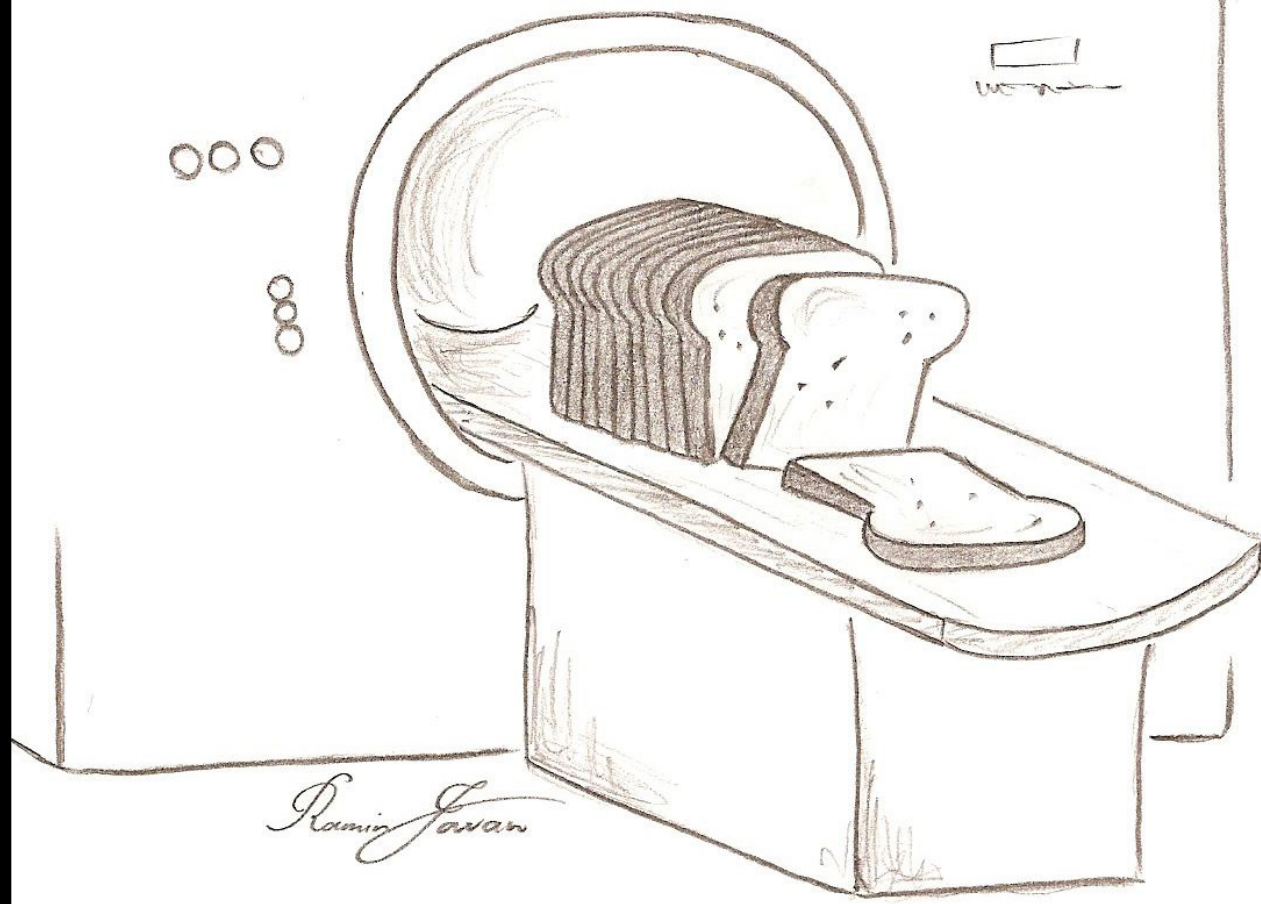
TABLE 1

The Newest Generation Computed Tomography Systems from Major Vendors Are Listed with Technical Specifications

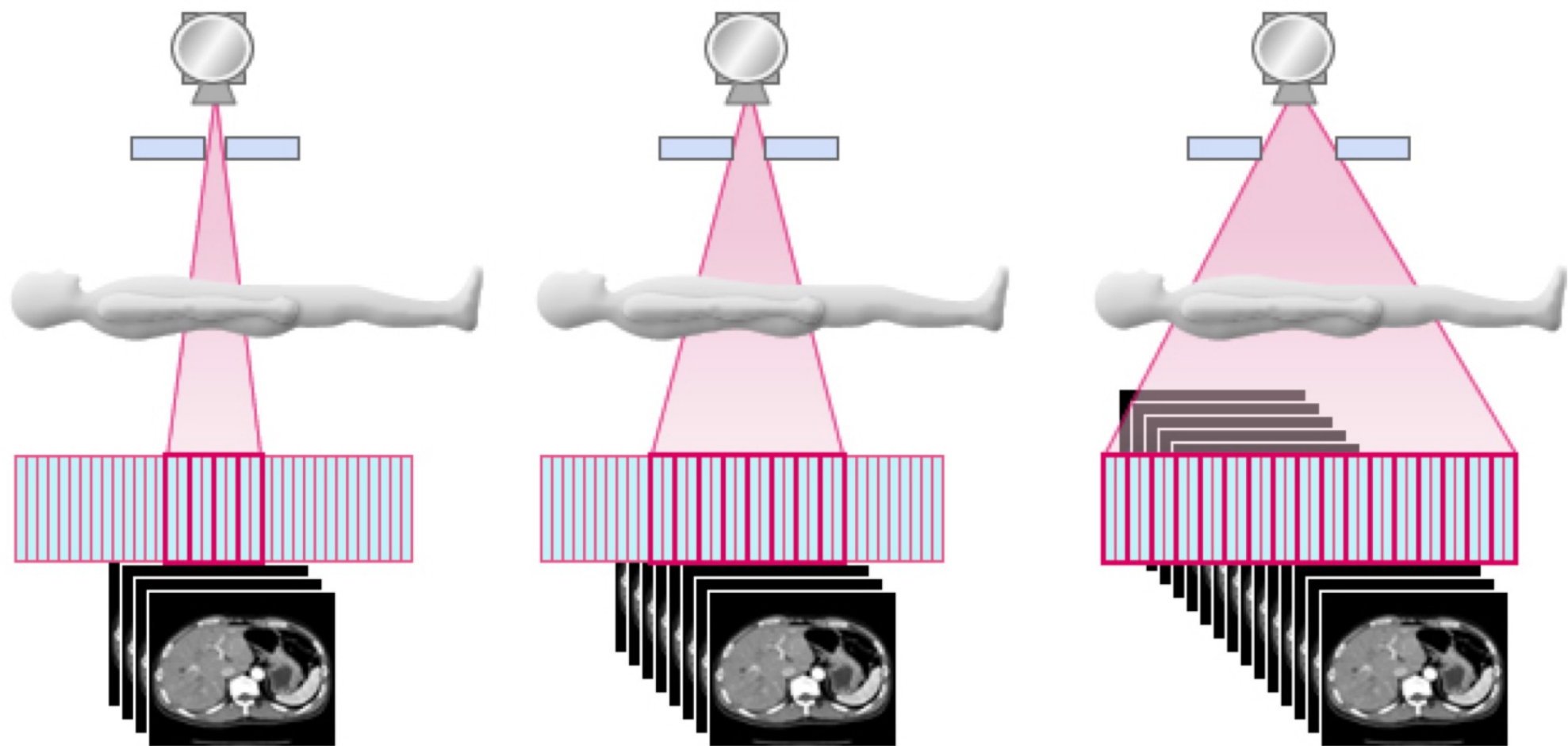
Manufacturer	Canon	GE	Philips	Siemens
Model	Aquilion One Genesis	Revolution Apex	Spectral CT 7500	Somatom Force
Number of x-ray sources	1	1	1	2
Detector rows	320	256 or 128	128	192 (2 × 96)
Slices per rotation	Up to 640	512 or 256	512	384 (2 × 192)
Voltage range	80–135 kVp	70–140 kVp	80–140 kVp	70–150 kVp
Amperage range	10–900 mA	10–1300 mA	10–1000 mA	20–1300 mA
Detector spacing	0.5 mm	0.625 mm	0.625 mm	0.4 mm
Z-axis coverage in one rotation	16 cm	16 cm or 8 cm	8 cm	5.76 cm
Fastest gantry rotation speed	0.275 s	0.28 s	0.27 s	0.25 s
Maximum acquisition speed	—	437 mm/s	—	737 mm/s

Spatial resolution

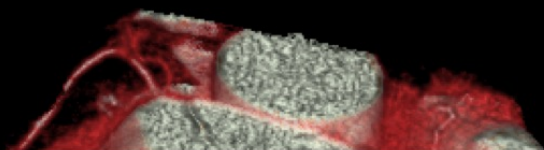
"Multi-Slice CT"



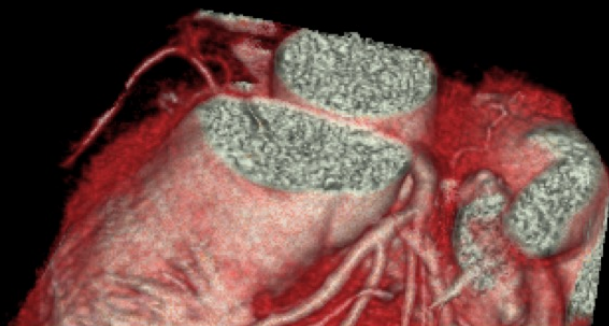
Ramin Javan



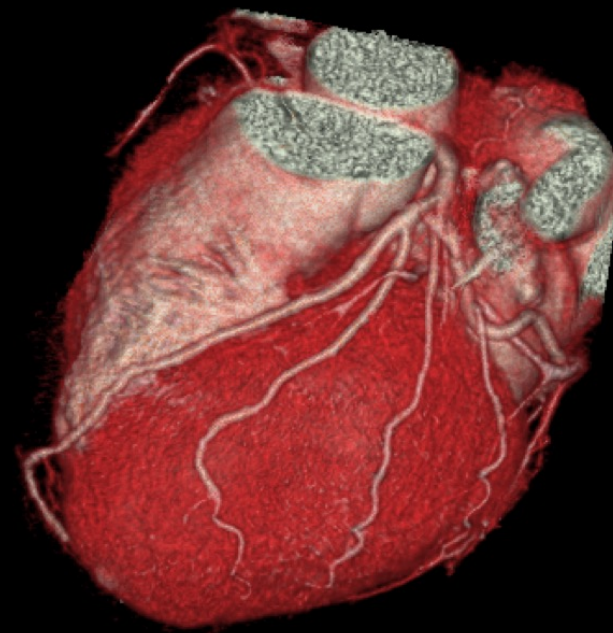
16



32



64



ECG-GATED CARDIAC TC



ECG-GATED CARDIAC TC

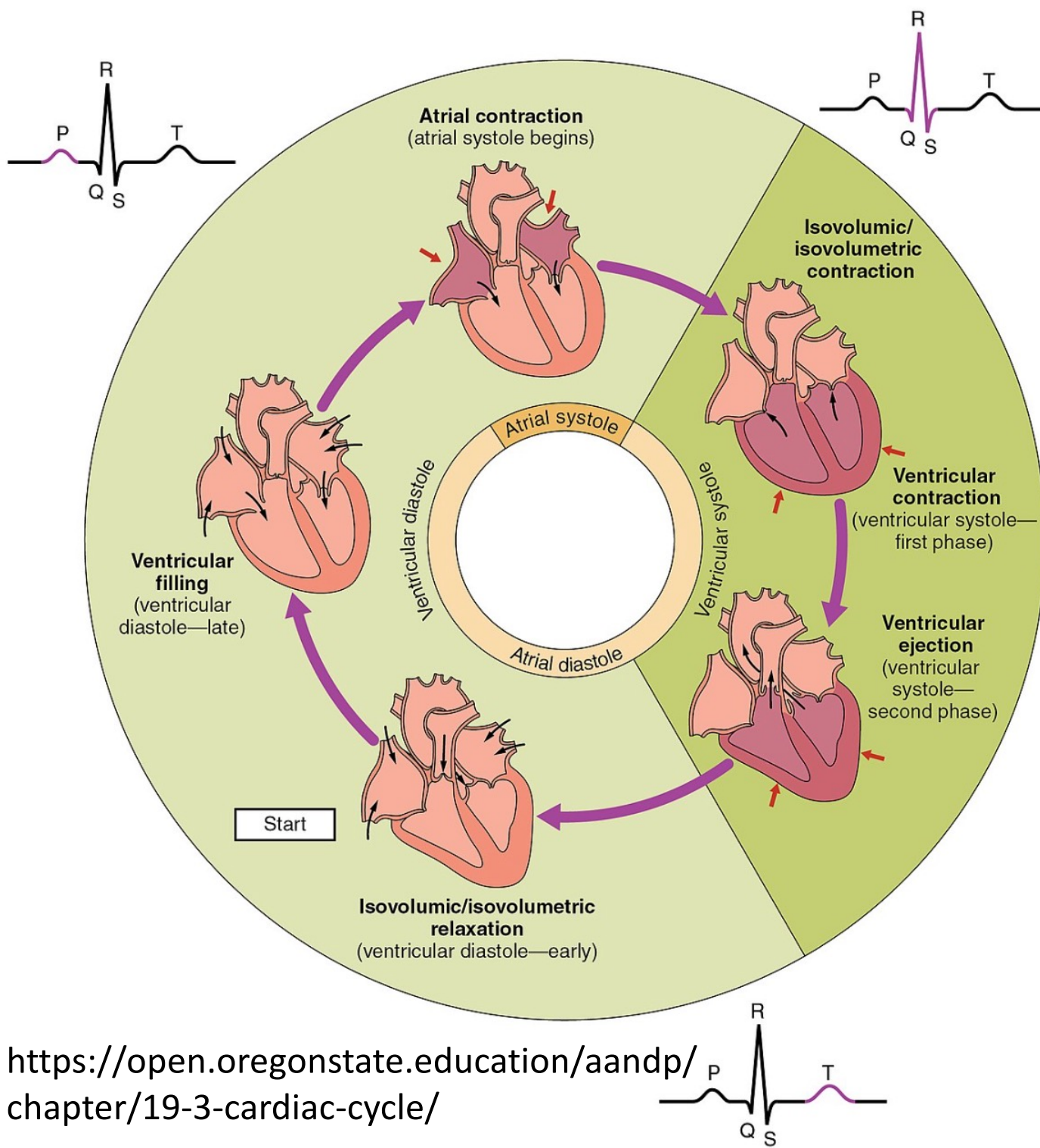
High temporal and spatial resolution

Dedicated software

ECG of the patient connected to the gantry

Acquisition / reconstruction of images synchronized with the heart rhythm





<https://open.oregonstate.edu/aandp/chapter/19-3-cardiac-cycle/>

Ingredients

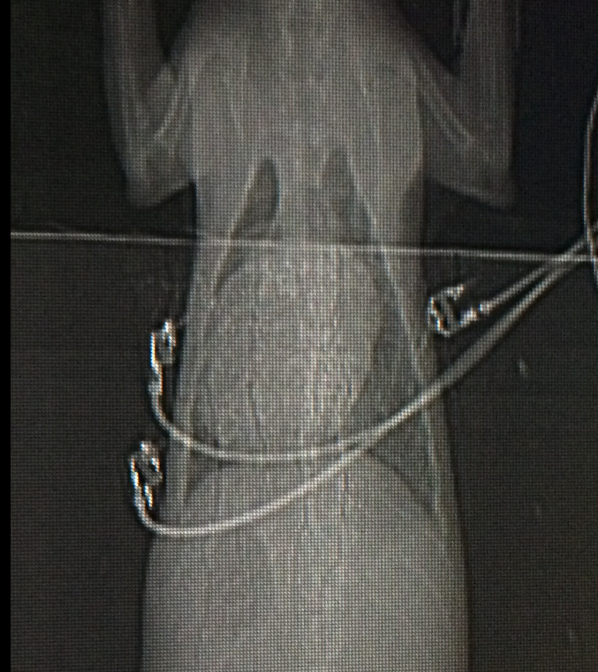
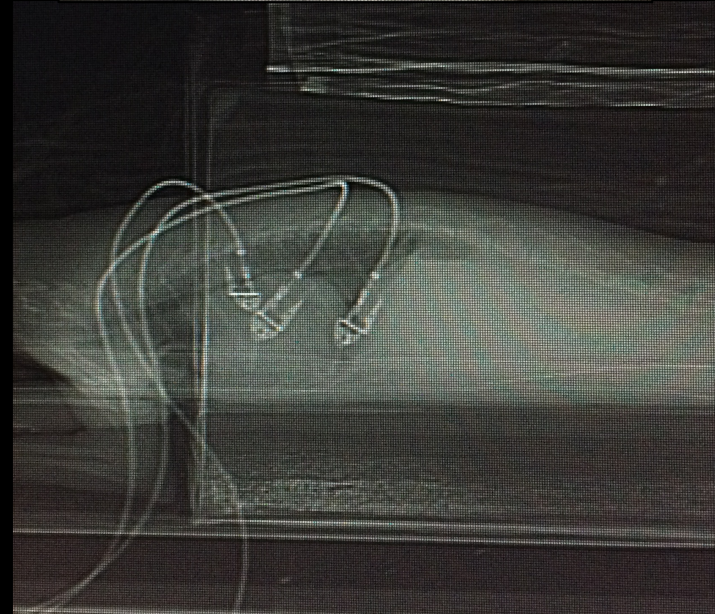


