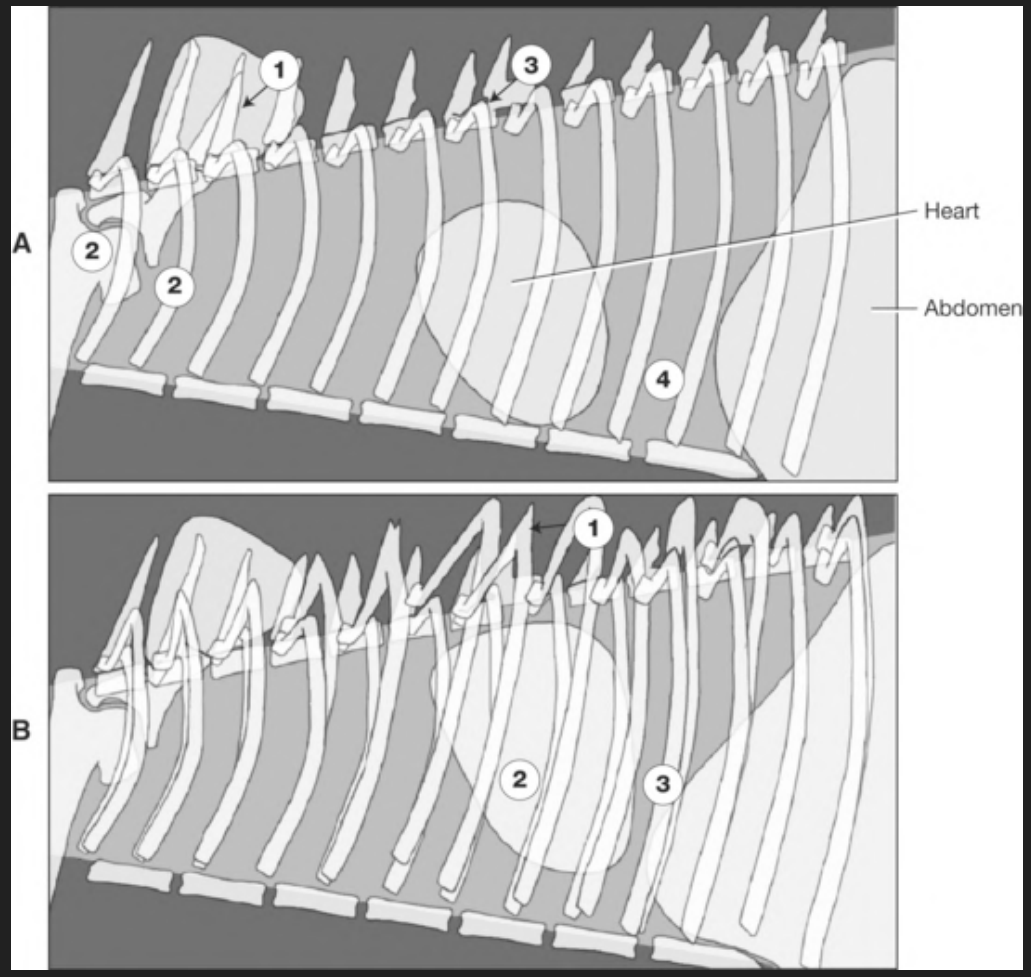
The heart and major vessels radiology in small animals

Mohammad Molazem

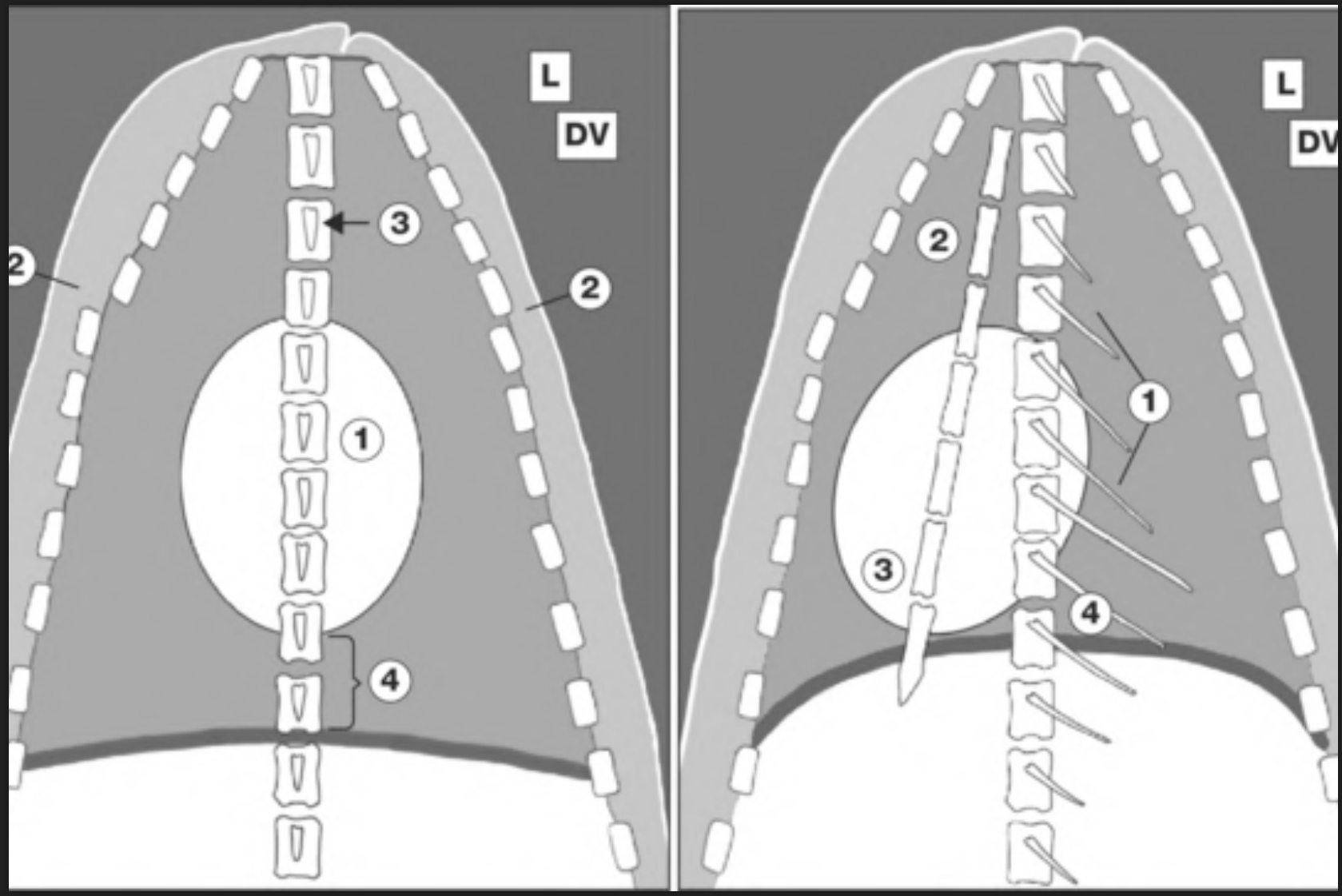
Clinical Findings	Very Suggestive of HF	Somewhat Suggestive of HF	Usually Opposes HF Diagnosis
History	• Previous HF diagnosis • Furosemide responsive cough/dyspnea	• Family history of HF or sudden death • Previous diagnosis of heart murmur	• Coughing cat • Vomiting then dyspneic • No loss in appetite • Normal respiratory rate
Physical examination	• Dyspnea and loud murmur in small-breed dog • Gallop sound • Jugular venous distention/pulses • Positive hepatojugular reflex	• Murmur, cough, tachycardia, and dyspnea in dog • Poor pulse quality and slow capillary refill time • Soft end-inspiratory crackles	• Absence of a murmur in small-breed dog • Cough induced by tracheal palpation • Obese dog with no history of weight loss • Transient cyanosis
Imaging	• Distended pulmonary veins or caudal vena cava on radiograph • Enlarged atria on echo (LA/Ao ratio >2)	• Cardiomegaly • Perihilar to caudal dorsal interstitial-alveolar lung pattern • Pleural effusion + cardiomegaly in cats	• Bronchiolar pulmonary pattern • DOG only: large amount pleural effusion in the absence of ascites • CAT only: large amount ascites in the absence of pleural effusion
ECG	• Atrial fibrillation • Left bundle branch block	• Chamber enlargement pattern (esp cat) • Sinus tachycardia • Other tachyarrhythmia	Respiratory sinus arrhythmia
Cardiac biomarkers	DOGS NTproBNP >3000 pg/mL BNP >6 pg/mL CATS NTproBNP >1000 pg/mL Markedly elevated cTnI		DOGS NTproBNP <900 pg/mL BNP <3 pg/mL CATS Normal CTnI NTproBNP <100 pg/mL

Key Point

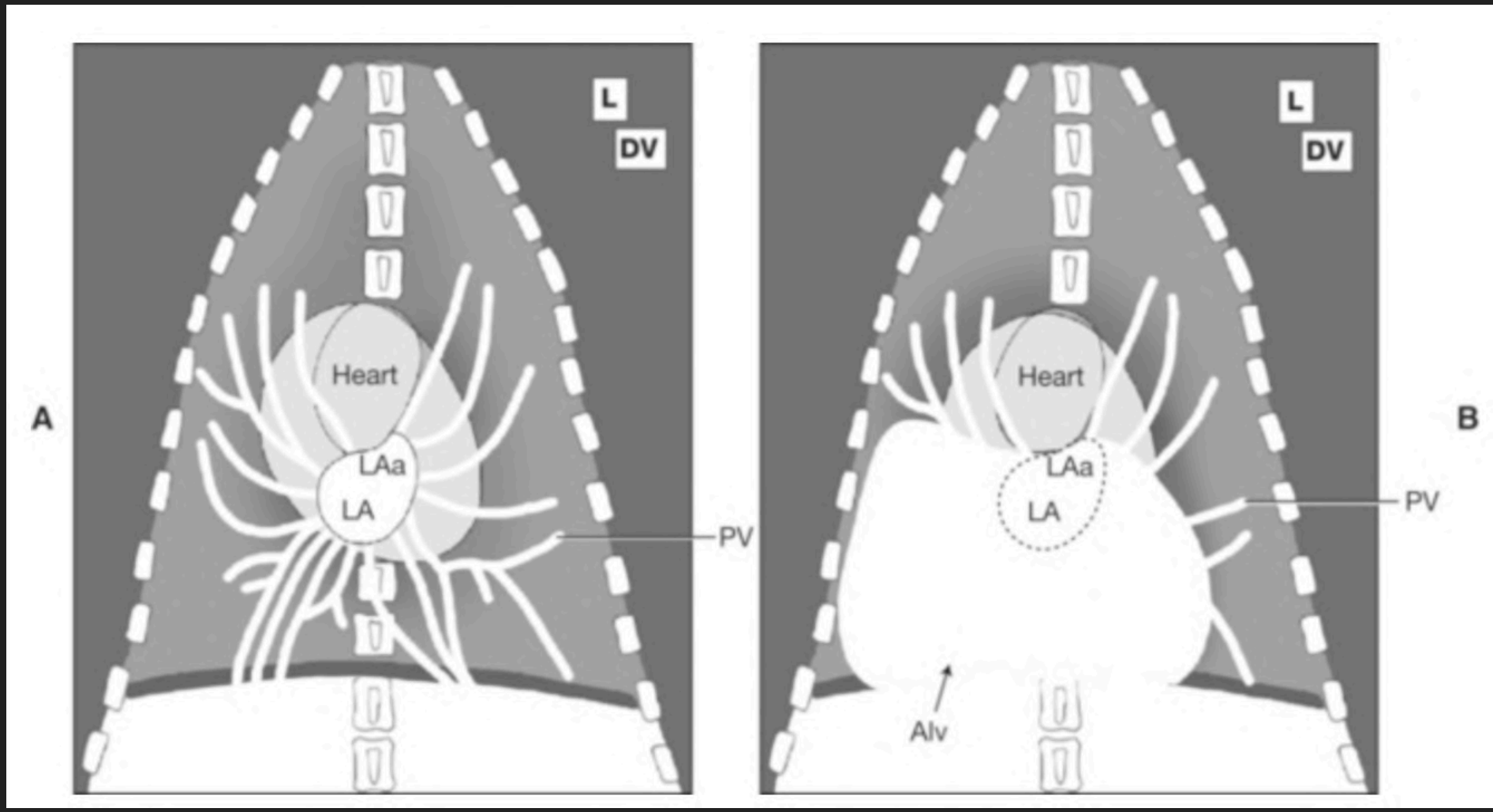
- A normal heart can appear diseased and vice versa when positioning is not adequate.
- Different breeds different shapes and sizes

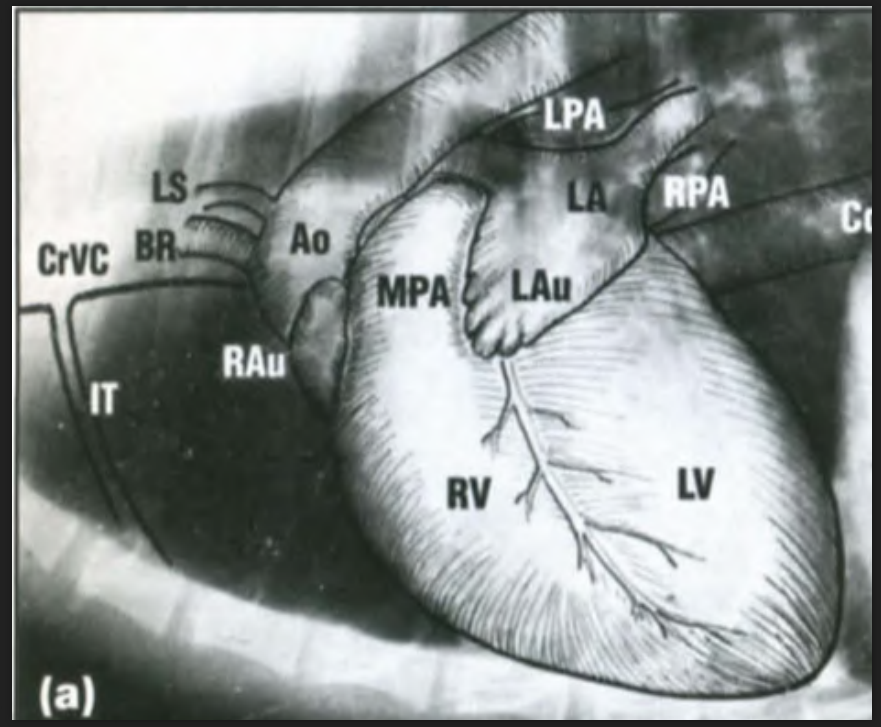


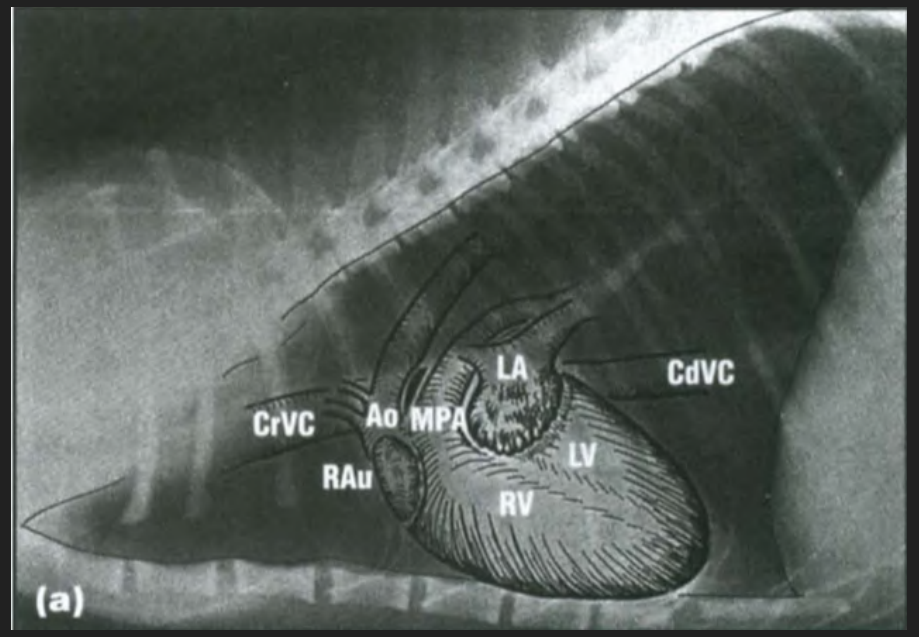
Lateral



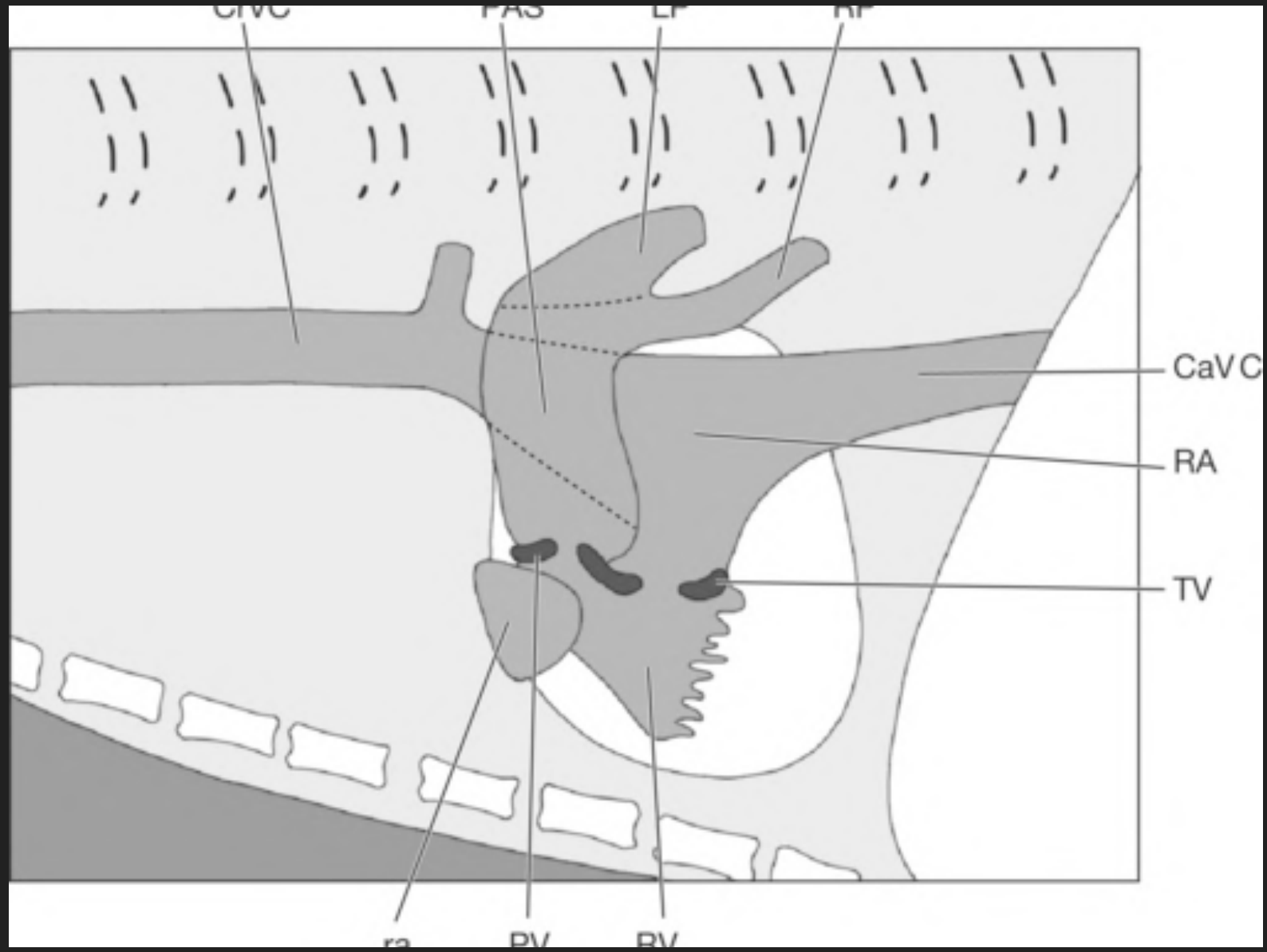
vd

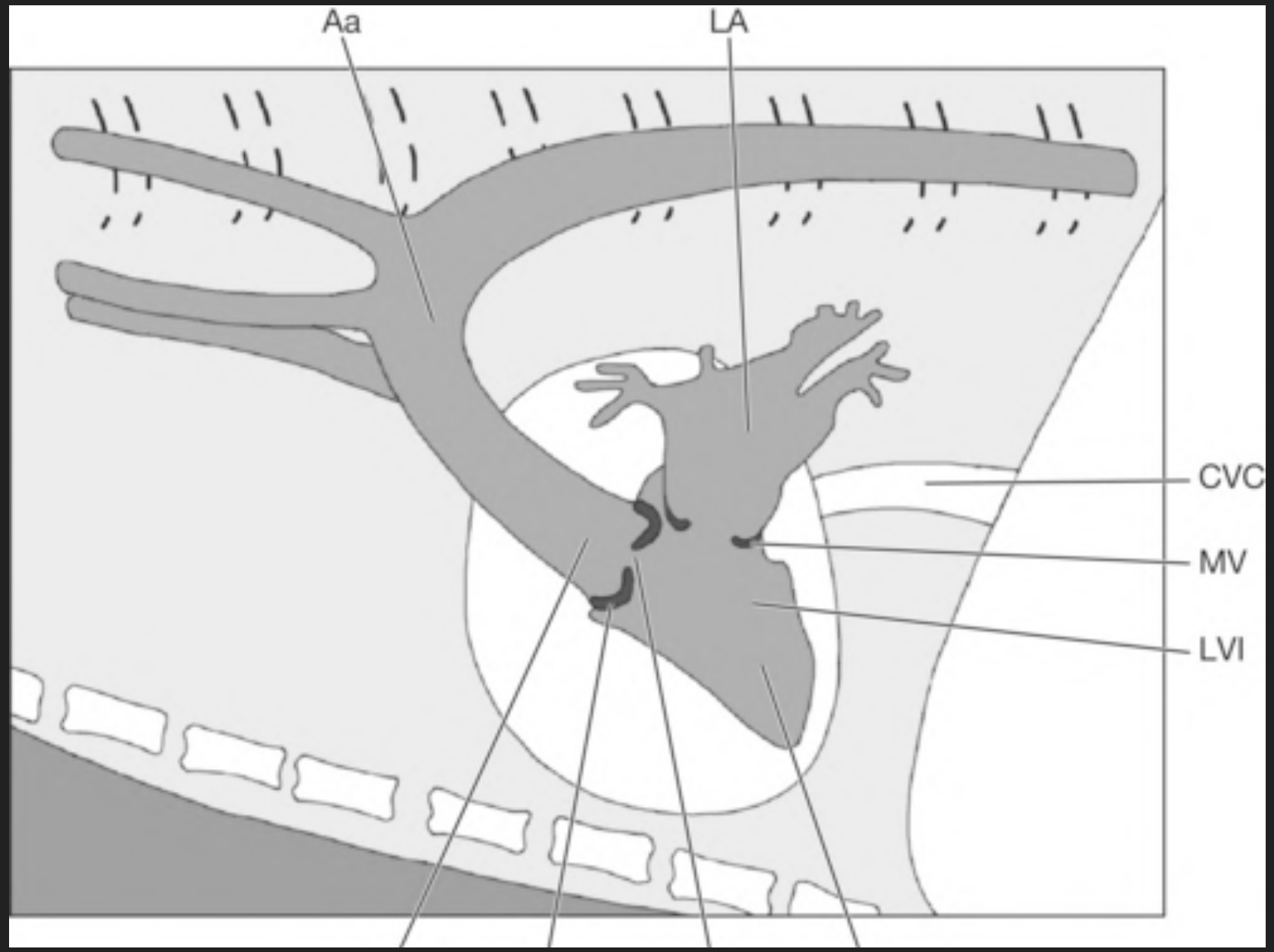

A
L
DV
Heart
LAa
LA
PV
B
L
DV
Heart
LAa
LA
PV
Alv

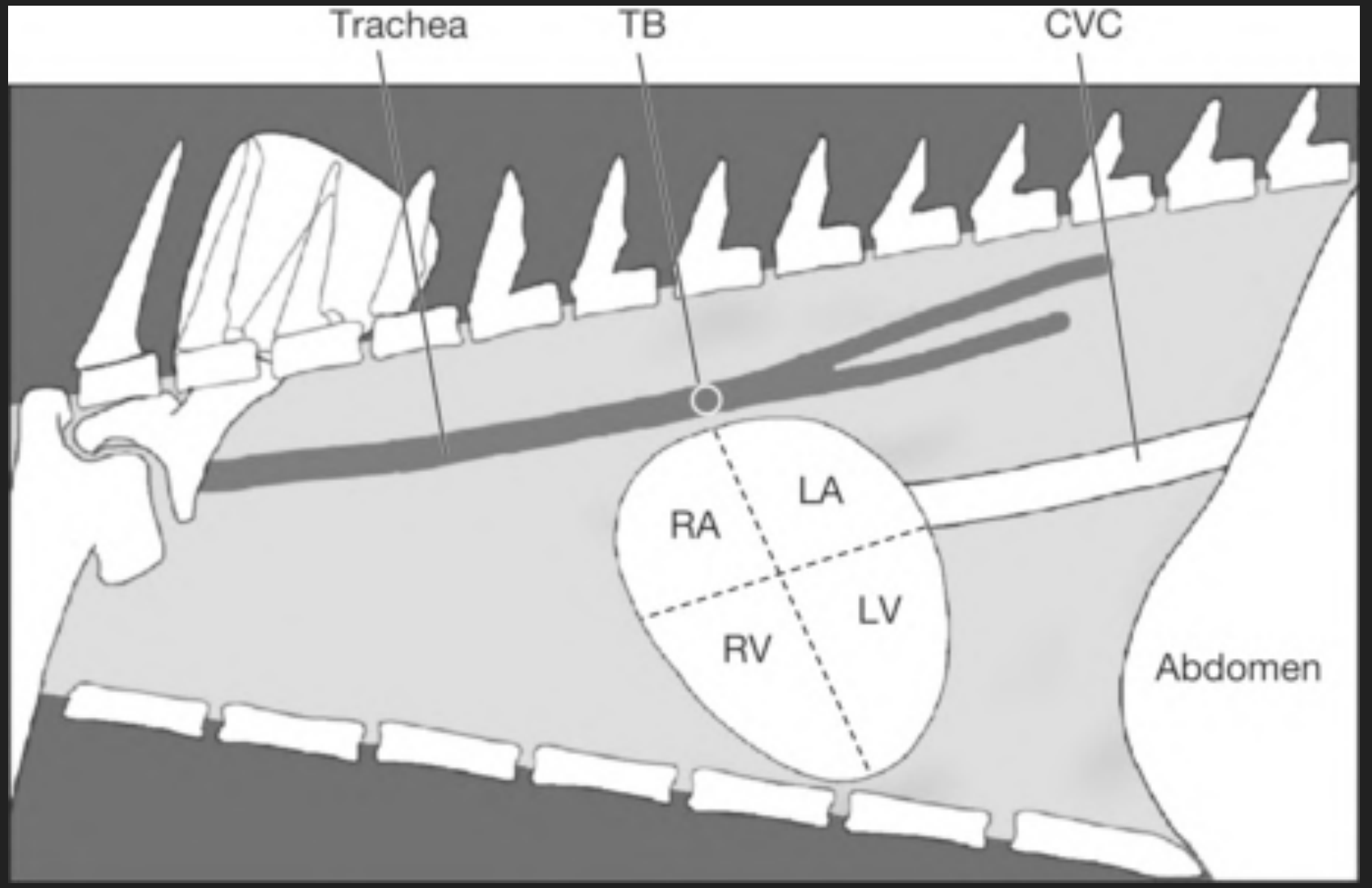


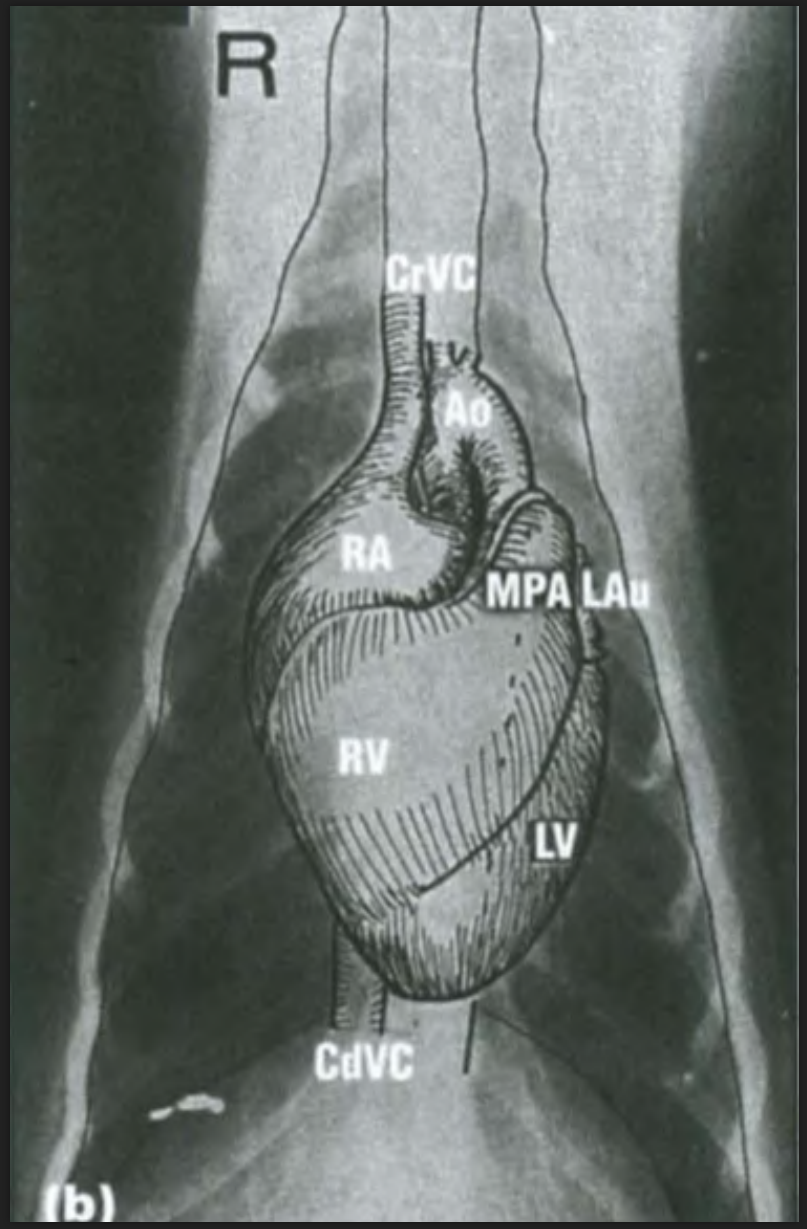


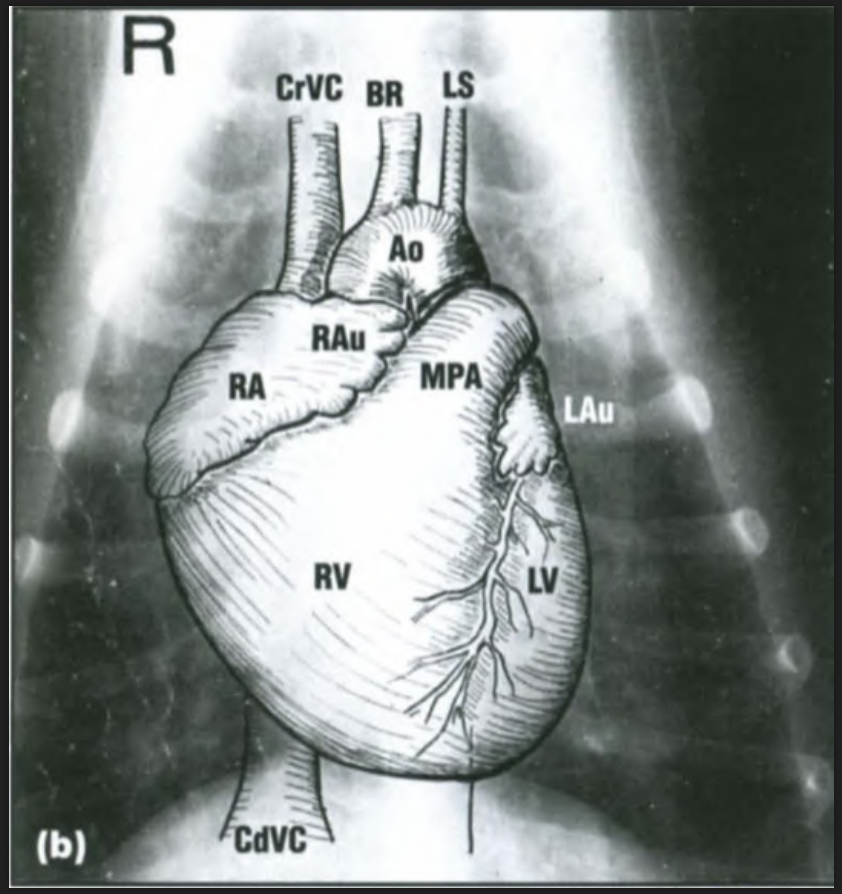
The heart and major vessels

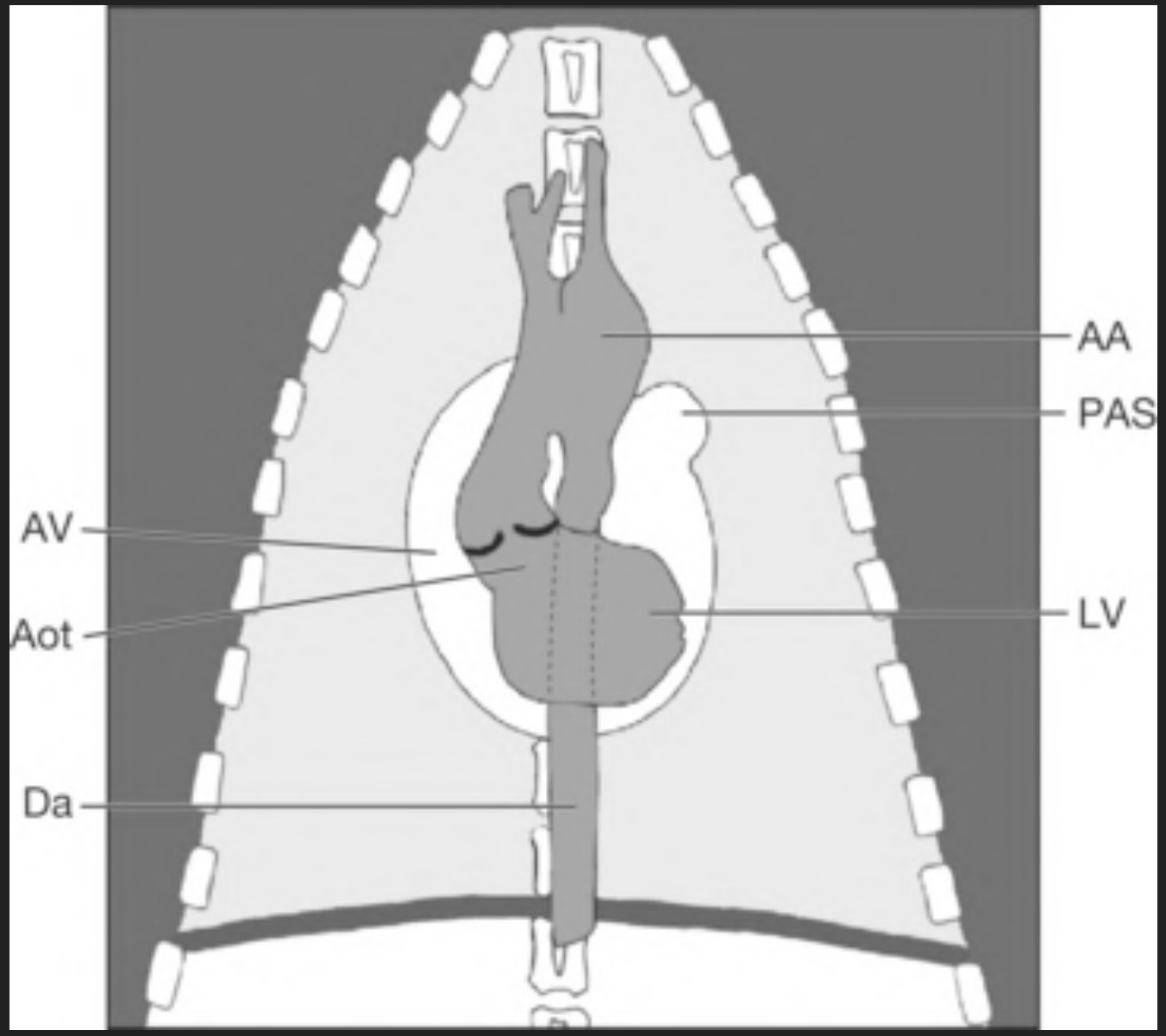

CaV C
RA
TV


Aa
LA
CVC
MV
LVI


Trachea
TB
CVC
RA
LA
RV
LV
Abdomen


R
CrVC
Ao
RA
MPA
LAu
RV
LV
CdVC
(b)