TEAM WORK





POSITIONING



WHAT DO WE NEED





Cardiac Trigger Monitor 3150

3:21

CONNECTED

II-FILT
30 - 160
5 MM/MV

108



XRAY OFF

NOT ARMED



PACER DETECT
DISABLED

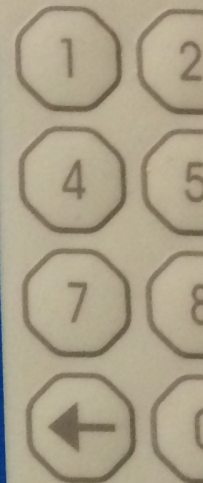
LEAD
II

OPTIONS

SIZE
5 MM/MV

PACER DETECT
DISABLED

EXIT

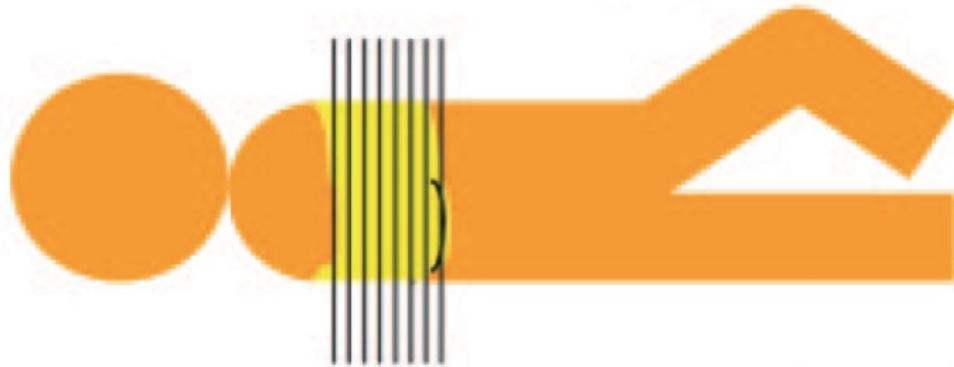


ECG

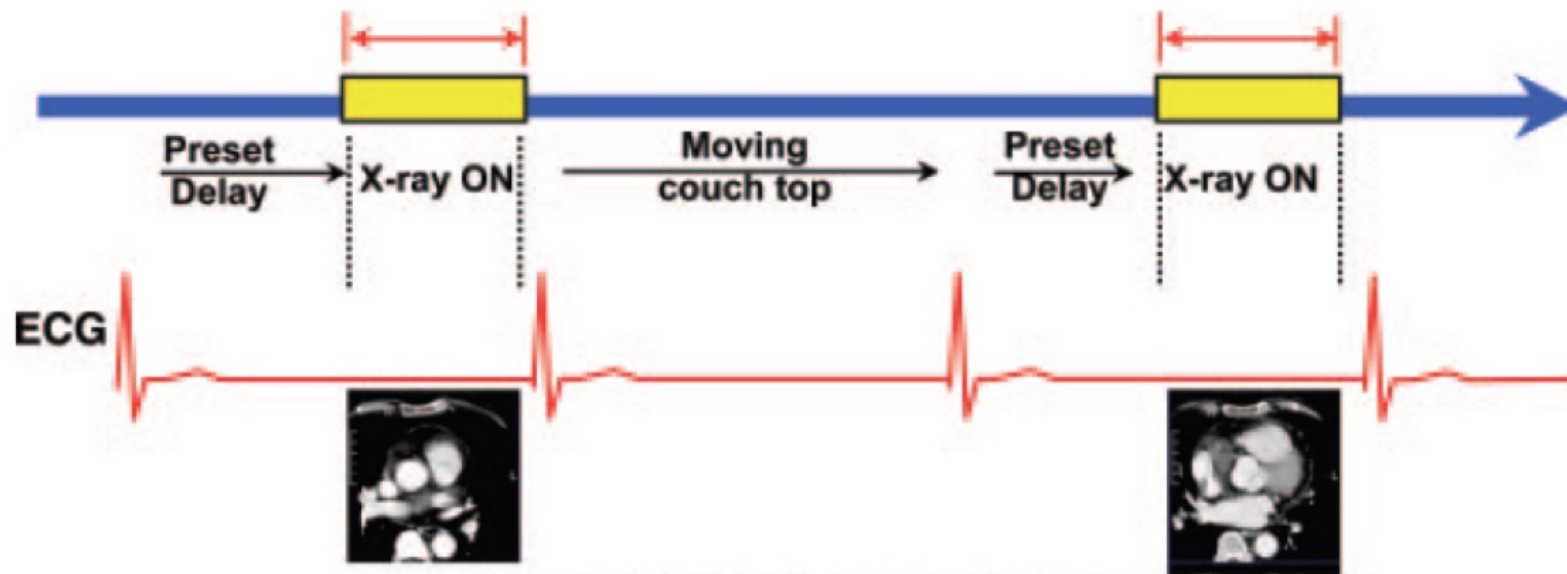


ECG GATED ACQUISITION

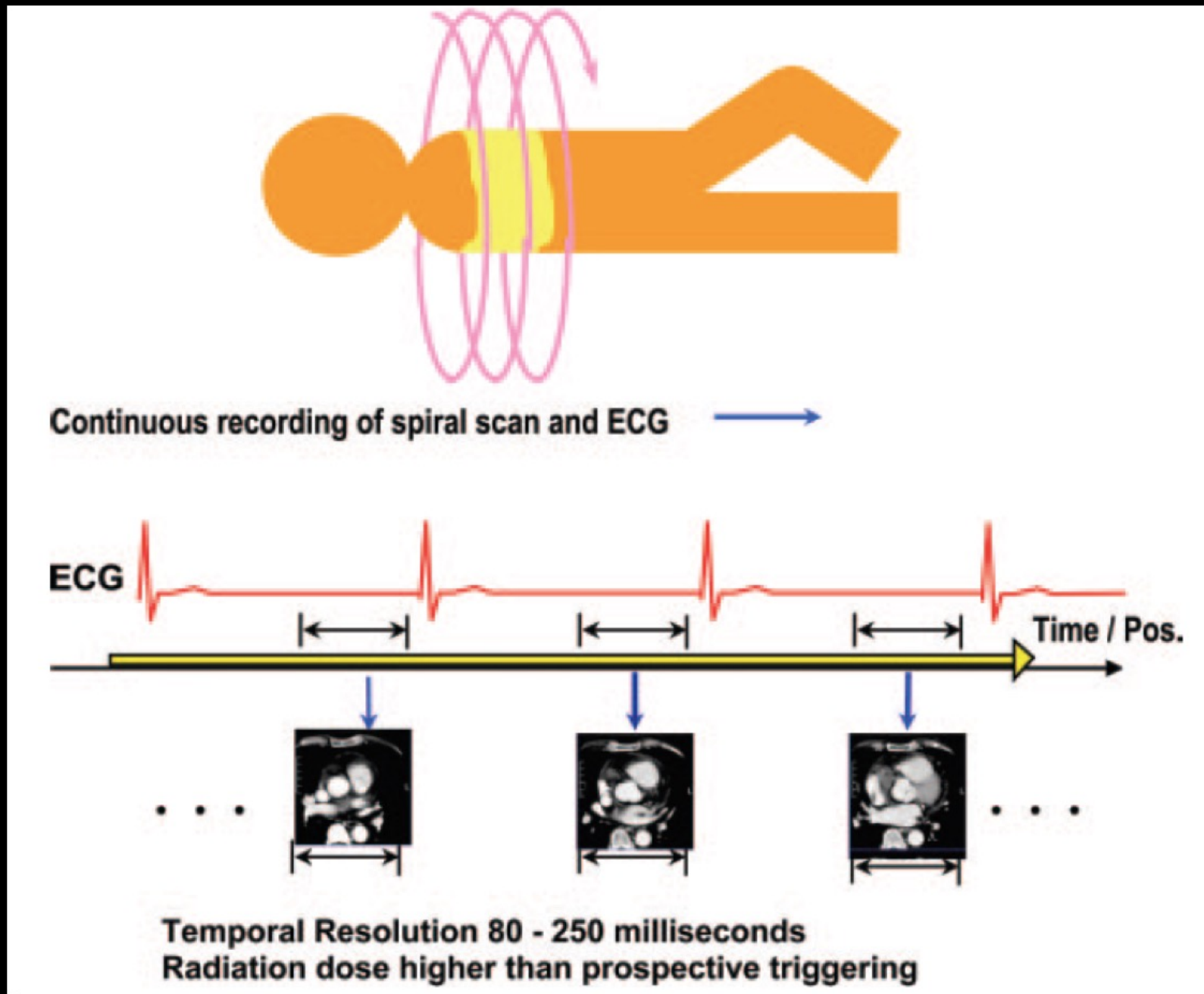
Prospective ECG Triggering



Conventional Axial "Partial Scan" (Step and Shoot)



Temporal resolution 200 – 250 msec
Radiation dose minimized
Limited data set



*Physics of Cardiac Imaging with Multiple-Row Detector CT. M.Mahesh and D.D. Cody.
RadioGraphics 2007 27:5, 1495-1509*

ECG GATED ACQUISITION

VOL. 55, No. 3

THORACIC CARDIOVASCULAR MDCTA IN COMPANION ANIMALS

231

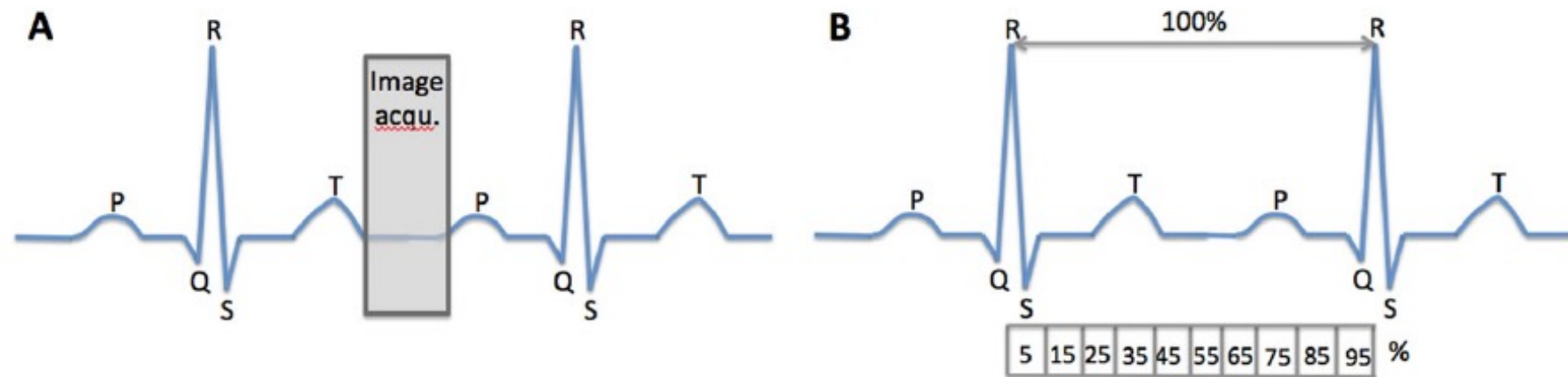
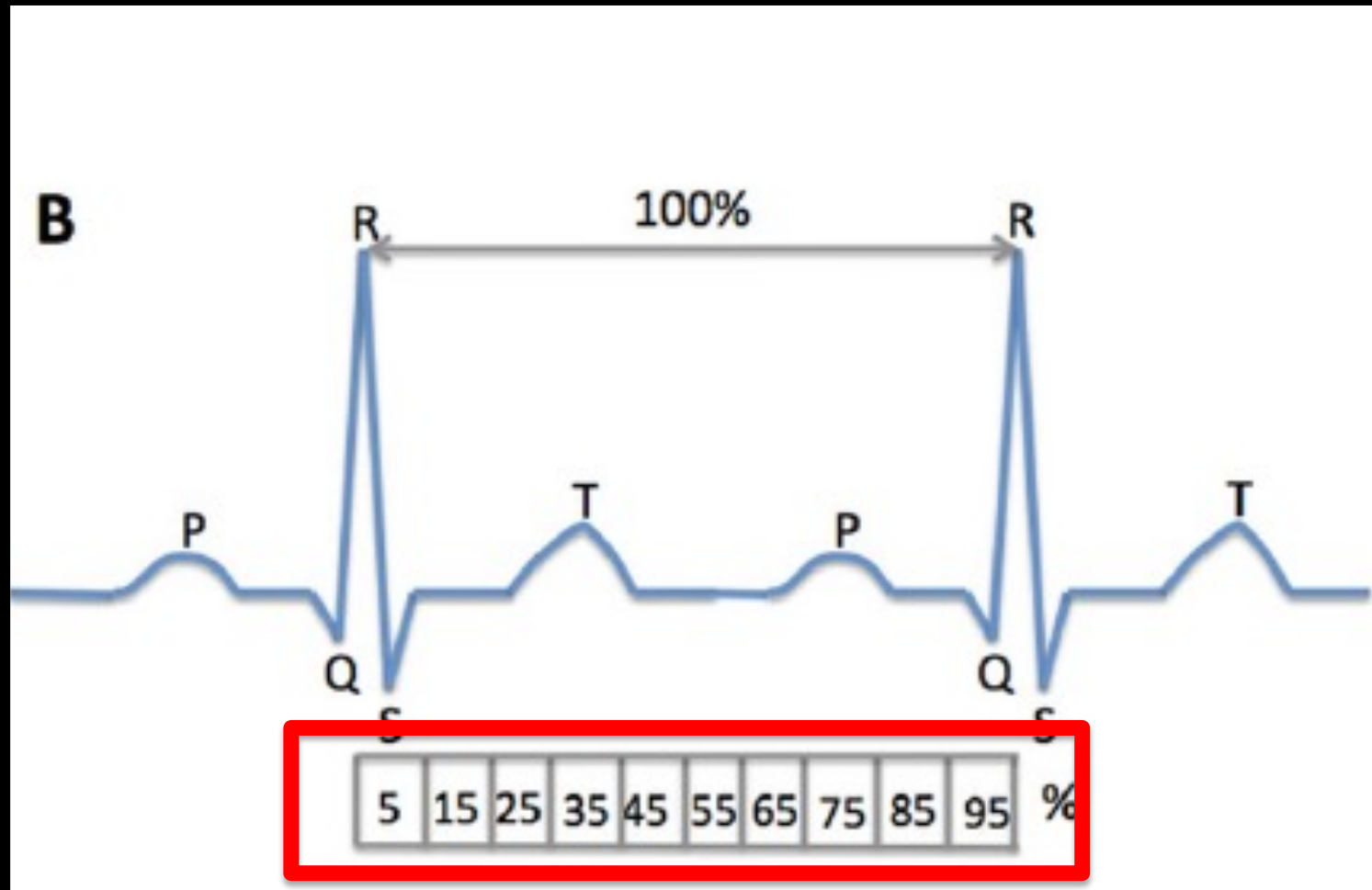


FIG. 1. EKG-gating strategies in cardiac CT: Using prospective gating (A) images are acquired over a predefined portion of one or more cardiac cycles, commonly end diastolic. Using retrospective gating (B) images are acquired over one or several full cardiac cycles and are retrospectively segmented into different phases of the cycle (commonly 5–10% intervals).

ECG GATED ACQUISITION



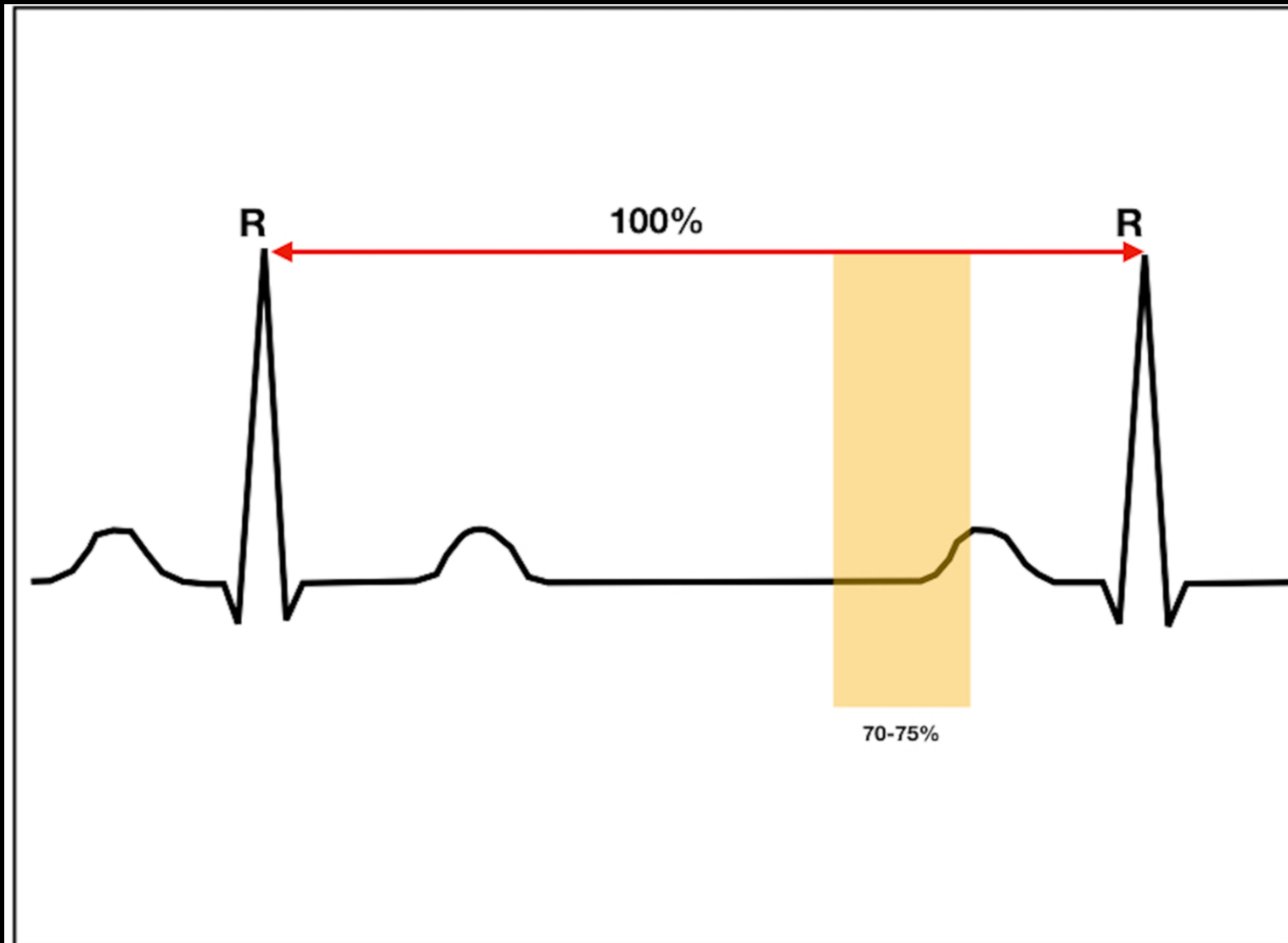


FIG 2: Most common reconstruction interval of the ECG gating detected in our case series, expressed as percentages of the R-R interval.

*Electrocardiogram-gated 16-multidetector computed tomographic angiography of the coronary arteries in dogs.
Auriemma E, Armienti F, Morabito S, Specchi S, Rondelli V, Domenech O, Guglielmini C, Lacava G, Zini E, Khouri T.*

LIMITING FACTORS

LIMITING FACTORS

- Heart frequency – arrhythmia
- What is the upper limit of heart frequency?
- Bradycardia, long diastolic phase, better image quality



CT PARAMETERS

- kV range 100-120
- mA range 300-400
- 250-500 ms gantry rotation time
- 0,625-1,25 mm slice thickness
- Heart rate adapted pitch
- FOV centered on the heart

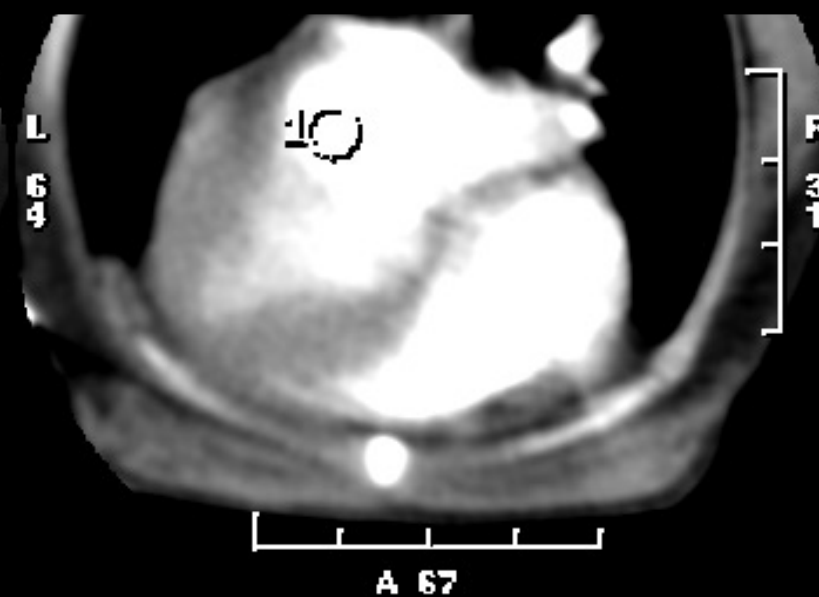
IMAGE ACQUISITION

SURVEY SCAN

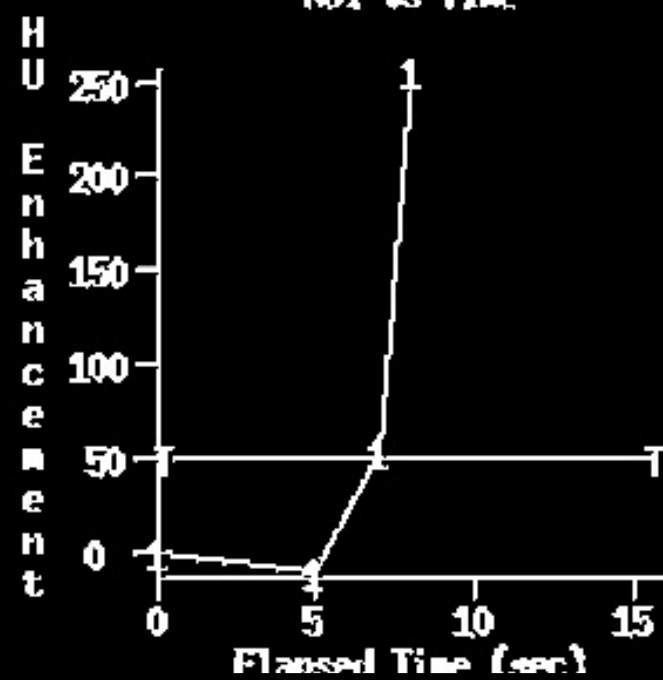


ROI





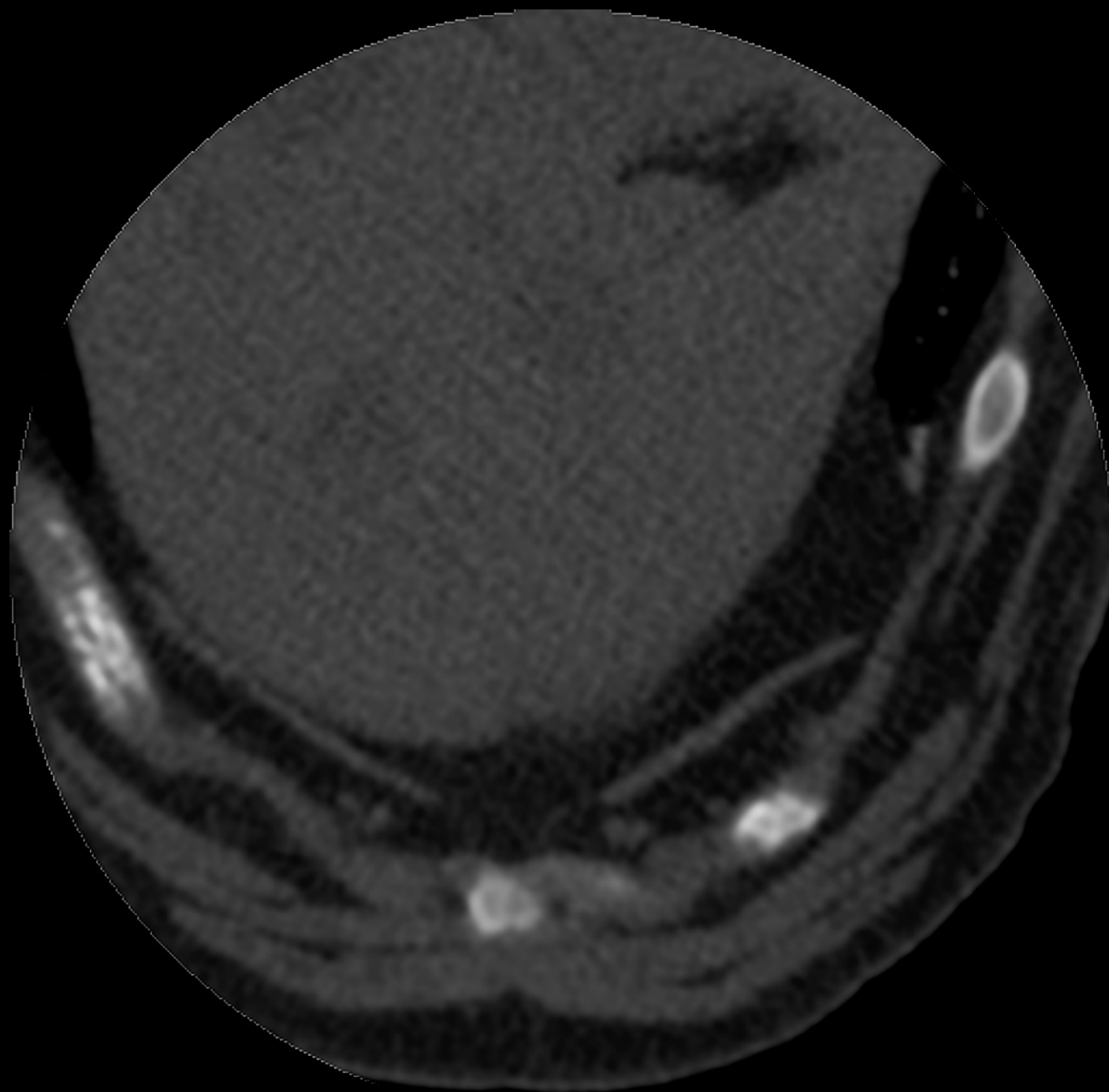
ROI vs Time



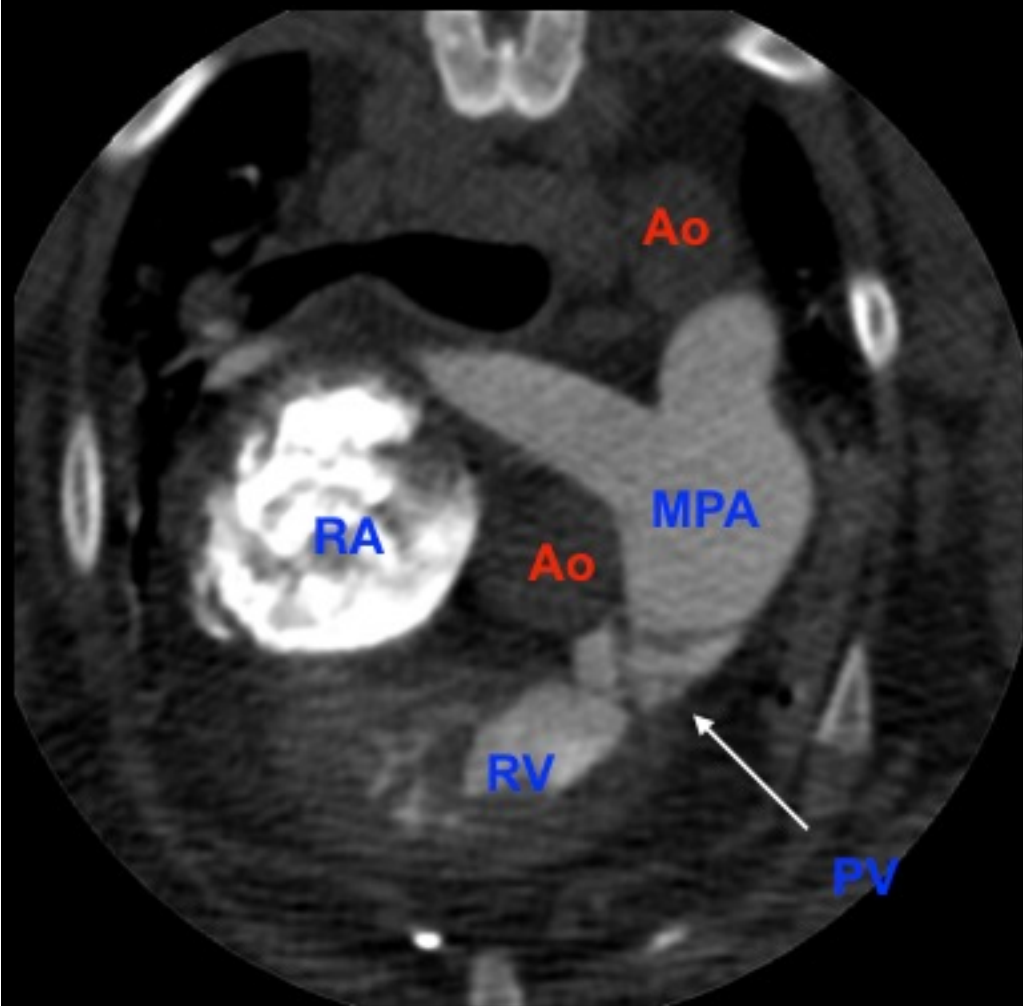
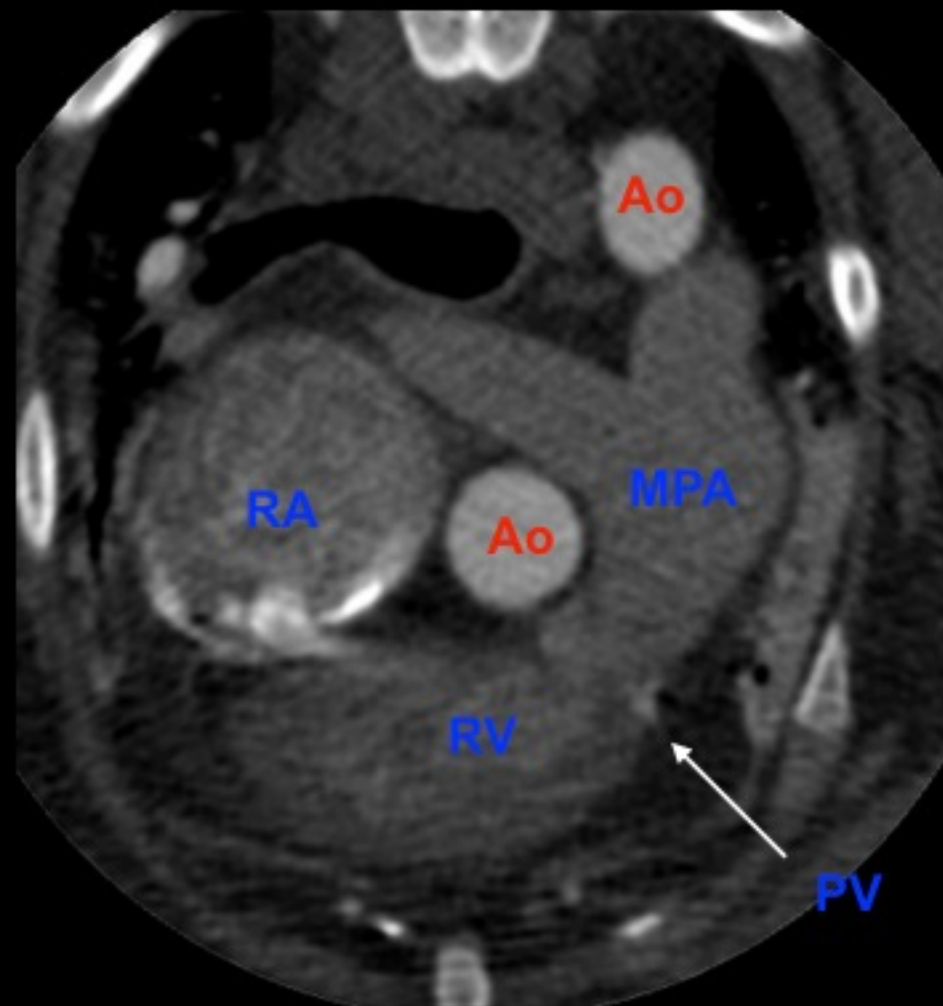
TIME	ROI 1
00:05	-9.90
00:07	52.70
00:08	256.00

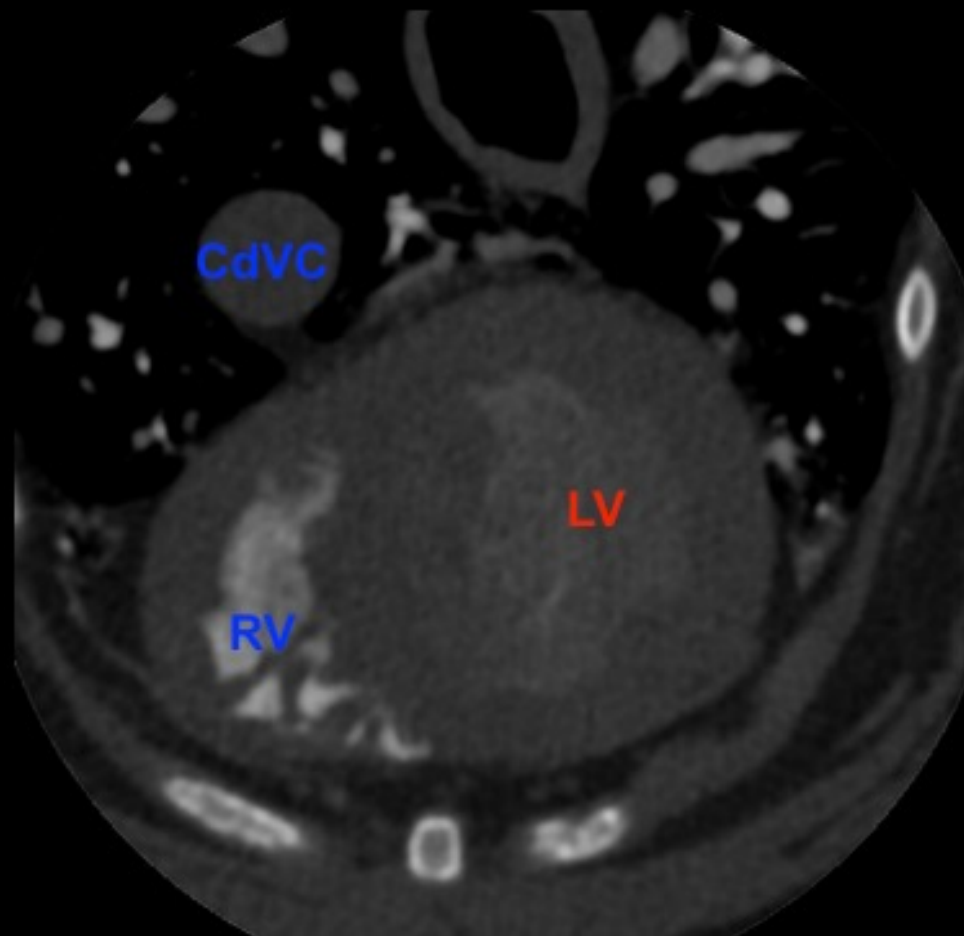
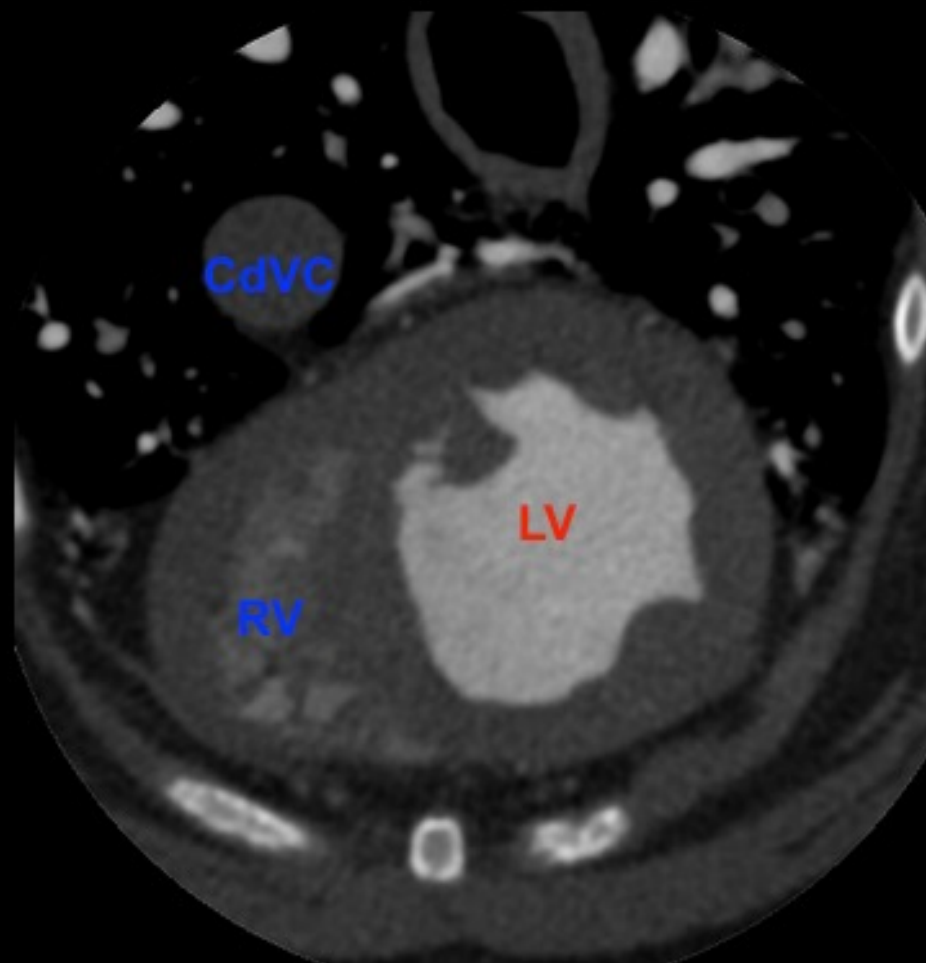
Elapsed Time = 00:10