R
CrVC
BR
LS
Ao
RAu
RA
MPA
LAu
RV
LV
CdVC
(b)

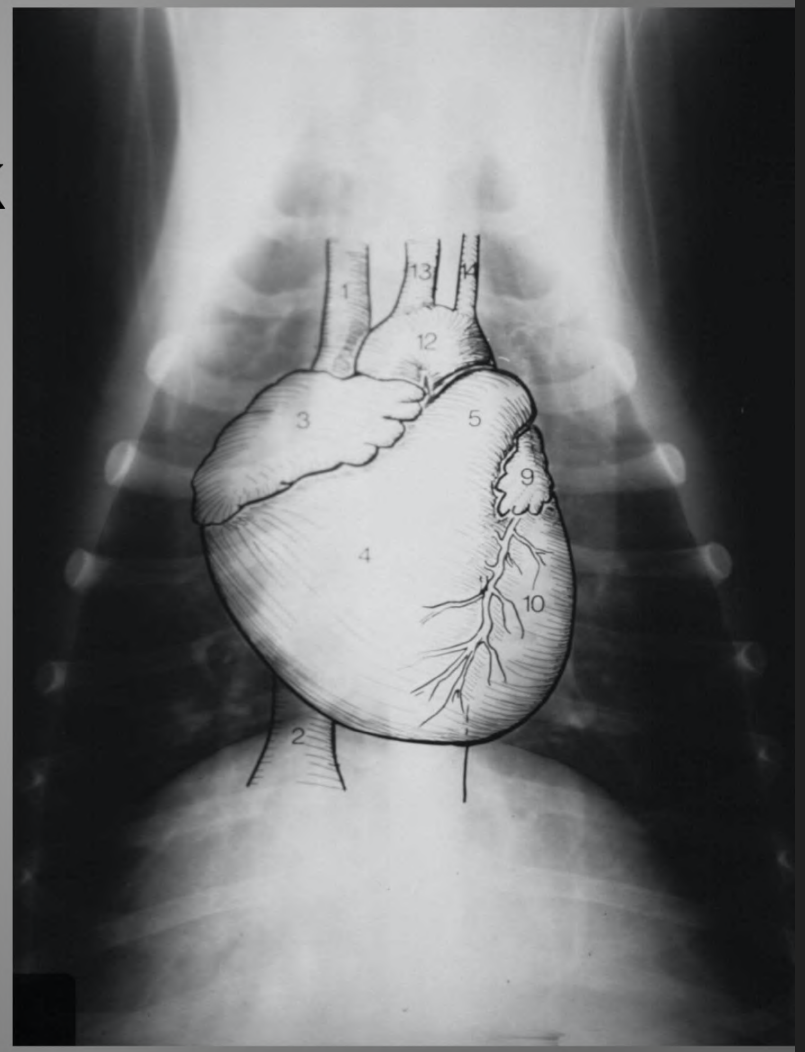

AA
PAS
AV
Aot
LV
Da

Normal Cardiac Silhouette

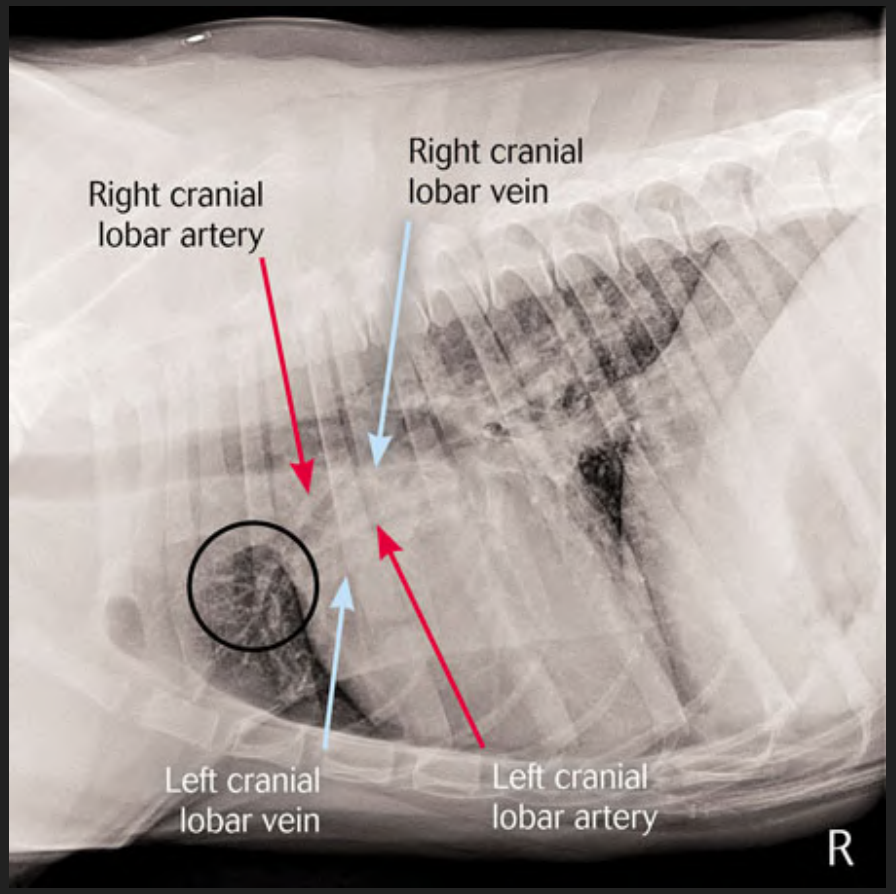
- Size is subjective
- Lateral views:
  - Dog = 2 ½ - 3 ½ intercostal spaces
  - Cat = 2 – 2 ½ intercostal spaces
- VD/DV views:
  - 65% the width of the thorax
- Objective:
  - Buchanan method
    - Vertebral heart scale

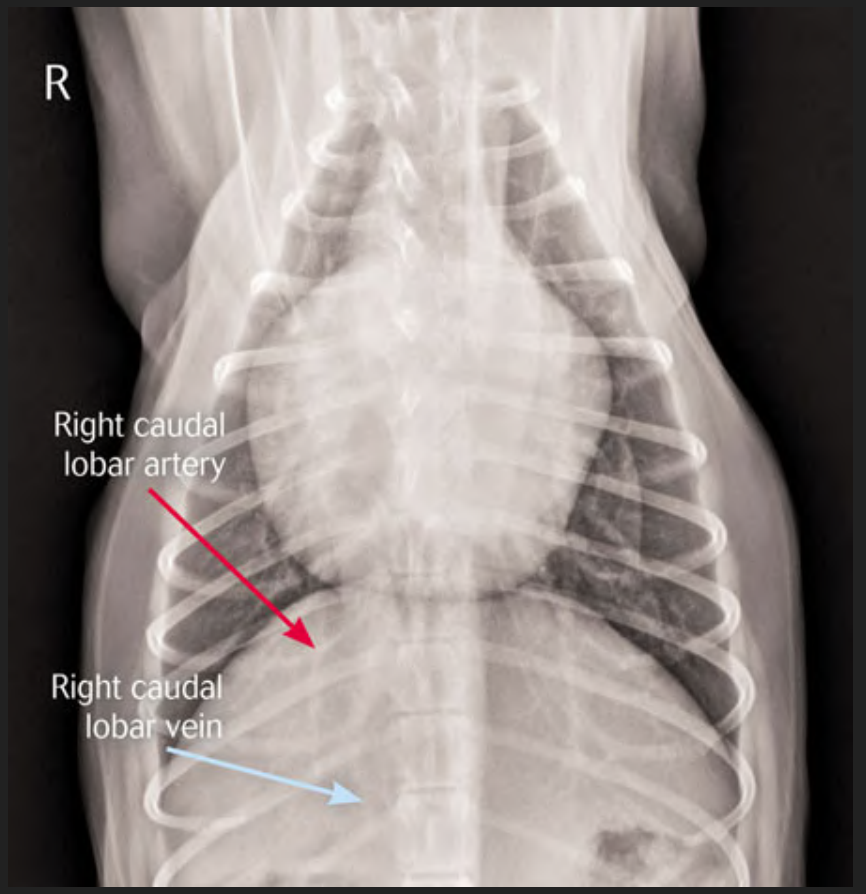
Clock Face

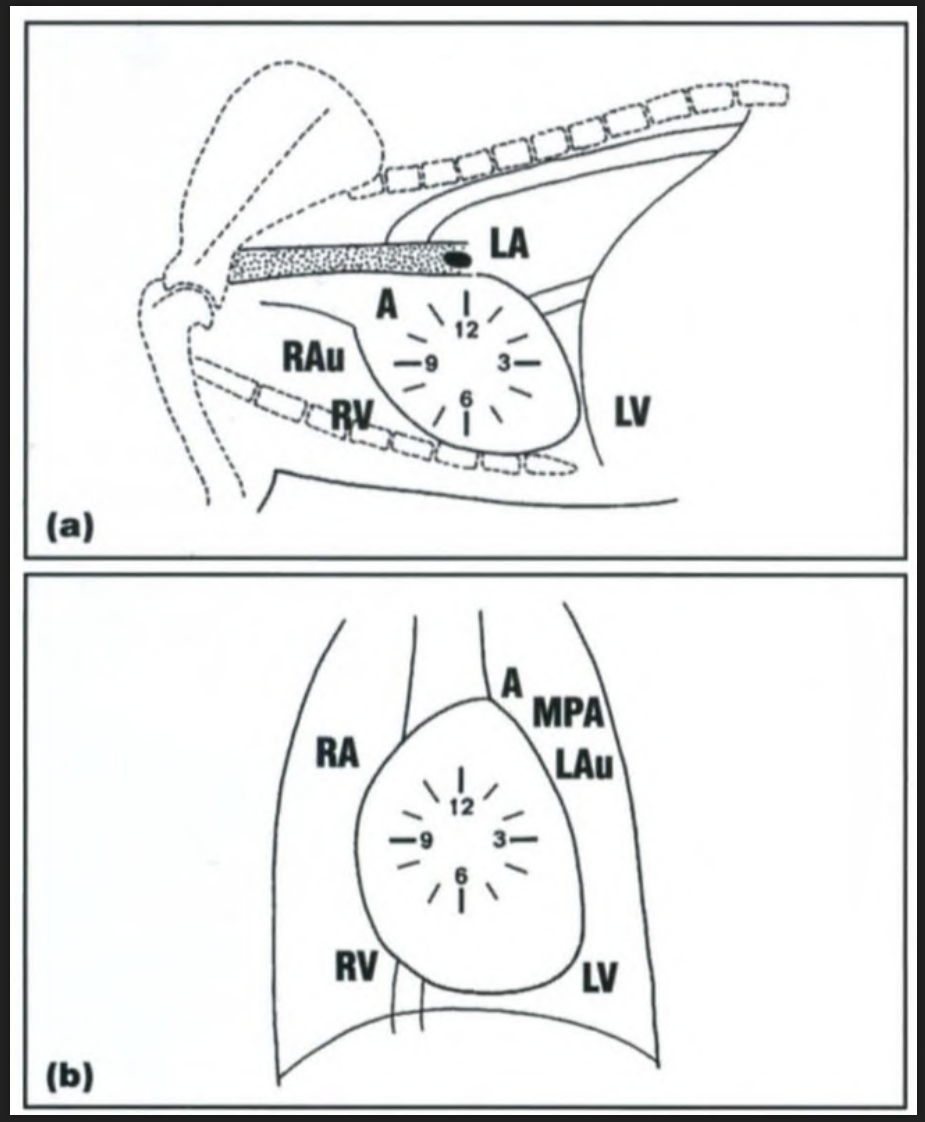
- 11-1 Aortic Arch
- 1-2 Main Pulmonary Trunk
- 2-3 Left Auricle
- 2-5 Left Ventricle
- 5-9 Right Ventricle
- 9-11 Right Atrium
- Centrally – Left Atrium




SID:6711
ID: 0050427 Patient: HAMILTON NIKA
Sex: DOB: ----/--/--
Date: 08.02.2010 11:56:18
THORAX DV

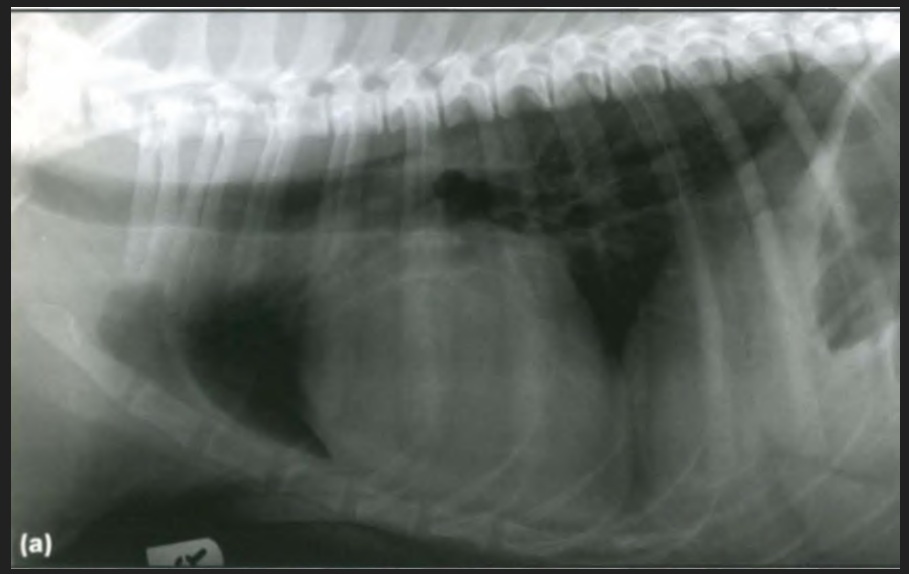

Right cranial
lobar artery
Right cranial
lobar vein
Left cranial
lobar vein
Left cranial
lobar artery
R


R
Right caudal
lobar artery
Right caudal
lobar vein

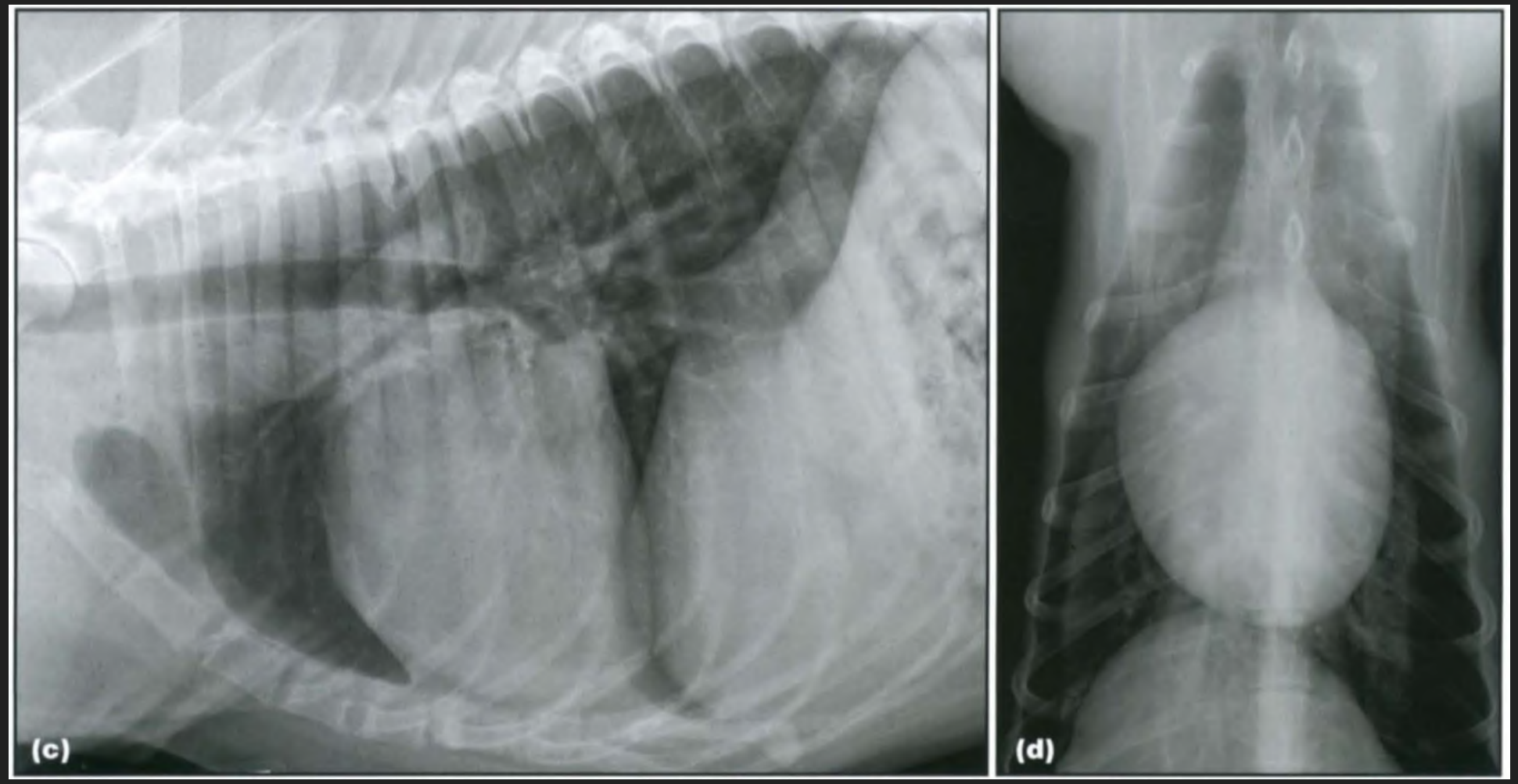

LA
A
12
9
3
6
RAu
RV
LV
(a)
A
MPA
RA
LAu
12
9
3
6
RV
LV
(b)


(a)

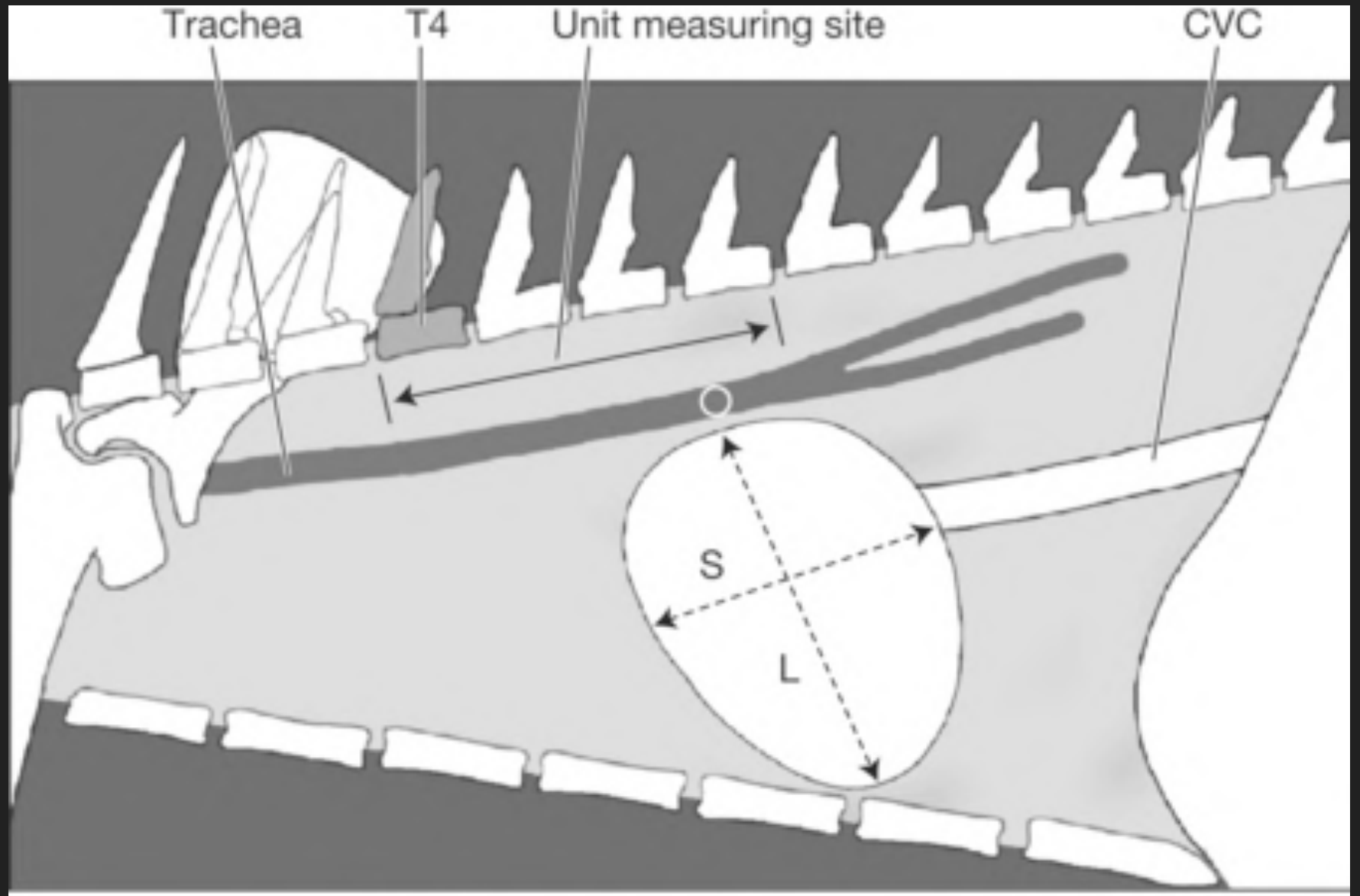

(b)



Golden Retriever

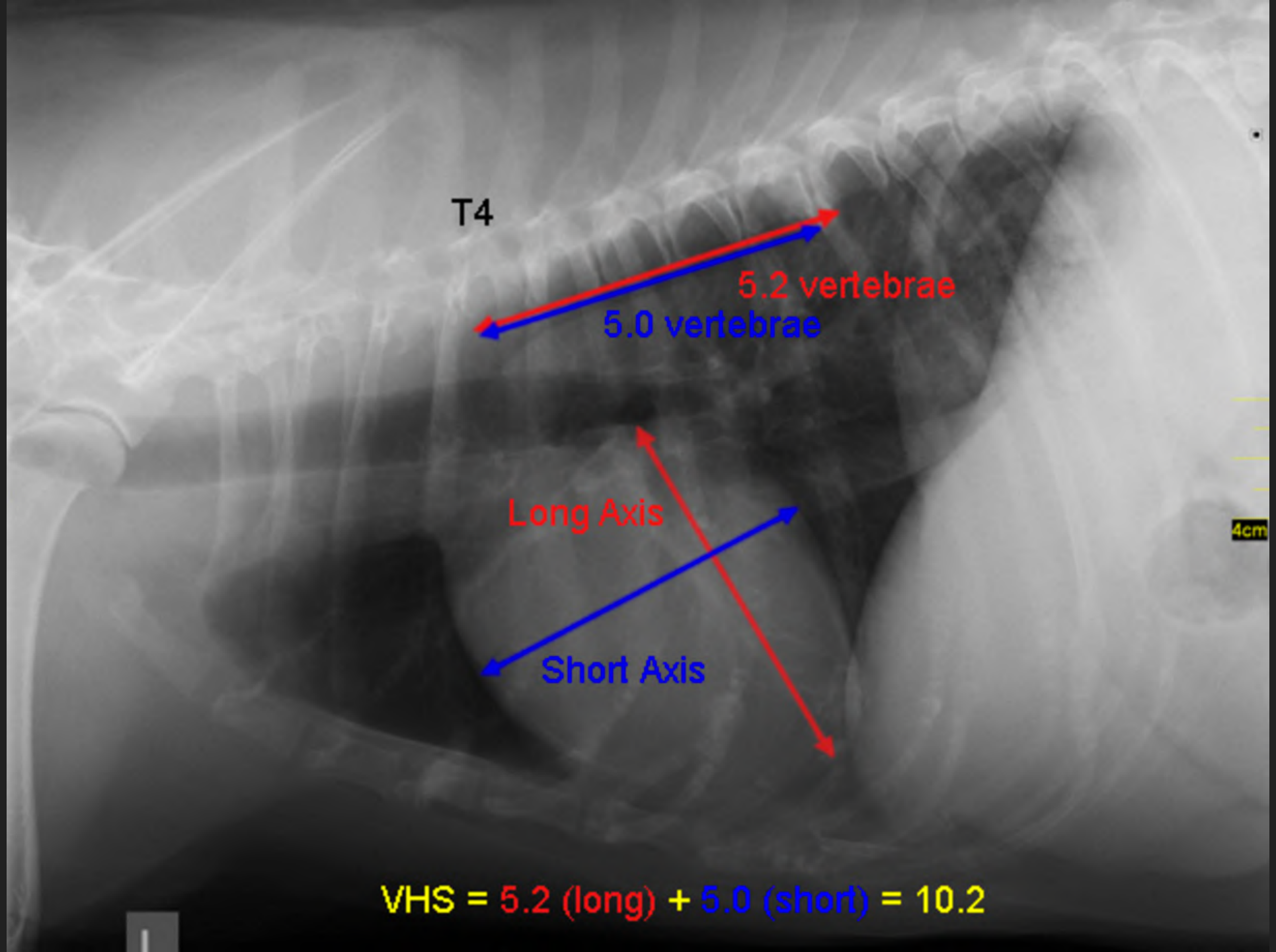


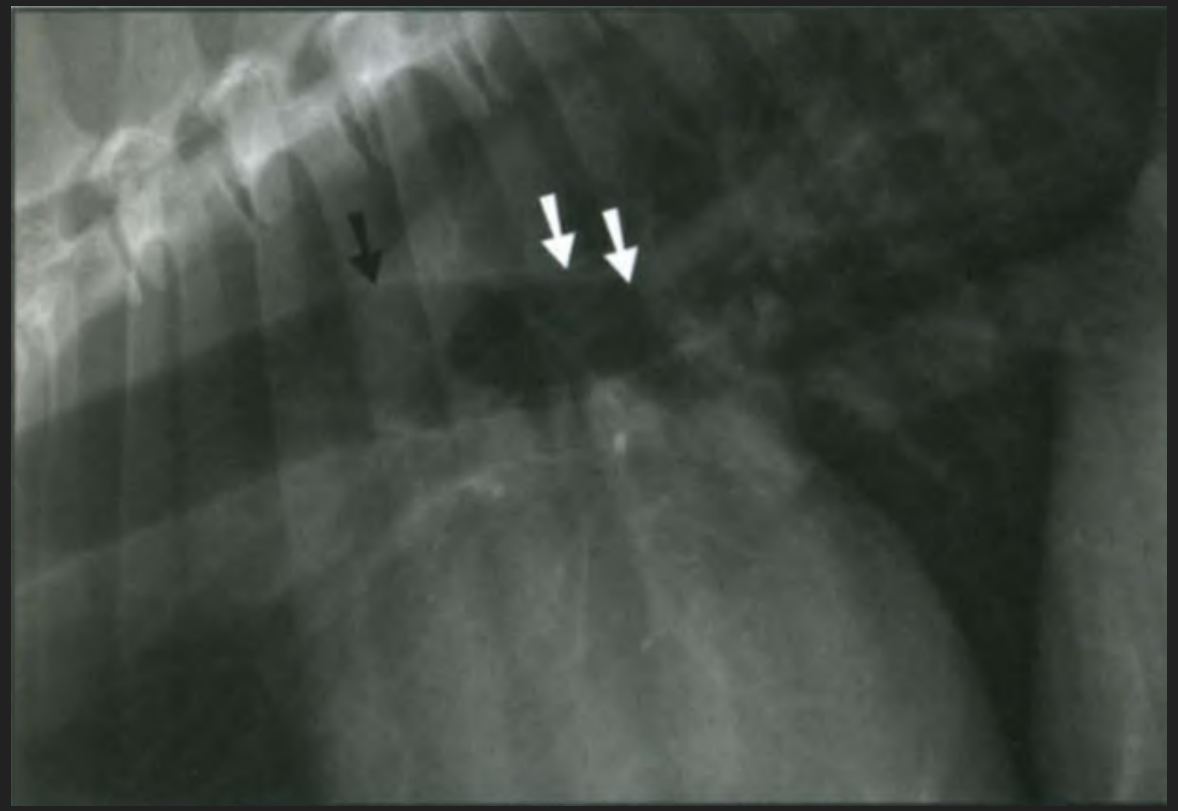
Dobermann

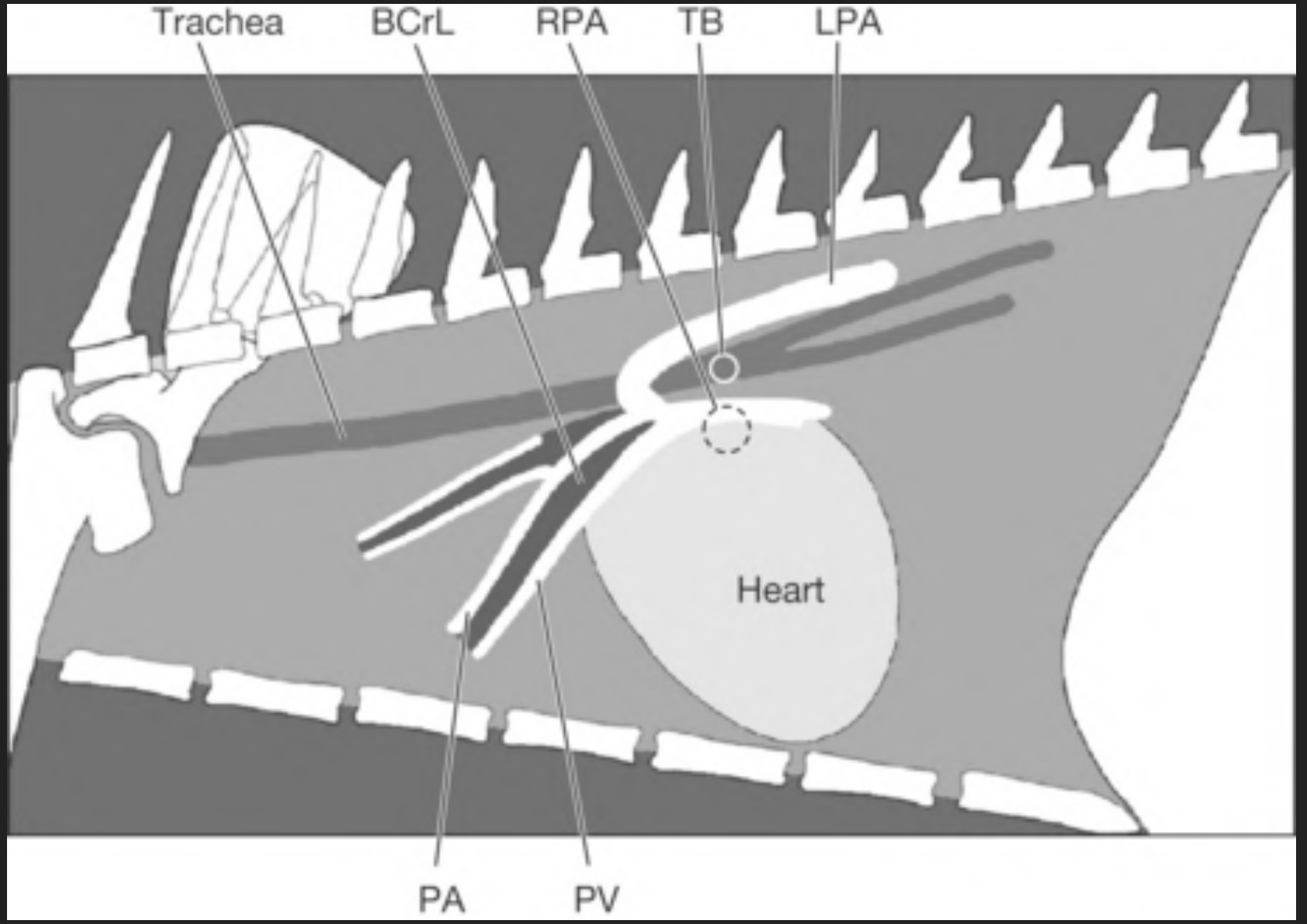


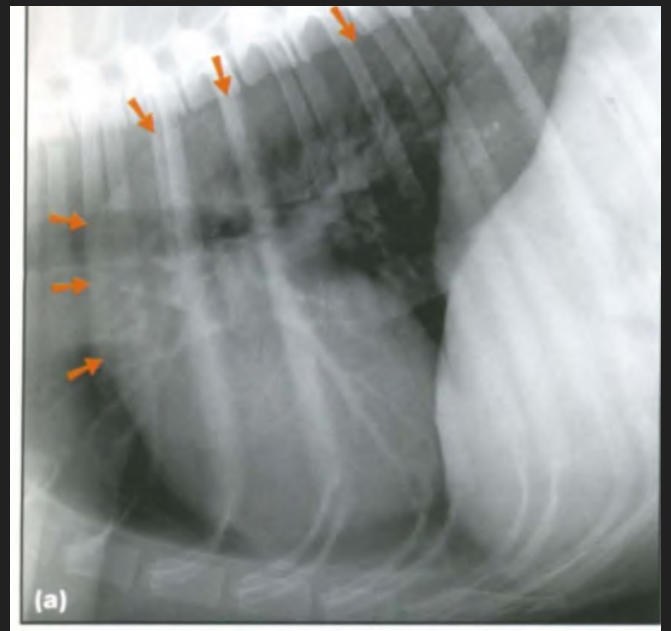
VHS = S + L

Measured in vertebral units beginning at T4.

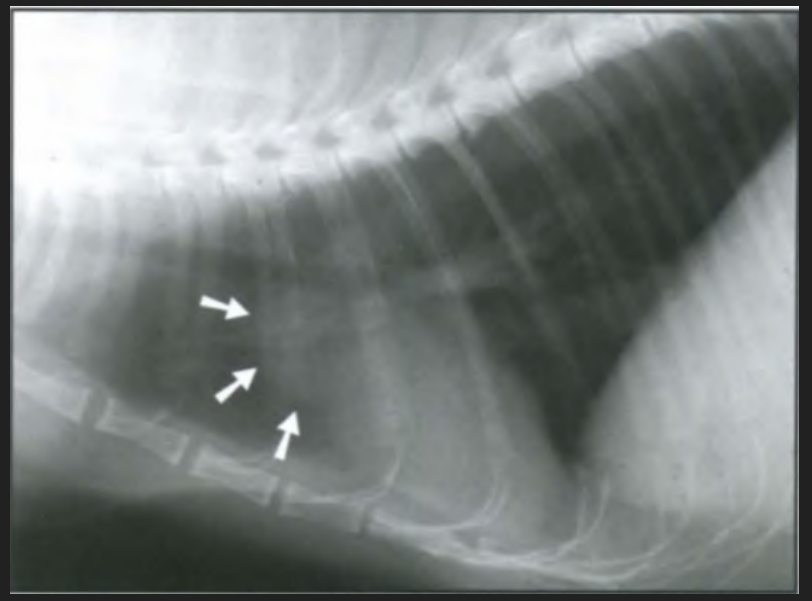

T4
5.2 vertebrae
5.0 vertebrae
Long Axis
Short Axis
4cm
VHS = 5.2 (long) + 5.0 (short) = 10.2

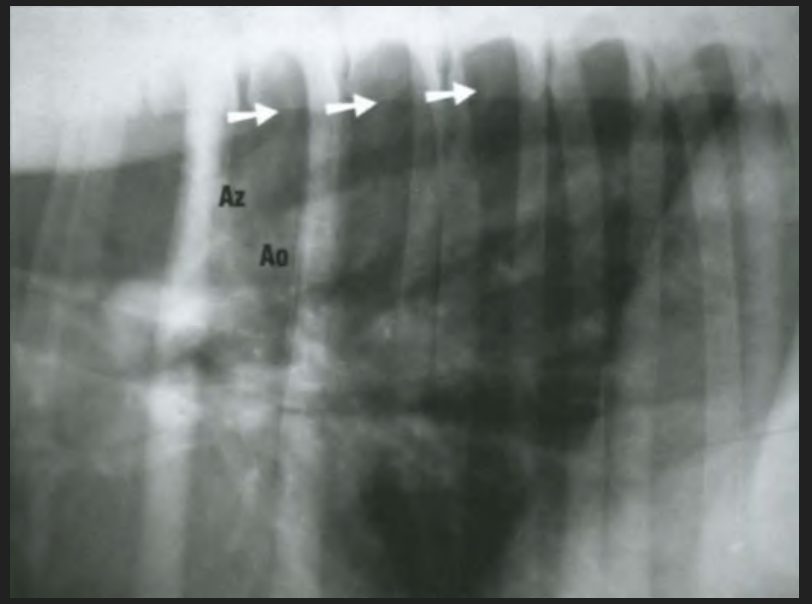


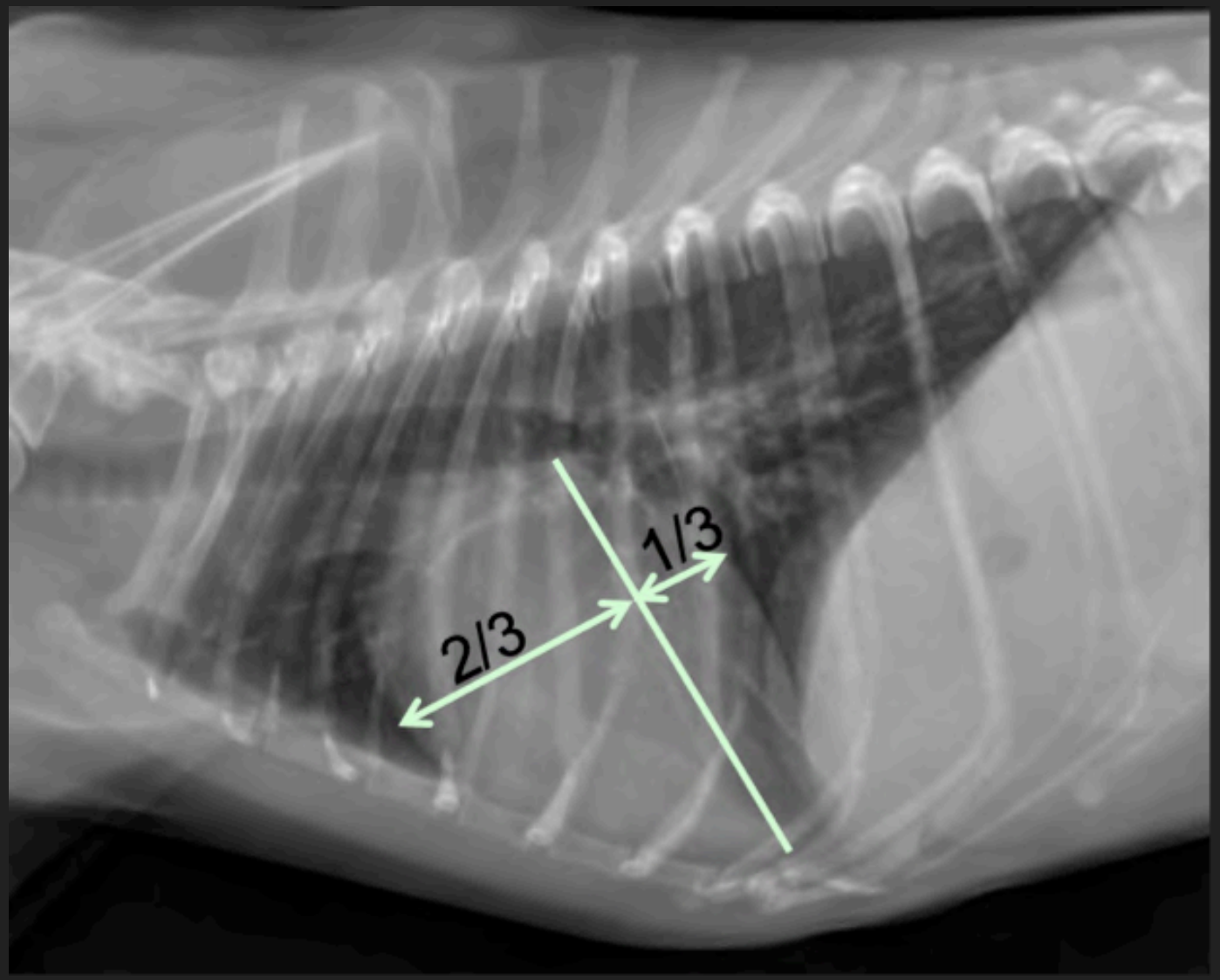

Trachea
BCrL
RPA
TB
LPA
Heart
PA
PV

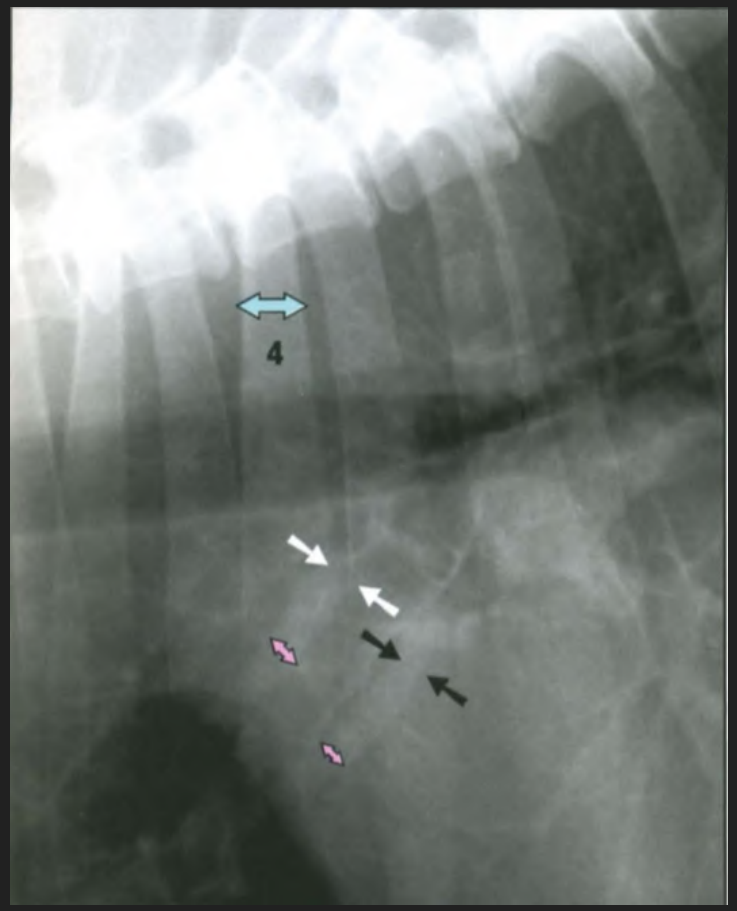

(a)

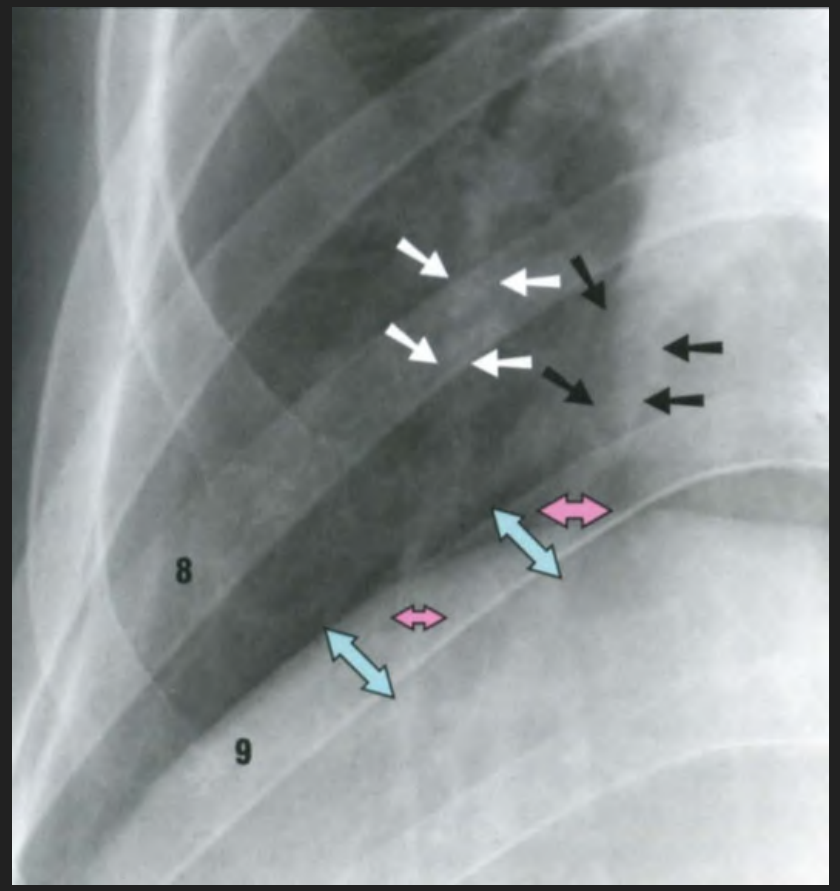

(b)