A. coronaria dx



A. coronaria sx

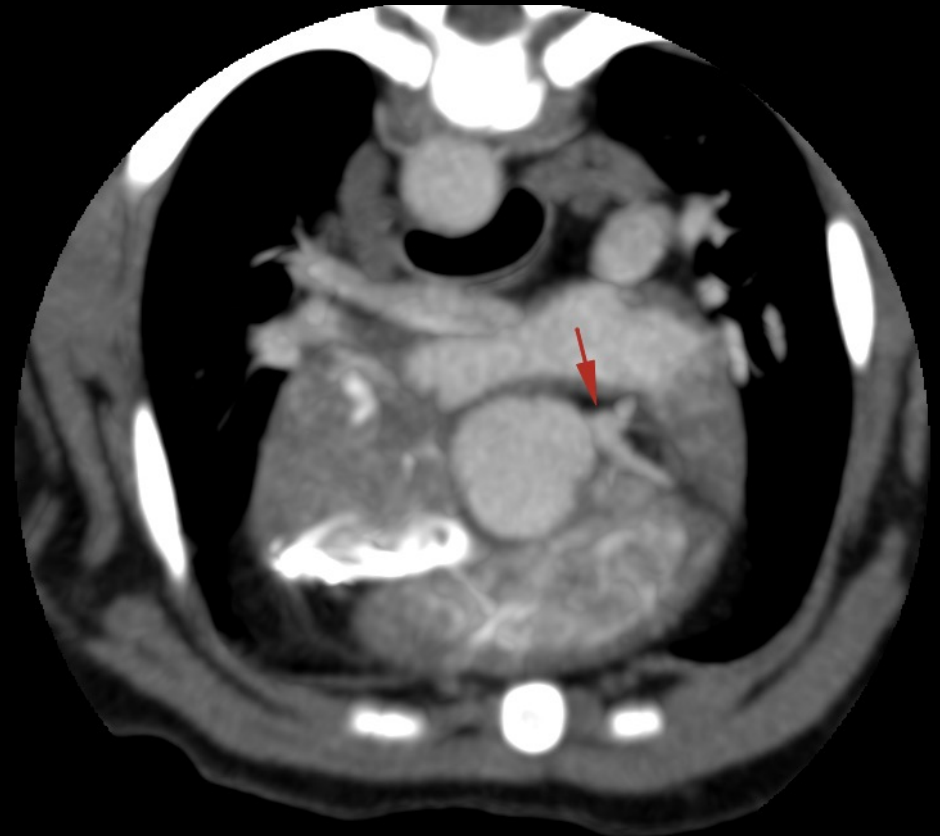
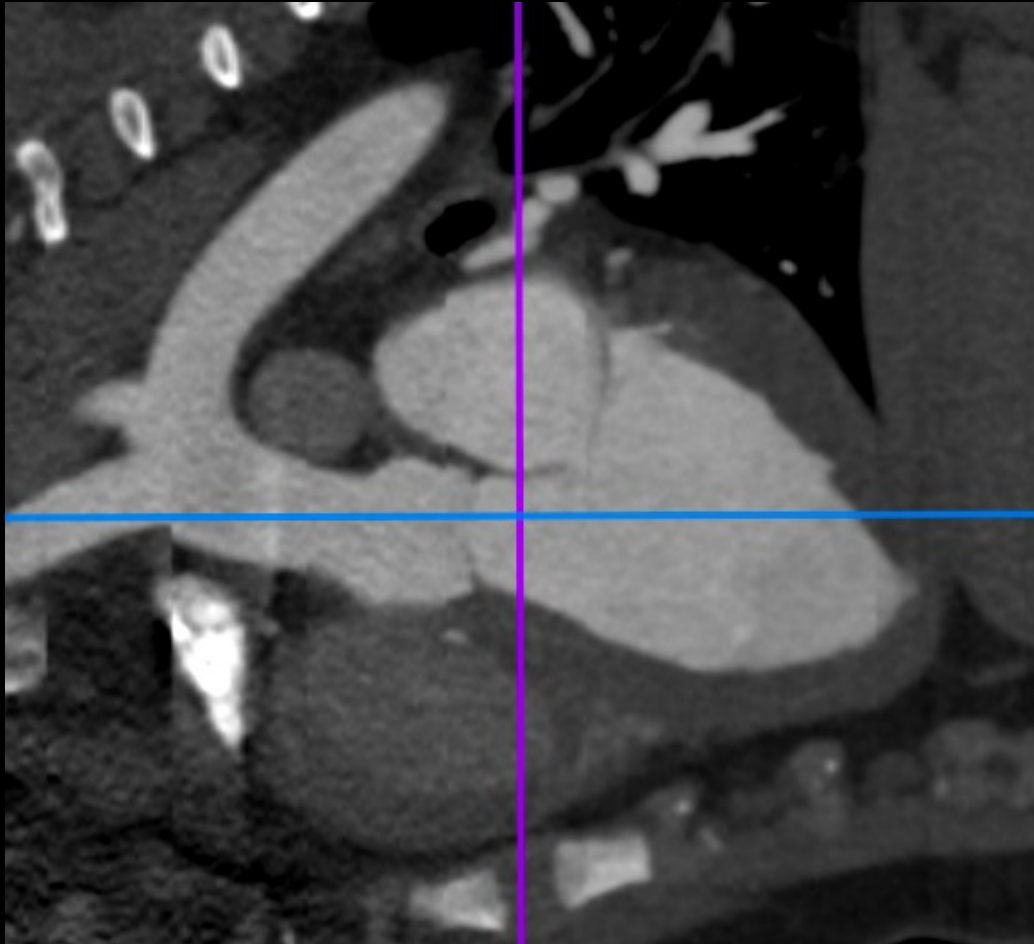
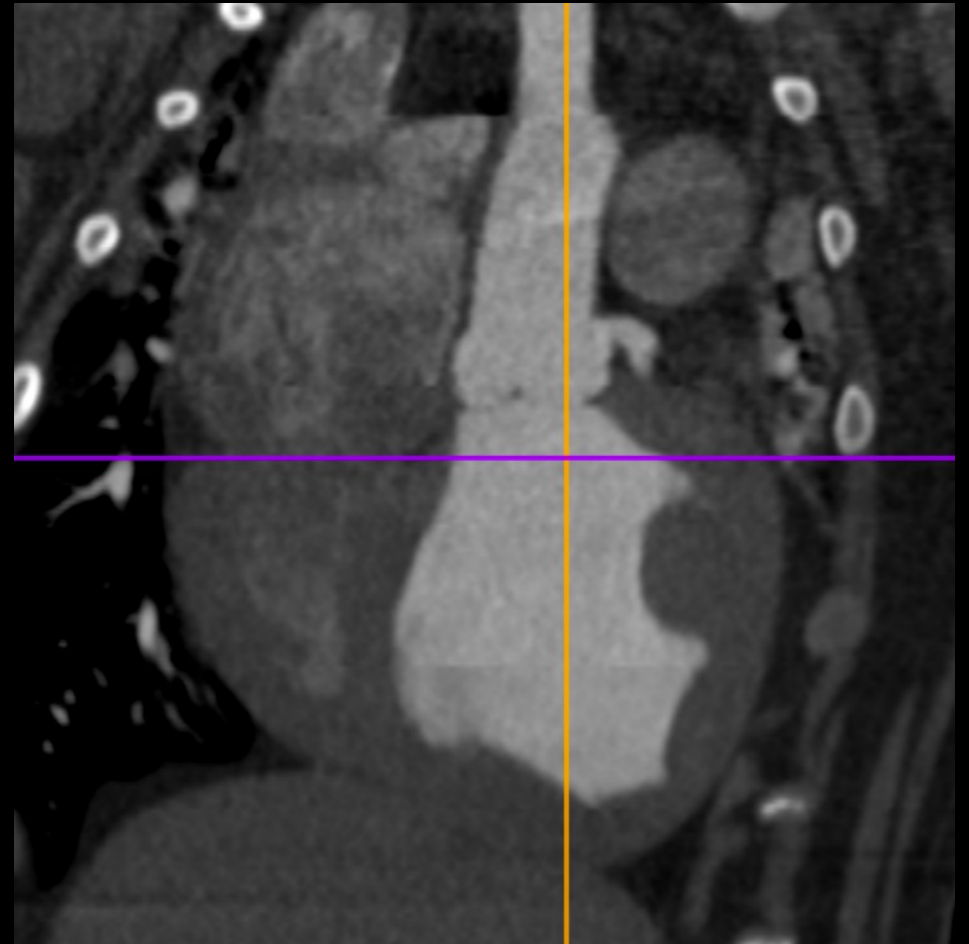
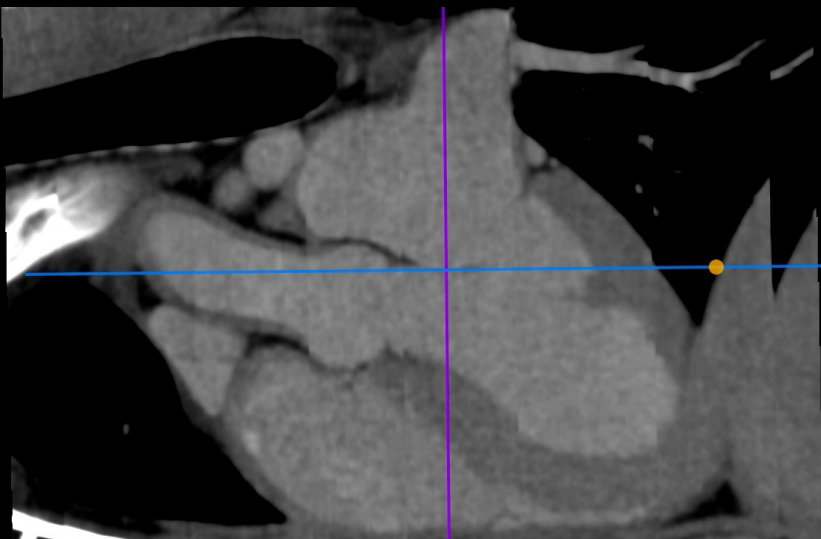
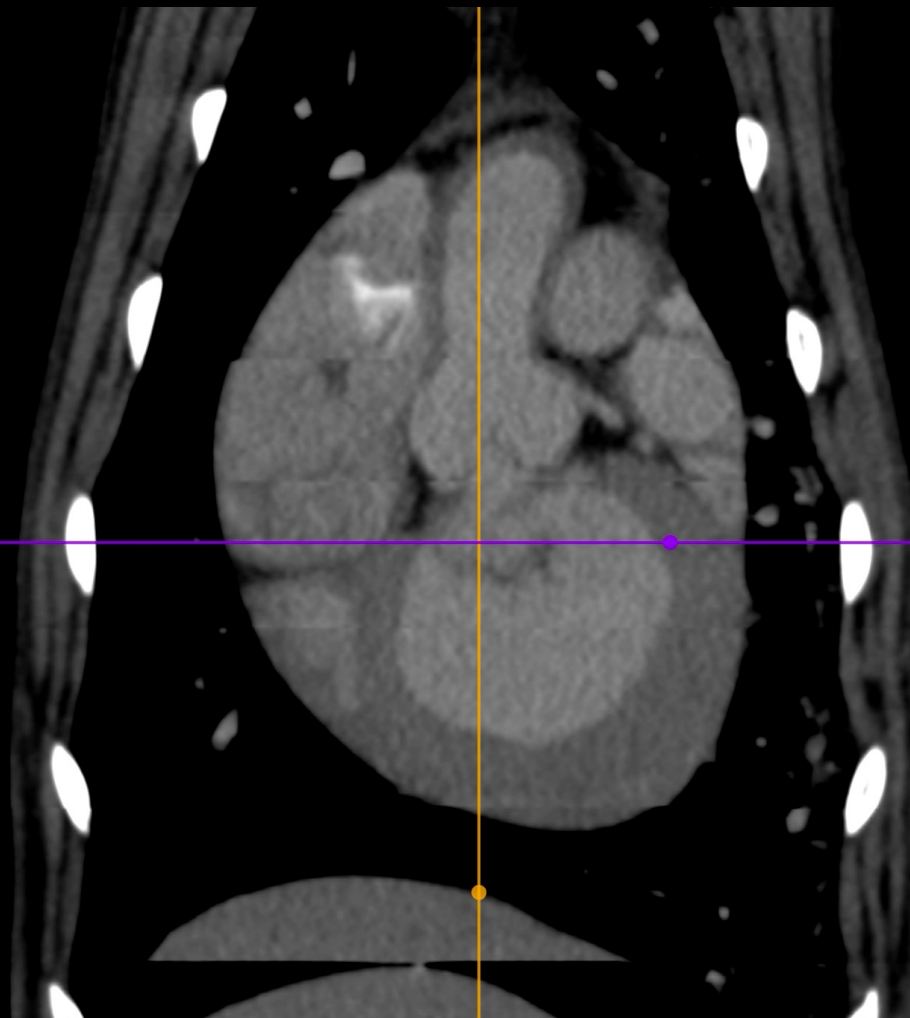
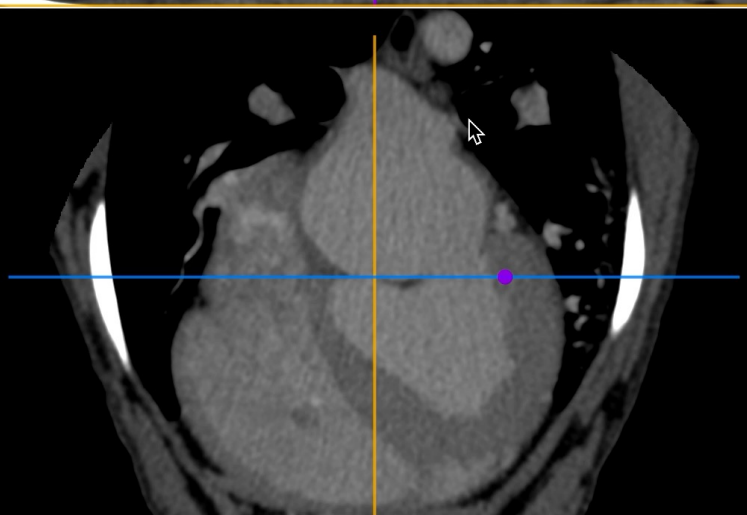
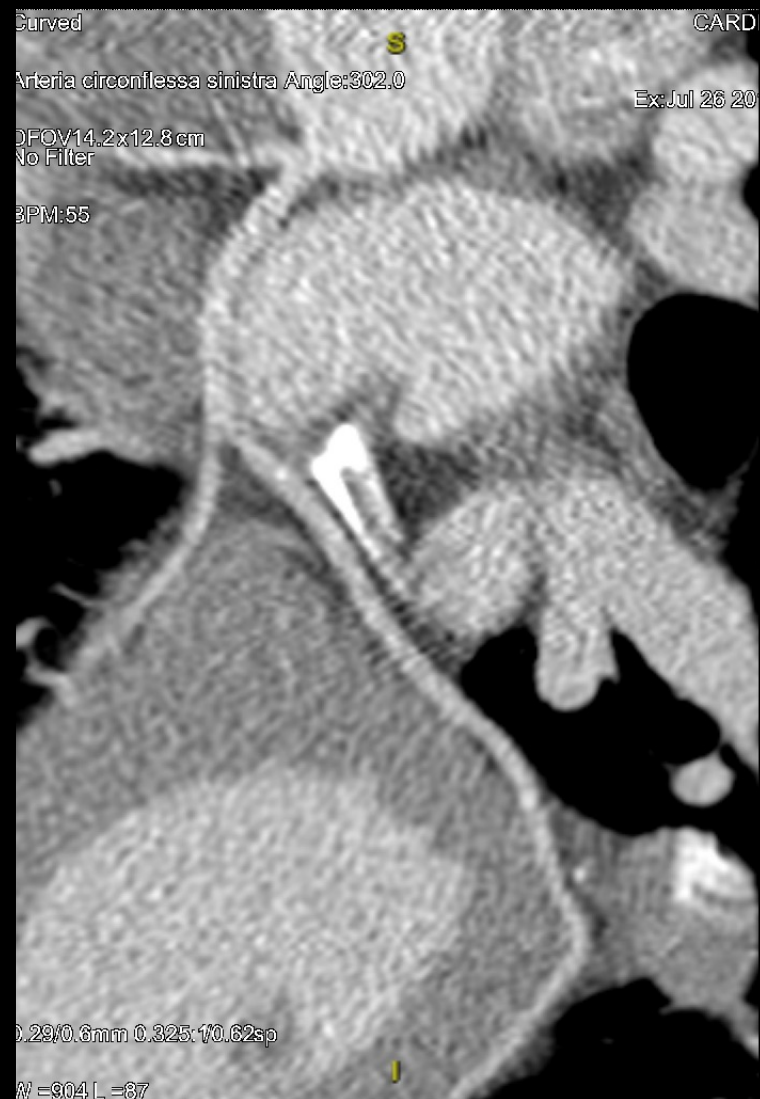


IMAGE MANIPULATION







Curved

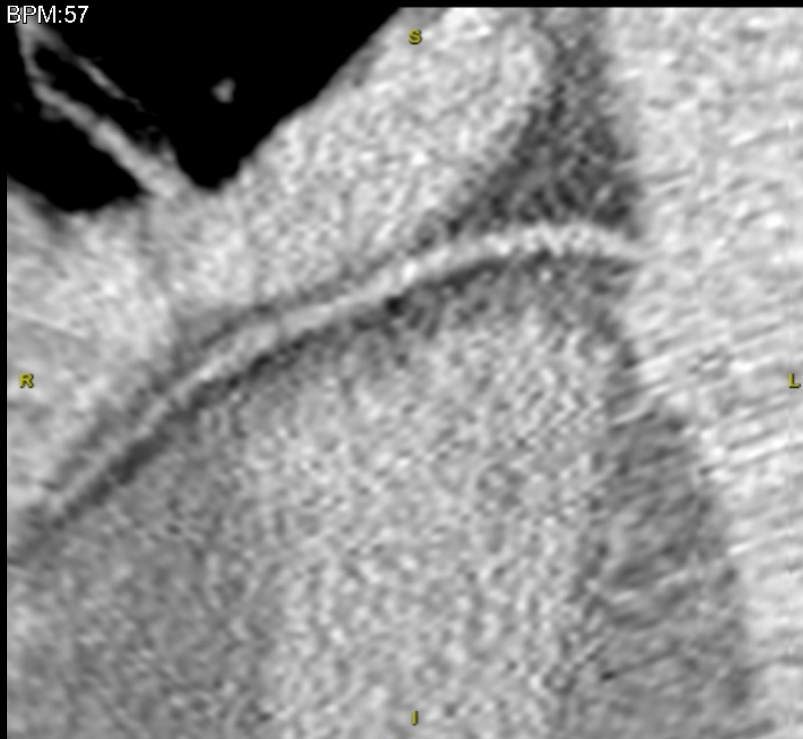
CARDI

Arteria coronarica destra Angle:-249.0

Ex:Jul 26 201

DFOV7.4 x6.7 cm
No Filter

BPM:57



0.29/0.6mm 0.325:1/0.62sp

W =908 L =88

Curved

CARDIC

Arteria coronarica destra Angle:-174.0

Ex:Jul 26 2016

DFOV7.5 x6.7 cm
No Filter

BPM:56



0.29/0.6mm 0.325:1/0.62sp

W =908 L =88

3D SPL CARDIC

Volume Rendering No cut

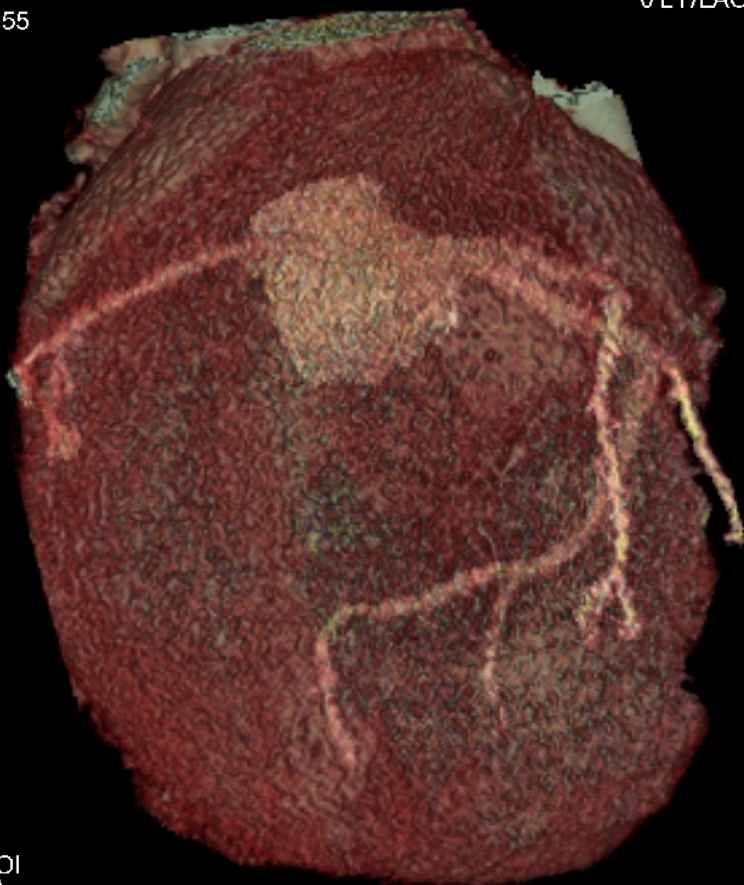
Ex:Jul 26 2016

DFOV11.9cm
STND No Filter Ph:75%

BPM:55

0 L17LA08CRA

R
A
S



No VOI
kV 80

0.6mm 0.325:1/0.62sp

W =1534 L =-255

IAR

3D SPR CARDIC

Volume Rendering No cut

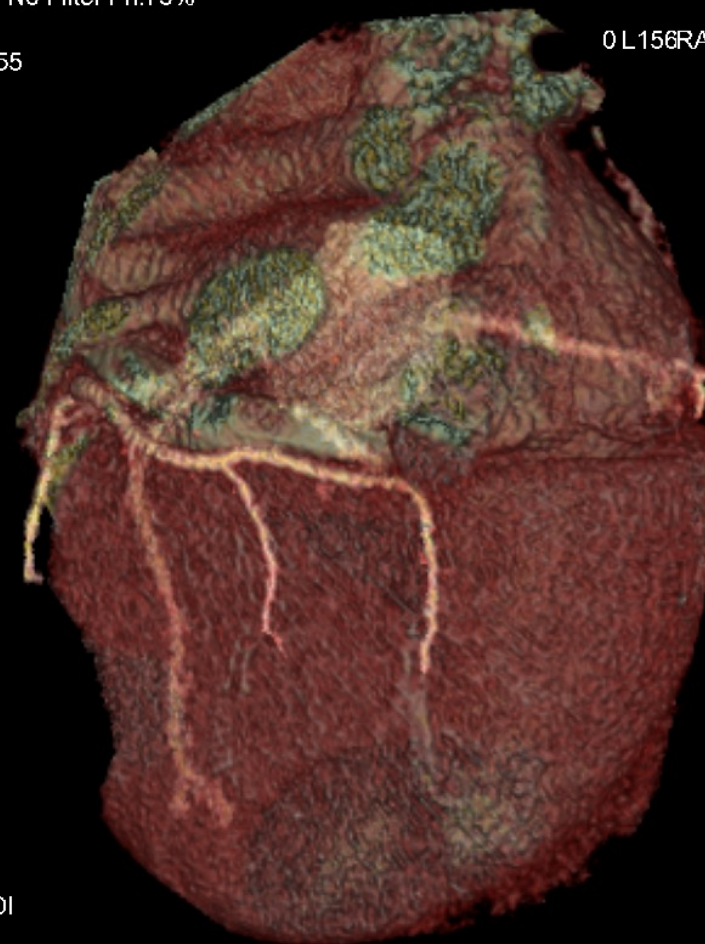
Ex:Jul 26 2016

DFOV12.2cm
STND No Filter Ph:75%

BPM:55

0 L156RA040CAL

L
P
S

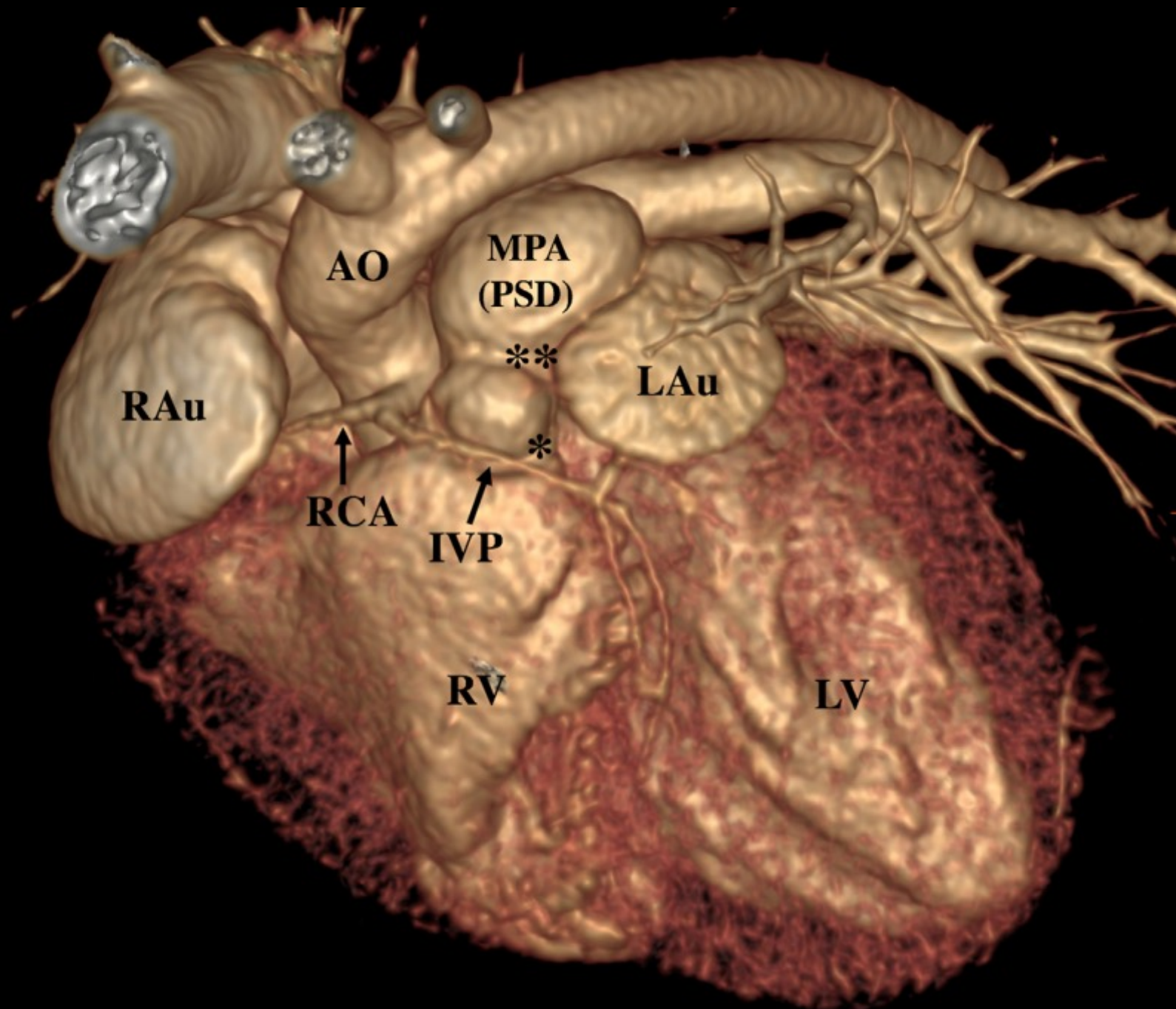


No VOI
kV 80

0.6mm 0.325:1/0.62sp

W =1534 L =-255

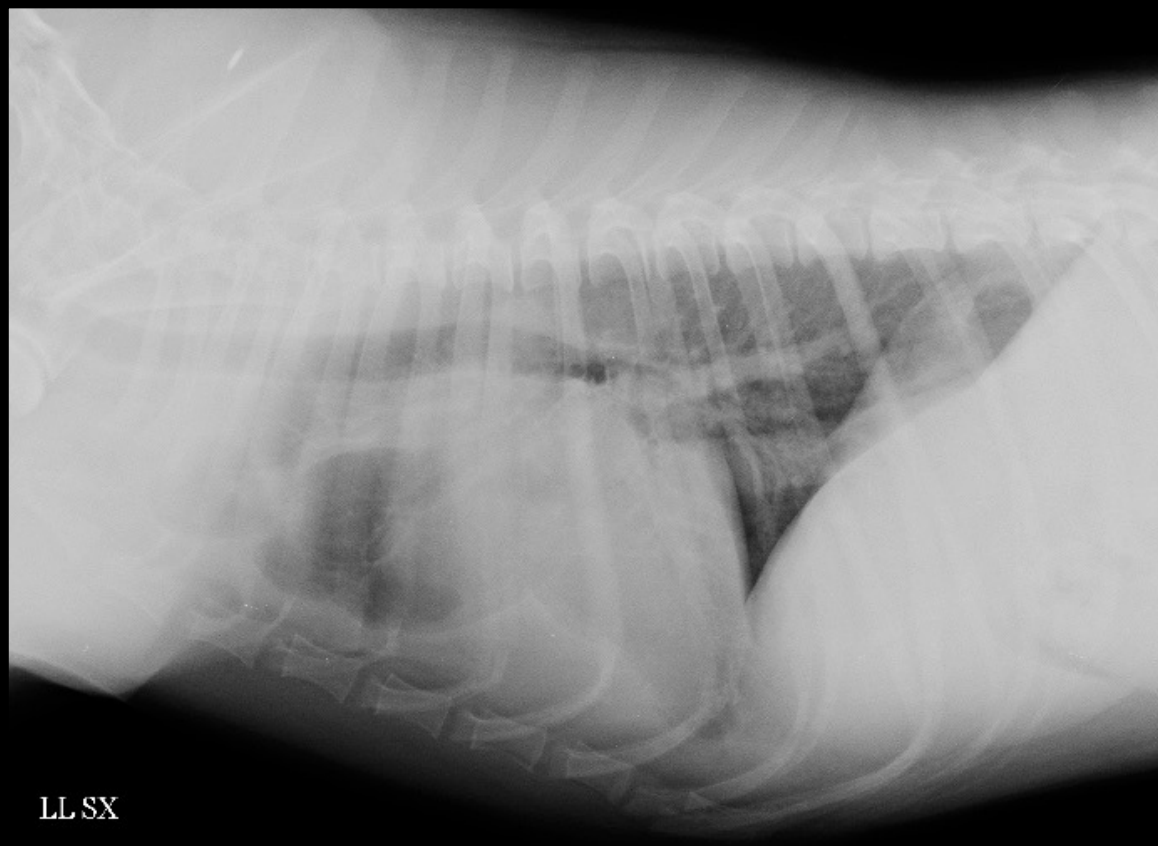
IAL



CLINICAL APPLICATIONS

Xbreed, M, 8 y

Depressed, polipnoic



Why ECG-gated CT?