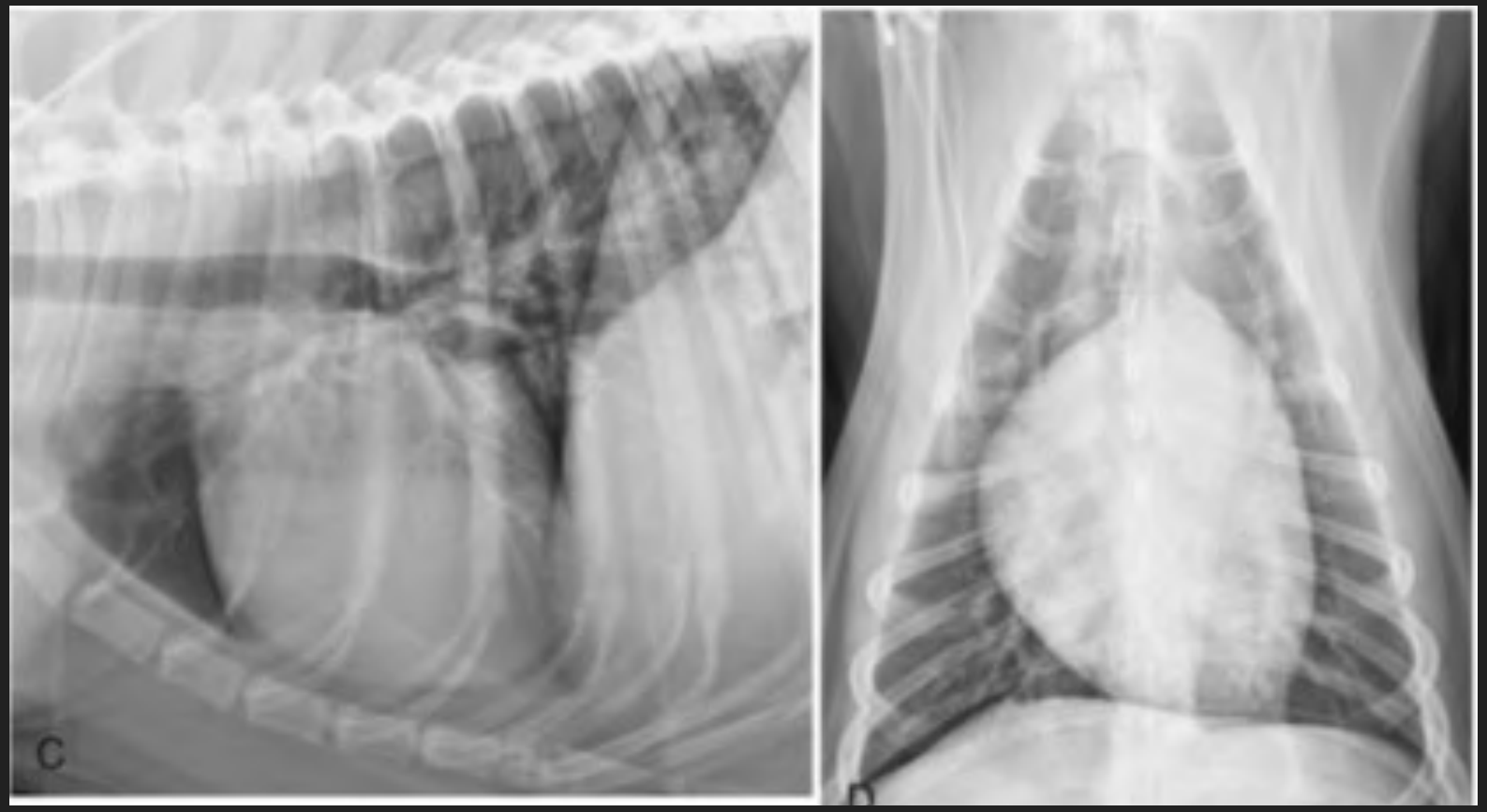

Az
Ao

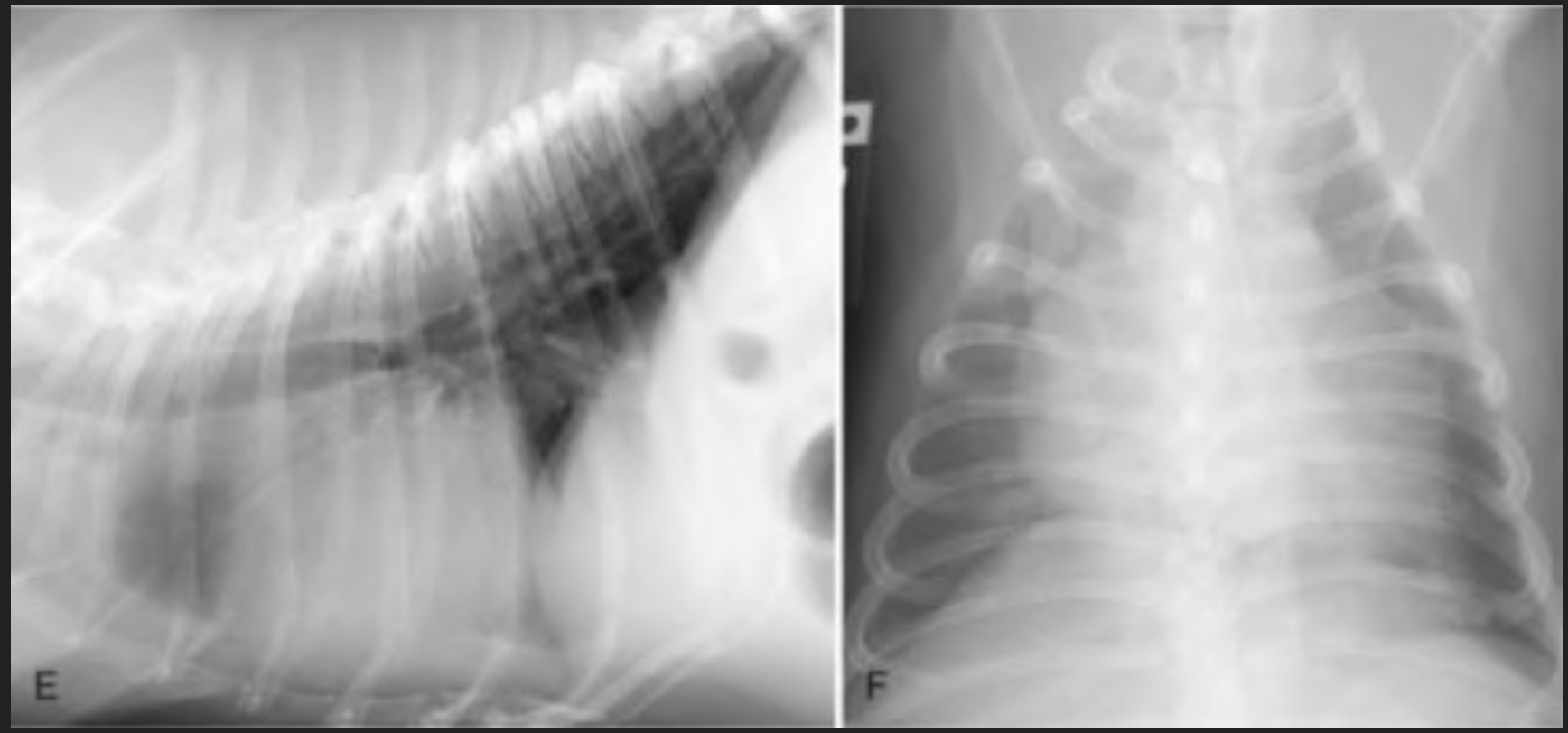

1/3
2/3

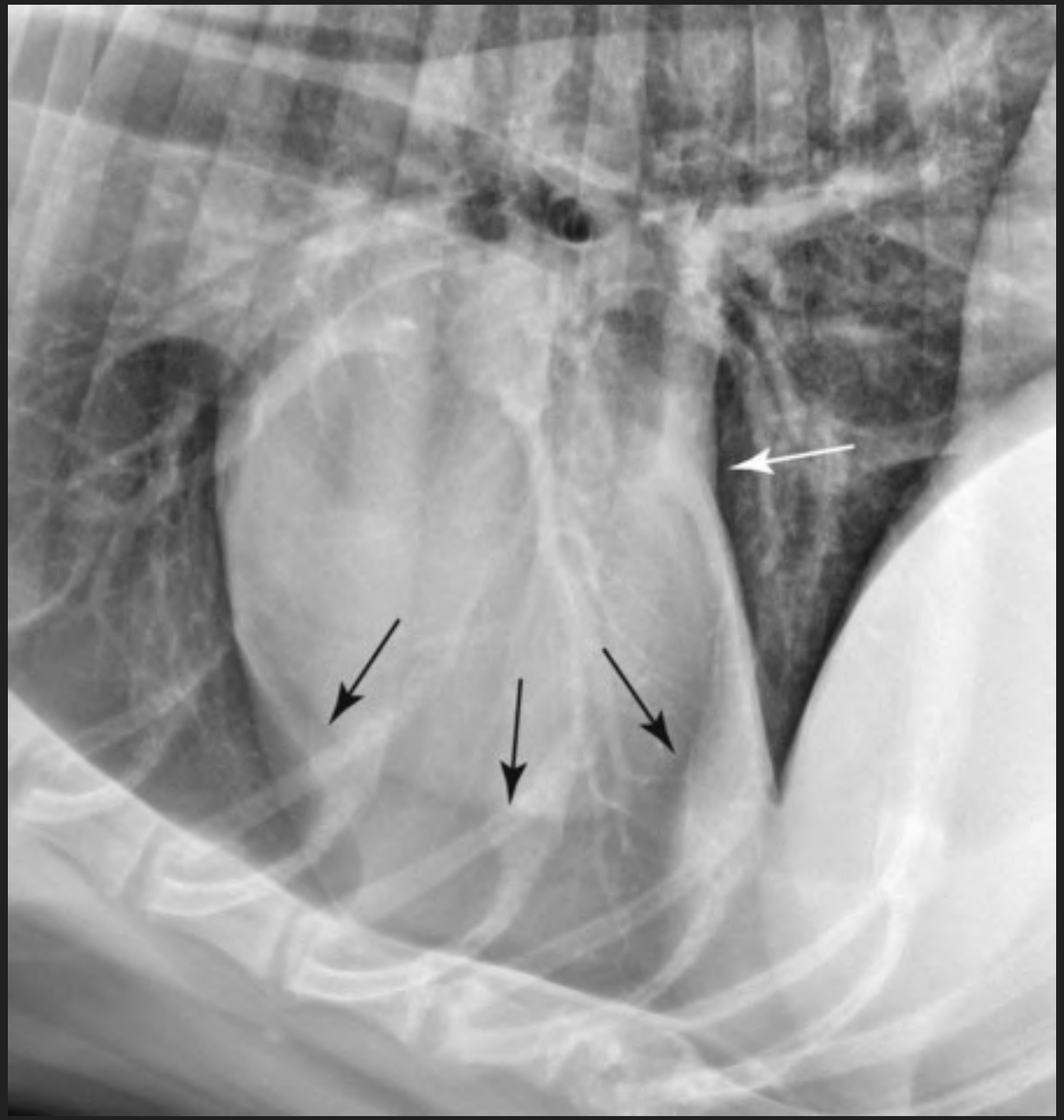

4

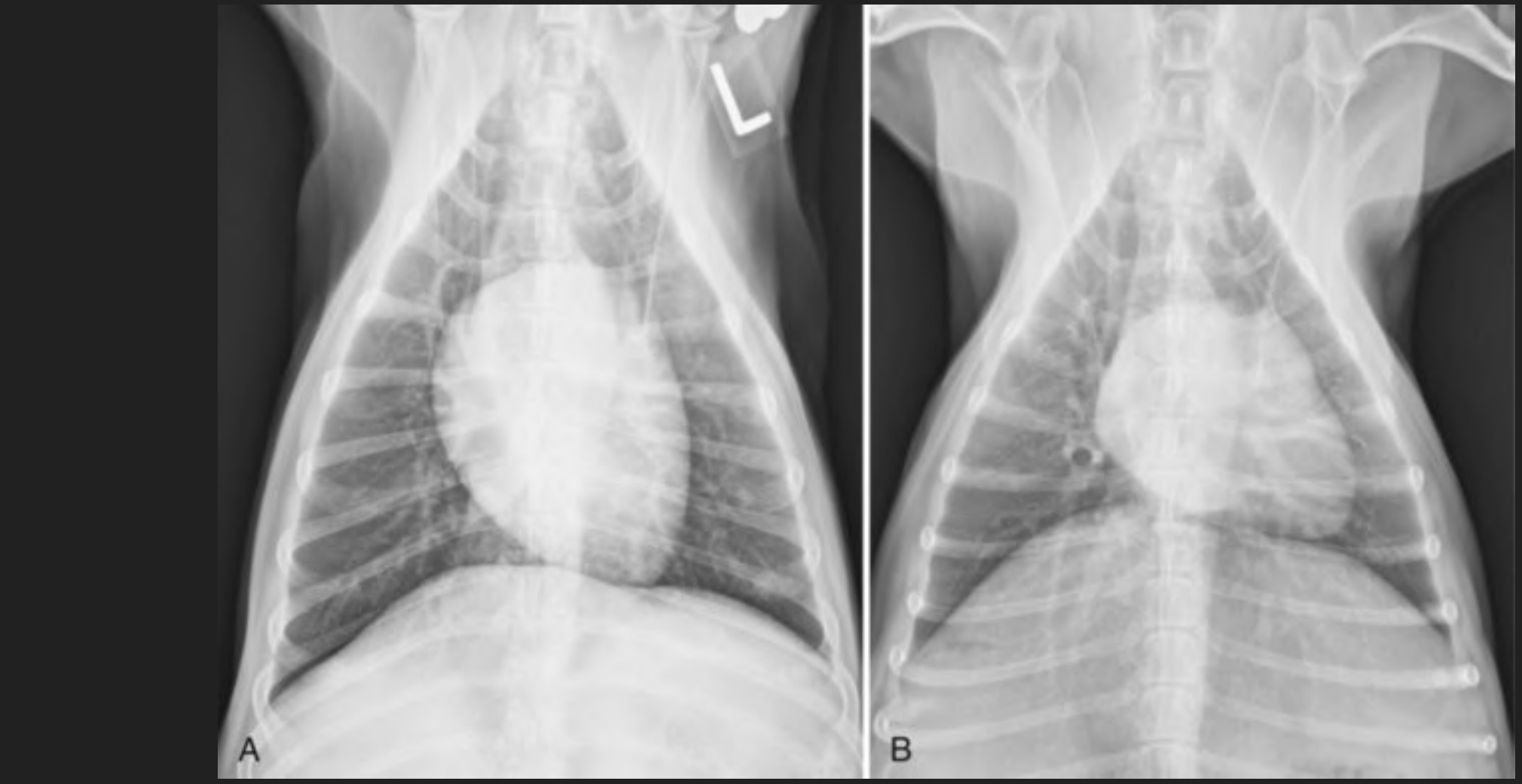

8
9

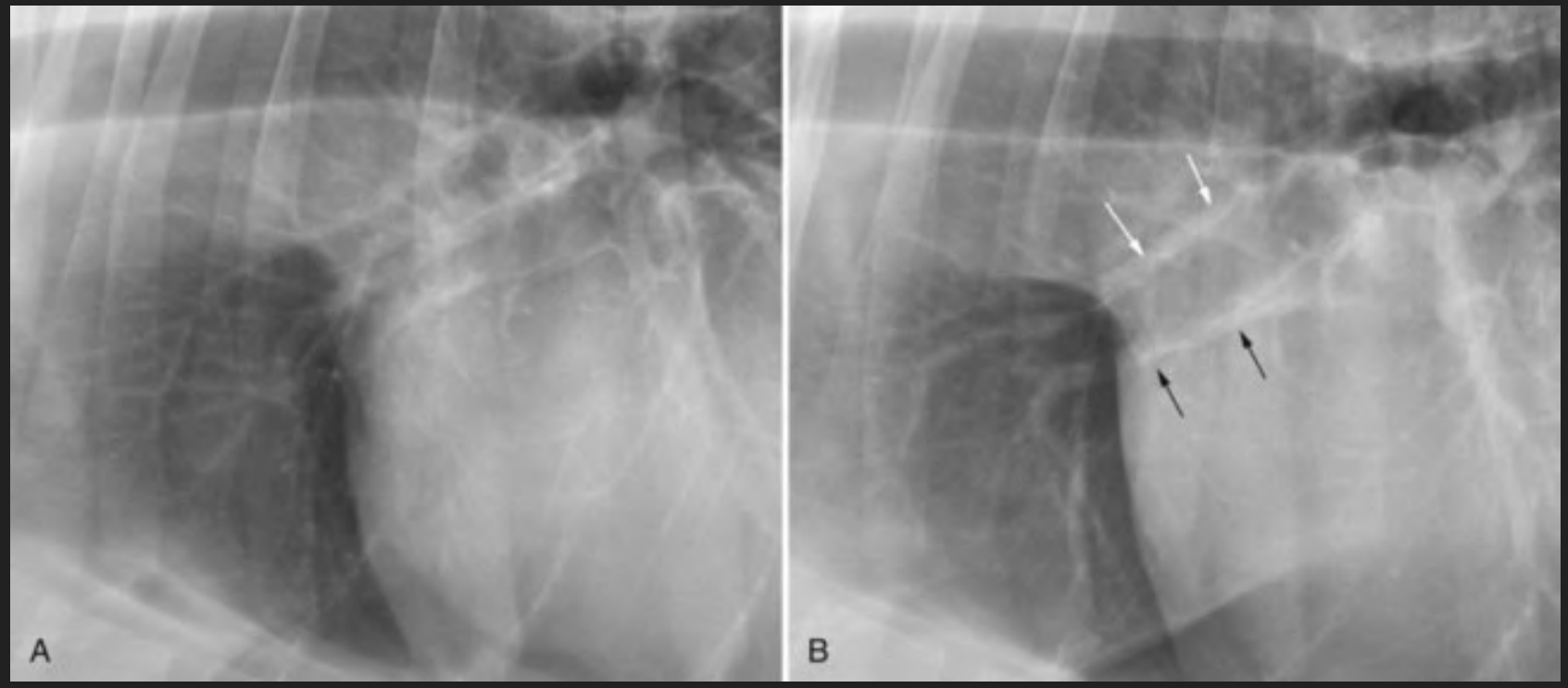

A
B

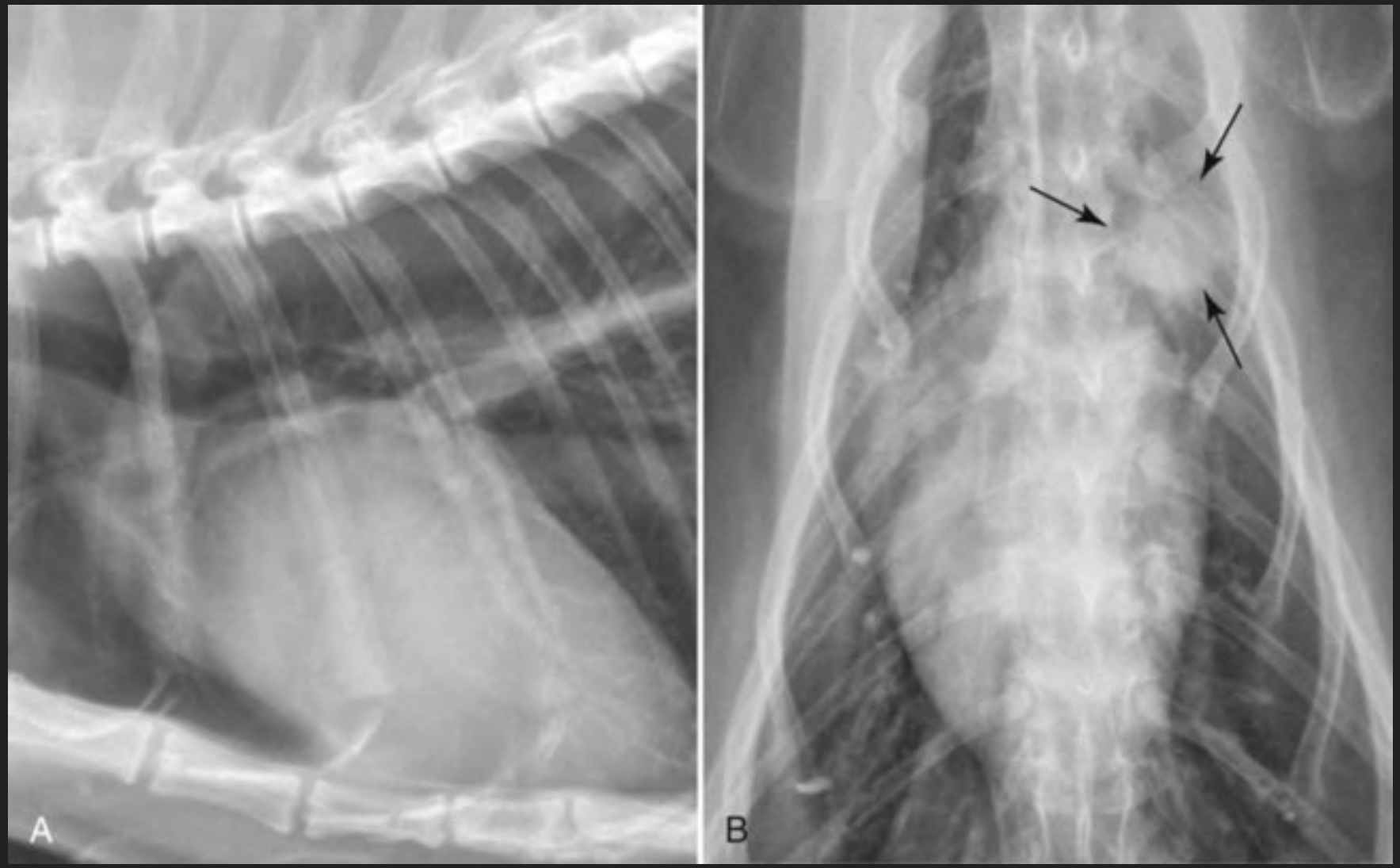

C
D

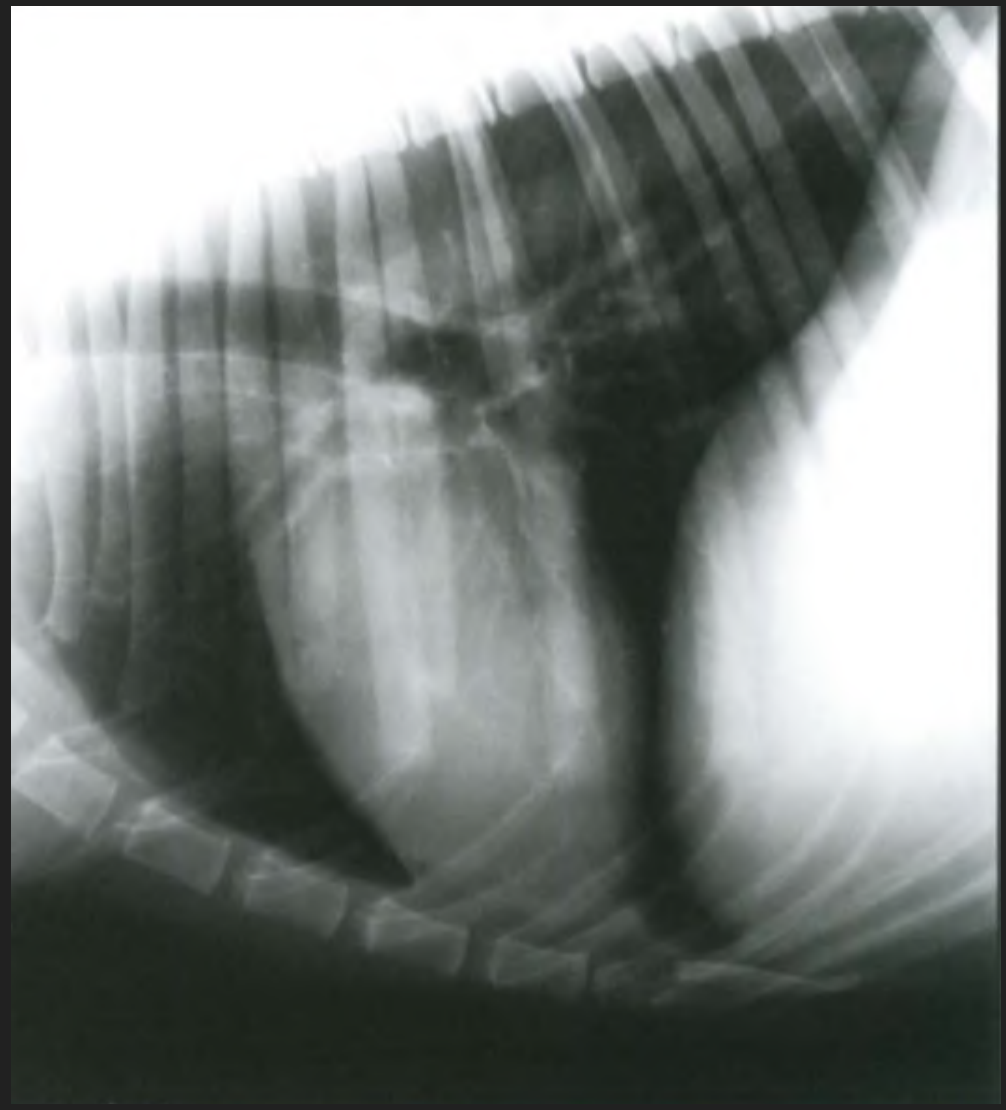

E
F




L
A
B

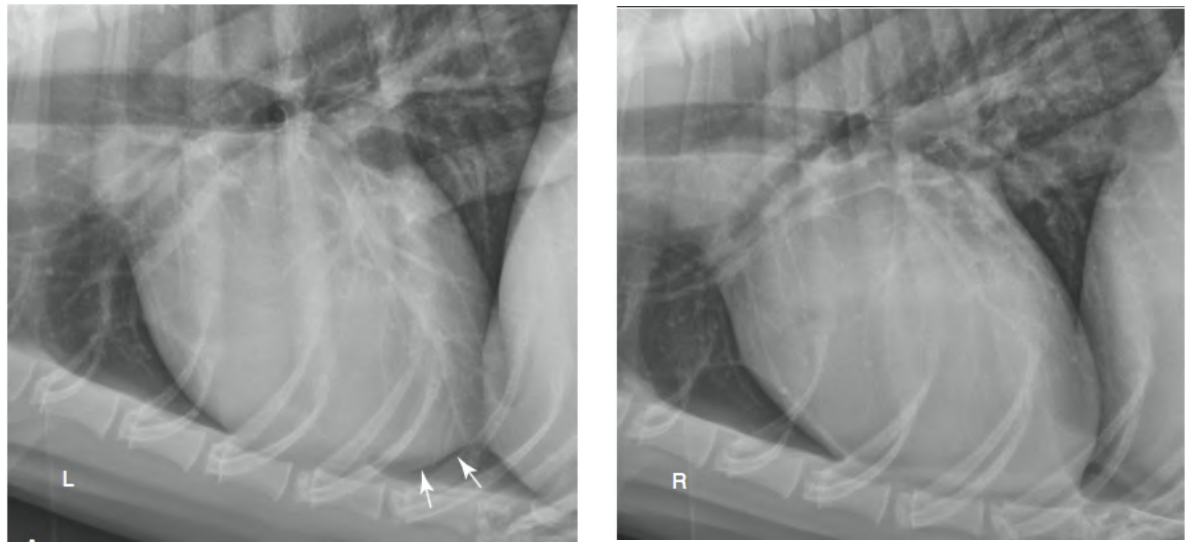

A
B


A
B



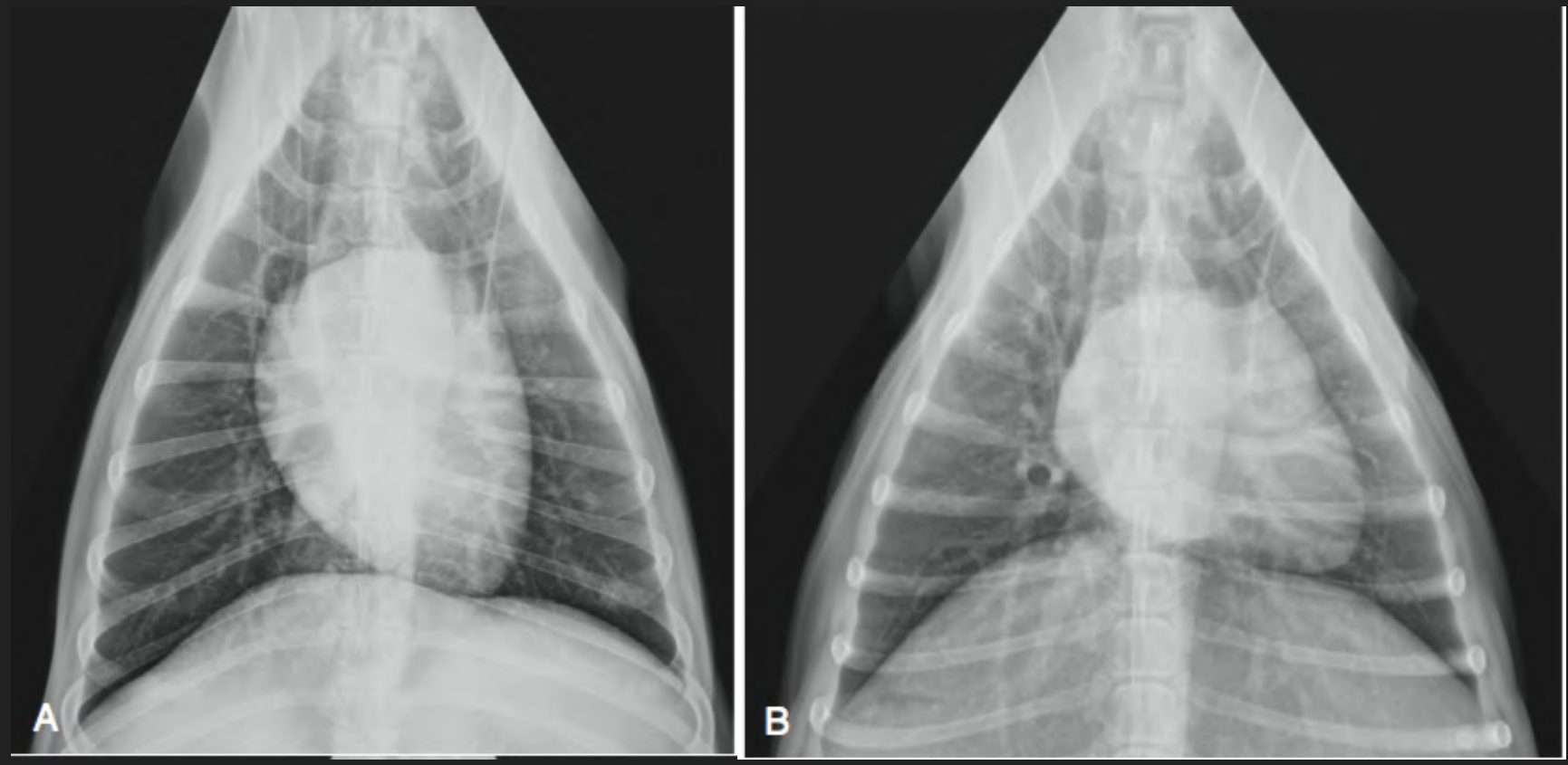
Heart/ Lateral

- The heart will appear slightly more round and the apex may be slightly elevated from the sternum in the left lateral view compared with the right lateral view.



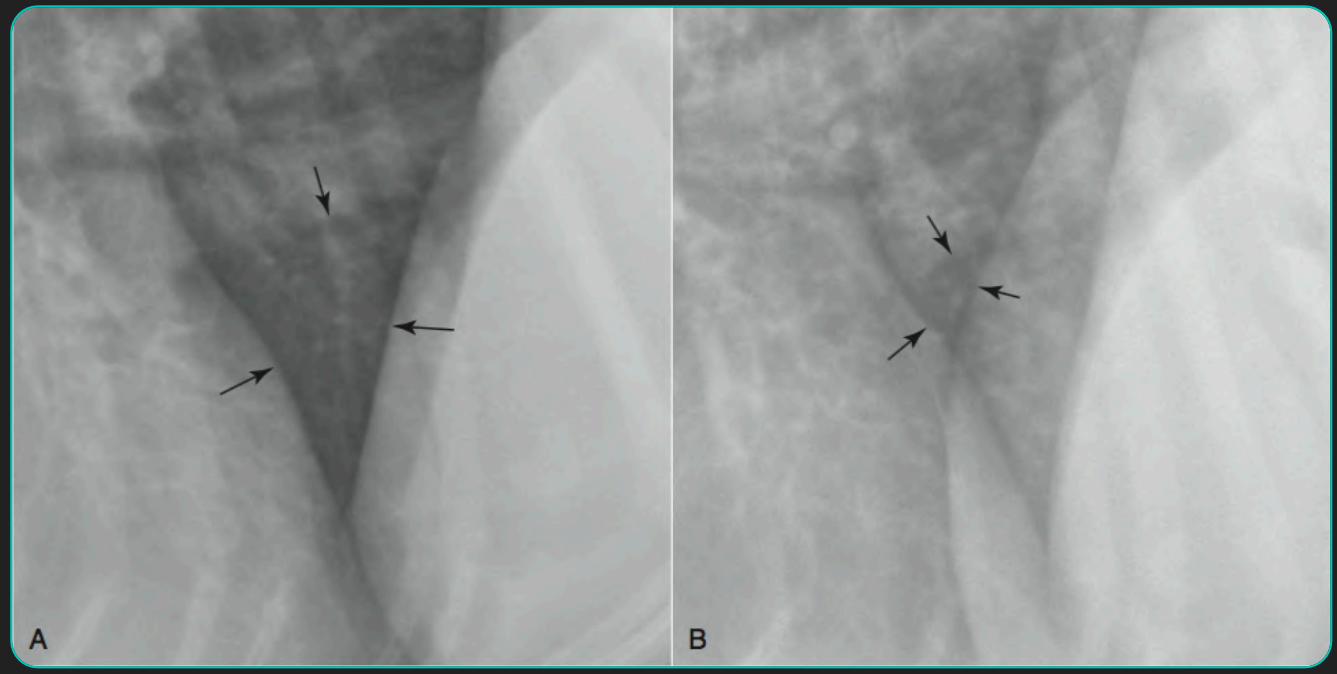
Heart/ VD,DV

- In DV radiograph:
  - diaphragm is displaced cranially where it contacts the heart and displaces it
  - The rounder appearance and displacement to the left misinterpreted as cardiomegaly.
- In VD
  - The heart is more upright



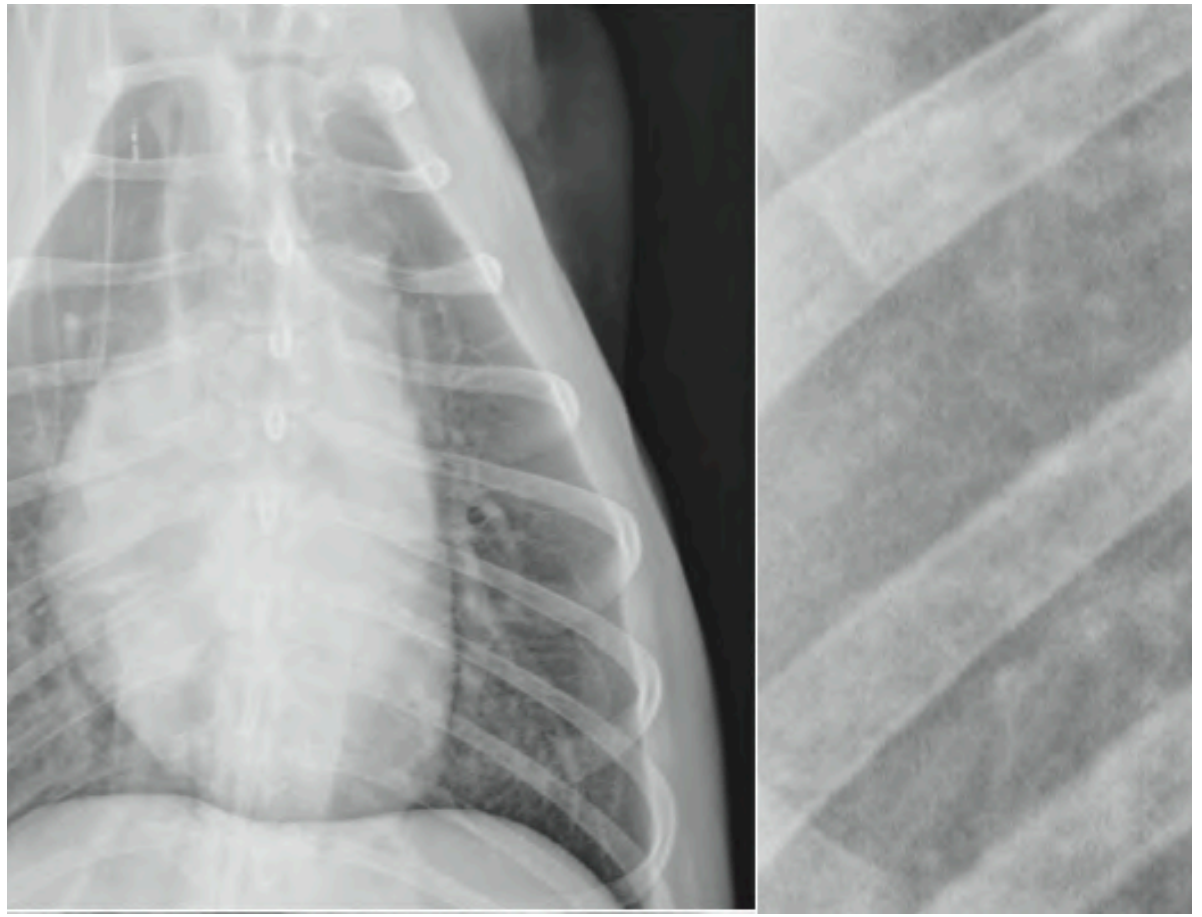
RADIOGRAPHIC TECHNIQUE:

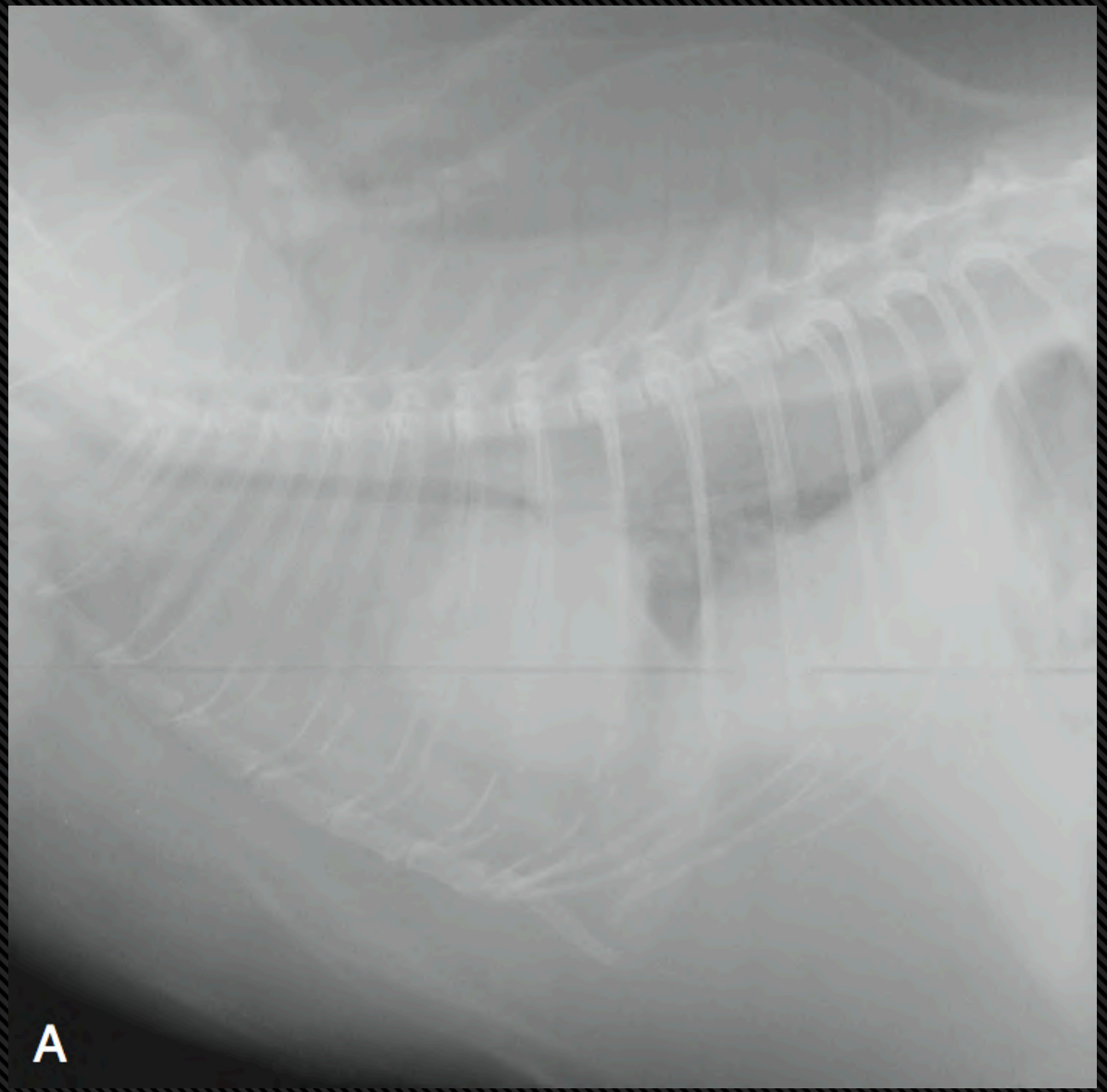
- high kVp–low mAs technique is preferable → long scale of contrast
- For patients thicker than 10 cm, a grid should be used
- Motion is the biggest enemy →the shortest exposure time and highest mA setting
- peak inspiration.

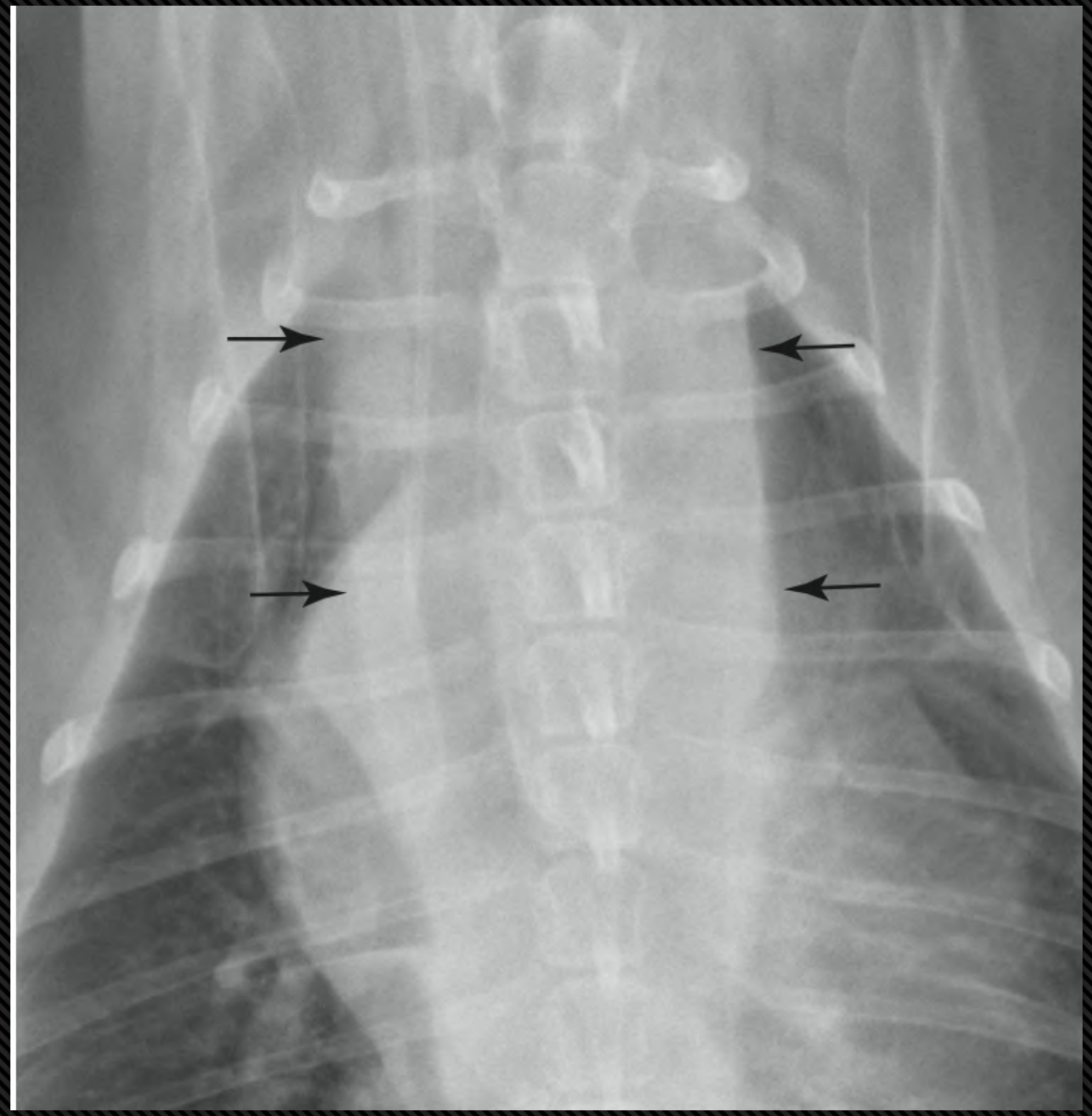


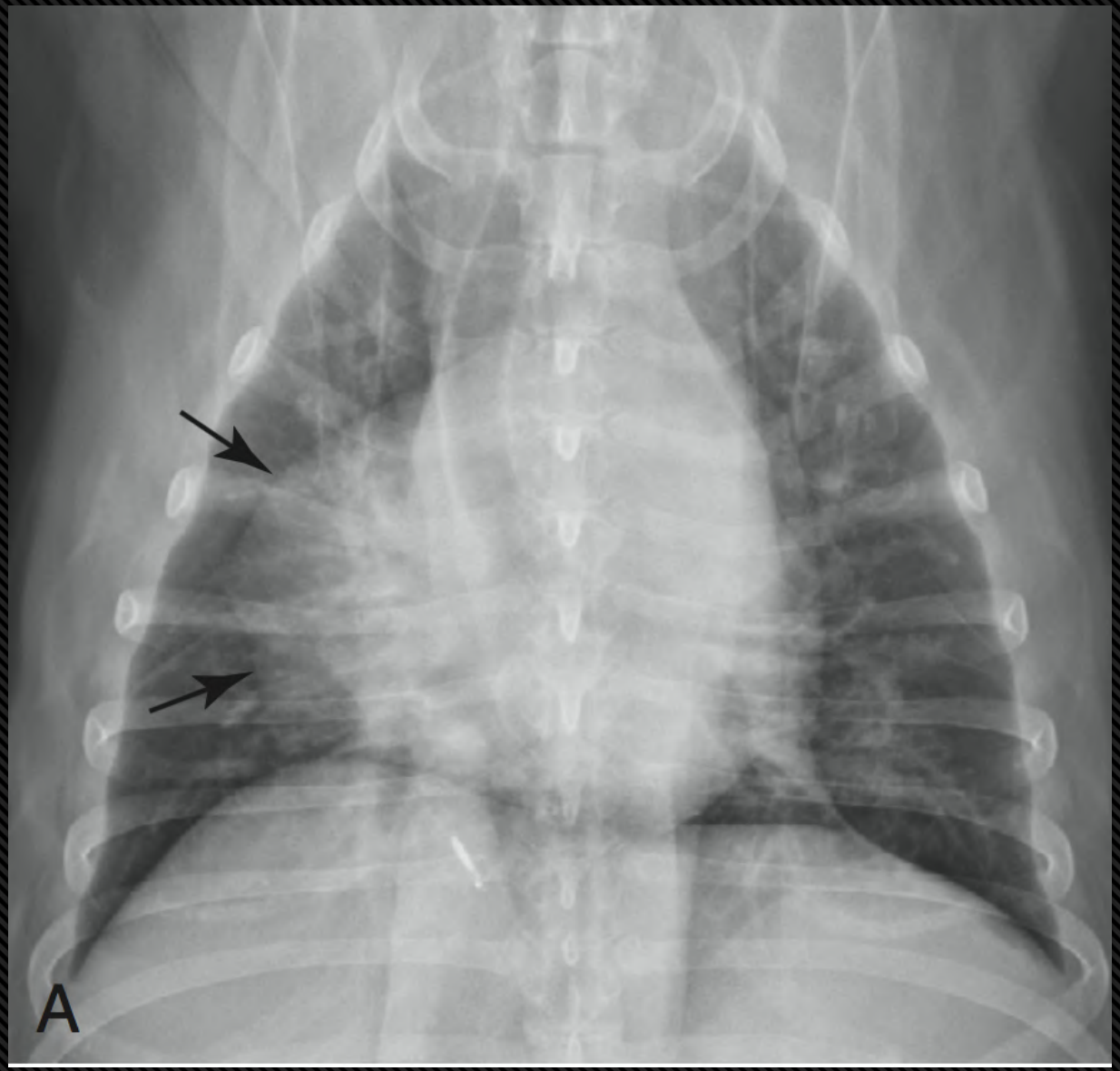
ANCILLARY FACTORS

- **Body Habitus**
  - overweight patients
  - The effect of overlying fat
  - Intrathoracic fat




A




A

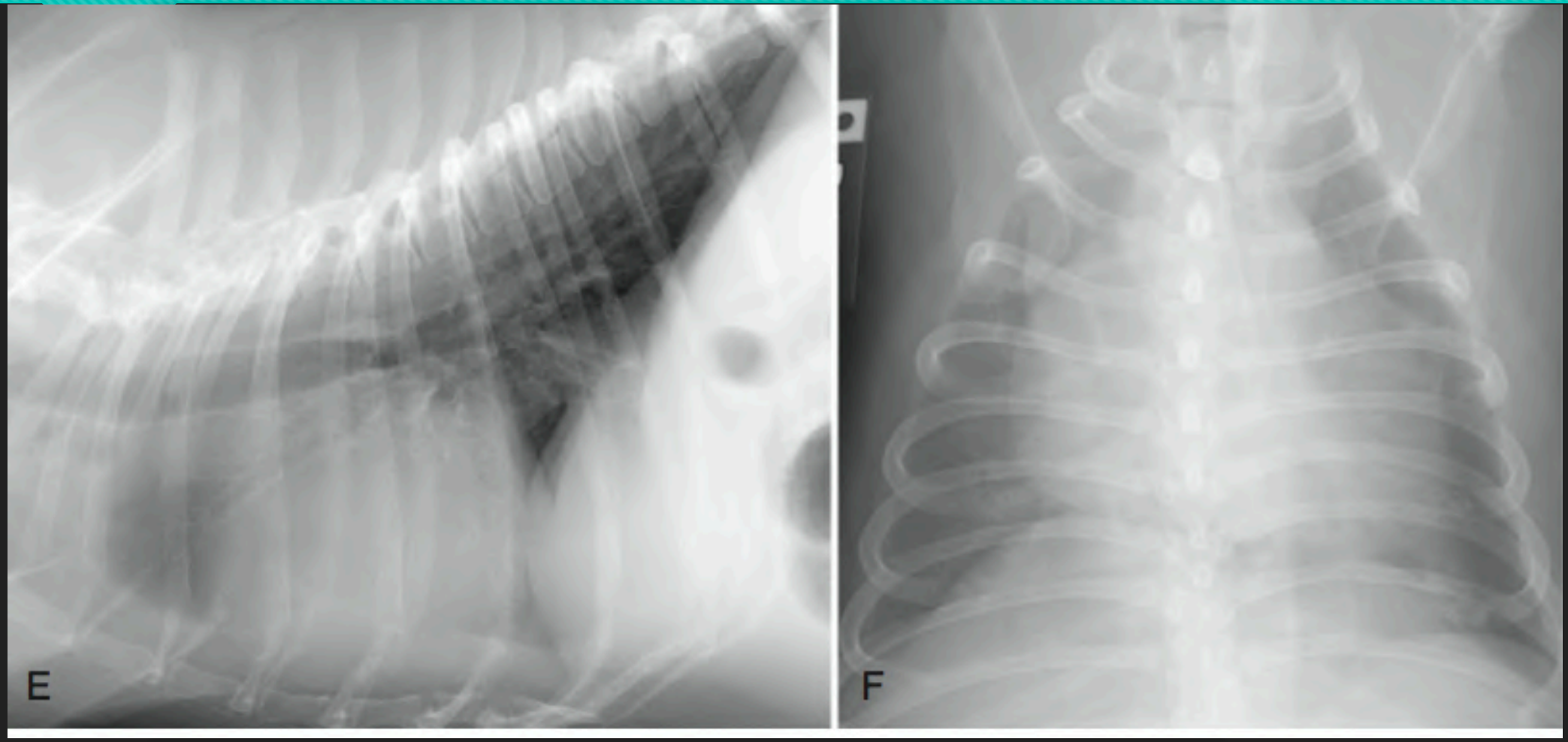
INTERPRETATION PARADIGM

- Are the radiographic views adequate
- Is the positioning adequate
- Is the radiographic technique adequate
- Was the patient sedated or anesthetized
- What is the breed and body habitus

Then read by the following order:

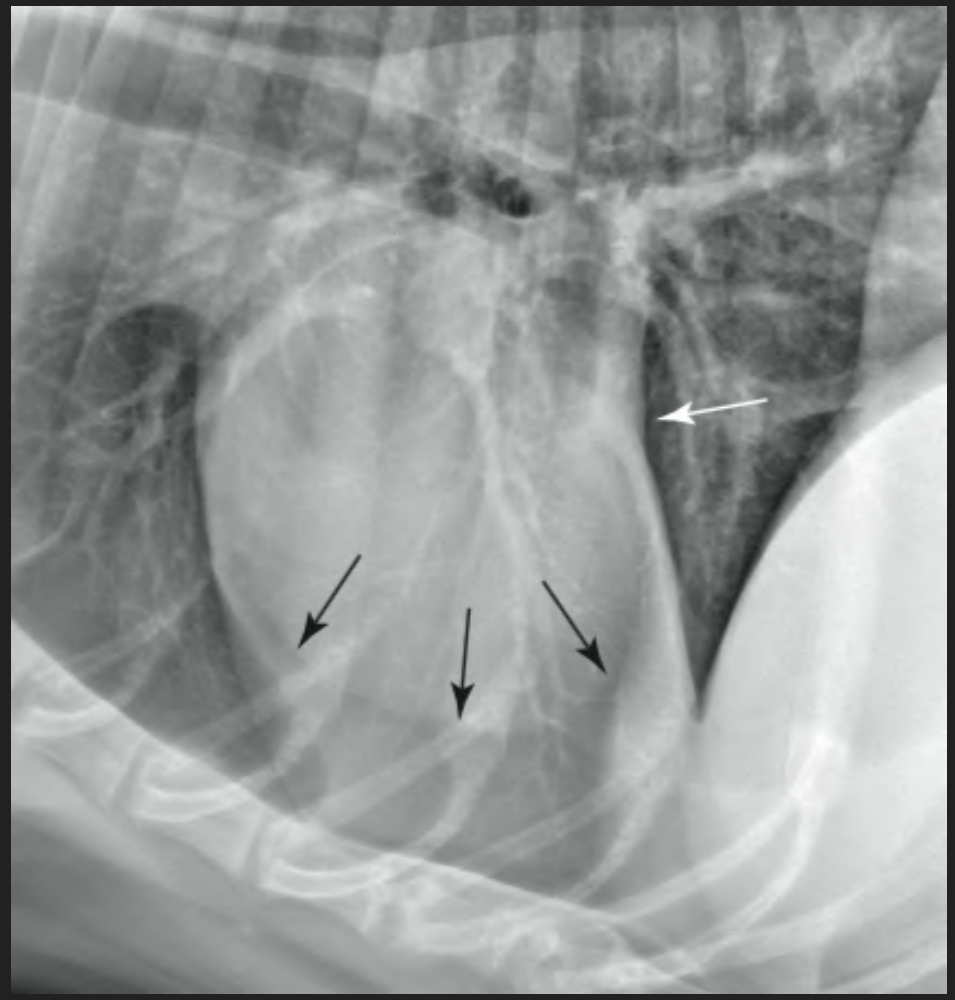
- (1) ribs, vertebrae, and sternebrae;
- (2) soft tissues of the thoracic wall;
- (3) pleural space;
- (4) mediastinum;
- (5) heart;
- (6) trachea
- (7) pulmonary vessels
- (8) the pulmonary parenchyma.

Canine and Feline Cardiovascular System



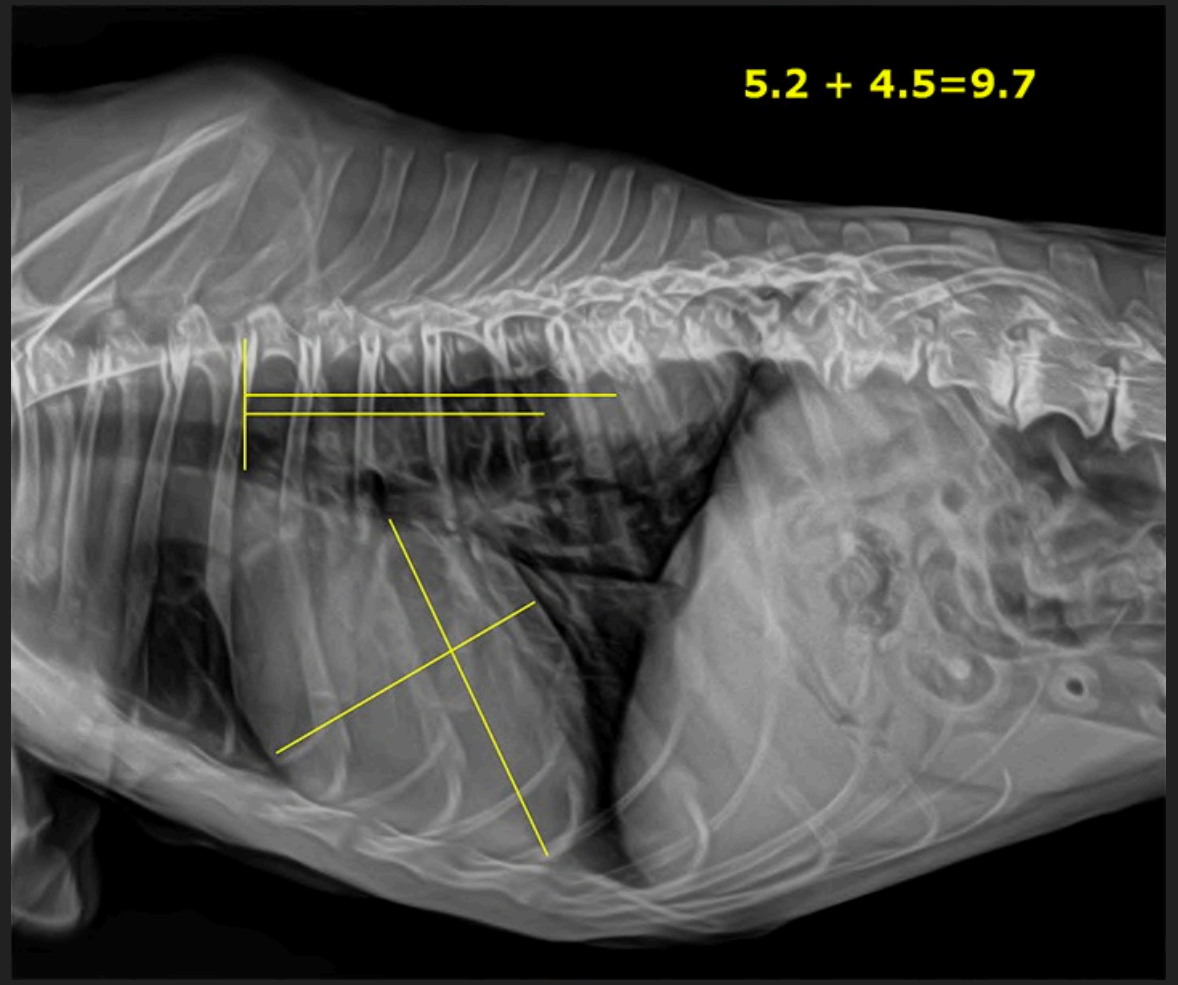
Cardiac Silhouette

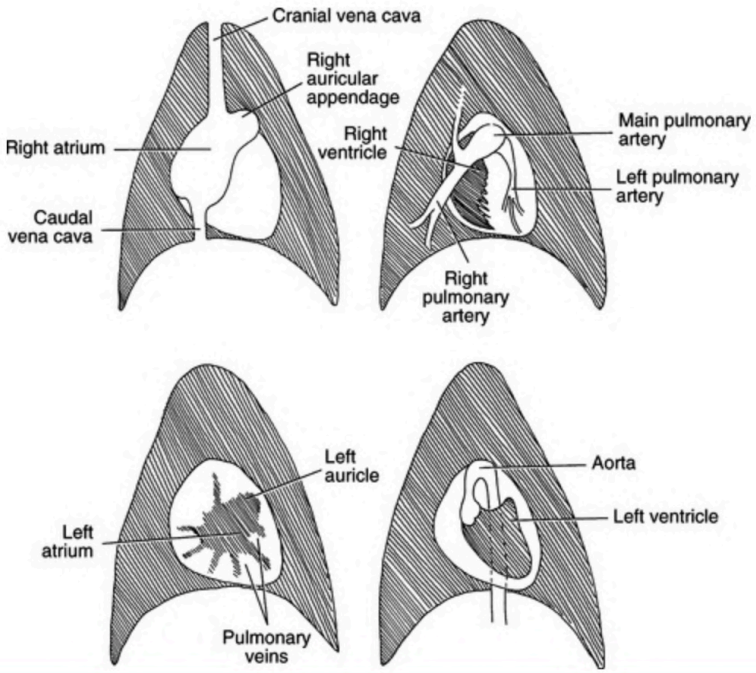
- In obese patients fat → increases the size of the cardiac silhouette.