Reduction / absence of pulsatility artifacts

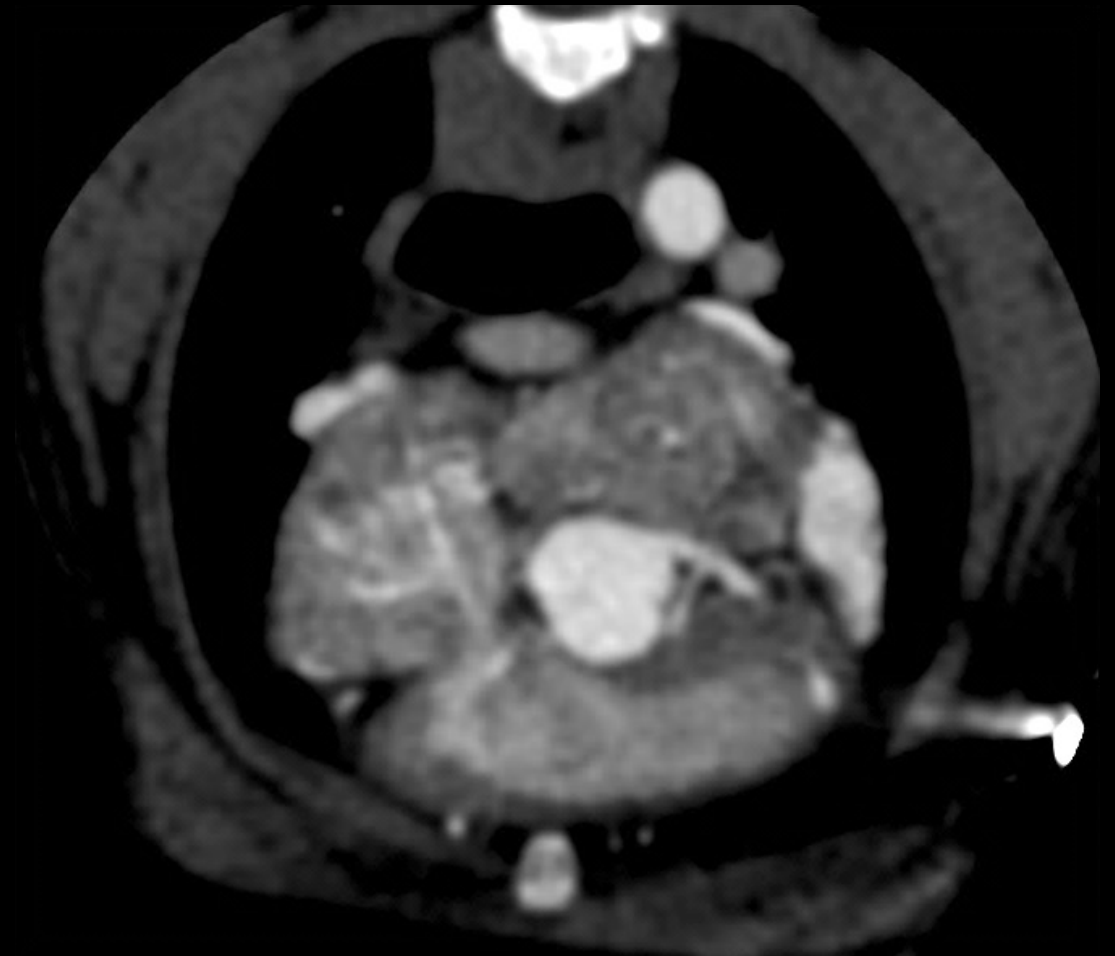
Precise pre-surgical evaluation

Vascular invasion

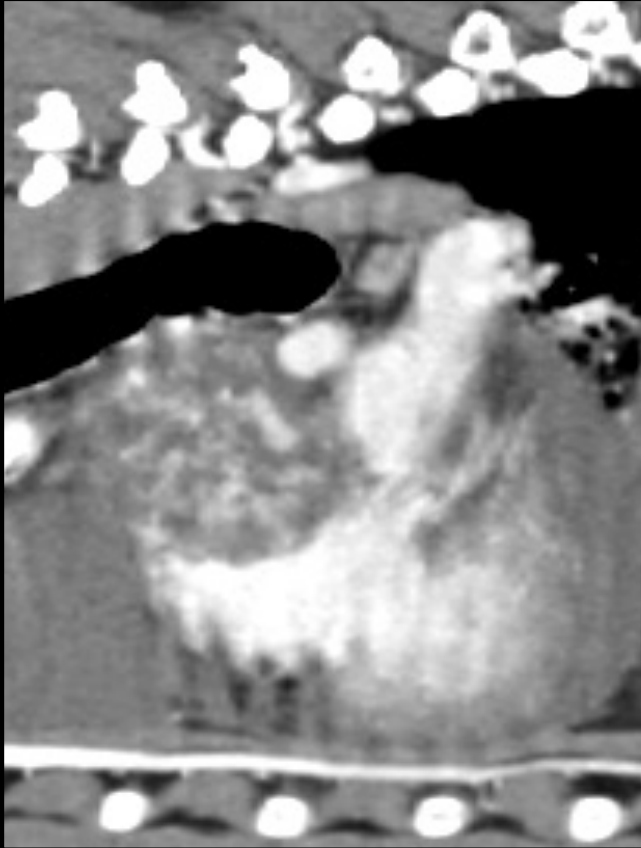
Coronary arteries involvement



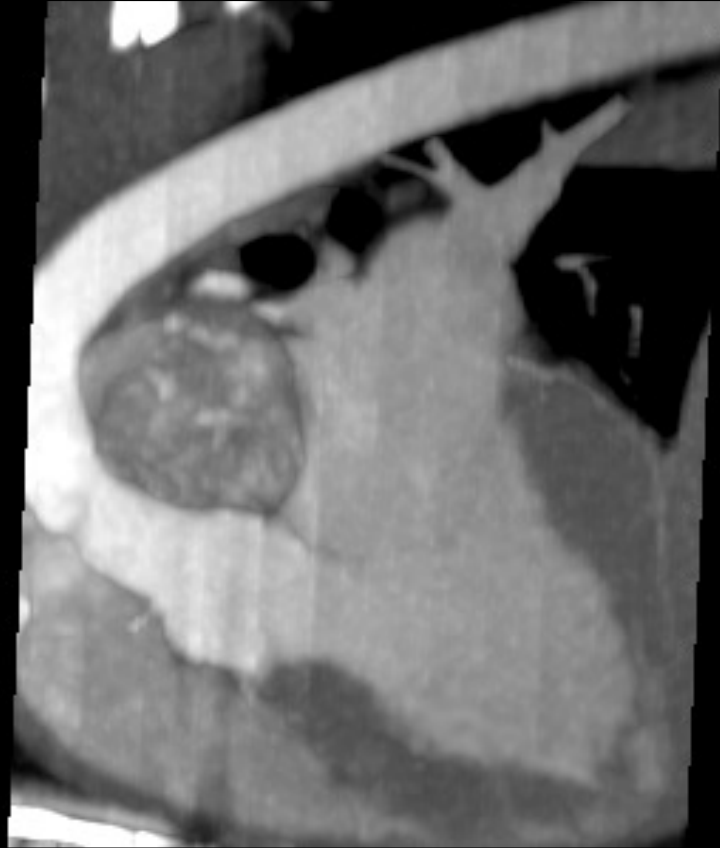
Non ECG GATED



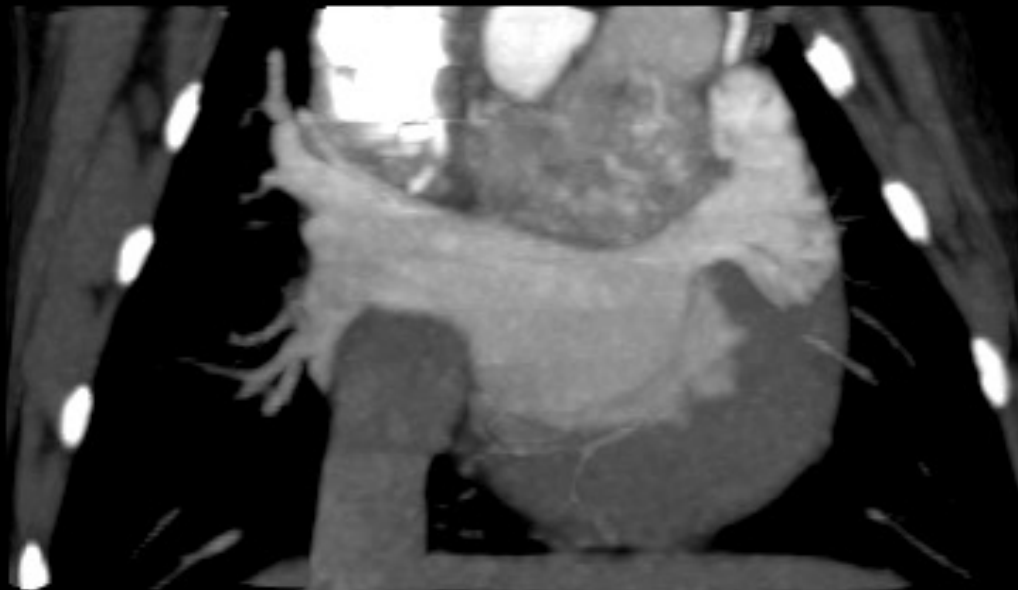
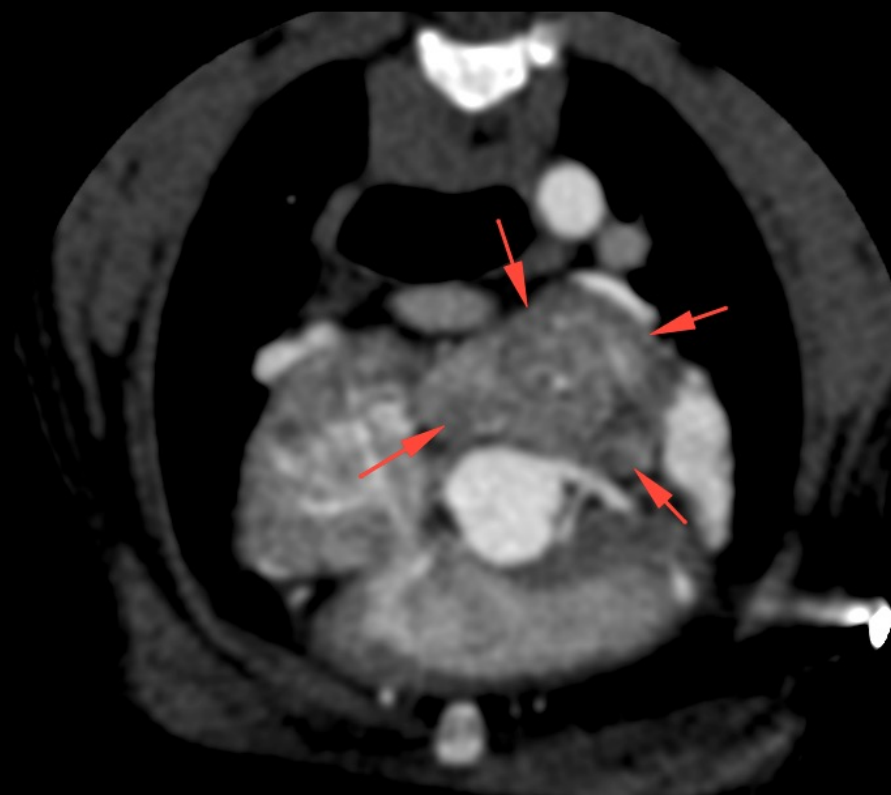
ECG GATED



Non ECG GATED



ECG GATED

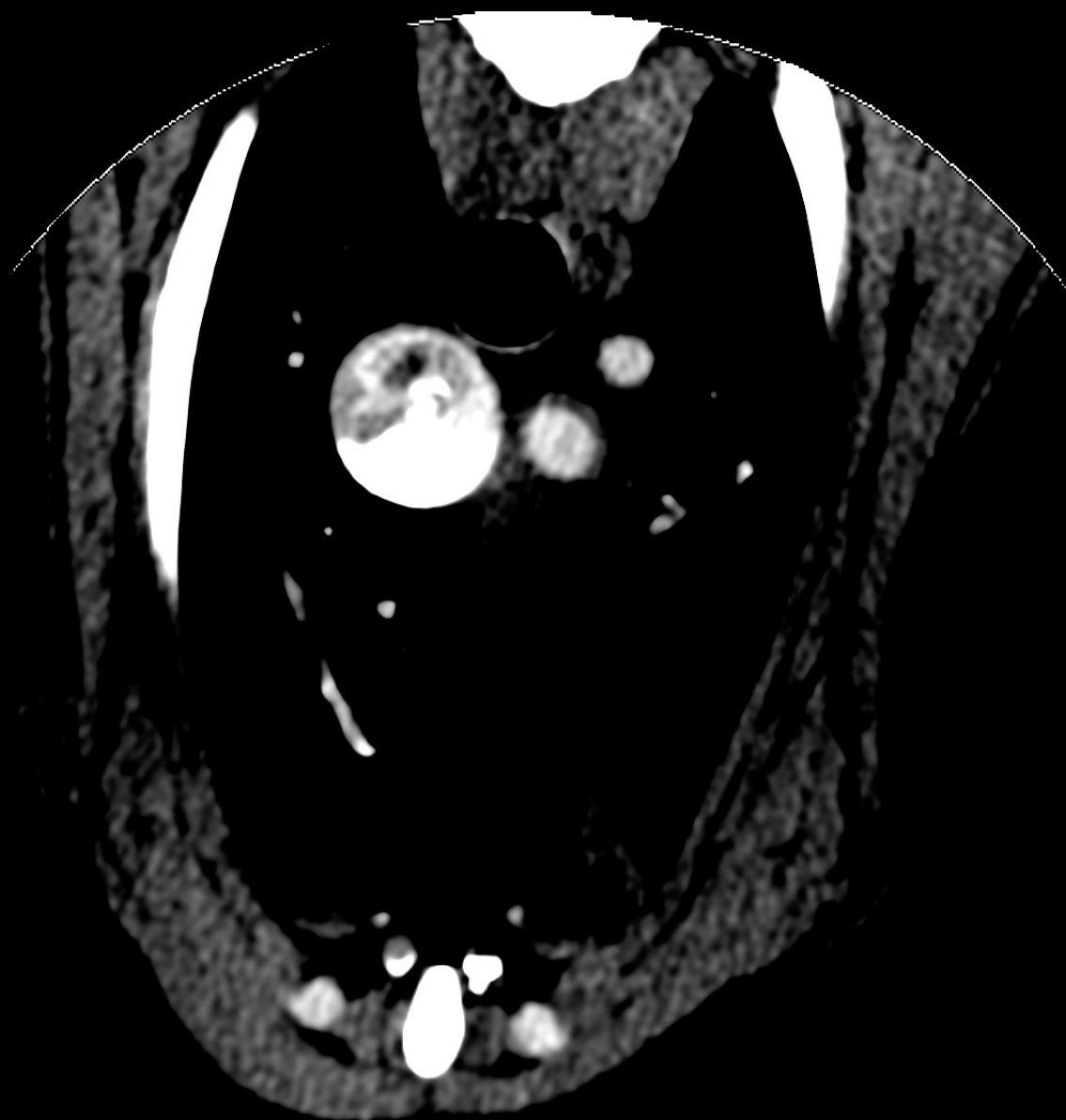


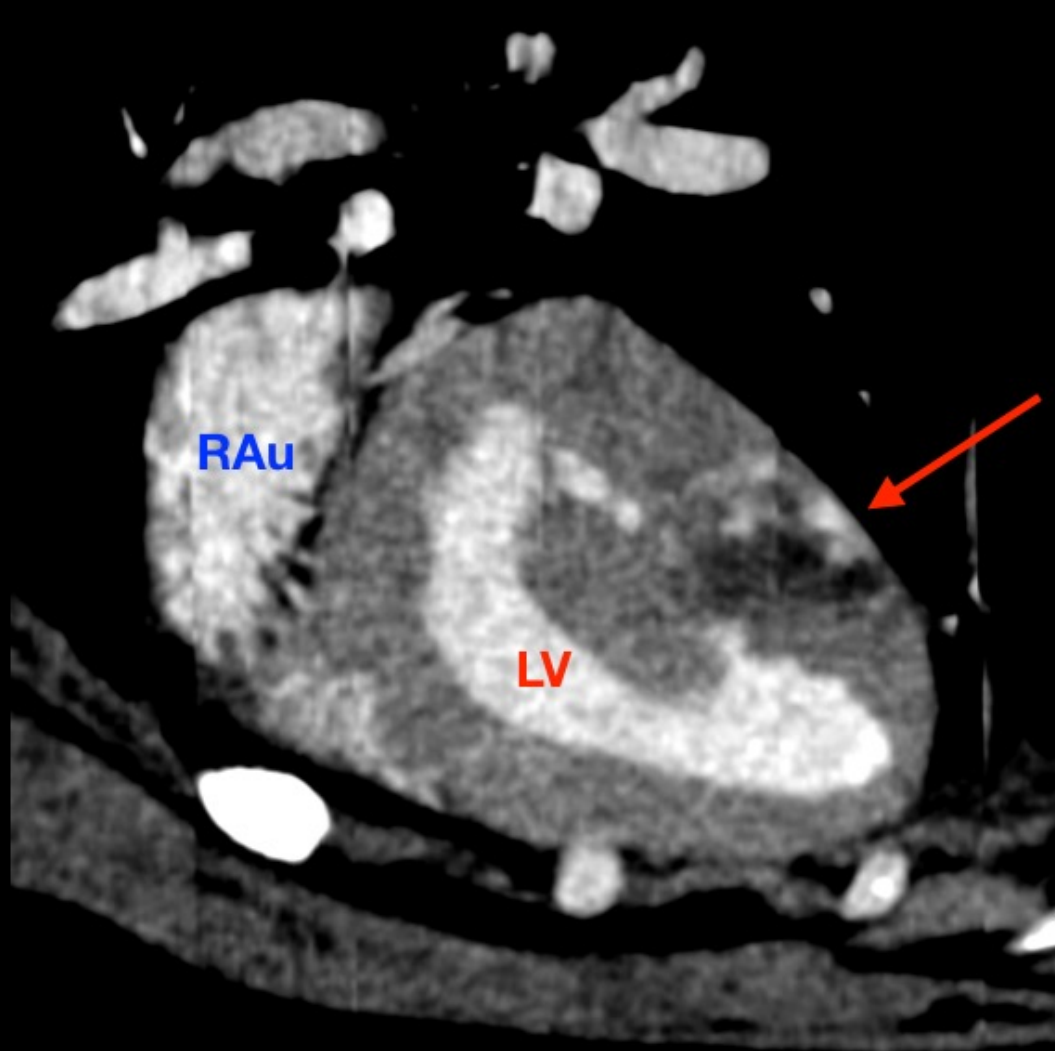
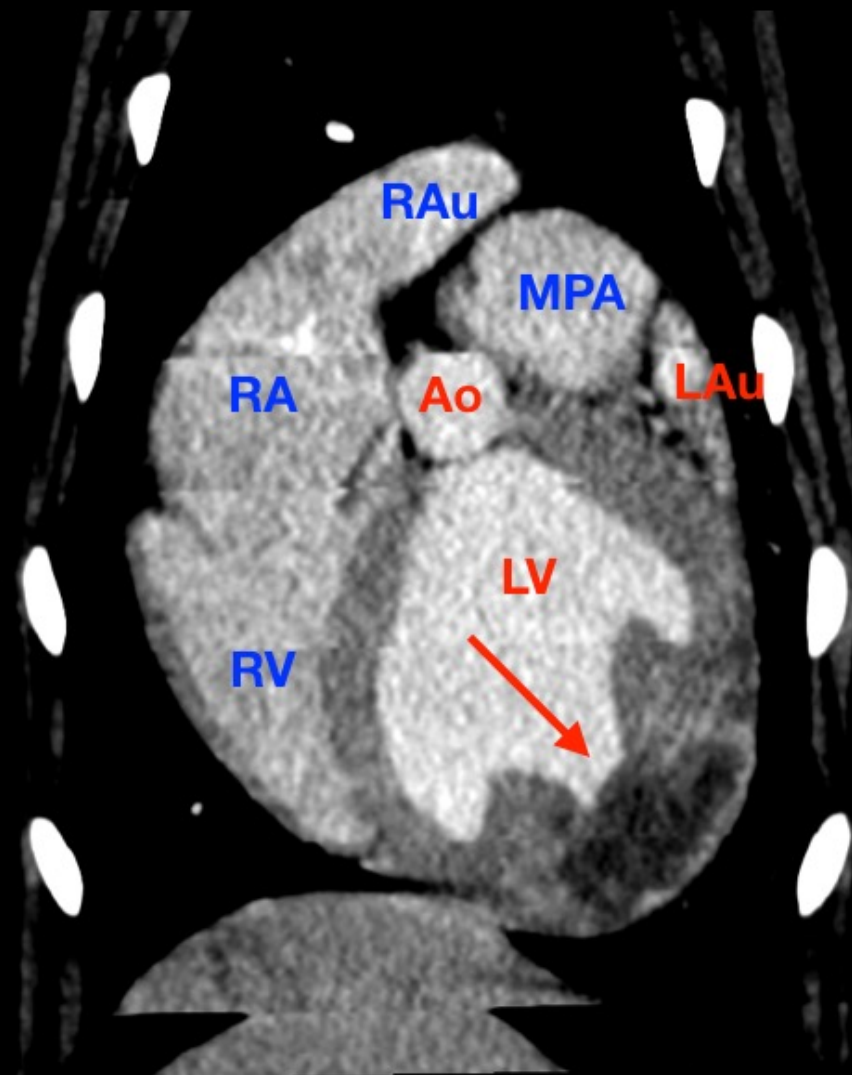
Applications in veterinary medicine

Cardiac neoplasia

Complex cardiac pathologies

Coronary artery assessment (pre-interv.)