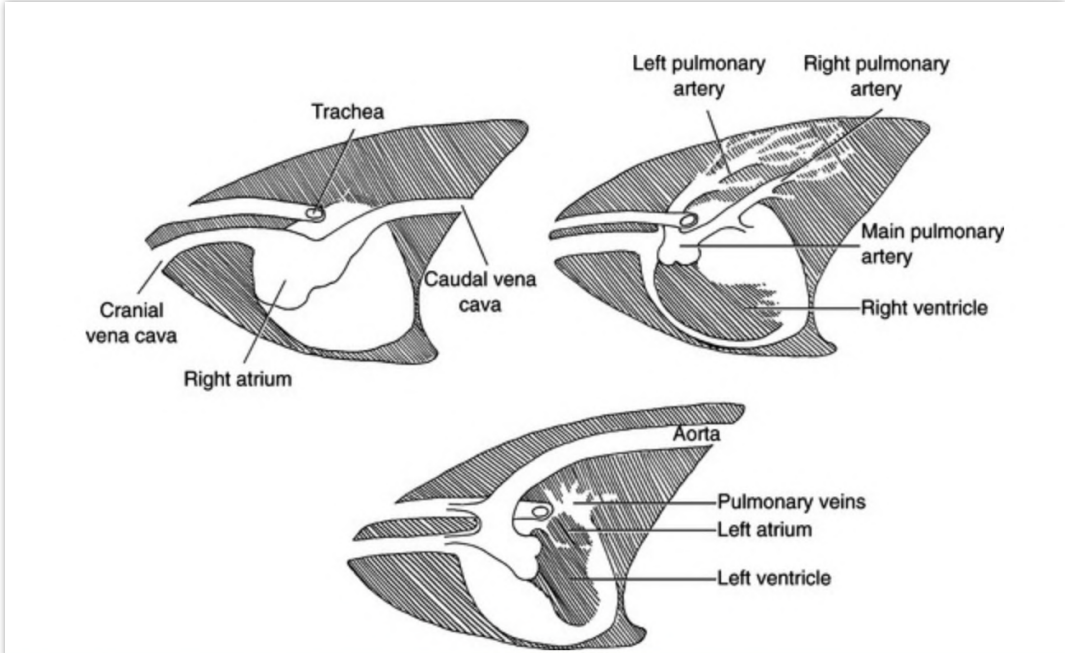


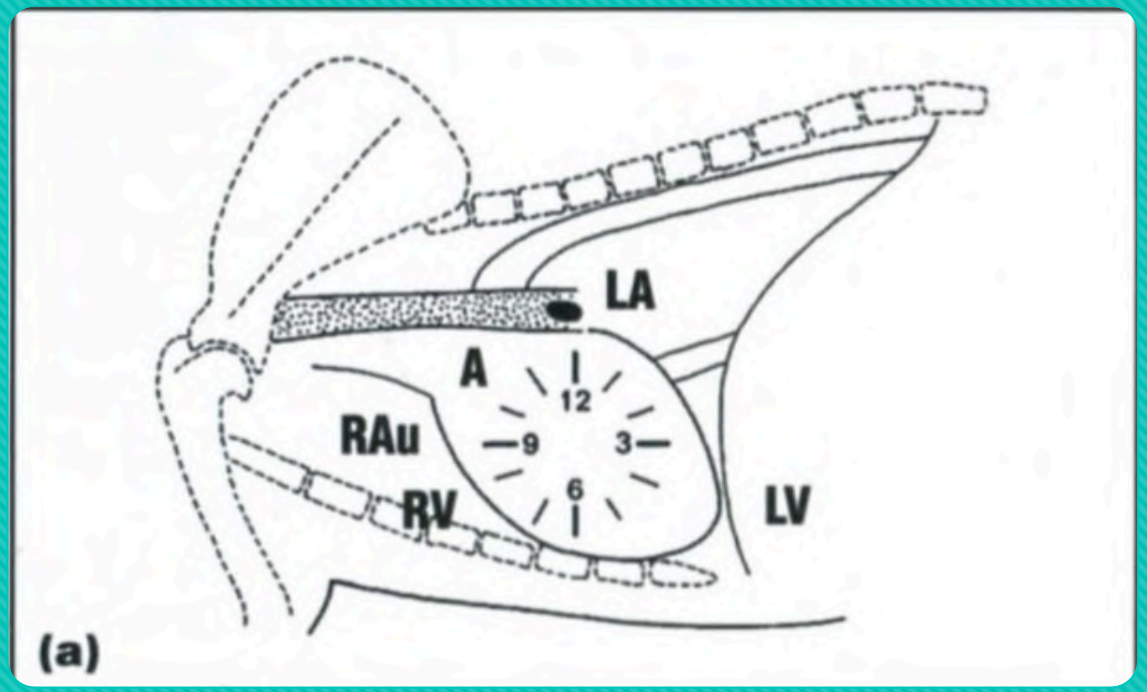
vertebral heart scale (VHS)

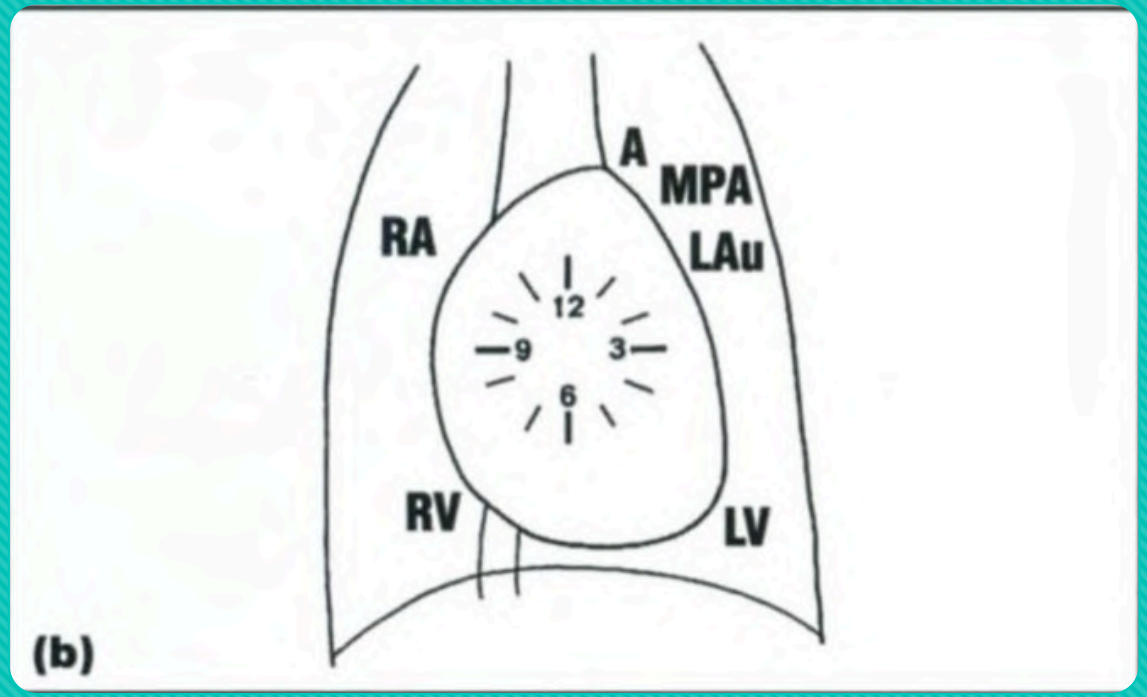
- The mean normal VHS is 9.7 vertebrae plus or minus one (8.7 to 10.7)!!
- respiratory and cardiac cycle can lead to a difference of nearly 1.0 vertebral body lengths
- the best use of the VHS is to compare cardiac size on serial radiographs of the same patient made over time to monitor disease progression or response to treatment.




Cranial vena cava
Right auricular appendage
Right atrium
Right ventricle
Main pulmonary artery
Left pulmonary artery
Caudal vena cava
Right pulmonary artery
Left auricle
Aorta
Left ventricle
Left atrium
Pulmonary veins

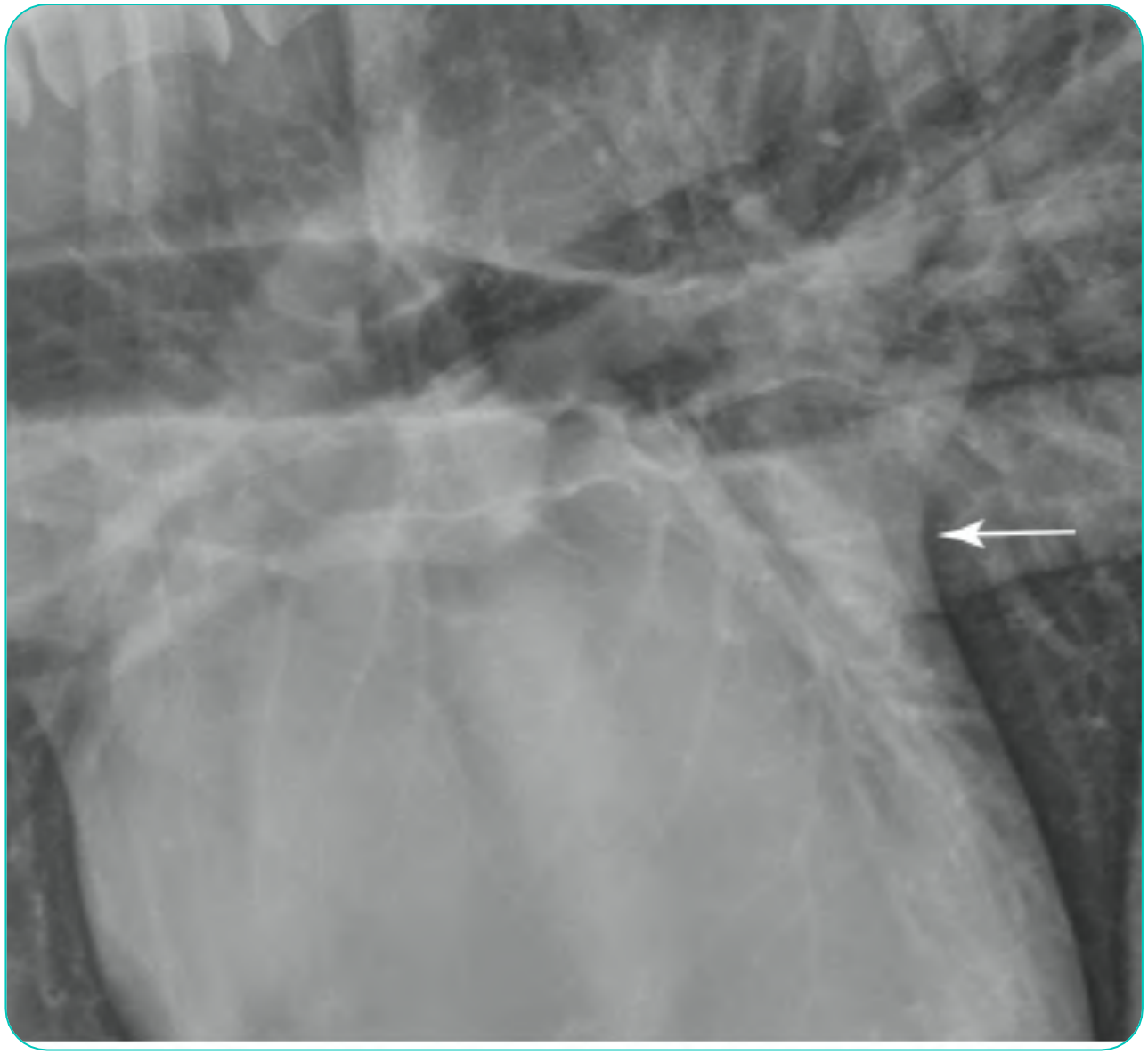

Trachea
Left pulmonary artery
Right pulmonary artery
Main pulmonary artery
Right ventricle
Caudal vena cava
Cranial vena cava
Right atrium
Aorta
Pulmonary veins
Left atrium
Left ventricle





Clockface analogy

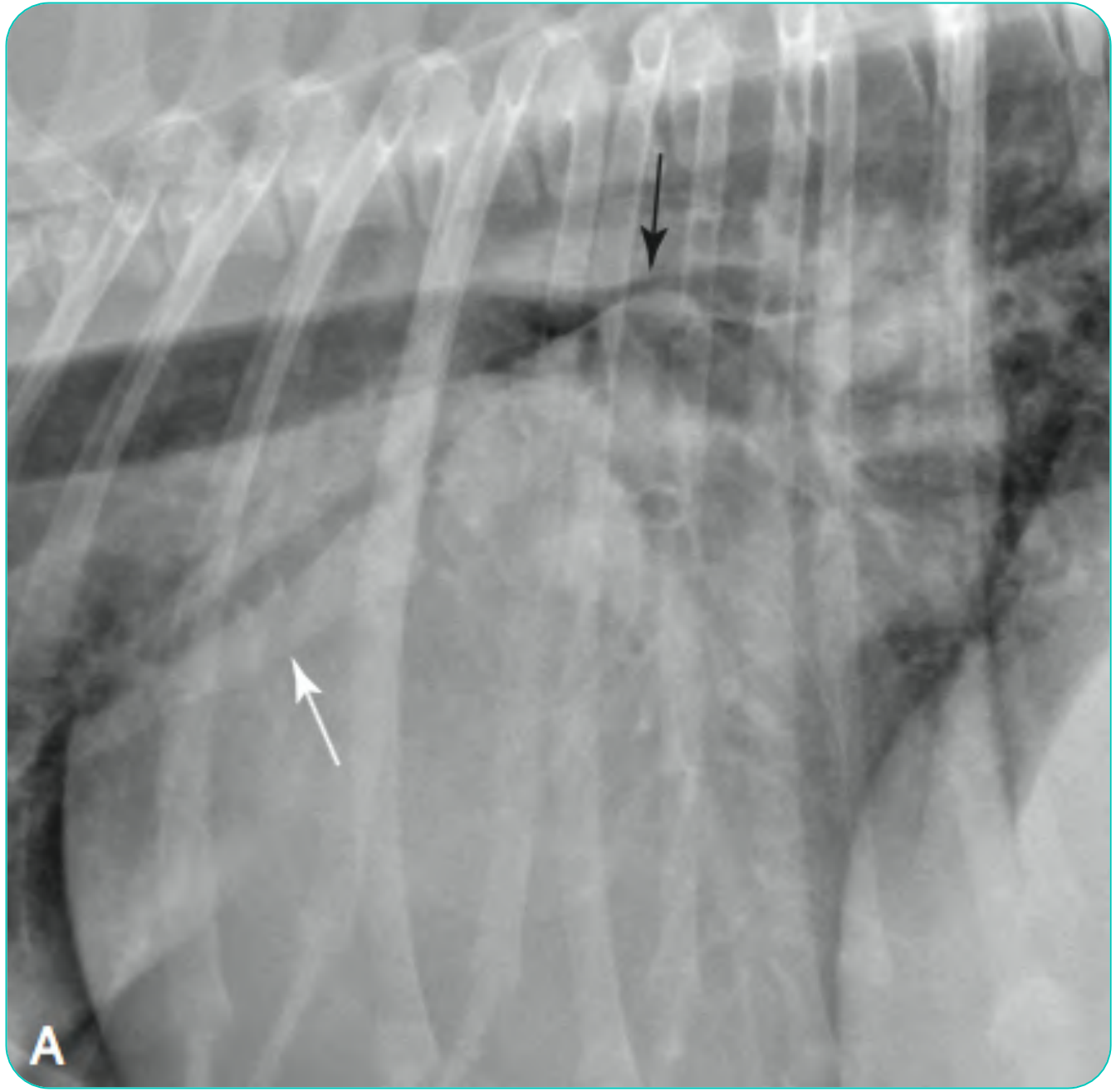
Radiographic Signs of Specific Cardiac Chamber Enlargement

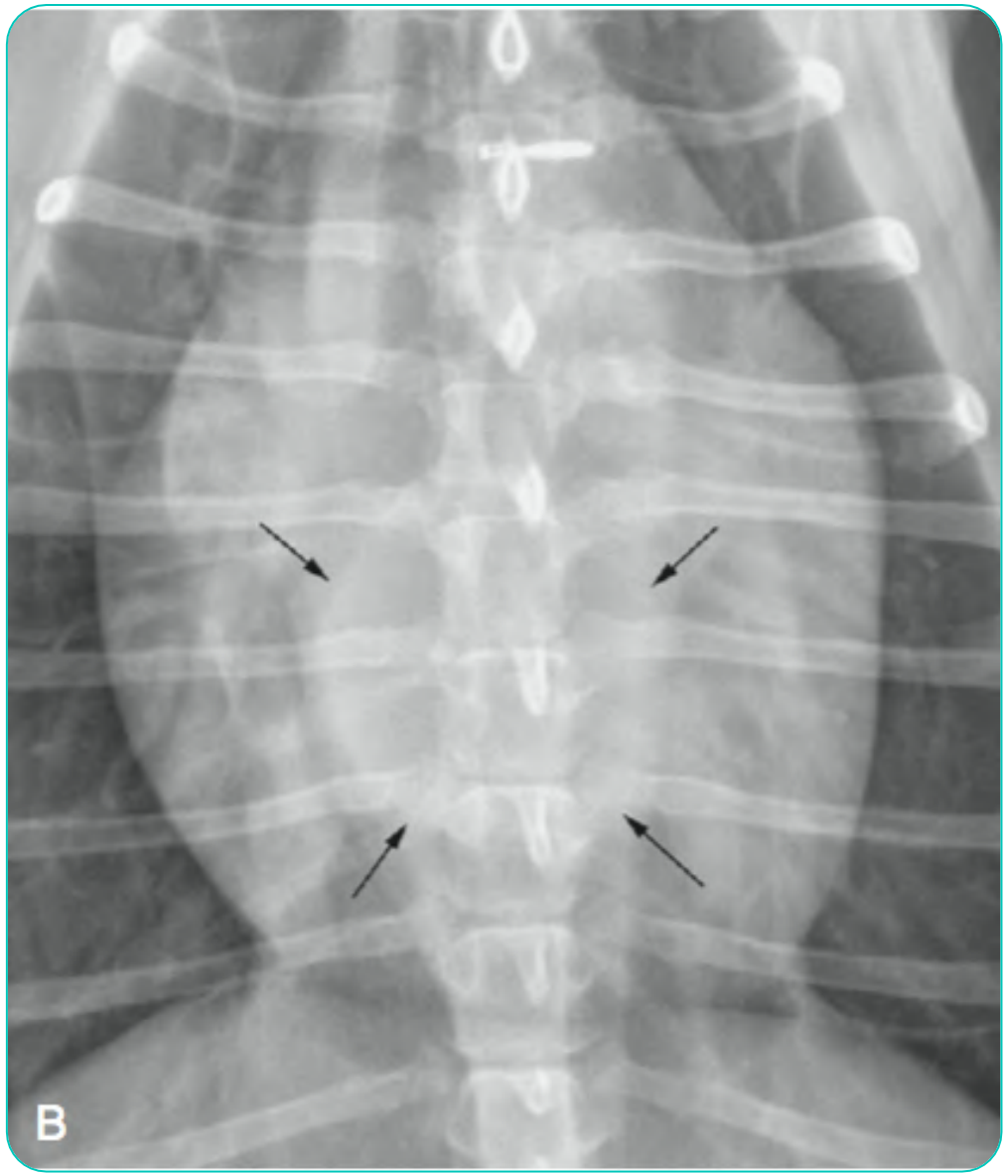


Left Atrium

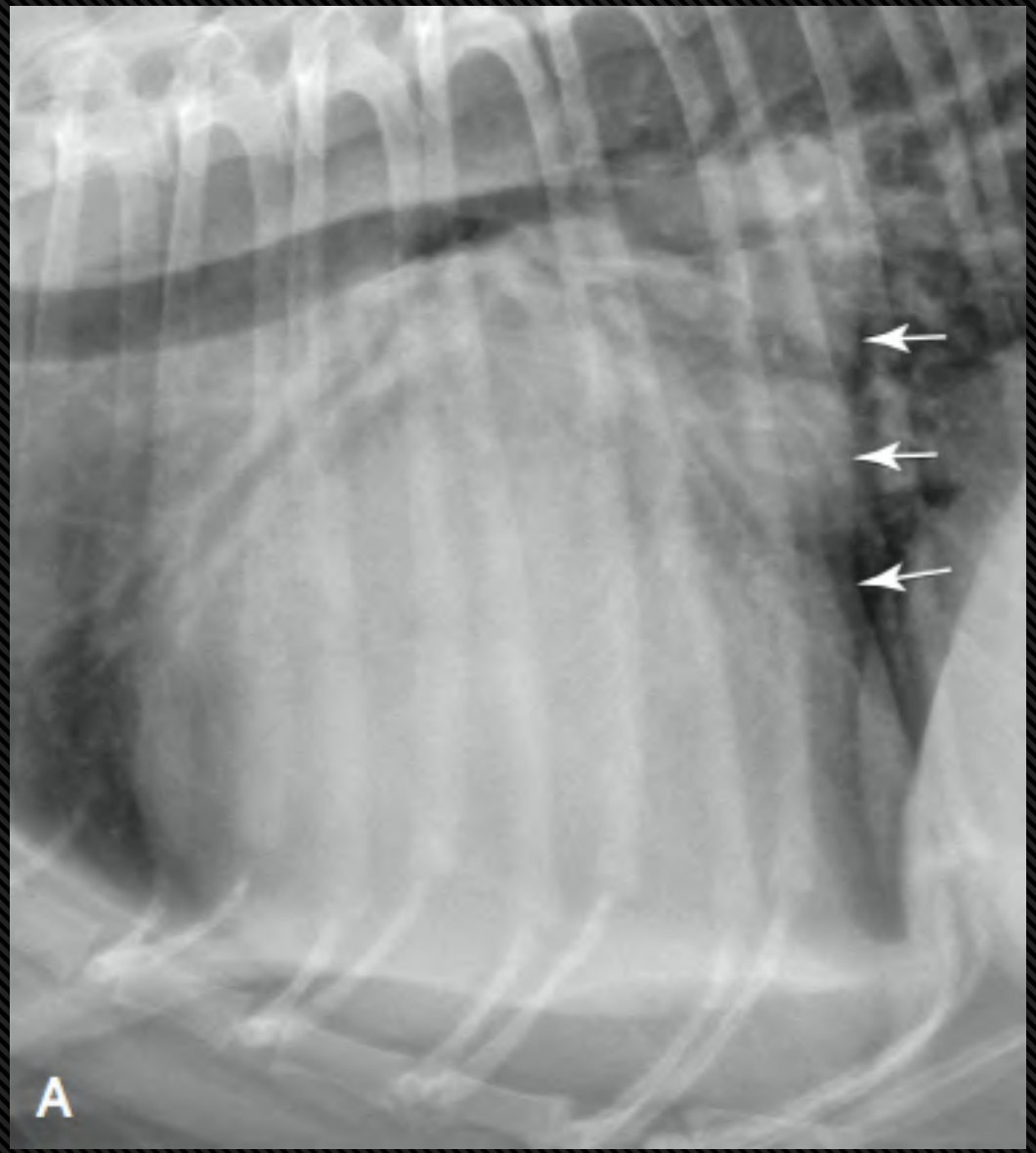
- Dilation:
  - most frequented Myxomatous mitral valve disease
  - left-to-right pulmonary overcirculation causing volume overload

- Narrowing of the bronchi is most likely not due solely to impingement from the subjacent dilated left atrium but more likely to coexisting bronchial chondromalacia with dynamic bronchial collapse.
- bronchomalacia will typically exhibit a cough



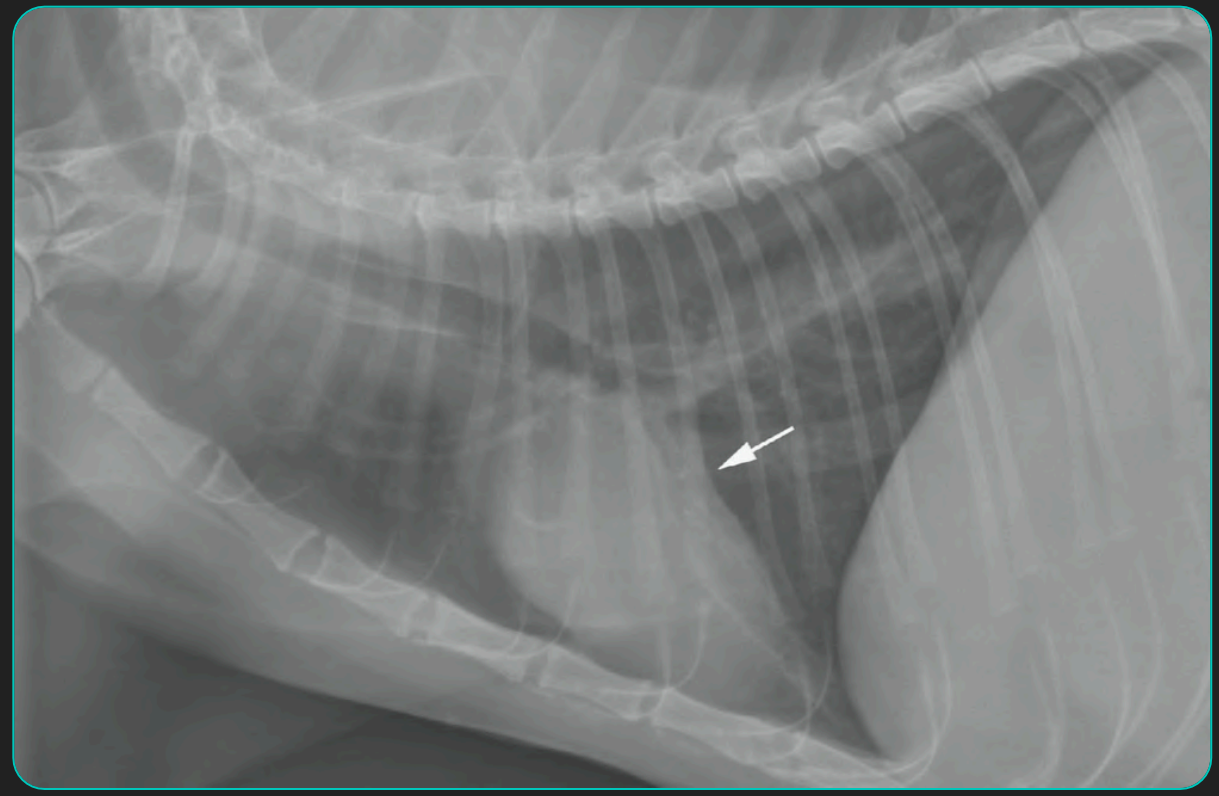


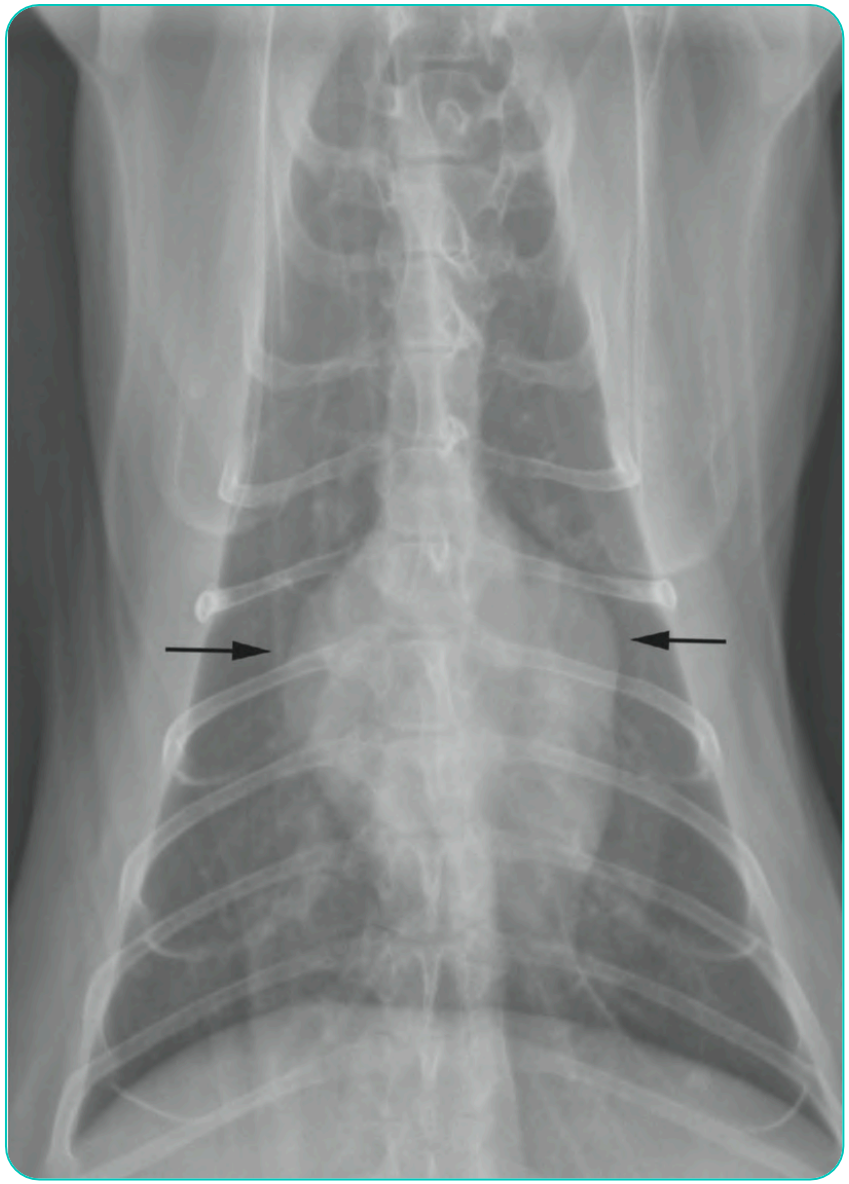
- Dilation of the left atrium may also cause divergence of the principal bronchi in the VD or DV view.


A

LA enlargement in cats

- In some cats, a focal concave defect will be present on the dorsocaudal aspect of the cardiac silhouette, but this is not as common as in the dog



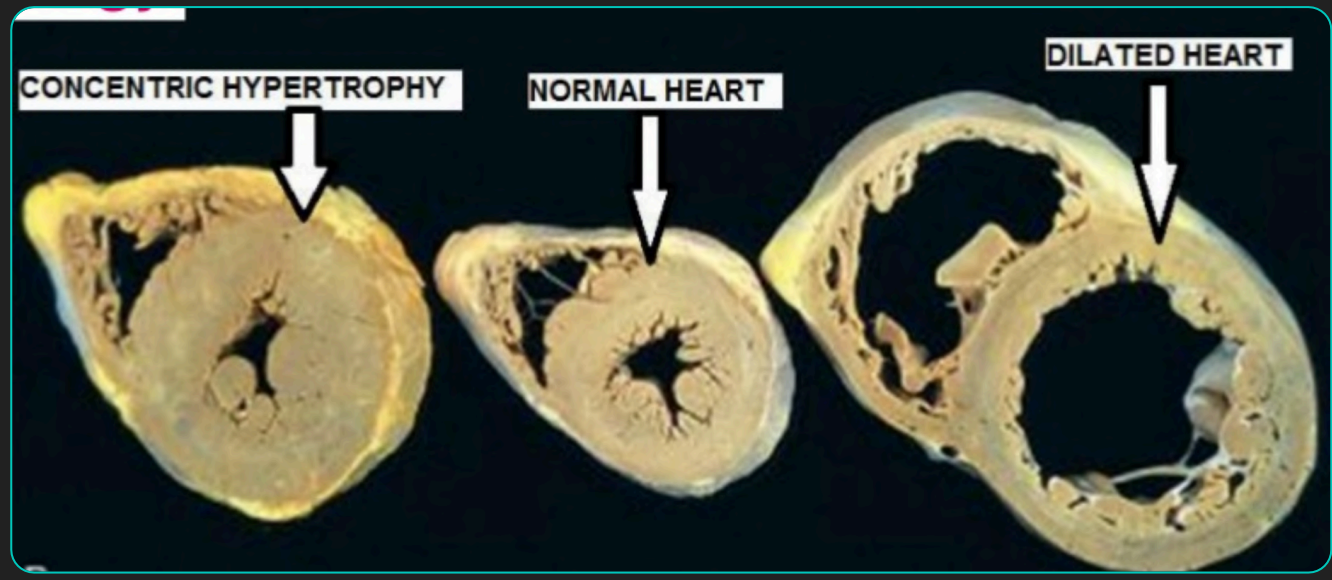


LA dilation in cats

- an increase in width of the cardiac base in the VD or DV view “valentine-shaped”.

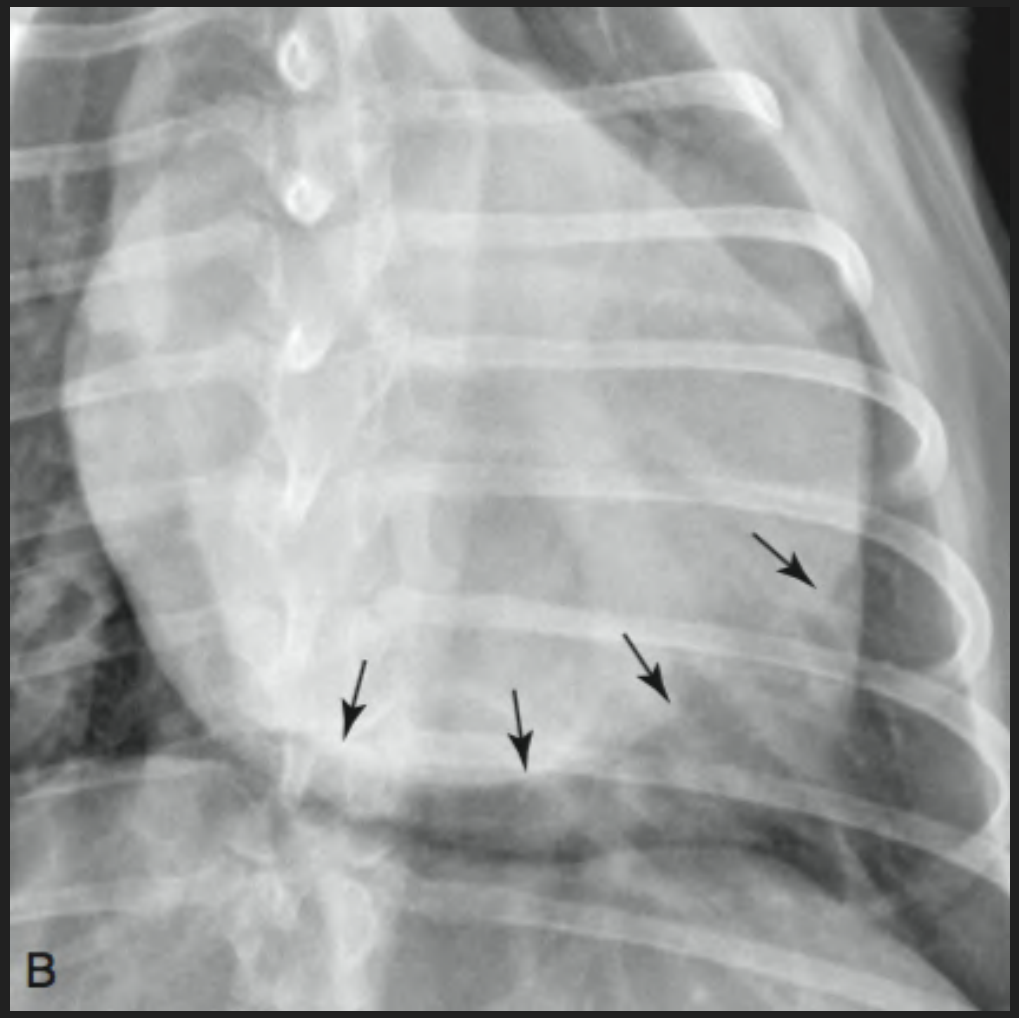
Left Ventricle enlargement

- Enlarges as a result of hypertrophy or dilation.
  - Concentric hypertrophy
    - Response to increased afterload such as with aortic stenosis
  - Eccentric hypertrophy
    - Response to increased preload, as in patent ductus arteriosus or mitral insufficiency



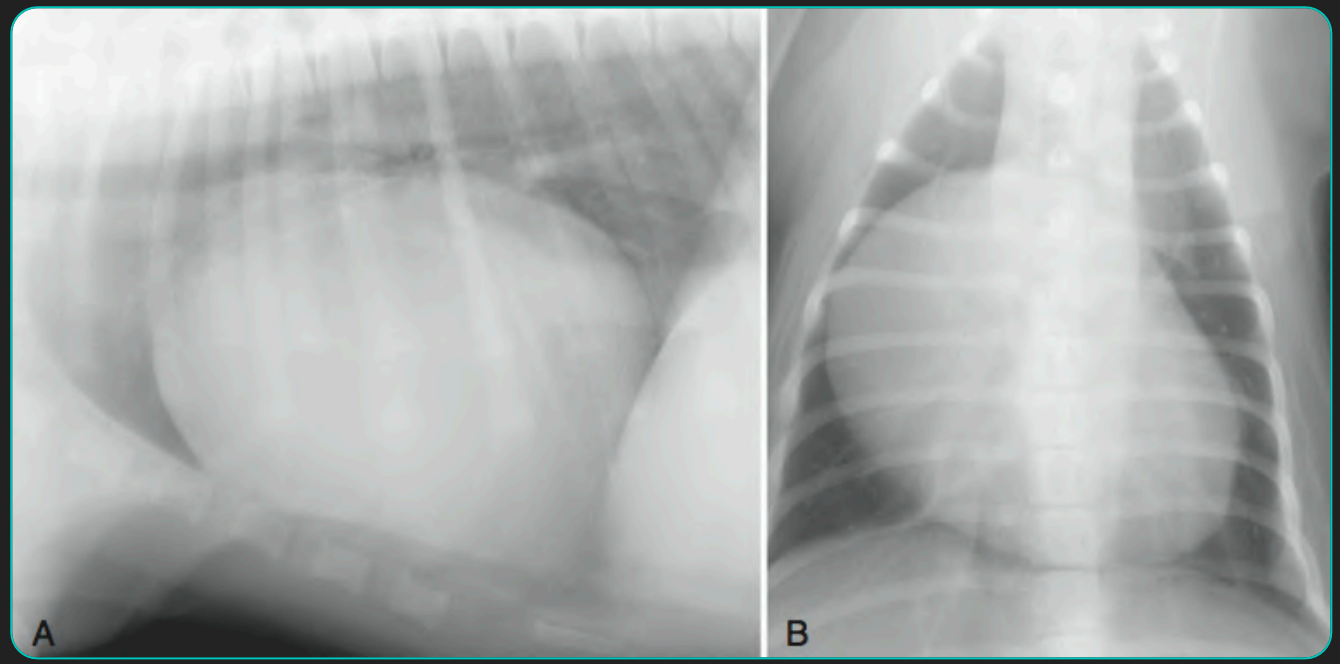
Left Ventricle Enlargement

- Severe, eccentric hypertrophy → elevation of the trachea → narrowing the angle between the trachea and the thoracic vertebrae.
- In the VD or DV view, the cardiac apex may appear more blunted, and the left heart border may appear to be more rounded than its normally straight appearance.



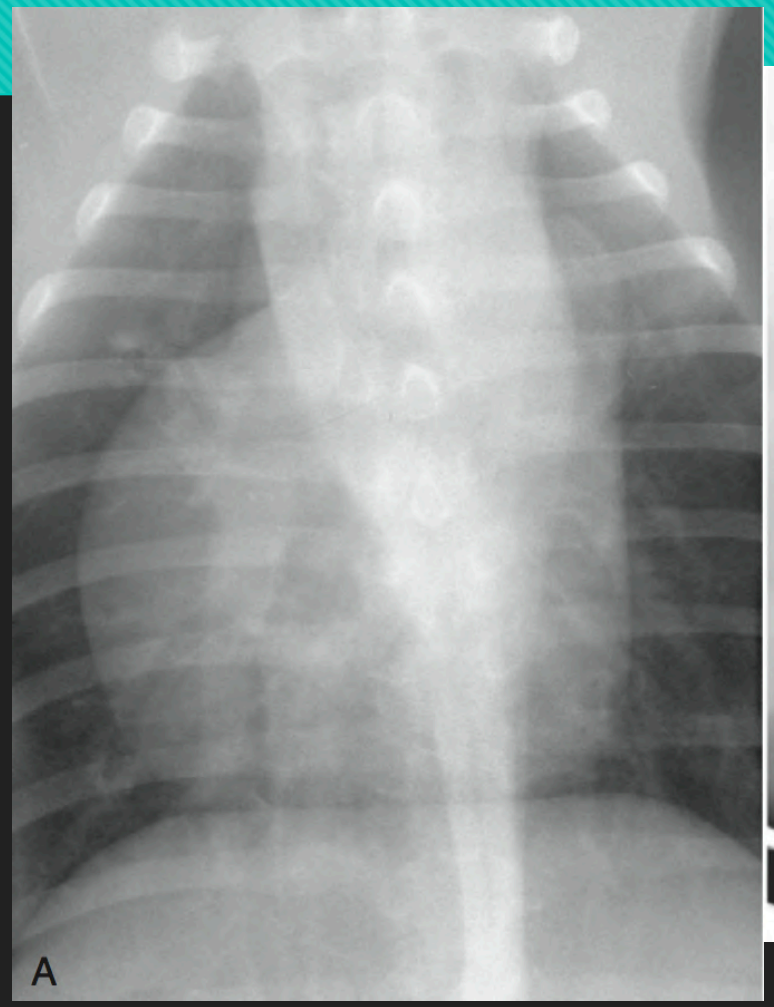
Right Atrium

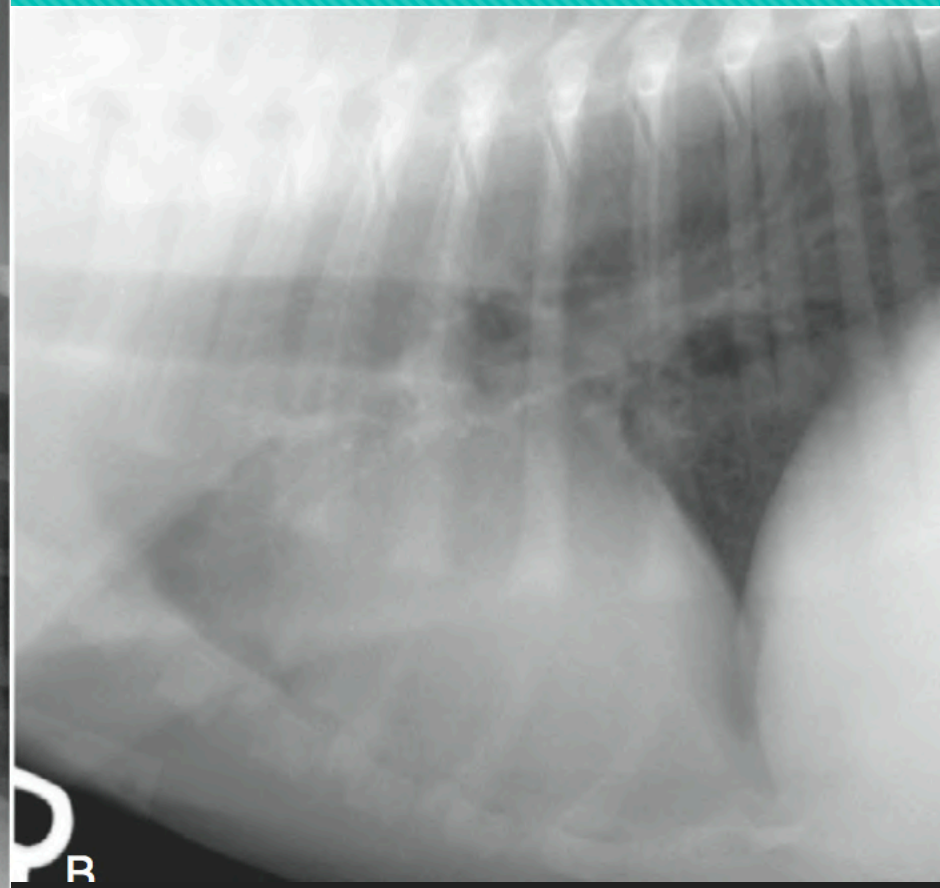
- is uncommon and occasionally seen in dogs with tricuspid dysplasia.
- dilation of the aortic arch and main pulmonary artery can also cause this radiographic appearance in the lateral view.
- In the VD or DV projection, an increased bulge in the right heart border from the 9 o'clock to 11 o'clock position may be present.



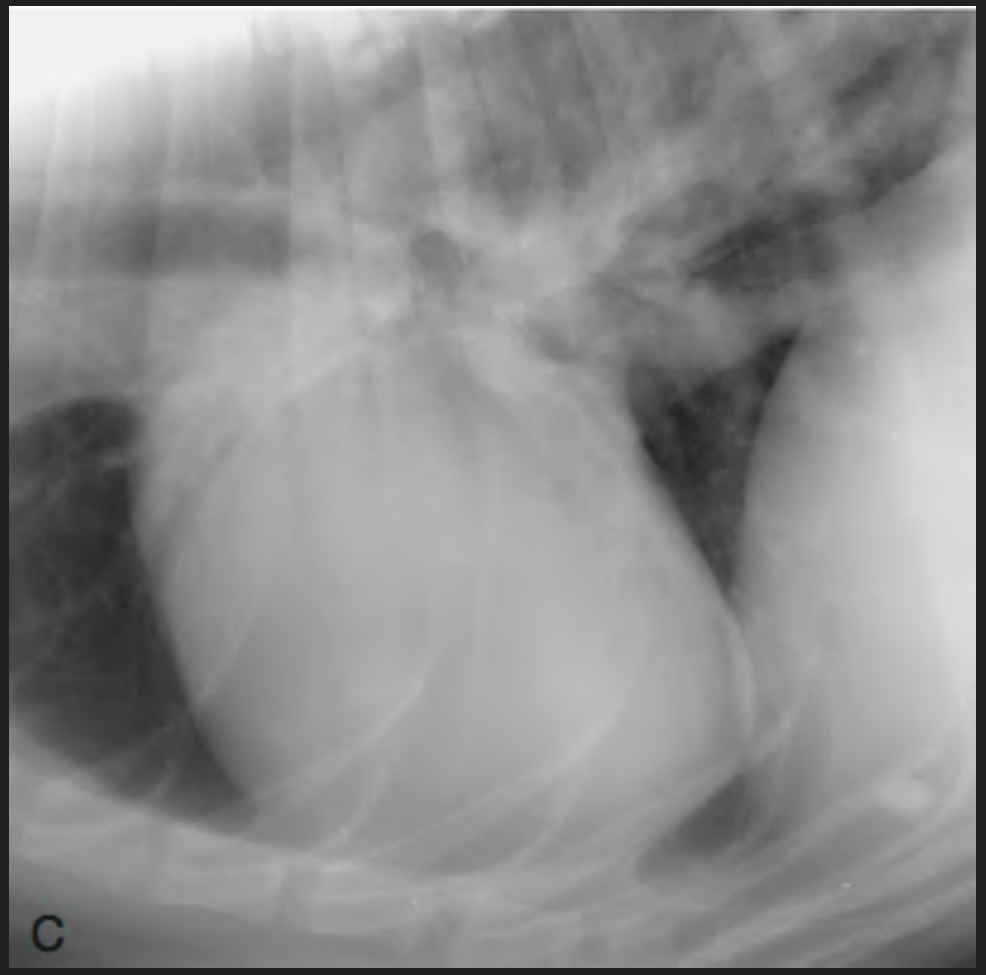
Right Ventricle

- in the cat is not common.
- in response to increased afterload, as with pulmonic stenosis or pulmonary hypertension, which is commonly seen in heartworm disease.
- normal=2.5 to 3 intercostal spaces
- deep-chested breeds=1.5 to 2 intercostal spaces
- barrel-chested breeds= 3 to 3.5 intercostal spaces



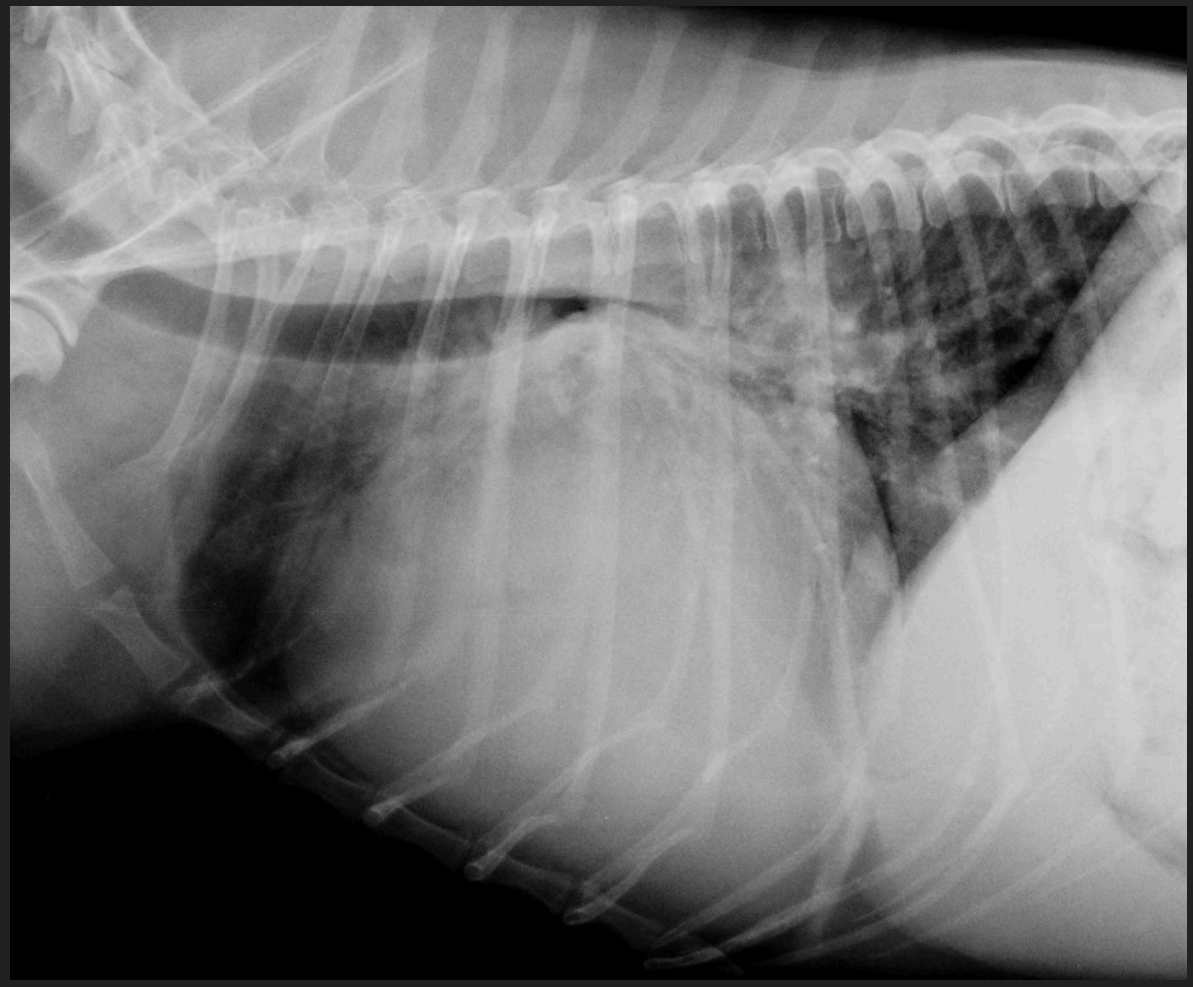


- Right ventricular hypertrophy can also lead to the cardiac apex being displaced dorsally from the sternum
- reversed letter D shape



Generalized Cardiomegaly

- Dilated cardiomyopathy is a common cause of generalized cardiomegaly.
- May misinterpreted because of underinflation of the lungs

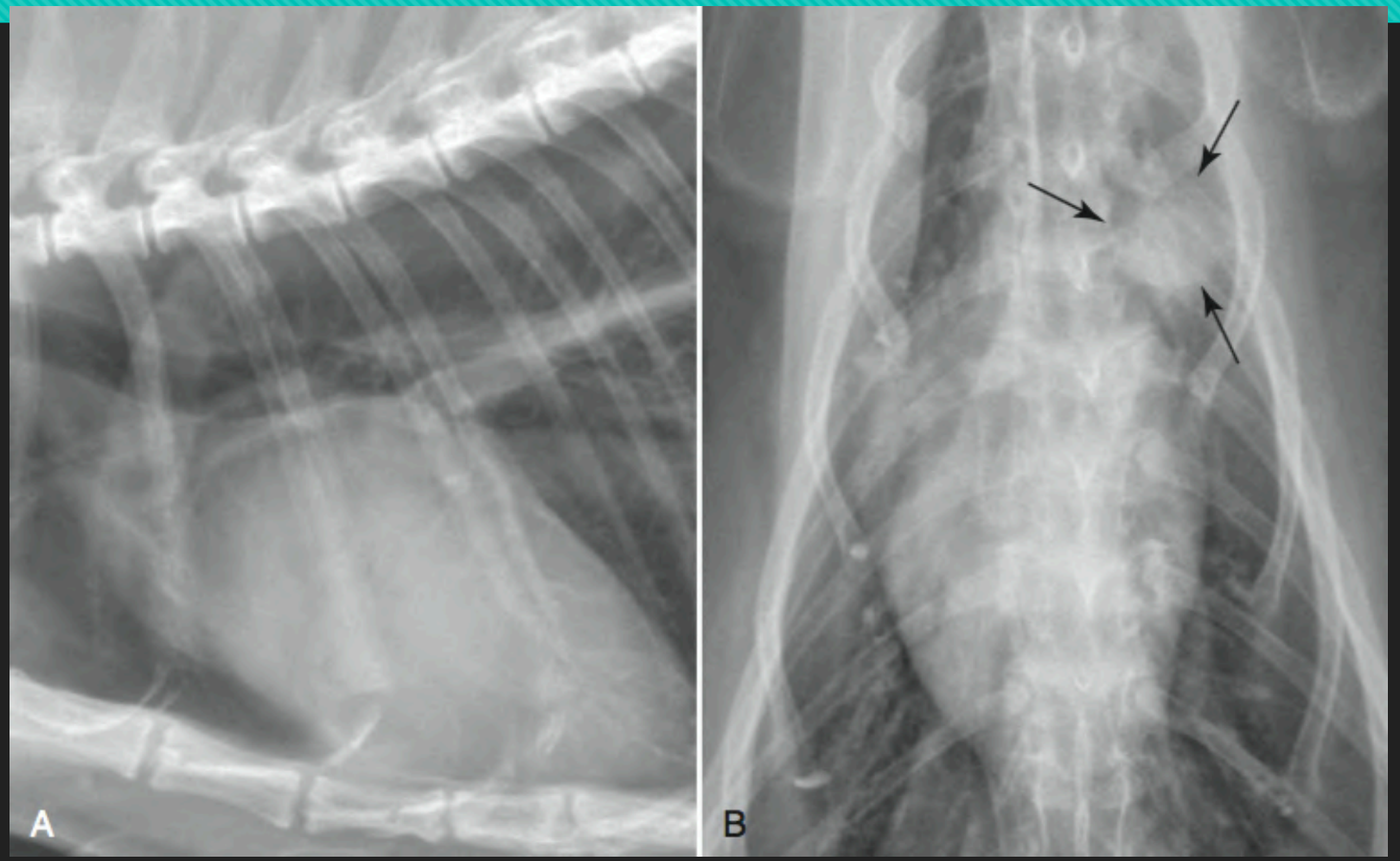


Radiographic Signs of Major Vessel Enlargement

- ***Caudal Vena Cava:***
  - Depends on the phase of respiration and cardiac cycle.
  - Should be less than the length of the fifth or sixth thoracic vertebral bodies in the lateral view. Or less than 1.5 times the diameter of the descending aorta.

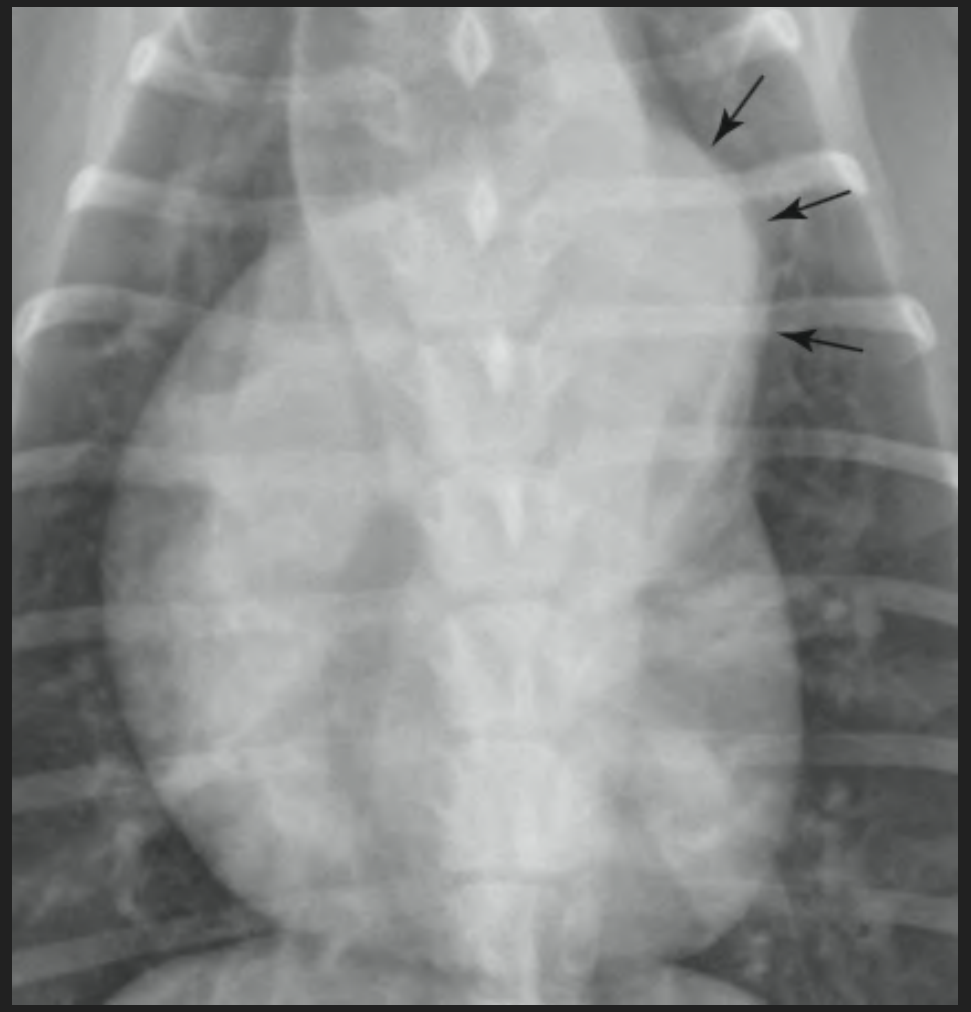
Radiographic Signs of Major Vessel Enlargement

- ***Aorta***
  - bulge in aortic stenosis and patent ductus arteriosus
  - Some older cats will have a tortuous aorta in the lateral view (serpentine contour)



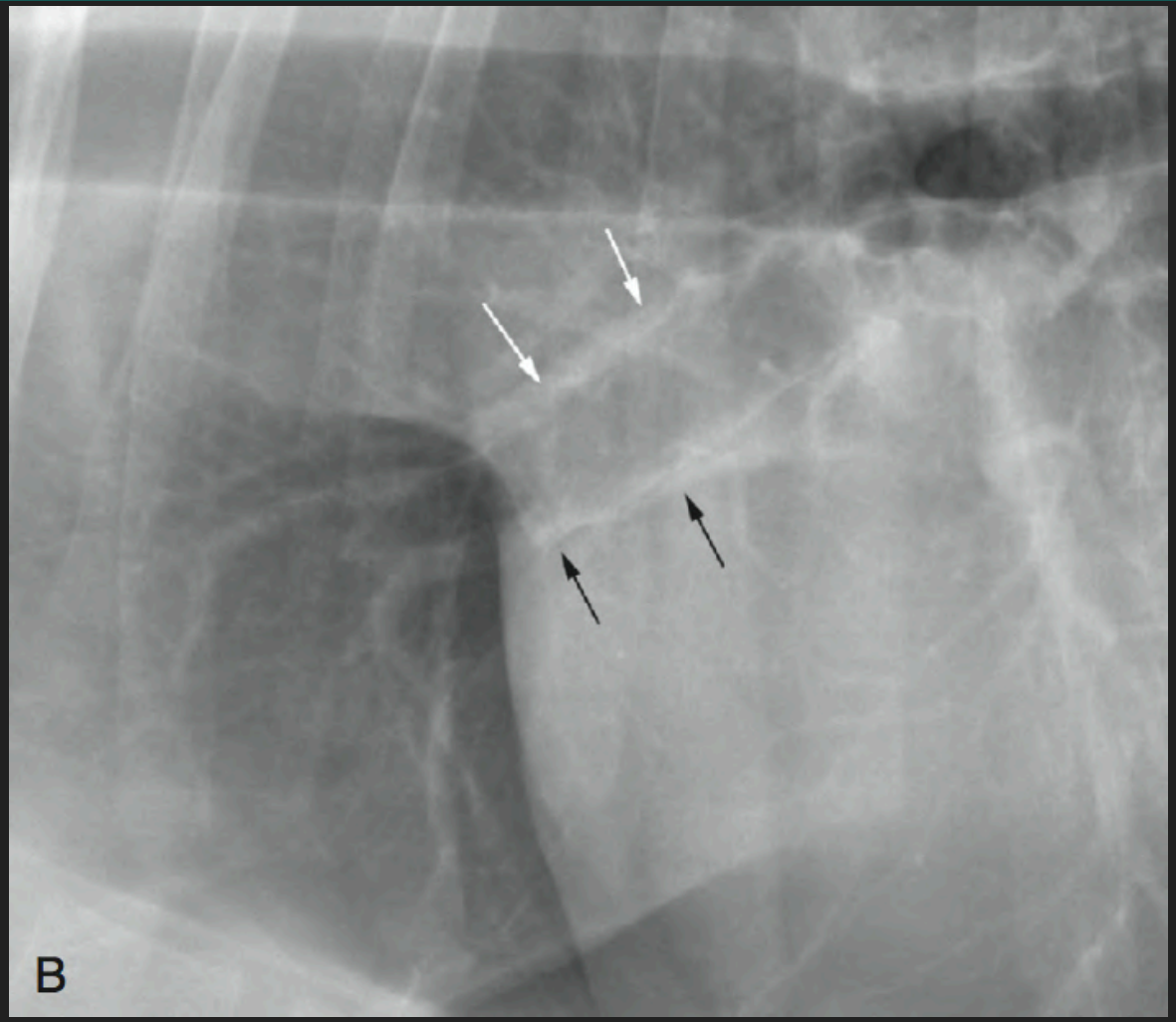
Main Pulmonary Artery

- focal bulge in the 1:00 o'clock position in VD or DV views: pulmonary hypertension, as from heartworm infection, and turbulence, as from pulmonic stenosis or patent ductus arteriosus.



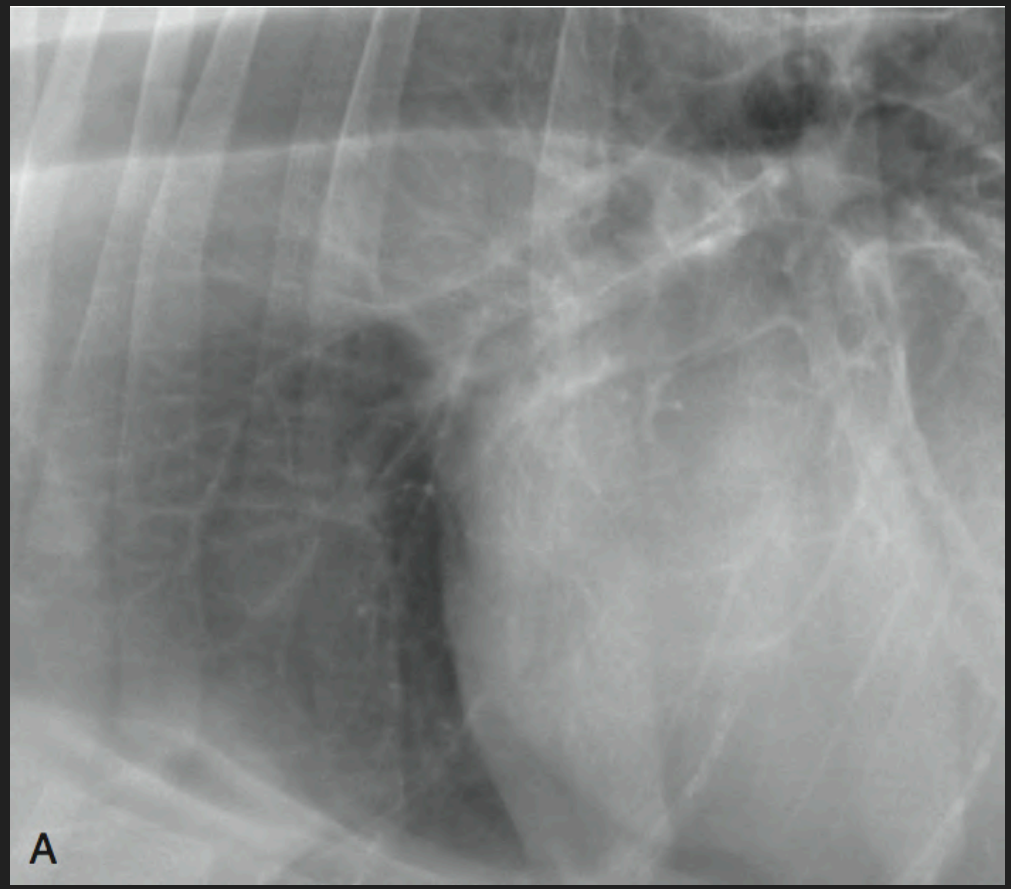
Radiographic Signs of Pulmonary Arterial and Venous Changes

- The right cranial lobar pulmonary artery and vein are valuable reference vessels, because they are best seen as individual structures when the animal is in left lateral recumbency