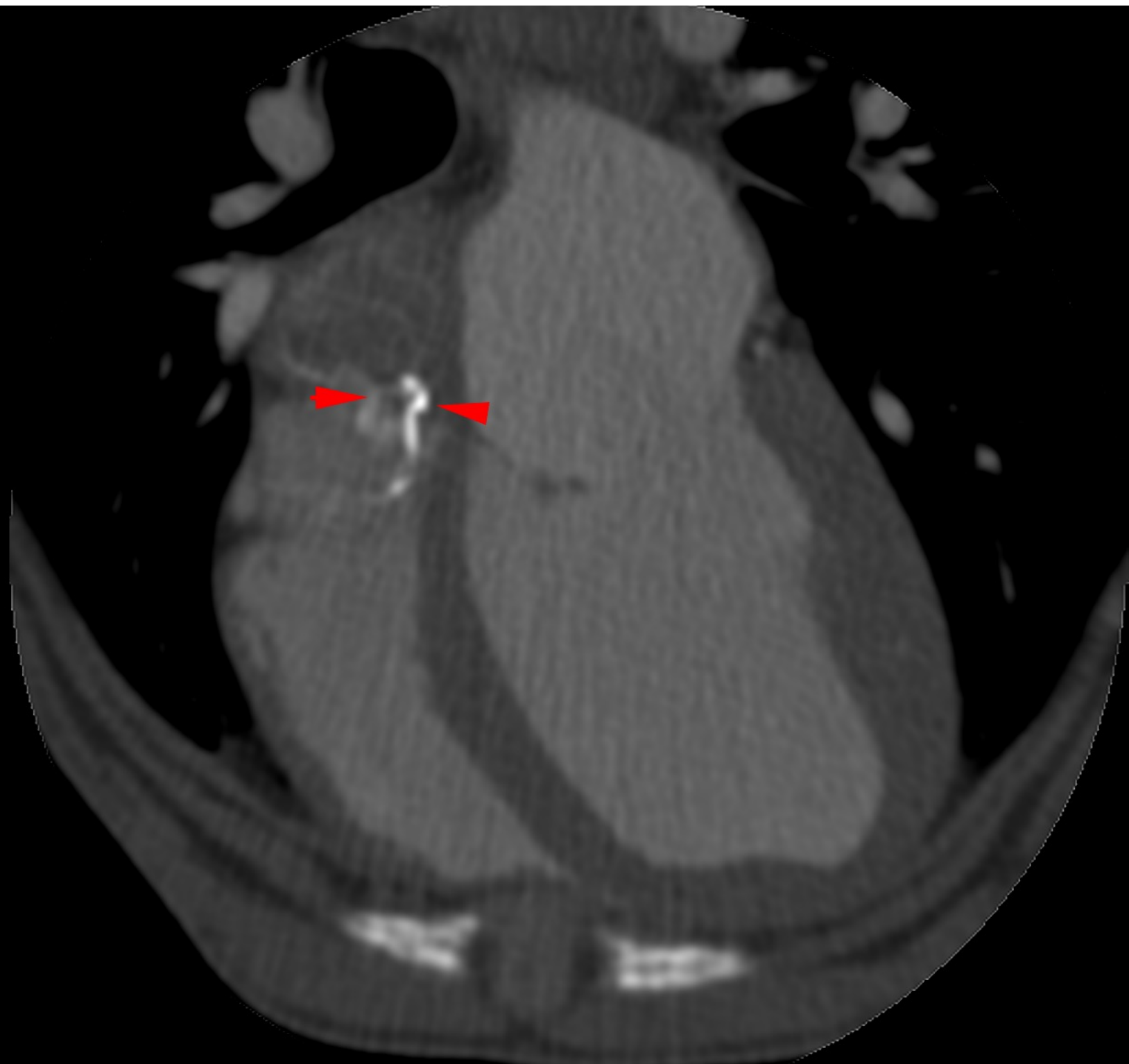
Applications in veterinary medicine

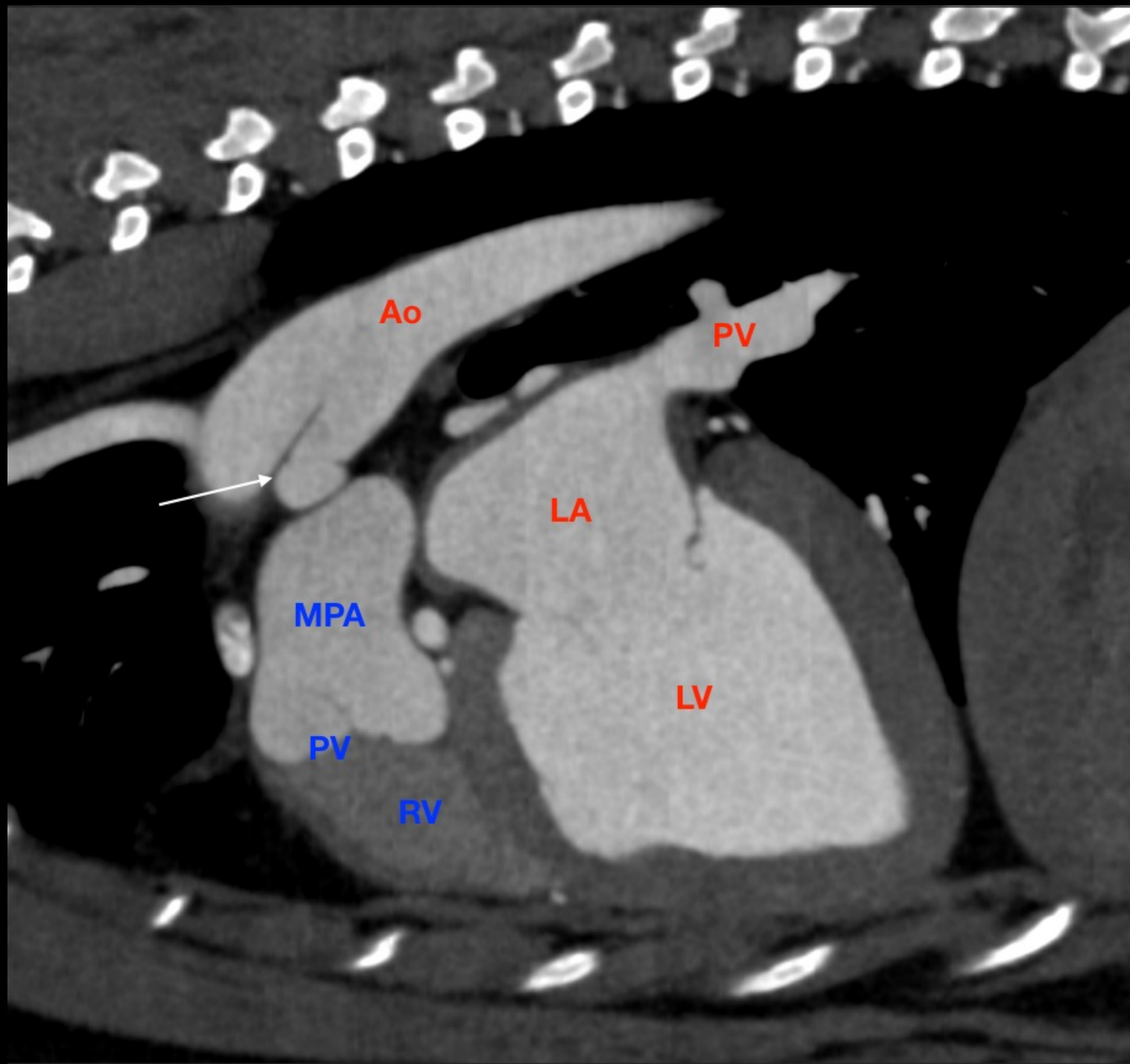
Cardiac neoplasia

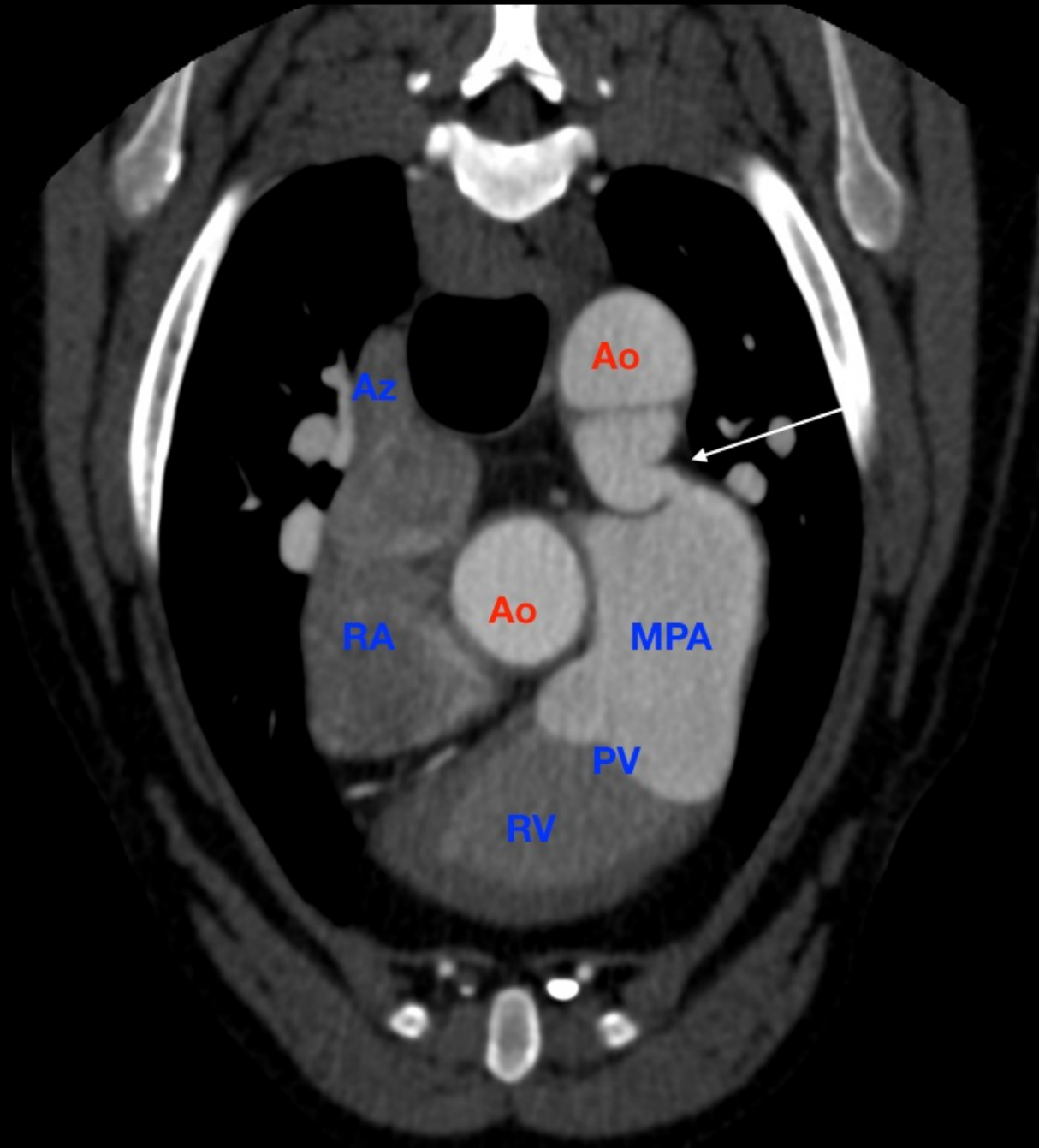
Complex cardiac pathologies

Coronary artery assessment (pre-interv.)









Epub 2018 Dec 11.

A pictorial view of the three-dimensional representation and comparative two-dimensional image orientation derived from computed tomography angiography in a dog with a patent ductus arteriosus

A B Saunders ¹, K R Doocy ², S A Birch ³

> J Vet Cardiol. 2016 Dec;18(4):418-426. doi: 10.1016/j.jvc.2016.08.003. Epub 2016 Sep 29.

Use of ECG-gated computed tomography, echocardiography and selective angiography in five dogs with pulmonic stenosis and one dog with pulmonic stenosis and aberrant coronary arteries

P Laborda-Vidal ¹, B Pedro ², M Baker ¹, A R Gelzer ¹, J Dukes-McEwan ¹, T W Maddox ¹

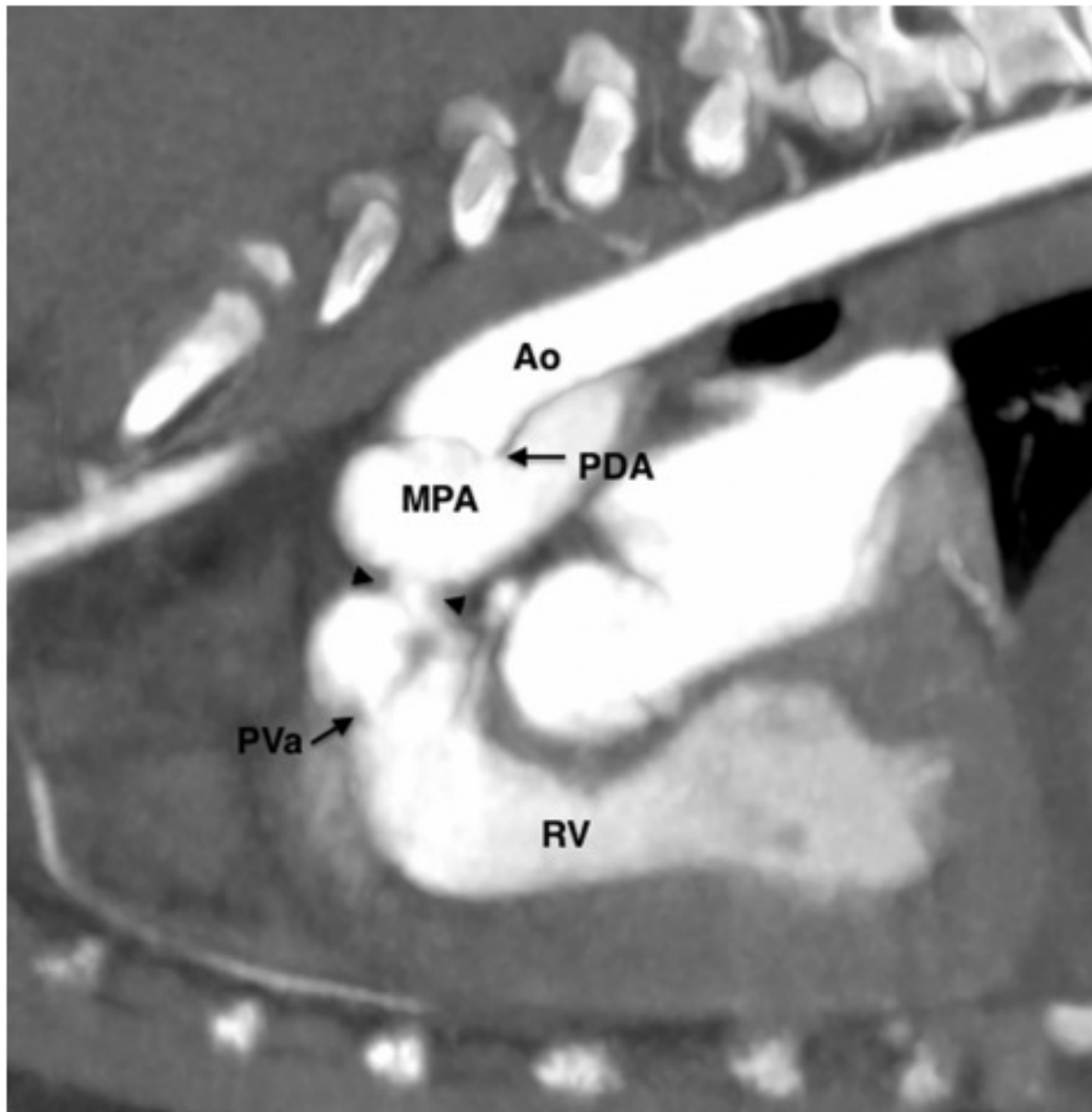


Figure 3 Maximal intensity projection at the level of the pulmonic valve (PVa) showing pulmonic stenosis, post-stenotic dilation of the main pulmonary artery (MPA), a supravulvar stenosis (arrowheads) and a patent ductus arteriosus (PDA, arrow; case 4). Ao, aorta; RV, right ventricle.

In conclusion, despite echocardiography remaining the gold standard for diagnosis and assessment of PS, ECG-gated-CTA is a complementary diagnostic method that may provide additional information, not only regarding CA anatomy but also concurrent cardiovascular anomalies. In addition, this may shorten surgery/anaesthesia time and reduce the amount of radiation to which the cardiologist is subjected during BVP.