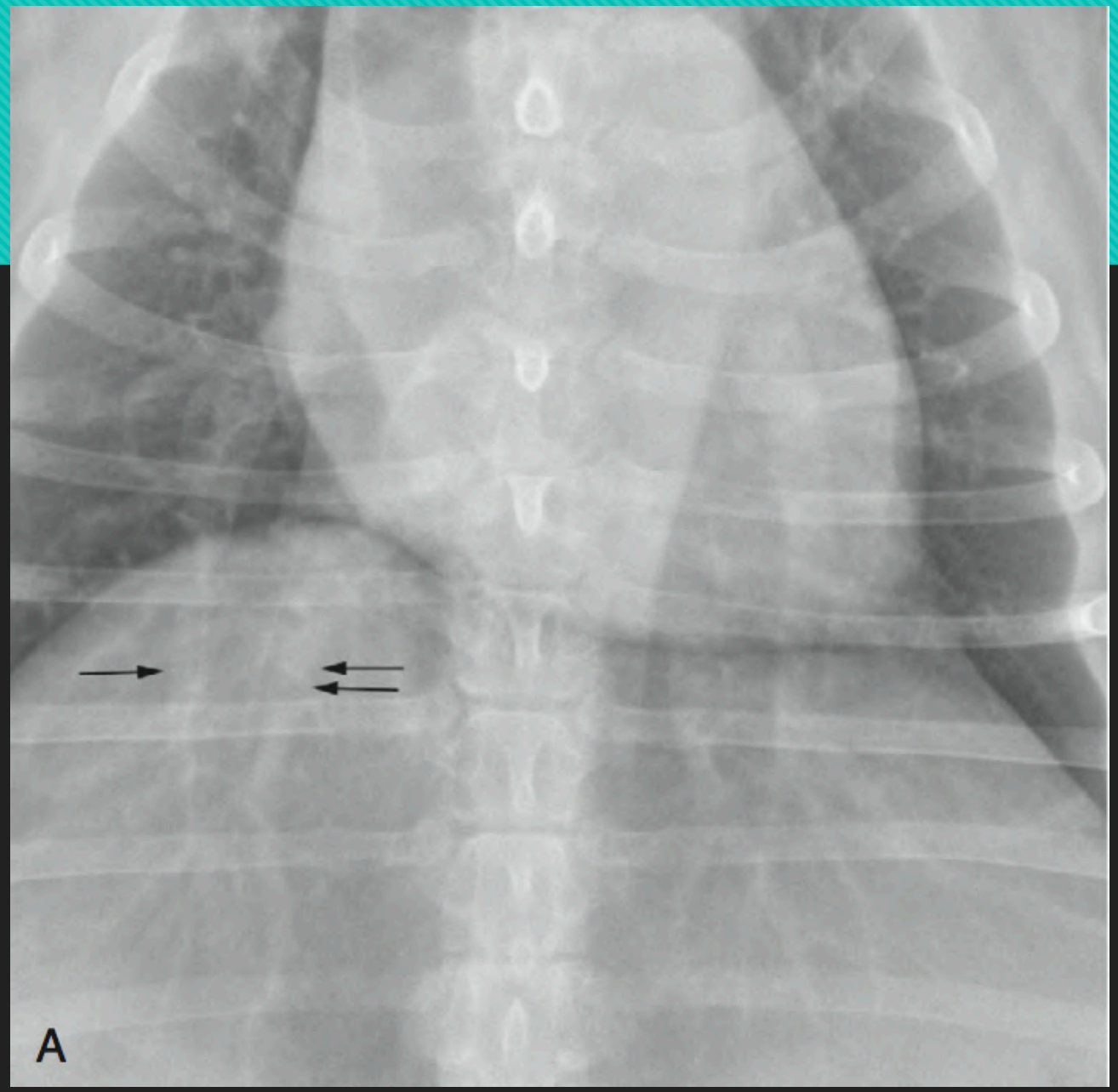


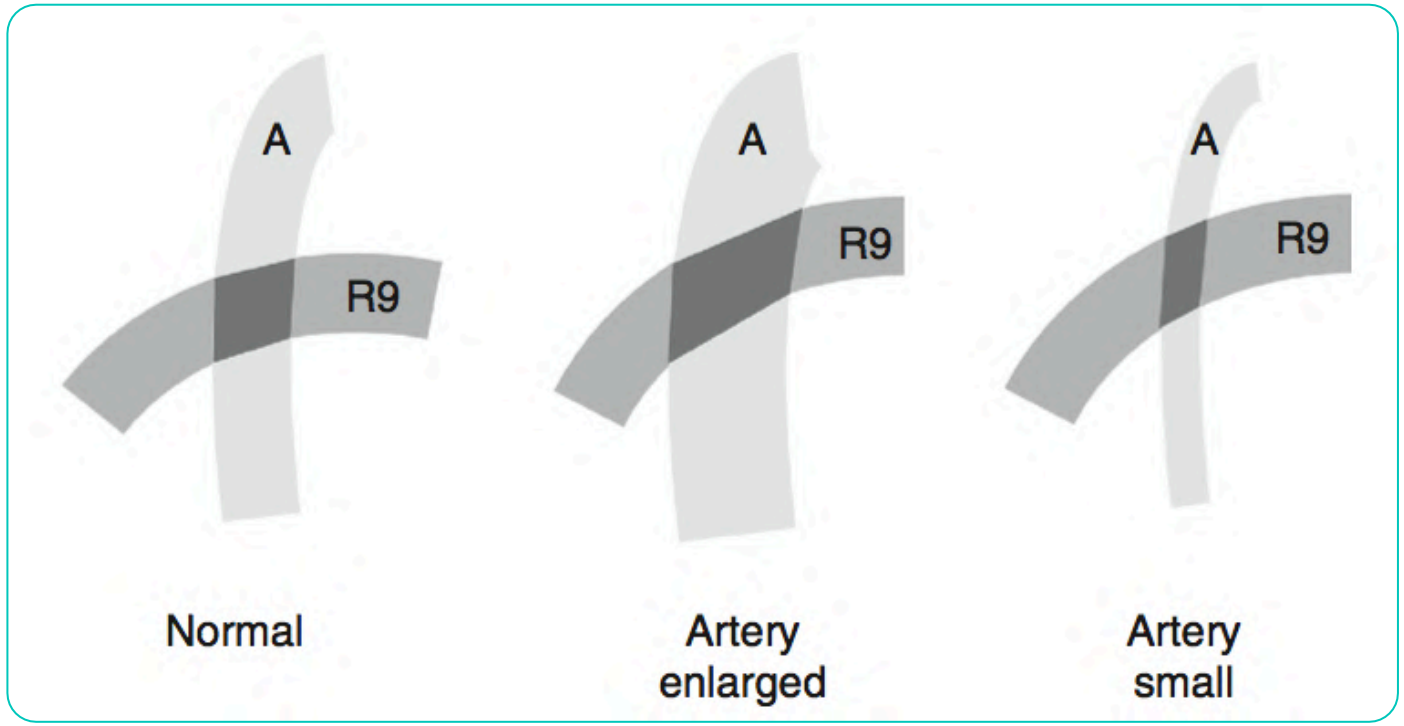
Radiographic Signs of Pulmonary Arterial and Venous Changes

- in right recumbency, the left and right pairs of cranial lobe vessels are almost always overlapped



- In a VD or DV projection:
  - The caudal lobe pulmonary vessels are better seen in the DV view than in the VD view,

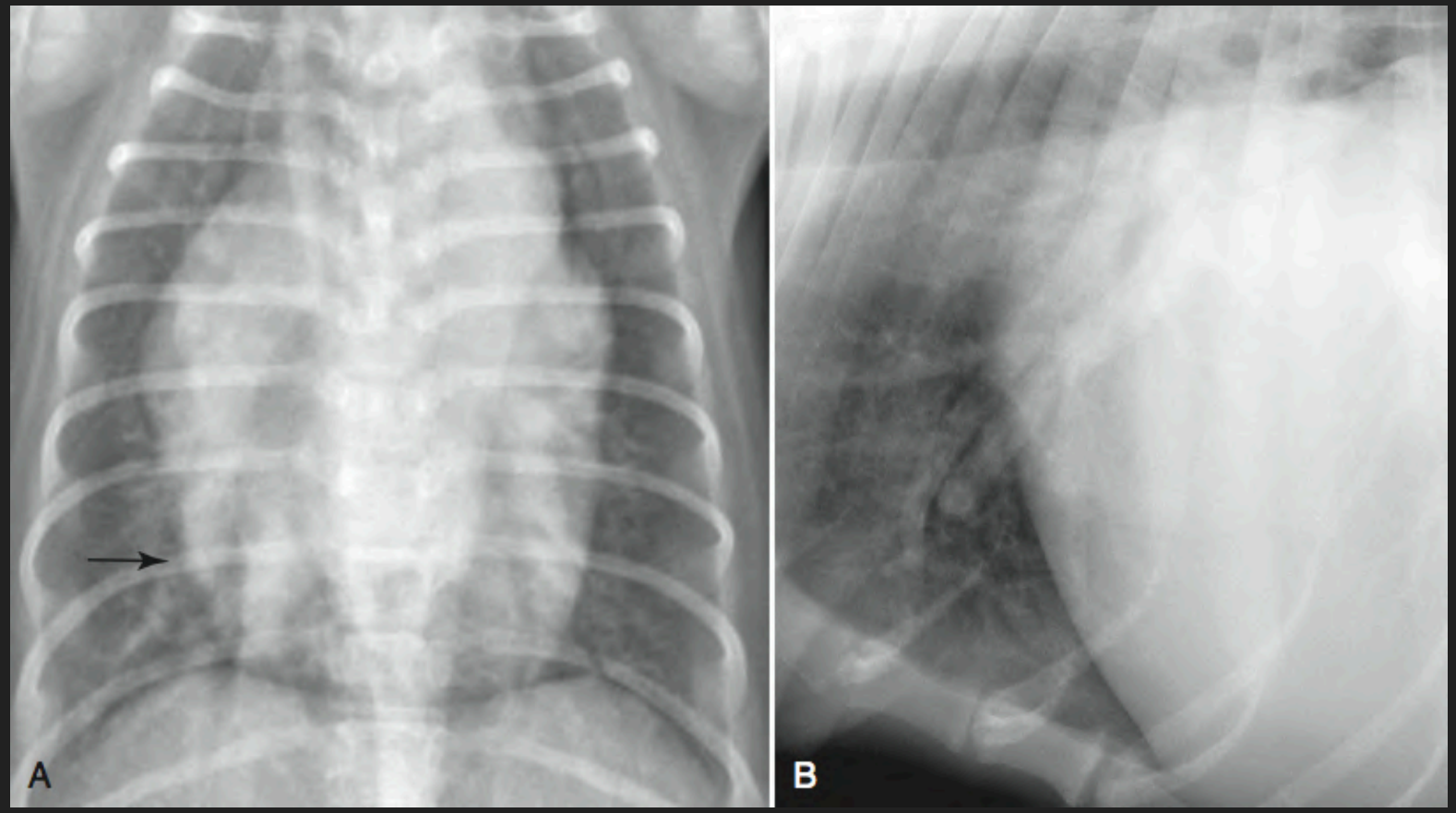




- Peripheral pulmonary arteries and veins should normally be approximately the same size (matched).

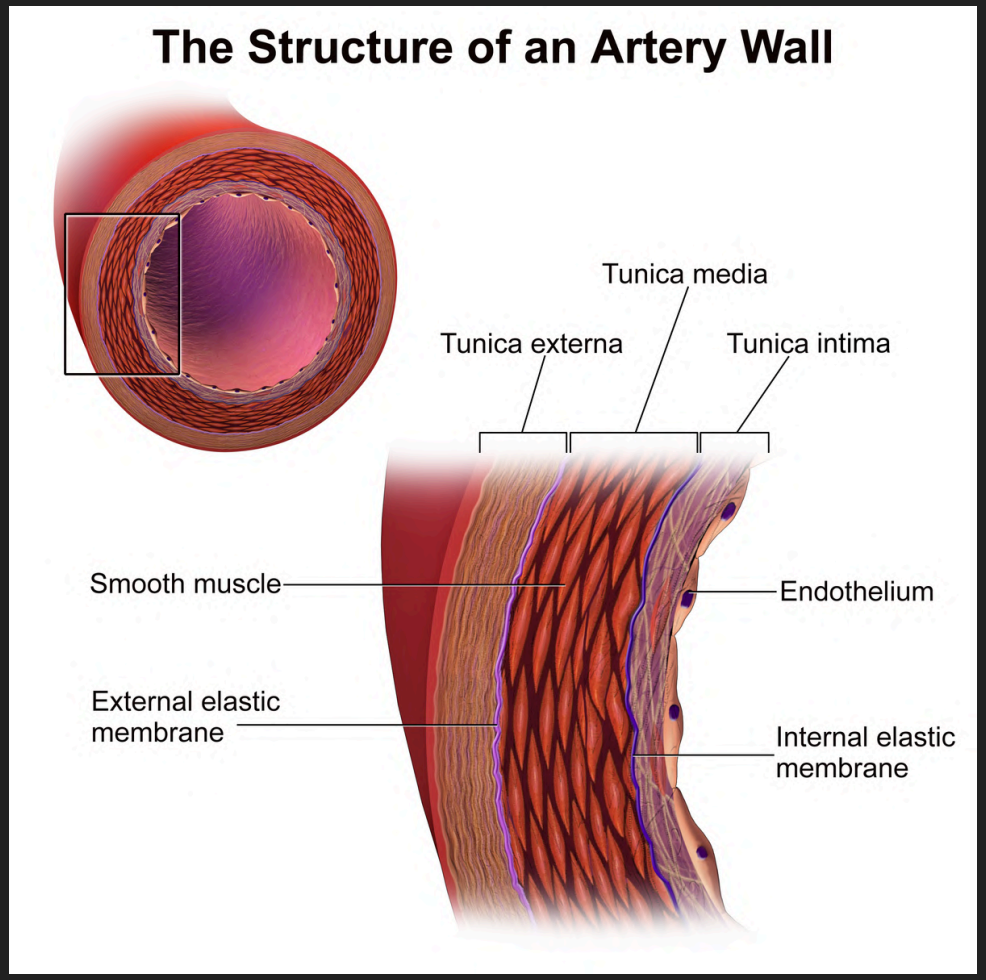
Conditions That May Increase the Size of Both Pulmonary Arteries and Pulmonary Veins

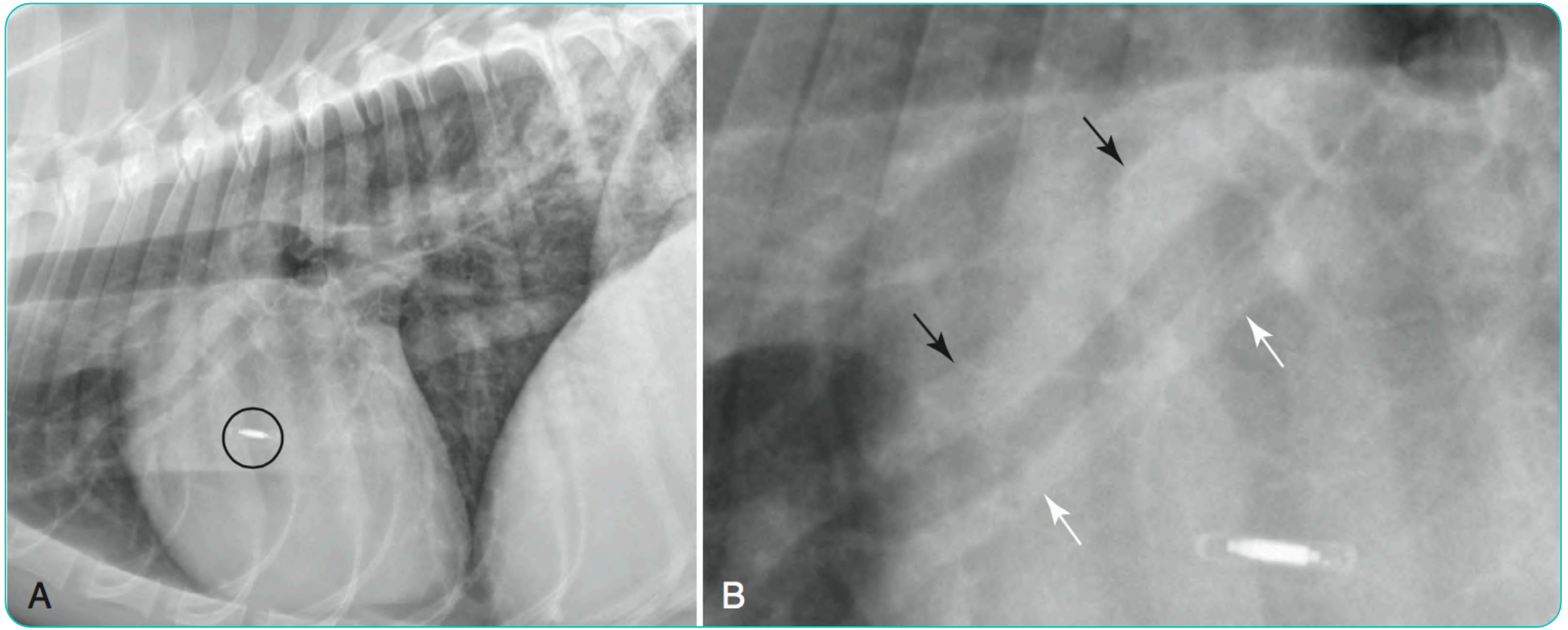
- Left-to-right shunt
  - - Patent ductus arteriosus
  - - Ventricular septal defect
  - - Atrial septal defect
- Peripheral arteriovenous fistula
- Iatrogenic intravenous fluid overload
- Fluid retention secondary to decreased cardiac output



Conditions That May Increase the Size of Pulmonary Arteries Without Associated Vein Enlargement

- Tunica intima proliferation or tunica media
  - hypertrophy Dirofilariasis
  - Angiostrongyliasis
  - Aelurostrongylus (feline)
- Thromboembolic disease or primary thromboses
  - Dirofilariasis
  - Angiostrongyliasis
  - Renal disease: Amyloidosis, glomerulonephritis
  - Septicemia
  - Pancreatitis
  - Hyperadrenocorticism
- Severe chronic lung disease

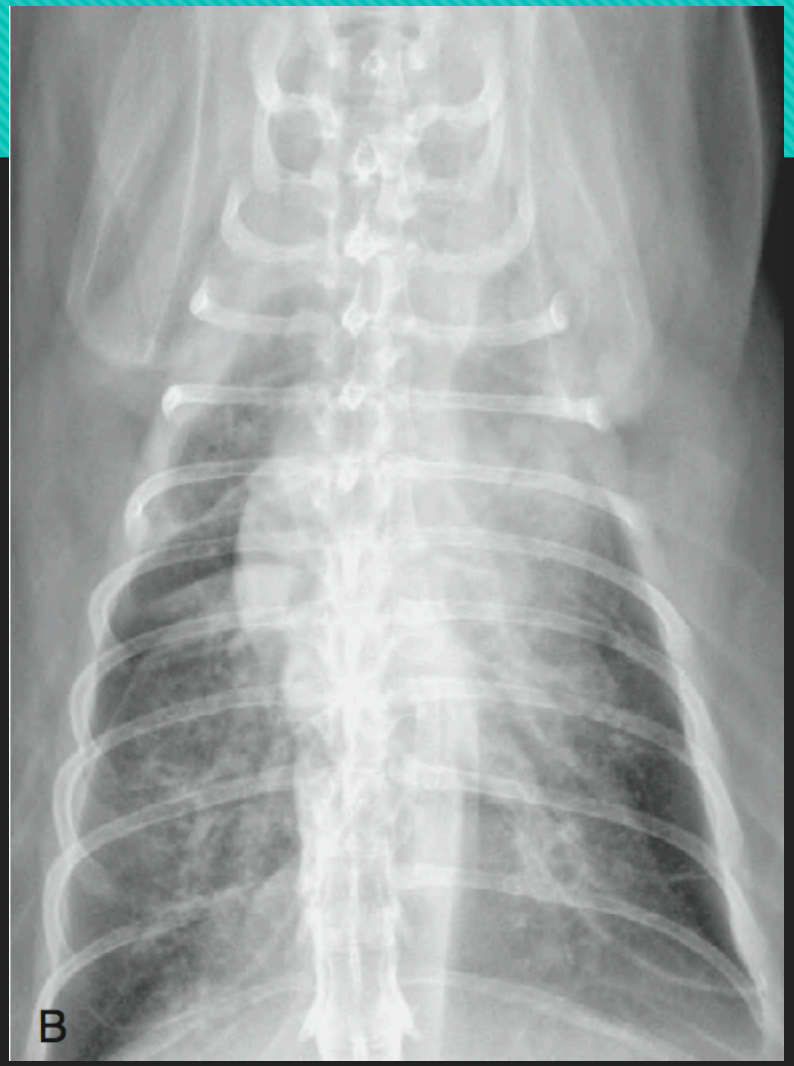




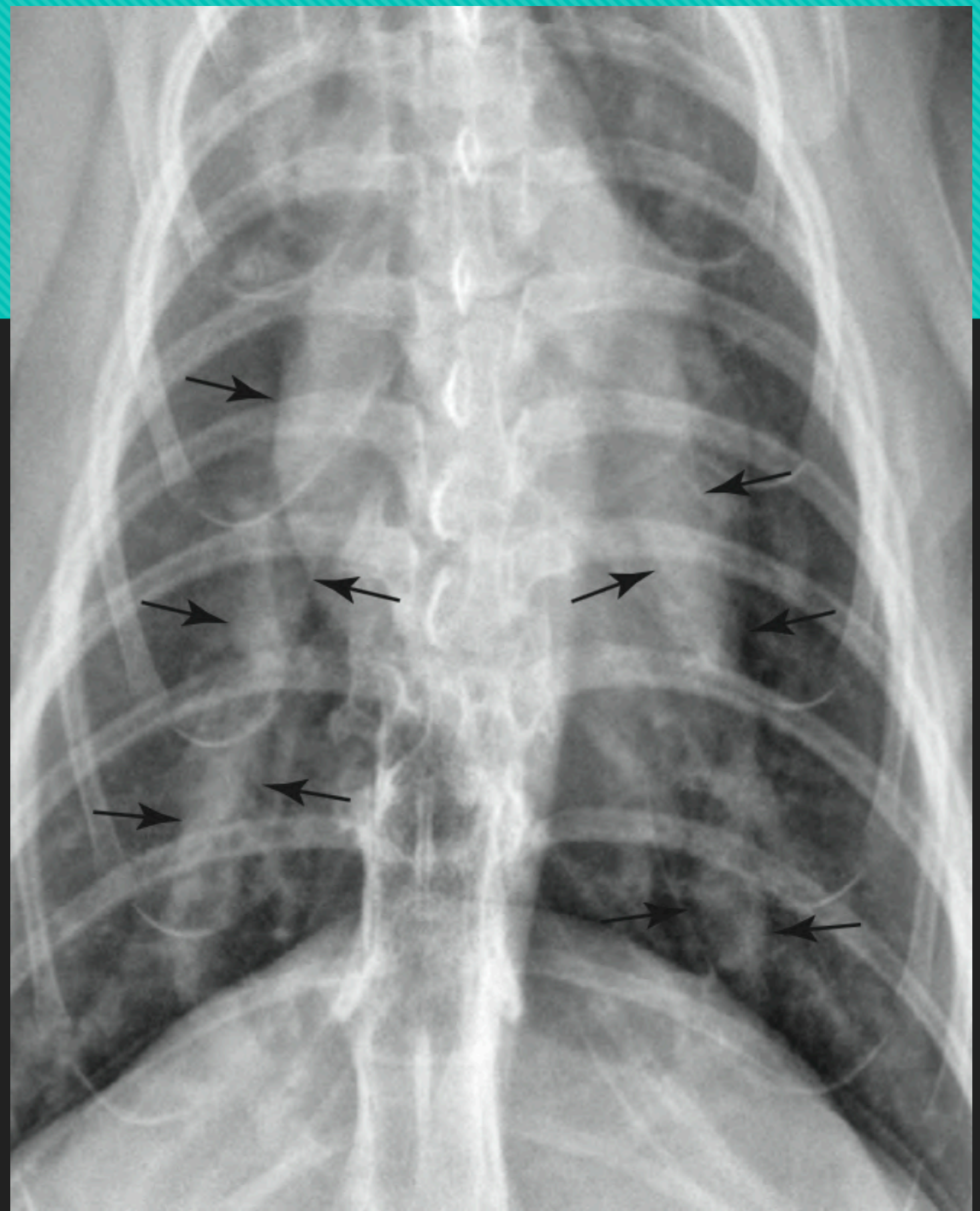
- the most commonly enlarged pulmonary arteries in spontaneous heartworm disease are the caudal lobar arteries with a predilection for enlargement of the right more than the left.

In cats

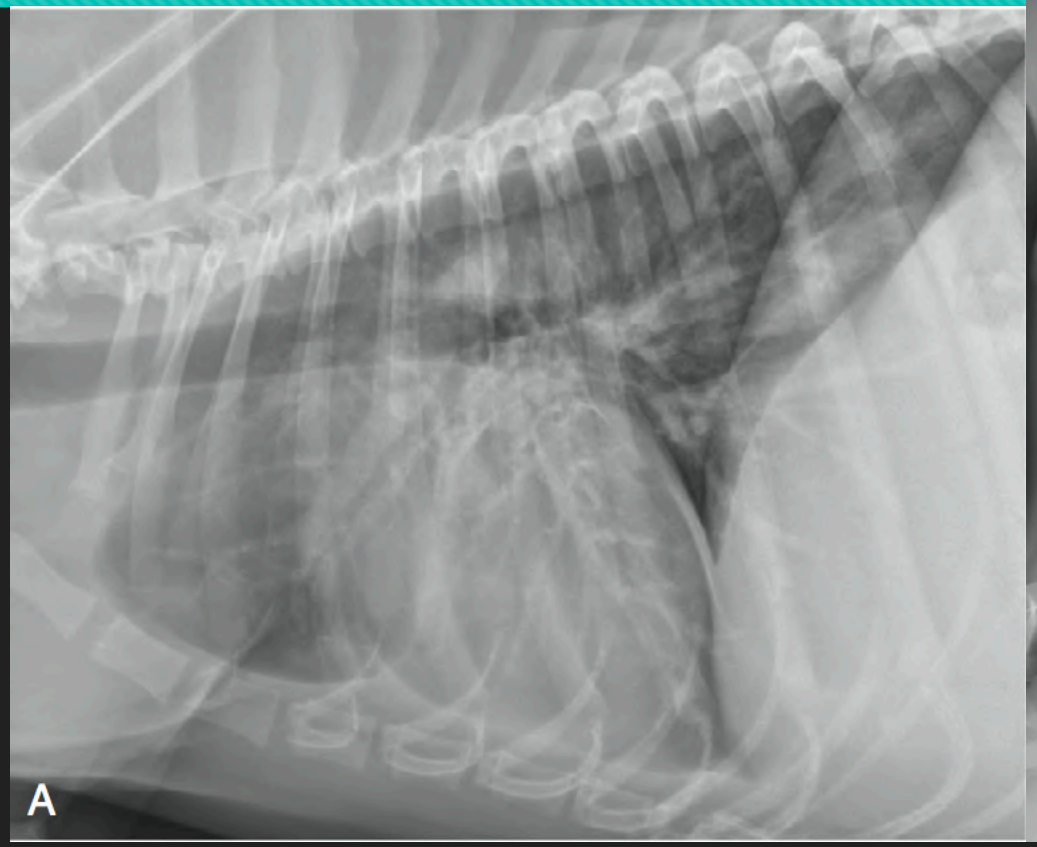
- with heartworm disease, enlargement of the main pulmonary artery is usually not visible radiographically.
- The peripheral pulmonary arteries can become visibly enlarged in cats with heartworm disease
- cats with bronchial disease should be considered suspects for heartworm disease even in the absence of classic vascular changes.
- interstitial cardiogenic pulmonary edema is rare Interstitial pulmonary edema typically progresses to

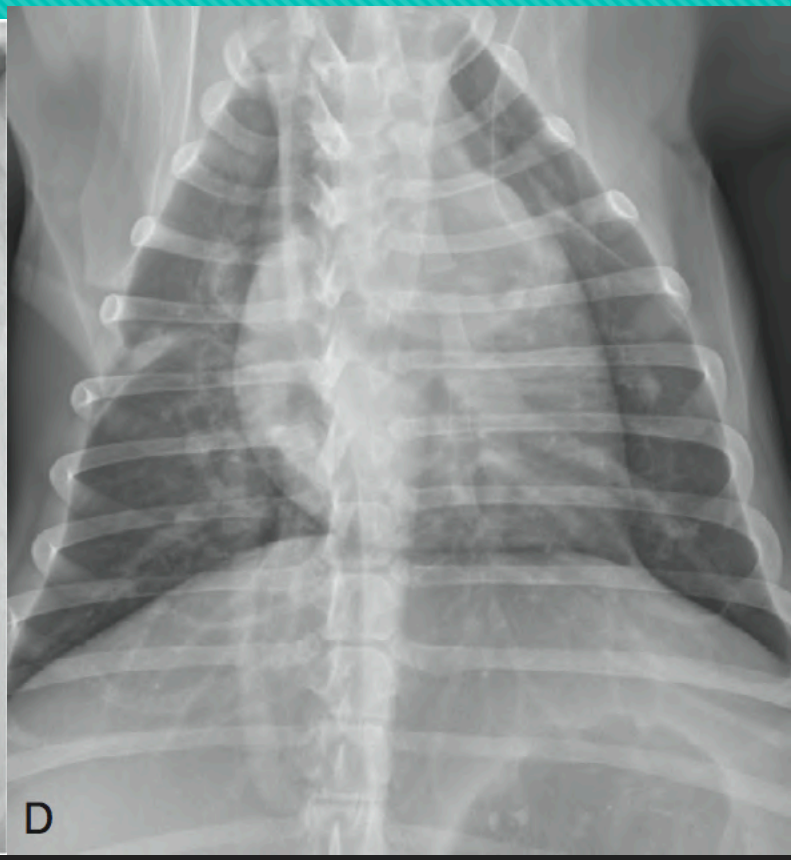


- The diagnosis of feline heart-worm disease is a challenge. Thoracic radiography and serum antibody tests are used to evaluate the index of suspicion while echocardiography and serum antigen tests are used for confirming infection.



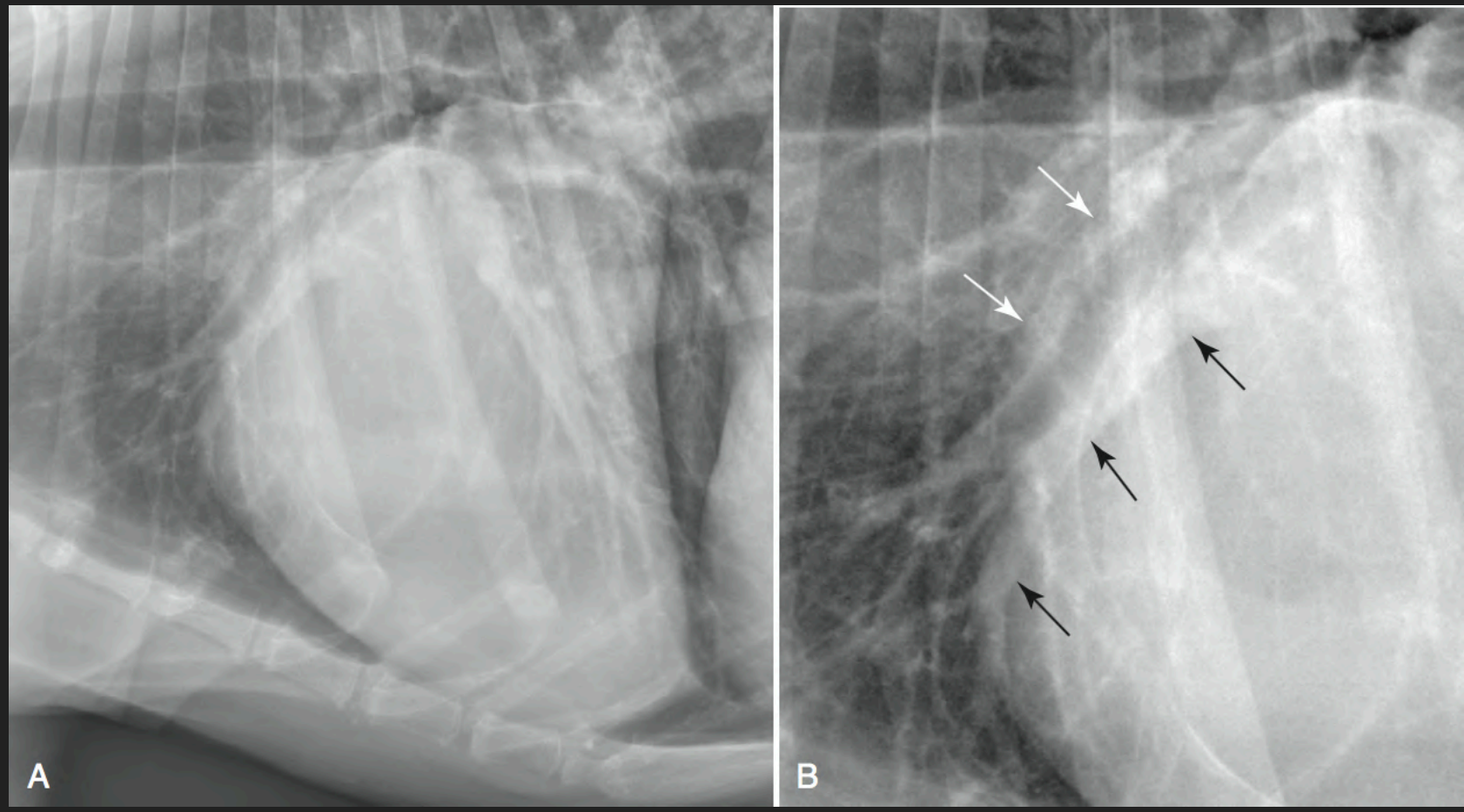
- dying worm emboli or blood clots → alveolar pattern





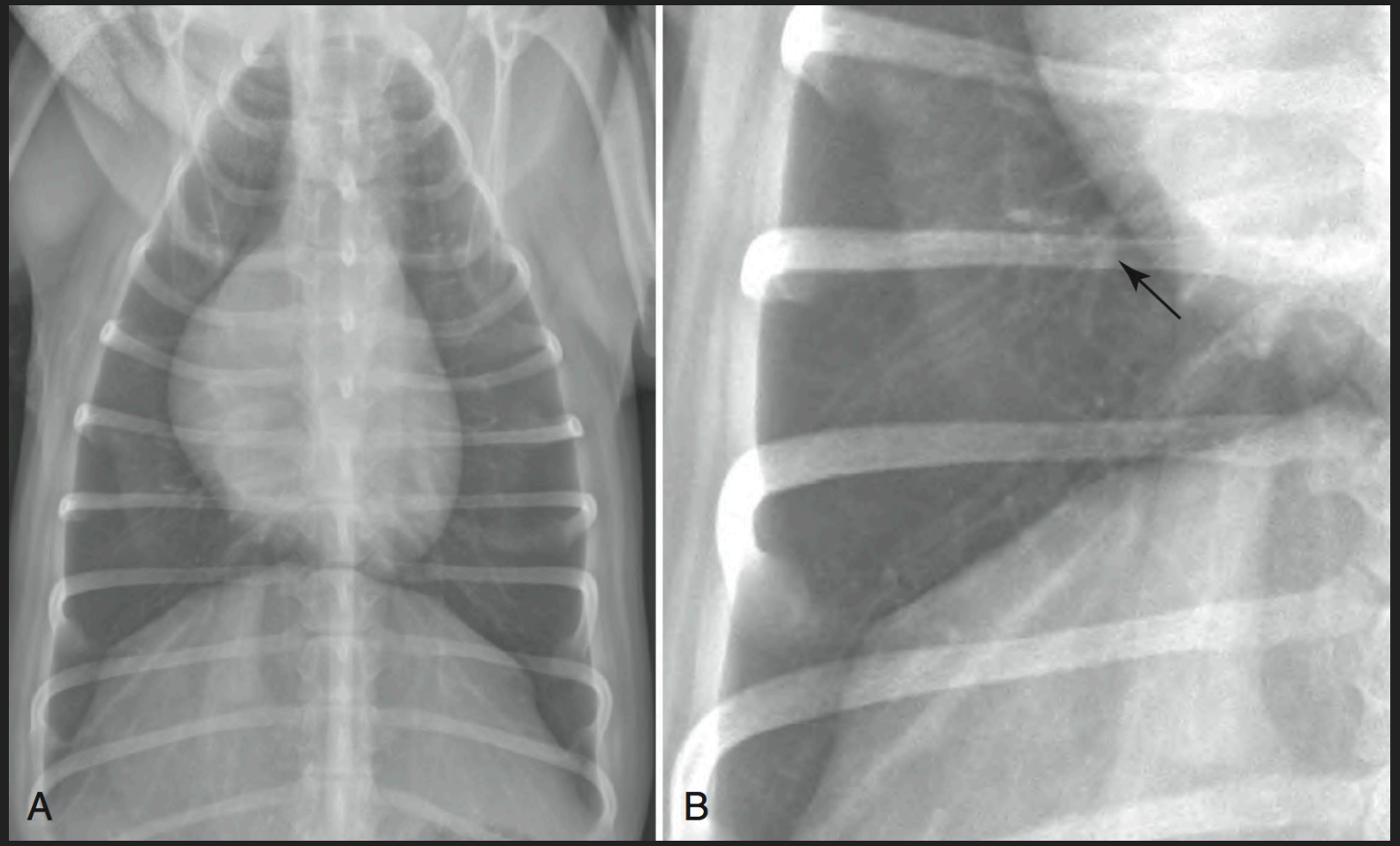
Conditions That May Increase the Size of Pulmonary Veins Without Associated Artery Enlargement

- **Cardiac**
  - Volume or pressure overload:
    Mitral insufficiency
    Mitral valvular endocardiosis
    Early left-to-right shunts
  - Primary myocardial disease
    - Myocardial failure (arrhythmias, fibrosis)
    - Dilatory cardiomyopathy
      Hypertrophic cardiomyopathy
    - Restrictive cardiomyopathy
- **Noncardiac Dysfunction**
  - Left atrial obstruction
    Mass (neoplastic or inflammatory) at heart base
    Thrombosis within left atrium



Conditions That May Decrease the Size of Pulmonary Arteries and Veins

- Right-to-left shunts
  - Tetralogy of Fallot
  - Ventricular septal defect with pulmonic stenosis
- Severe pulmonic stenosis with decreased cardiac output
- Hypovolemia
- Shock
- Dehydration

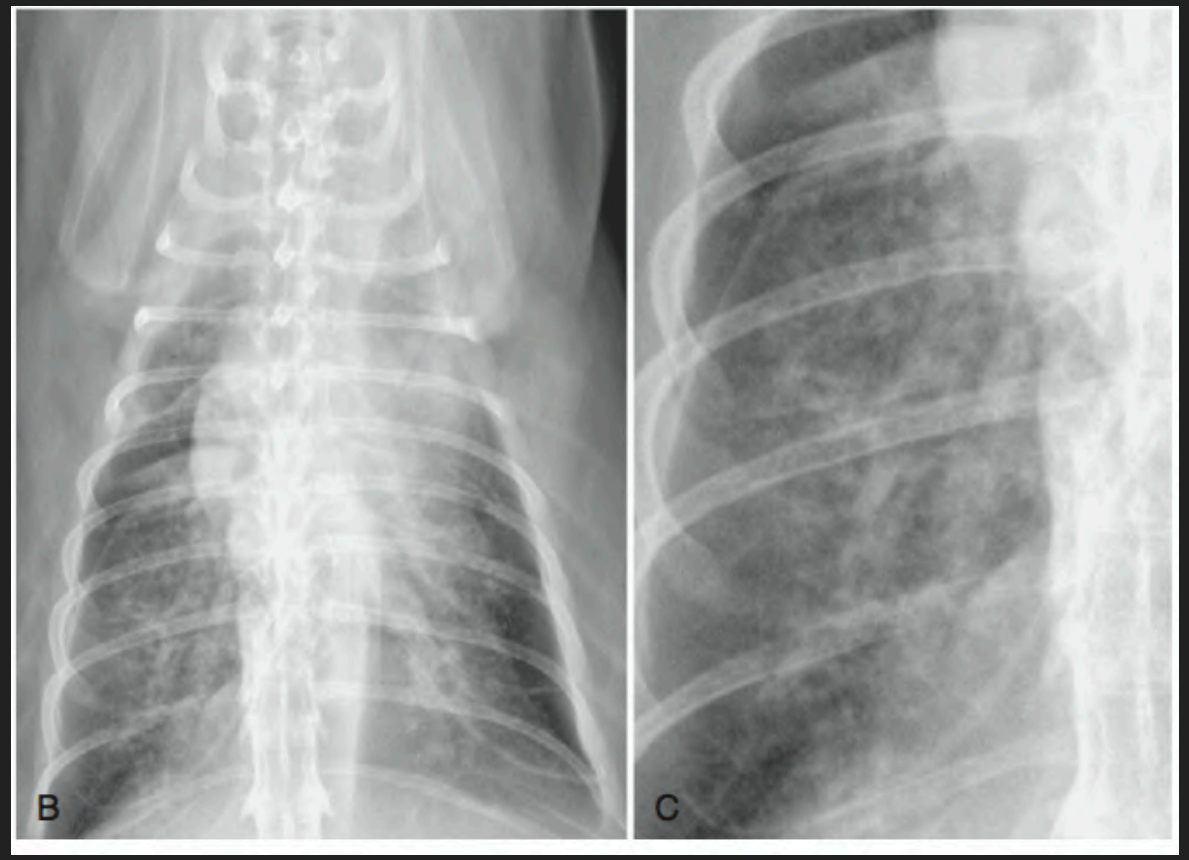


Congestive Heart Failure

- Backward left-sided heart failure → Pulmonary venous hypertension → transudation of fluid from the pulmonary capillaries into the lung interstitium, → hazy, unstructured interstitial pulmonary edema→ alveolar edema.
- Dorsocaudal distribution in dogs but any distribution is possible.
- A perihilar distribution is also possible but this is overemphasized.