Applications in veterinary medicine

Cardiac neoplasia

Complex cardiac pathologies

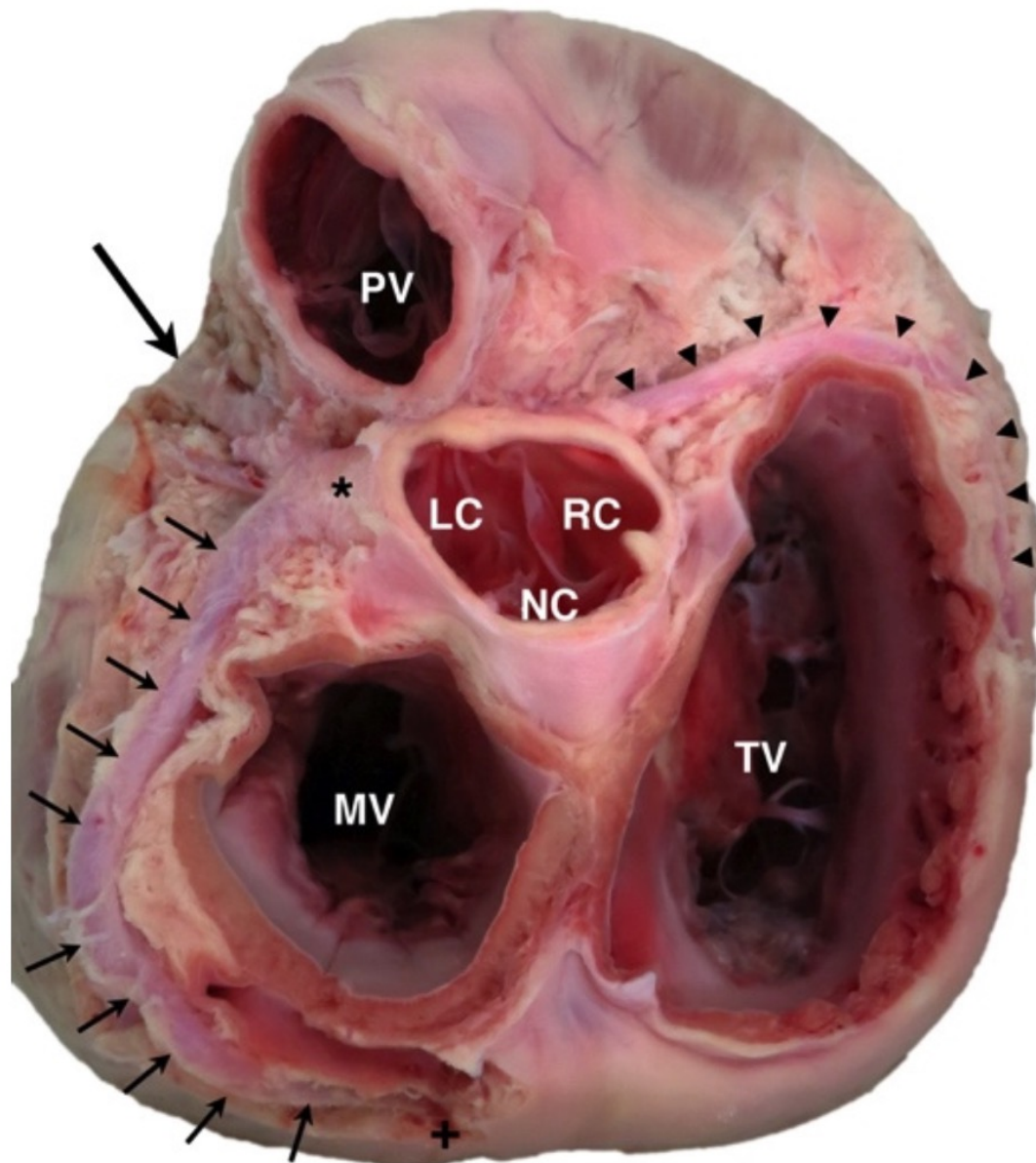
Coronary artery assessment (pre-interv.)

64-MULTIDETECTOR COMPUTED TOMOGRAPHIC ANGIOGRAPHY OF THE CANINE CORONARY ARTERIES

RANDI DREES, ALEX FRYDRYCHOWICZ, SCOTT B. REEDER, MARIE E. PINKERTON, REBECCA JOHNSON

Canine coronary artery angiography (CTA) was performed in four anesthetized healthy dogs using 64-multi-detector computed tomography. Esmolol, a β -1 adrenergic receptor antagonist, and sodium nitroprusside, an arteriolar and venous dilator, were administered to enhance visualization of the coronary arteries by reducing heart rate and creating vasodilation. The left main coronary artery with its three main branches and the right coronary artery were visualized and subdivided in 13 segments for evaluation. Optimal reconstruction interval, expressed as percentage of the R-to-R interval, was determined at 5% in 2.9%, 35% in 1%, 75% in 21.2%, 85% in 43.3%, and 95% in 31.7% of the segments. Overall image quality was good in 41.3% of the segments and excellent in 14.4%. There was blur in 98.1%, motion in 17.3%, and stair step in 6.7% of the evaluated segments, but these artifacts did not interfere with anatomic depiction of the arteries. Cross-sectional anatomy of the coronary arteries as evaluated from the coronary CTA agreed well with gross anatomic evaluation and published information. The use of esmolol did not lead to the target heart rate of 60–65 beats/min. Nitroprusside had no significant effect on visualized length or diameter of the coronary artery branches. Coronary CTA is useful for the anatomic depiction of coronary artery branches in the dog. © 2011 *Veterinary Radiology & Ultrasound*, Vol. 52, No. 5, 2011, pp 507–515.

Key words: dog, heart, MDCT.



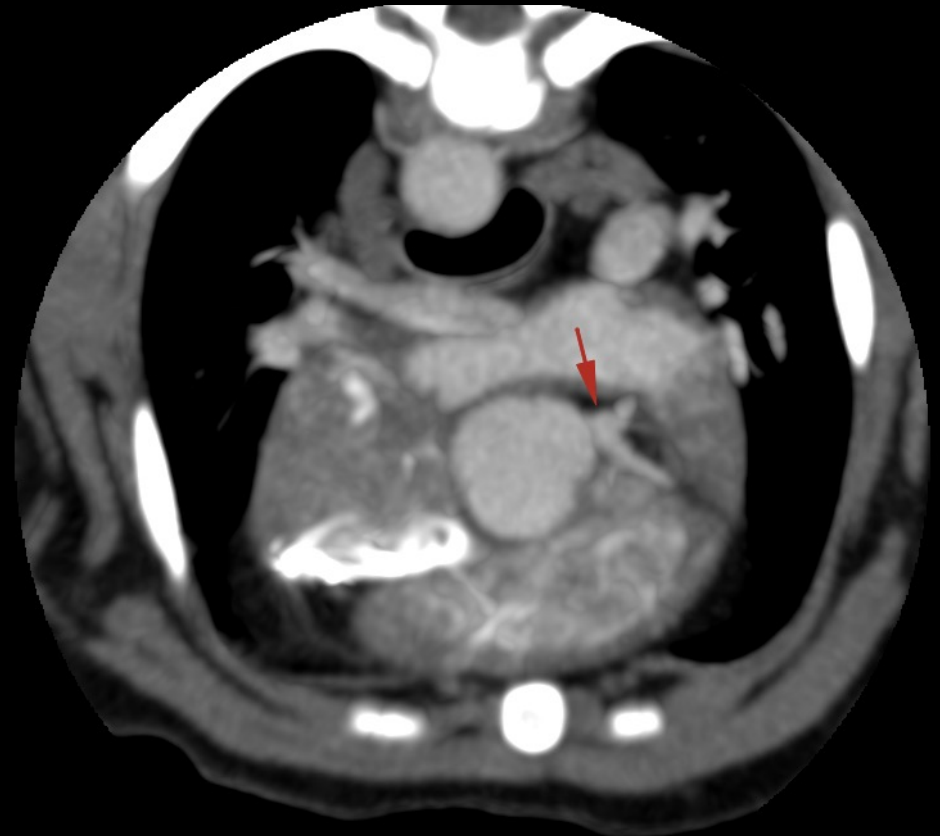
Coronary Artery Anomalies in Animals

Brian A Scansen Vet Sci. 2017 Apr 12;4(2):20.

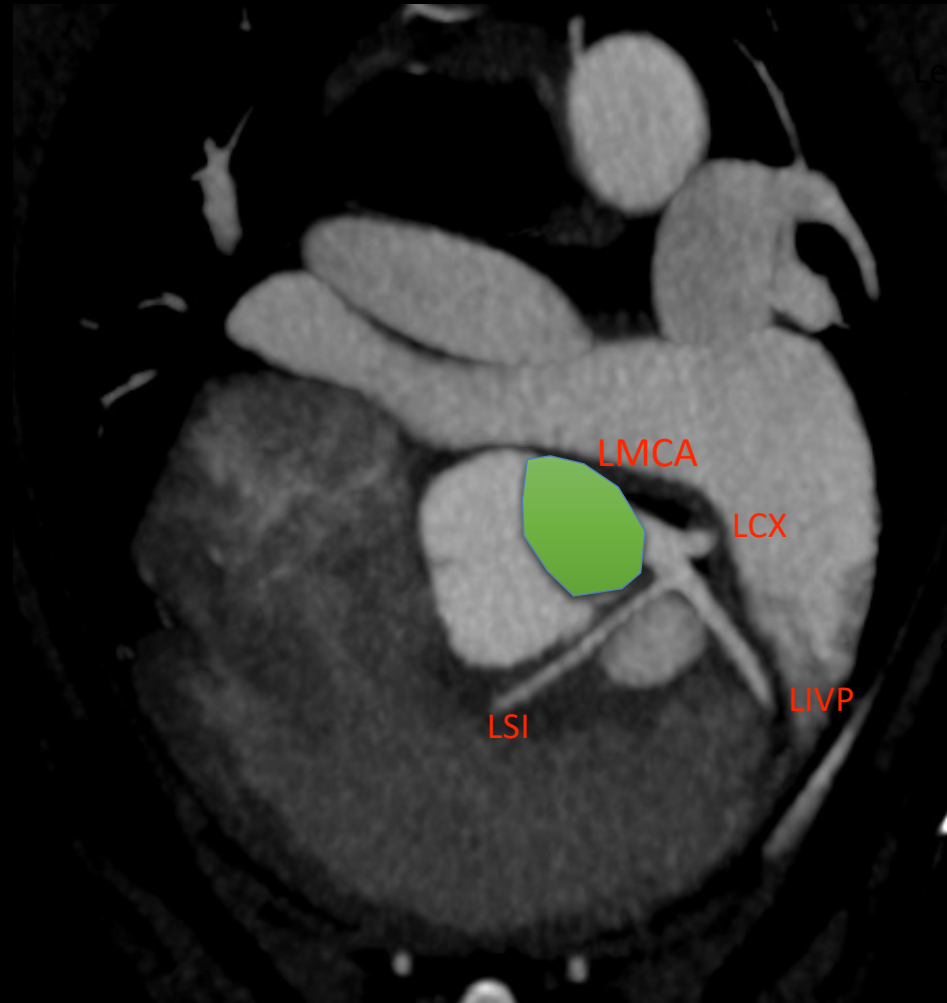
A. coronaria dx



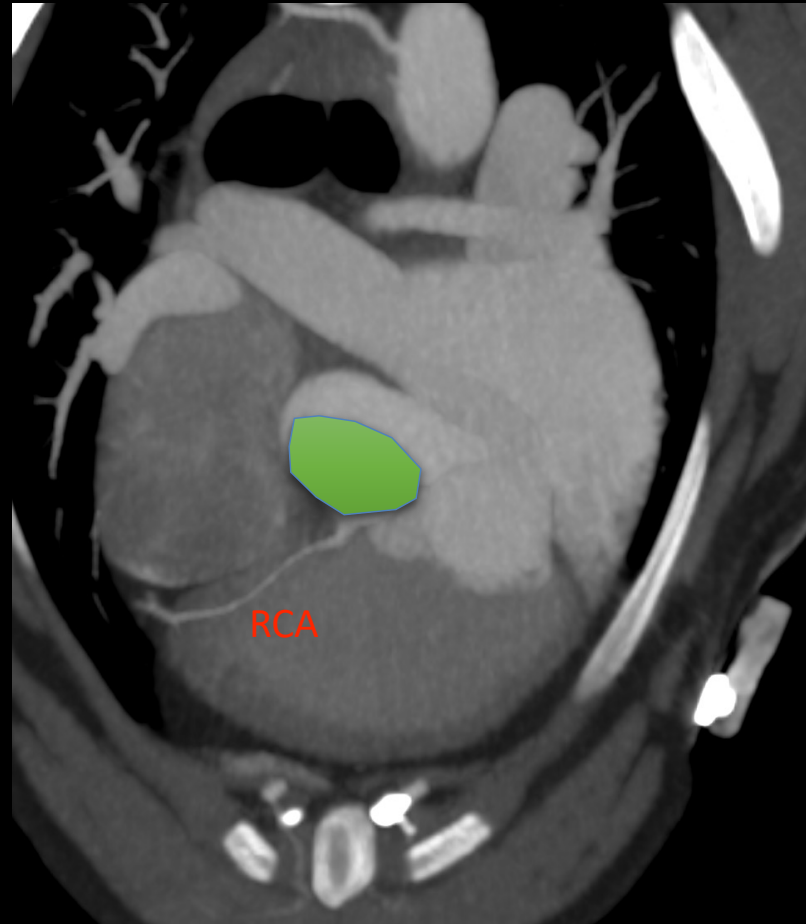
A. coronaria sx



A. coronaria sx

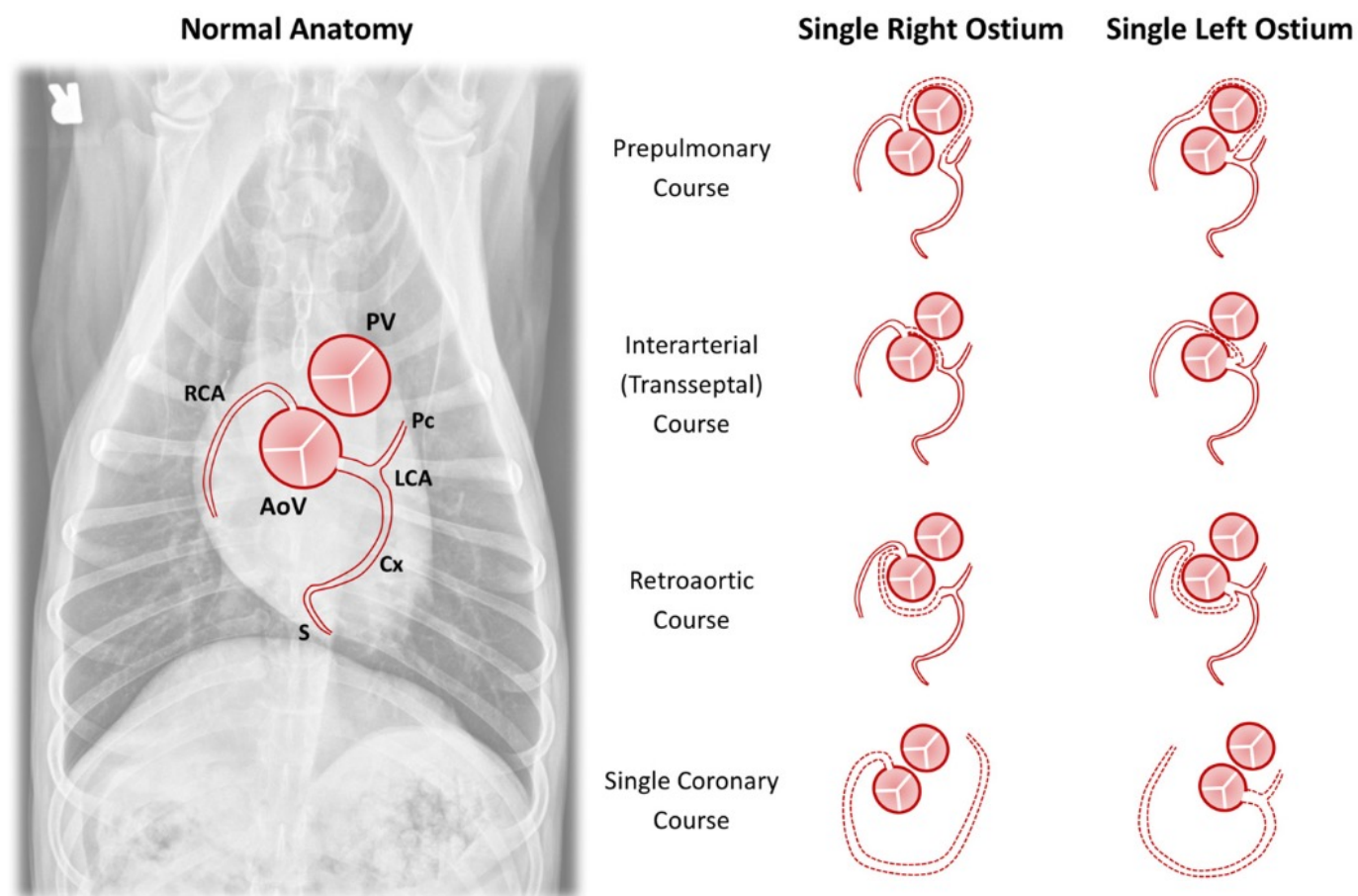


A. coronaria dx

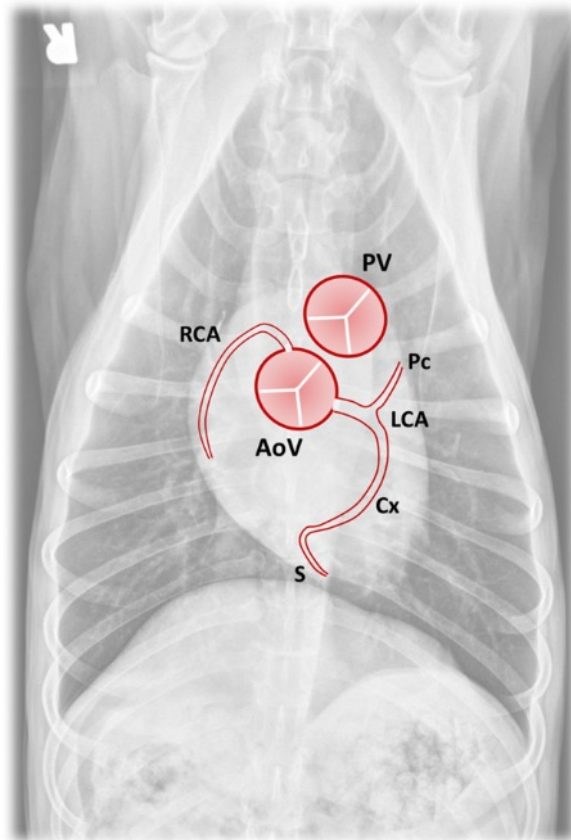


Coronary Artery Anomalies in Animals

Brian A Scansen ¹



Normal Anatomy



Single Right Ostium

Single Left Ostium

Prepulmonary
Course



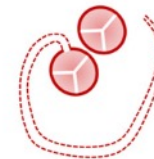
Interarterial
(Transseptal)
Course



Retroaortic
Course



Single Coronary
Course



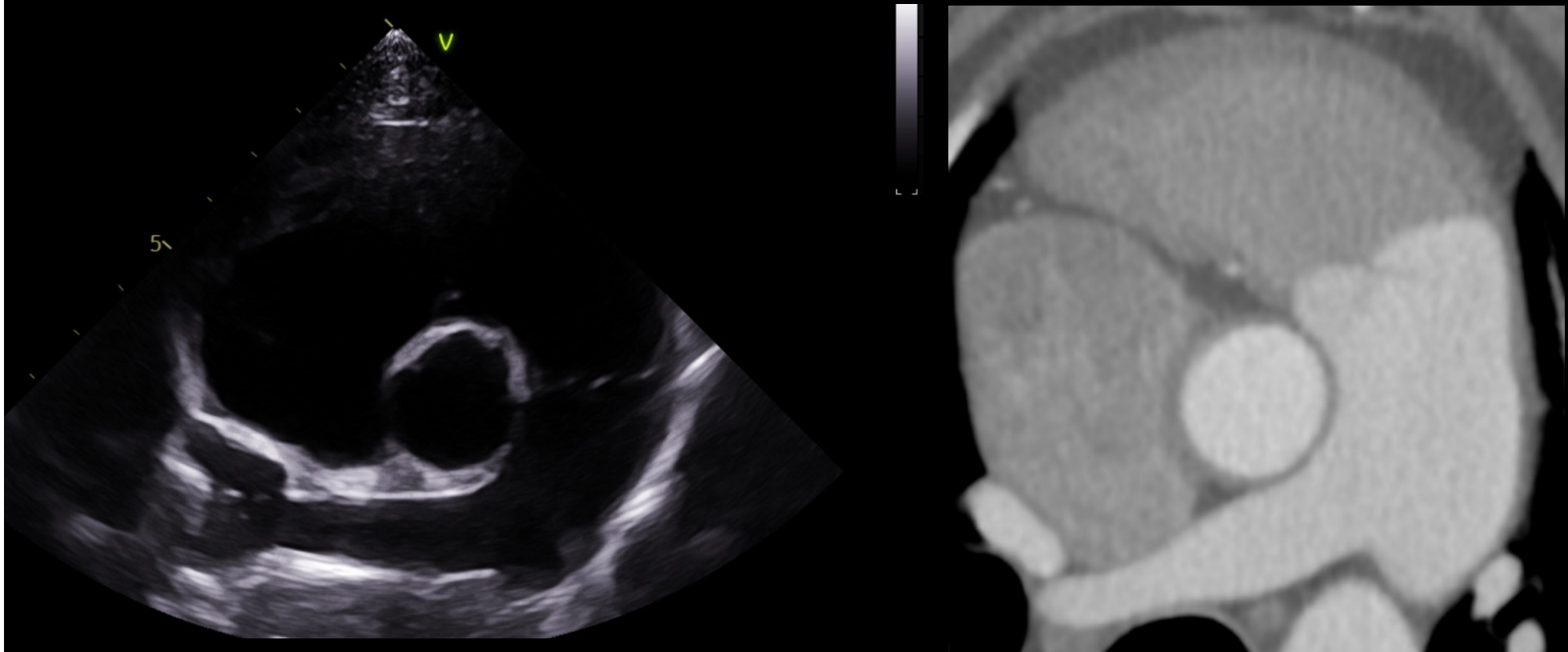
Single Right Ostium

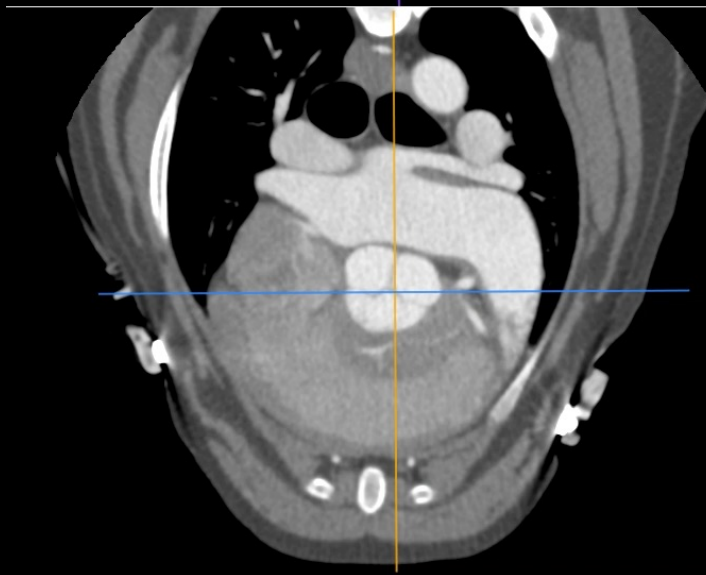
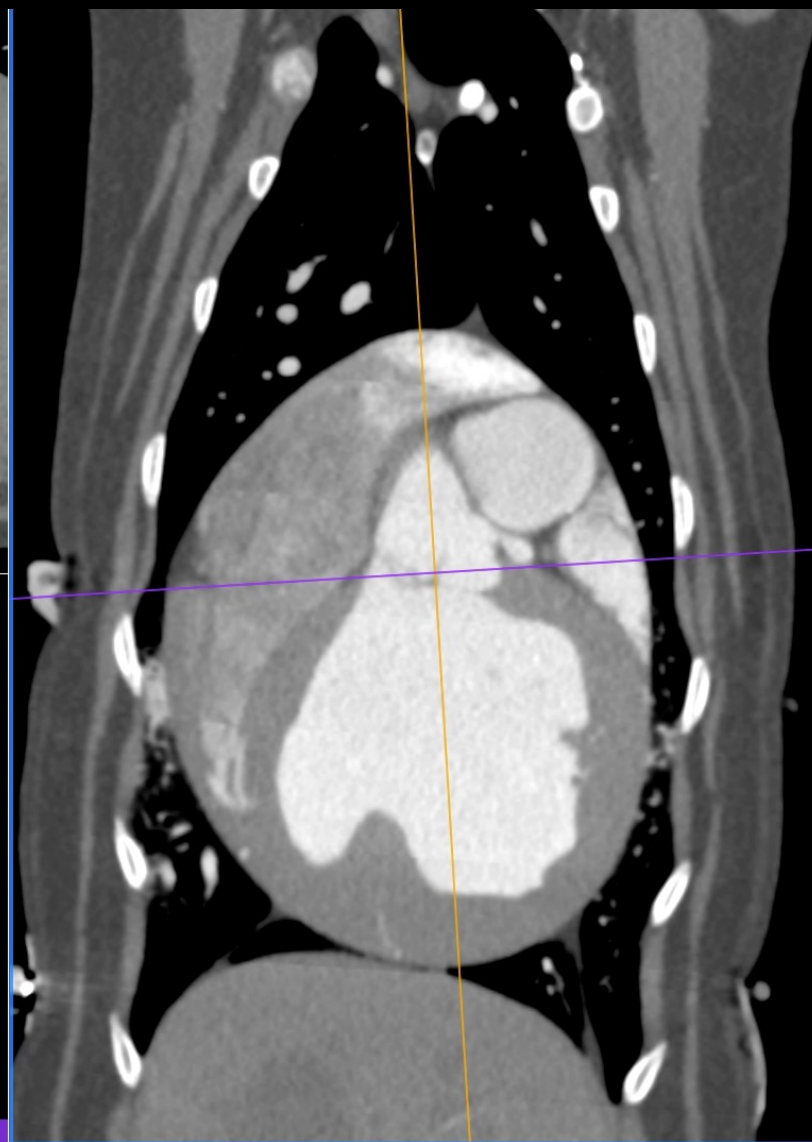
Single Left Ostium

Prepulmonary
Course

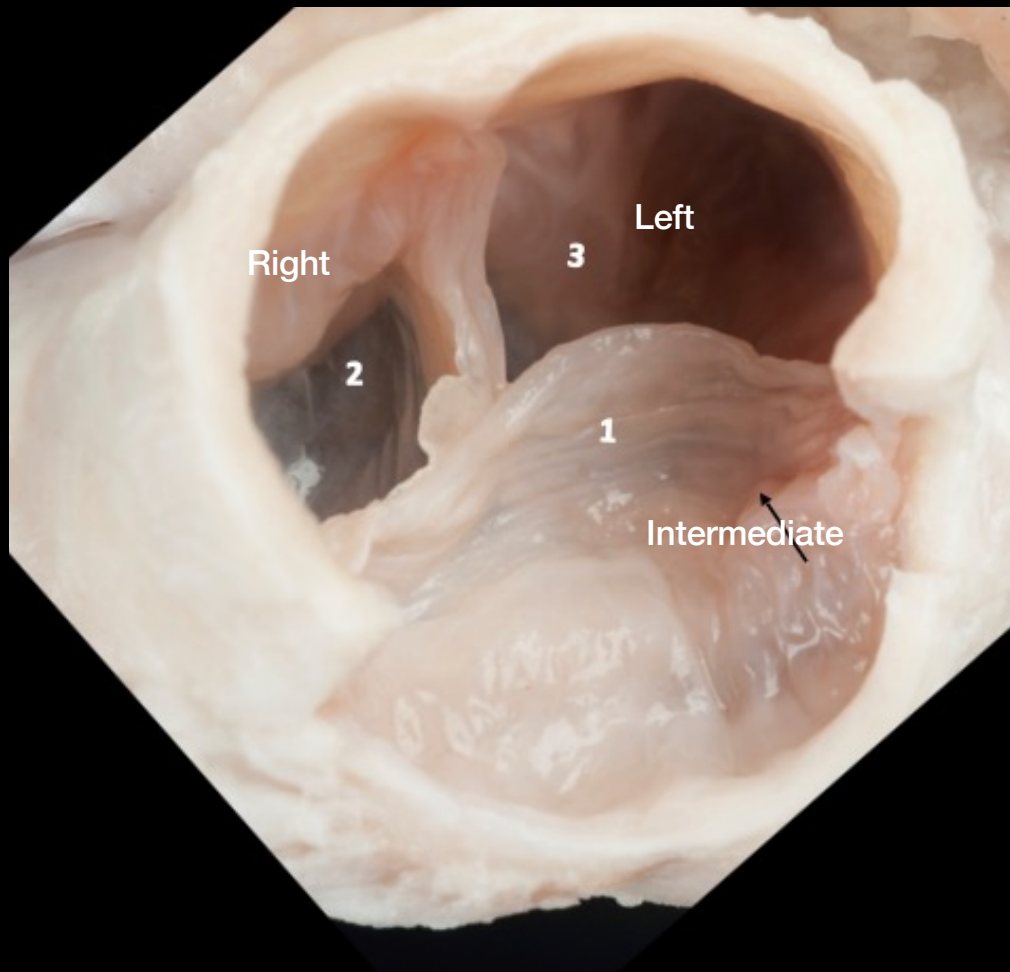
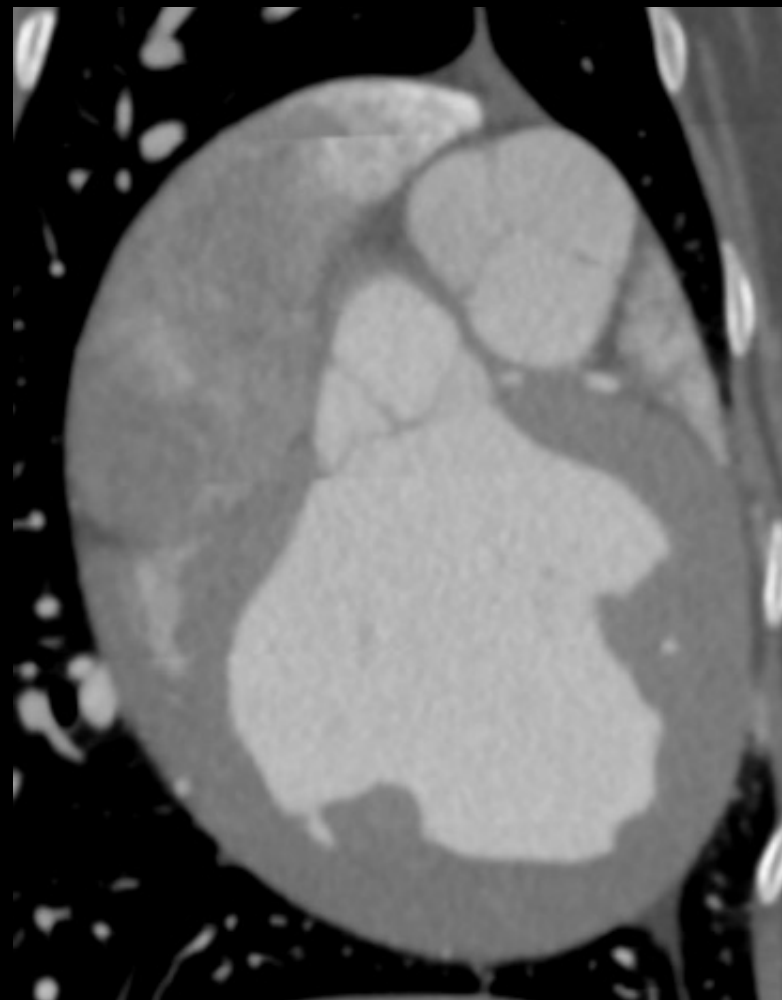


Pulmonary artery









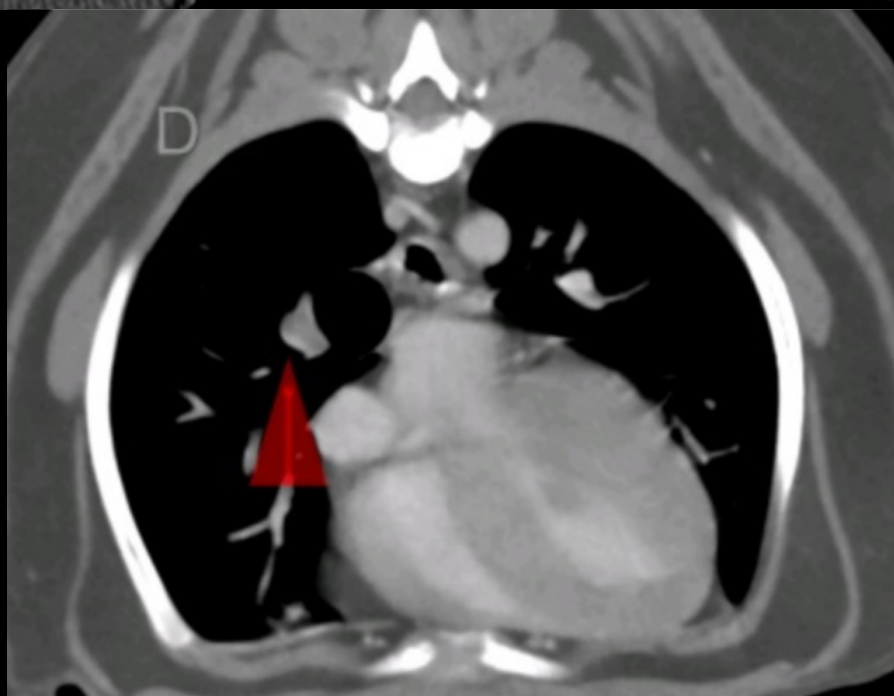
Applications in veterinary medicine

Cardiac neoplasia

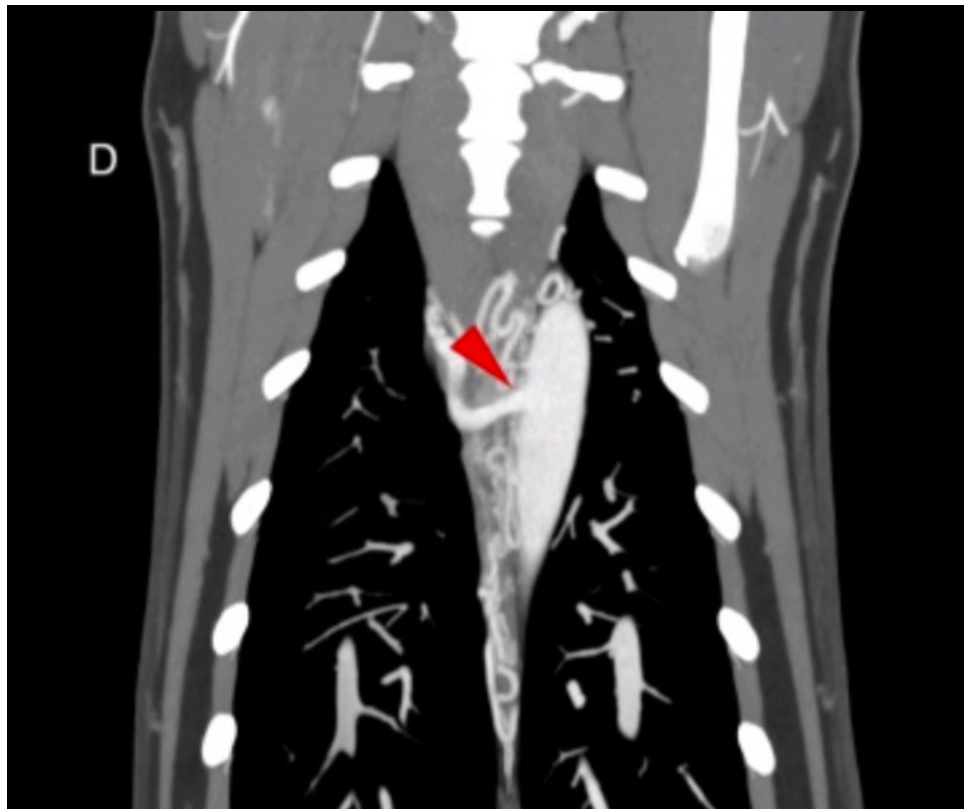
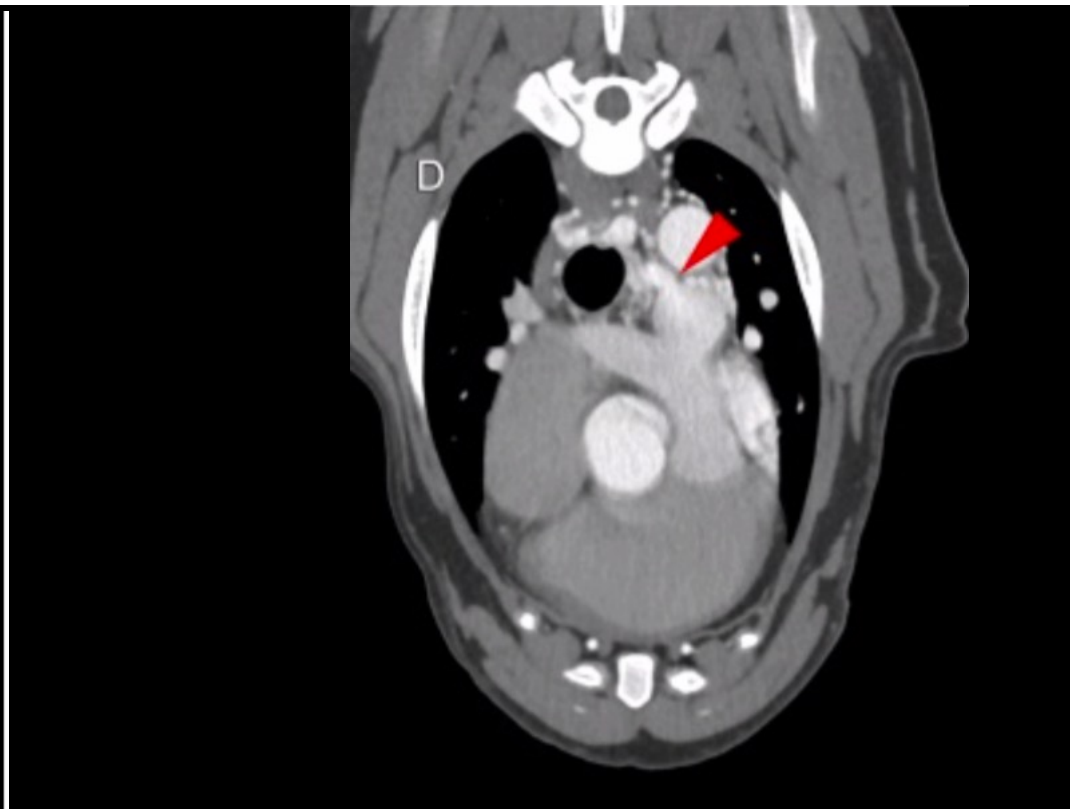
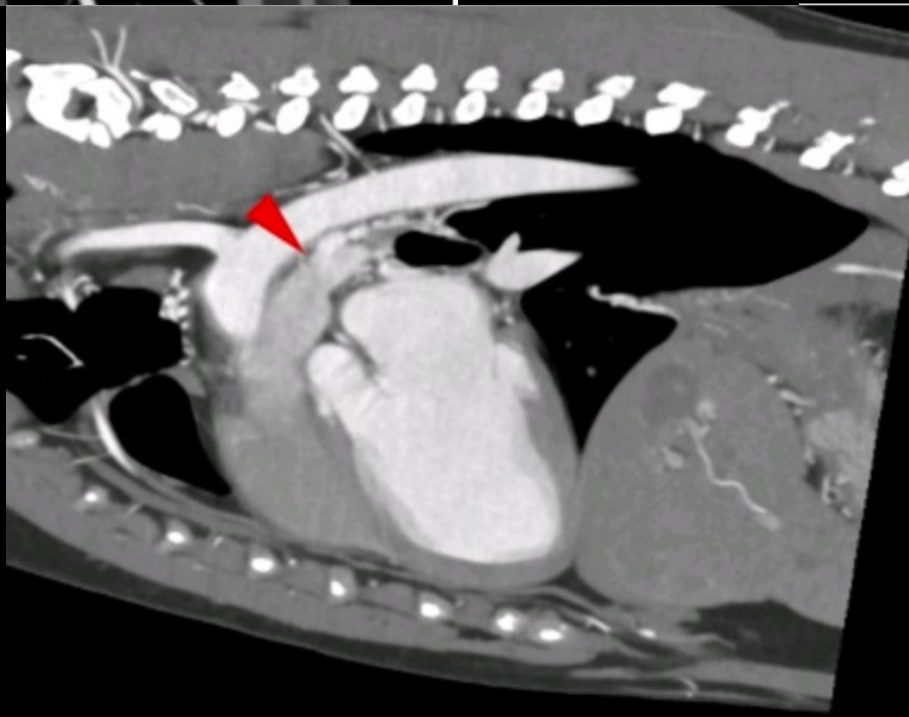
Complex cardiac pathologies

Coronary artery assessment (pre-interv.)

Pulmonary vascular anomalies







MULTIDETECTOR-ROW COMPUTED TOMOGRAPHY PATTERNS OF BRONCHOESOPHAGEAL ARTERY HYPERTROPHY AND SYSTEMIC-TO-PULMONARY FISTULA IN DOGS

GIANLUCA LEDDA, MARCO CALDIN, GIORGIA MEZZALIRA, GIOVANNA BERTOLINI

Anomalies involving arterial branches in the lungs are one of the causes of hemoptysis in humans and dogs. Congenital and acquired patterns of bronchoesophageal artery hypertrophy have been reported in humans based on CT characteristics. The purpose of this retrospective study was to describe clinical, echocardiographic, and multidetector computed tomography features of bronchoesophageal artery hypertrophy and systemic-to-pulmonary arterial communications in a sample of 14 dogs. Two main vascular patterns were identified in dogs that resembled congenital and acquired conditions reported in humans. Pattern 1 appeared as an aberrant origin of the right bronchoesophageal artery, normal origin of the left one, and enlargement of both the bronchial and esophageal branches that formed a dense network terminating in a pulmonary artery through an orifice. Pattern 2 appeared as a normal origin of both right and left bronchoesophageal arteries, with an enlarged and tortuous course along the bronchi to the periphery of the lung, where they communicated with subsegmental pulmonary arteries. Dogs having Pattern 1 also had paraesophageal and esophageal varices, with the latter being confirmed by videoendoscopy examination. Authors conclude that dogs with Pattern 1 should be differentiated from dogs with other congenital vascular systemic-to-pulmonary connections. Dogs having Pattern 2 should be evaluated for underlying pleural or pulmonary diseases. Bronchoesophageal artery hypertrophy can be accompanied by esophageal venous engorgement and should be included in the differential diagnosis for esophageal and paraesophageal varices in dogs. © 2015 American College of Veterinary Radiology.

Key words: bronchoesophageal artery, computed tomography, CTA, dog, systemic-to-pulmonary artery fistula.

Applications in veterinary medicine

Cardiac neoplasia

Complex cardiac pathologies

Coronary artery assessment (pre-interv.)

Pulmonary vascular anomalies (pulmonic stenosis and pre-interventional assessment)