Congestive Heart Failure

- Radiographic visualization of interstitial cardiogenic pul- monary edema is rare because it is short lived
- Cardiogenic pulmonary edema is more often patchy in cats
- The pattern of pulmonary edema distribution in dogs with mitral insufficiency has been associated with the direction of the regurgitant jet. A symmetric distribution was associated predominantly with a central mitral regurgitant jet, whereas an asymmetric distribution was usually associated with an eccentric jet.
- Some cats with left heart failure also have a component of pleural effusion



Congestive heart failure

- Right-sided heart failure:
  - bilateral pleural effusion with varying degrees of secondary pulmonary atelectasis, ascites, and hepatosplenomegaly.

Acquired Cardiovascular Lesions

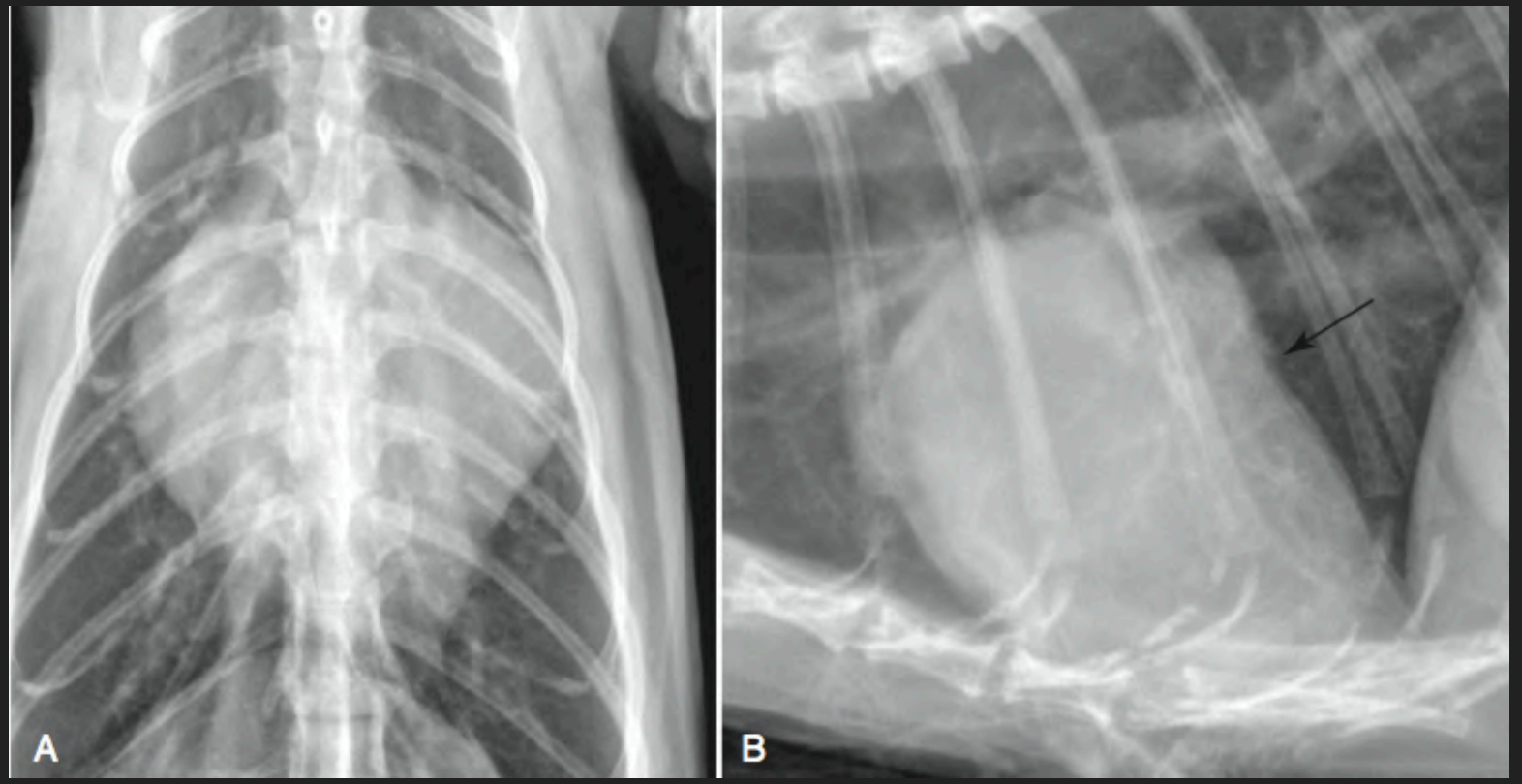
- ***Mitral Insufficiency***
- ***Heartworm Infection***
  - radiographic changes can vary from no abnormal findings or only a mildly affected cardiovascular system to severe involvement
- ***Cardiomyopathy***

dilated cardiomyopathy.

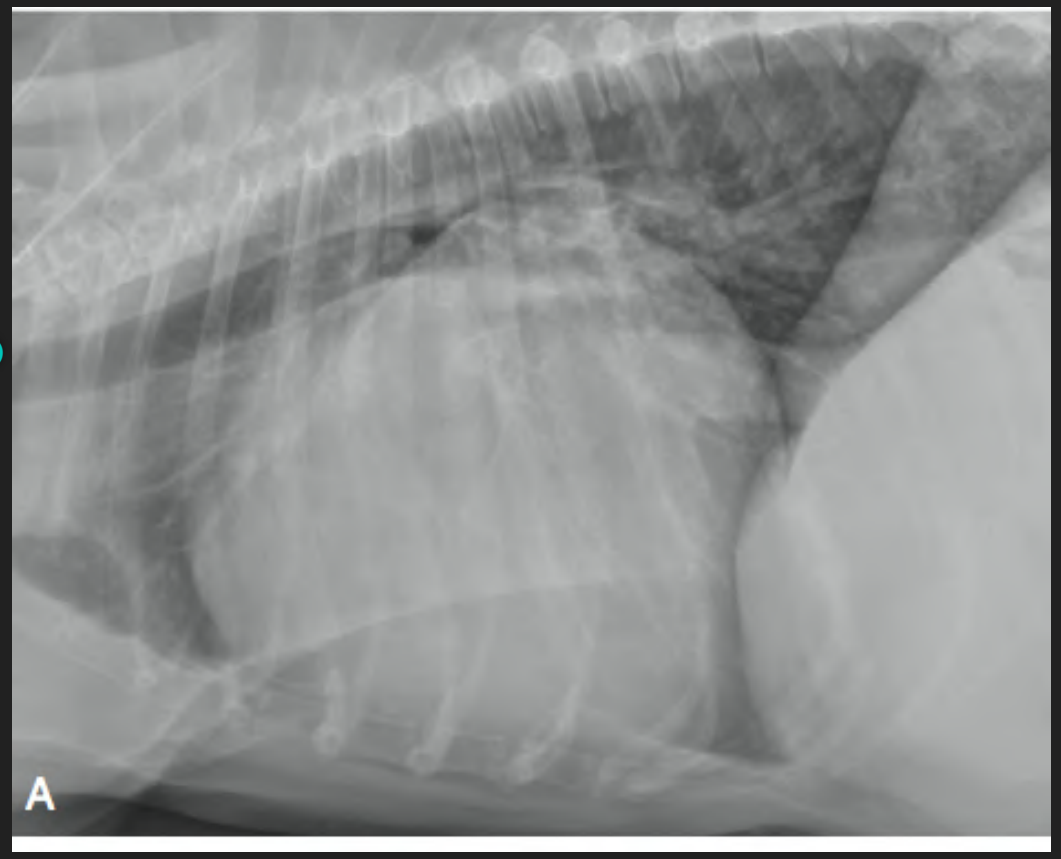
- Doberman pinscher,
- Great Dane,
- Cocker spaniel, and
- Boxers.

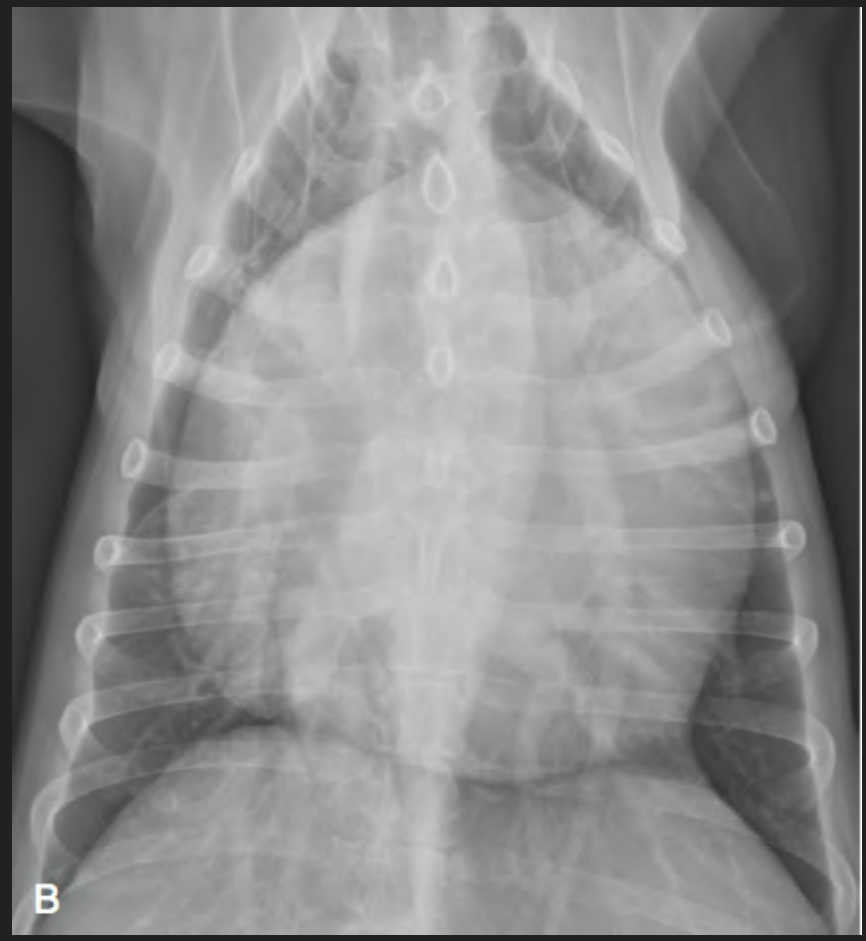
Hypertrophic cardiomyopathy

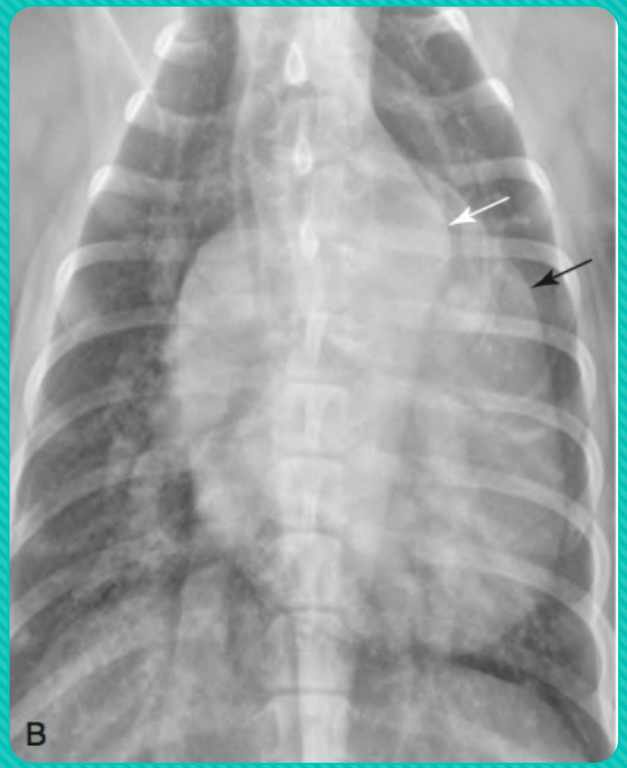
- more common in cats.
- “valentine” heart shape
-

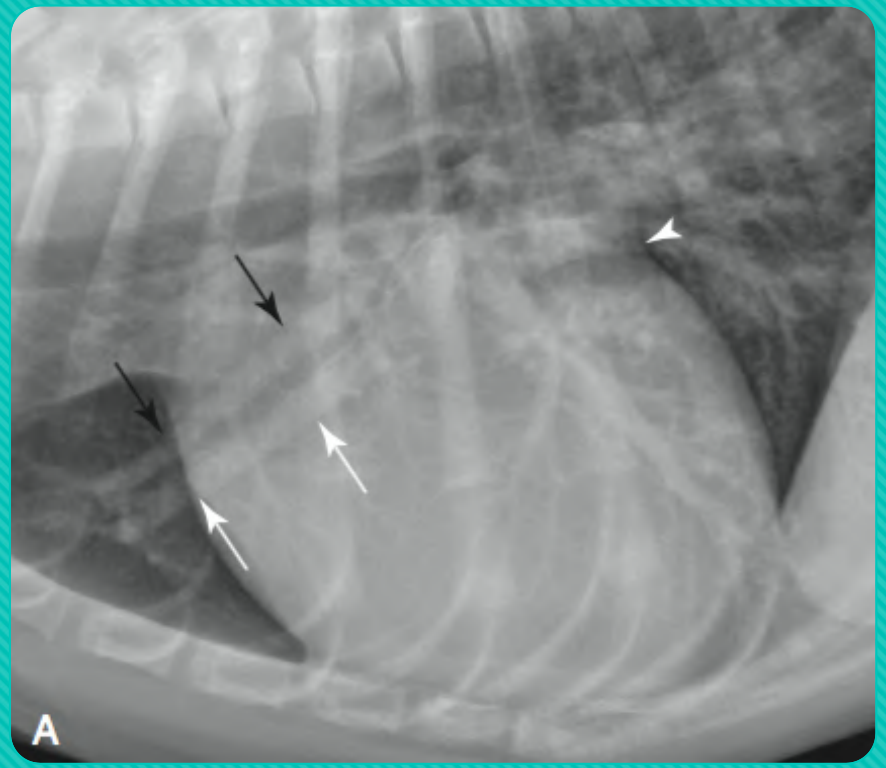


Pericardial Effusion





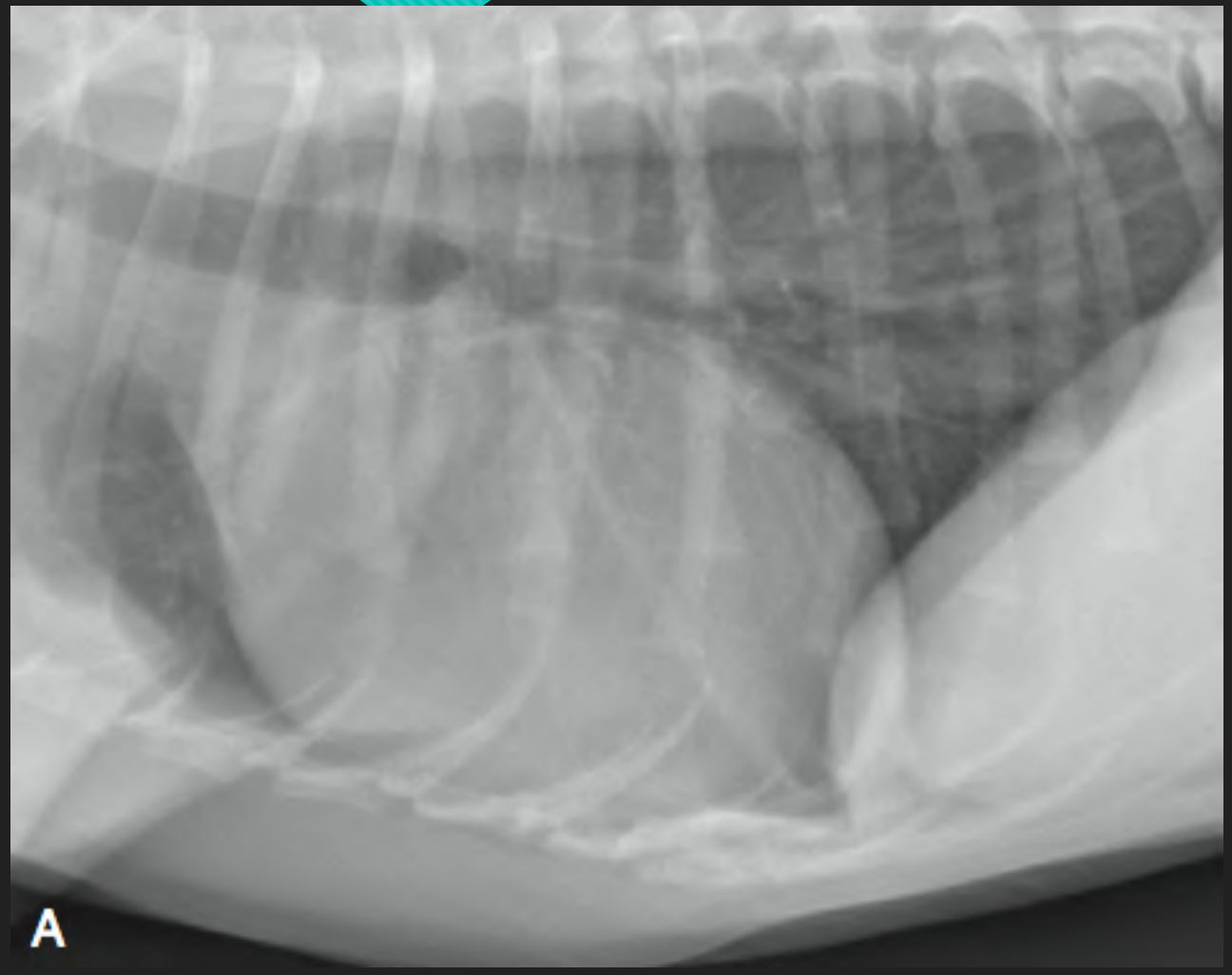


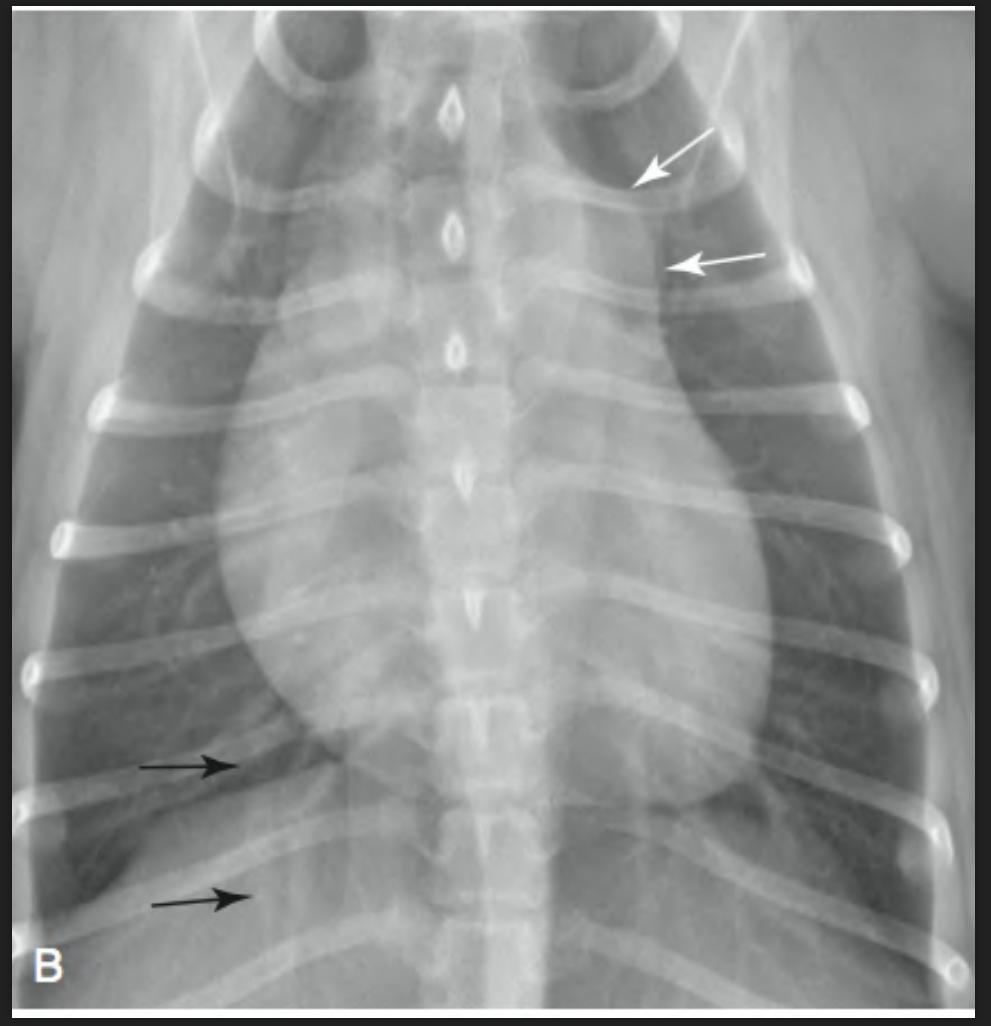


Congenital Cardiovascular Lesions

Patent Ductus Arteriosus

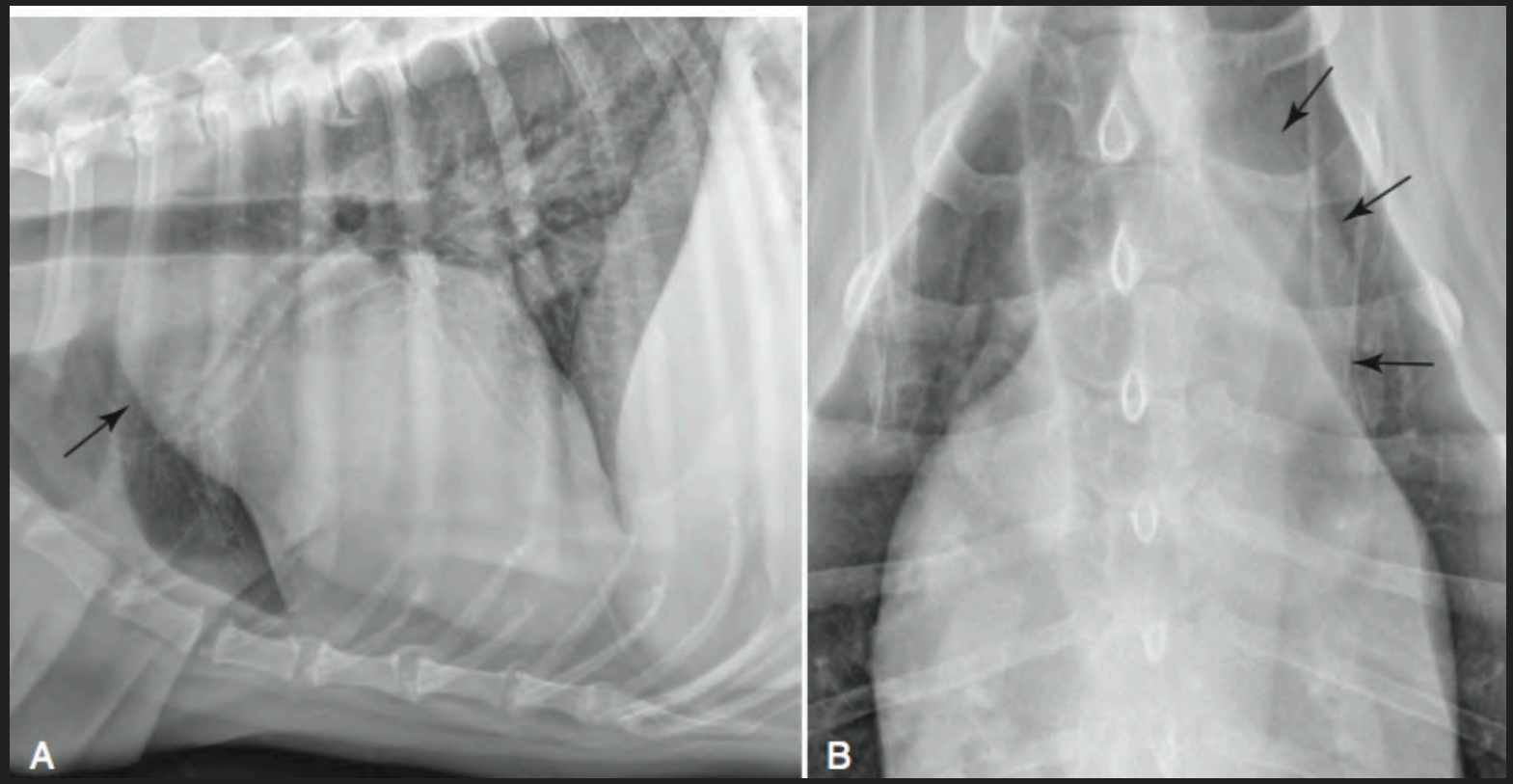
Pulmonic Stenosis



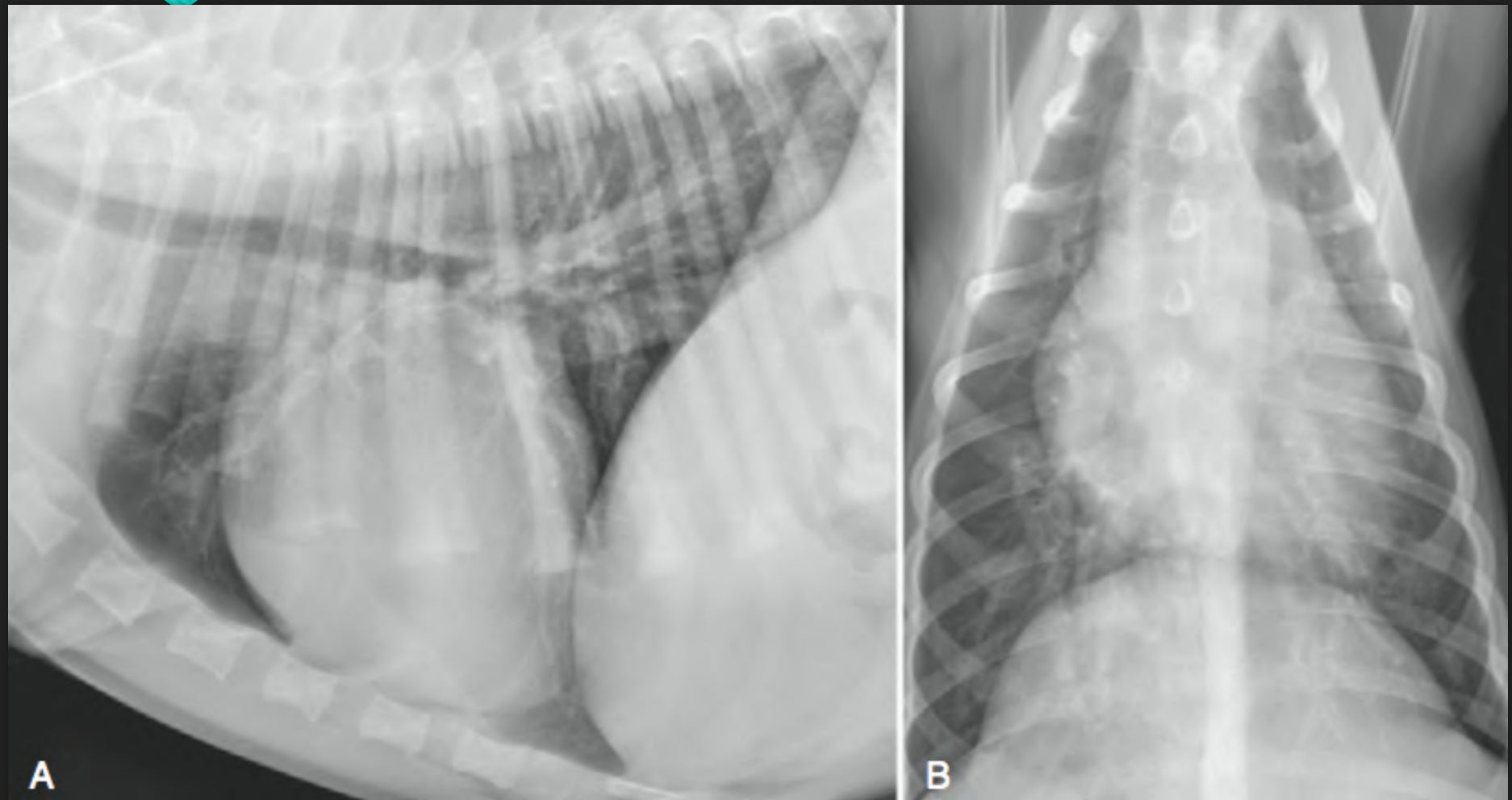


Aortic Stenosis

- Narrowing of the subvalvular region of the left ventricle is more common than primary valvular stenosis.

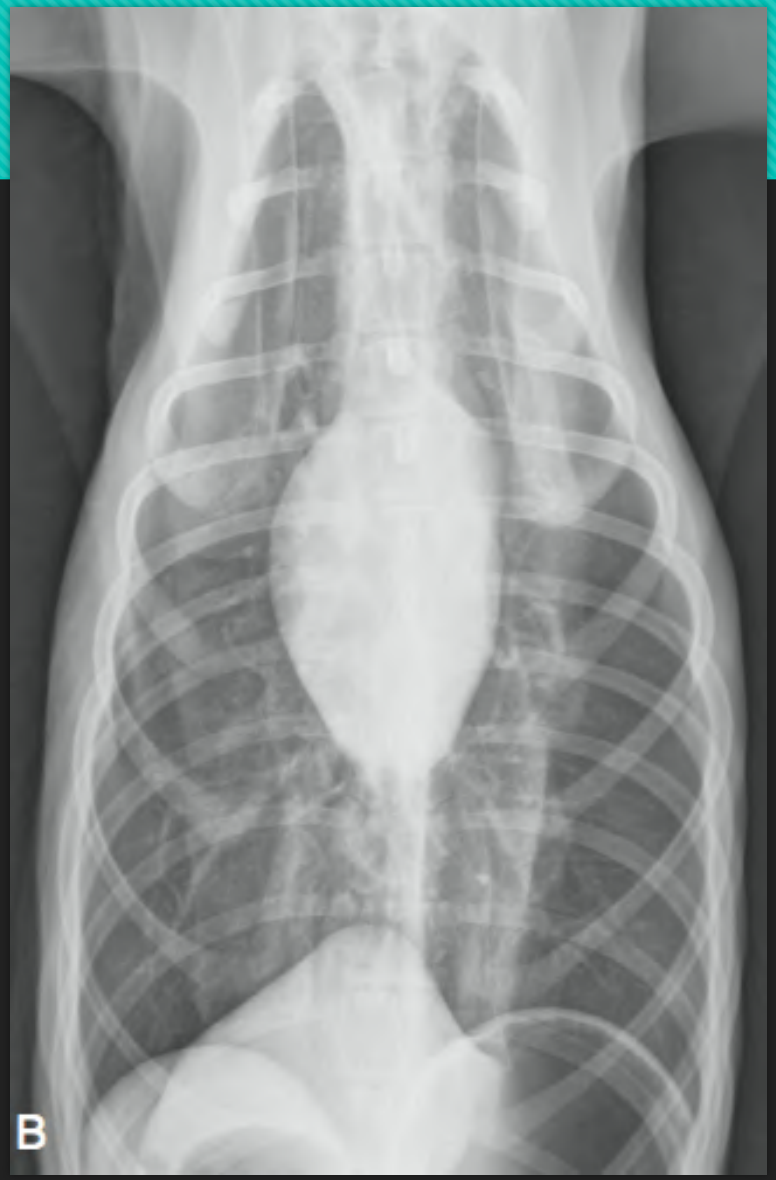


Ventricular Septal Defect



Reduction in Heart Size

- blood loss
- dehydration
- metabolic hypovolemia,
- Addison's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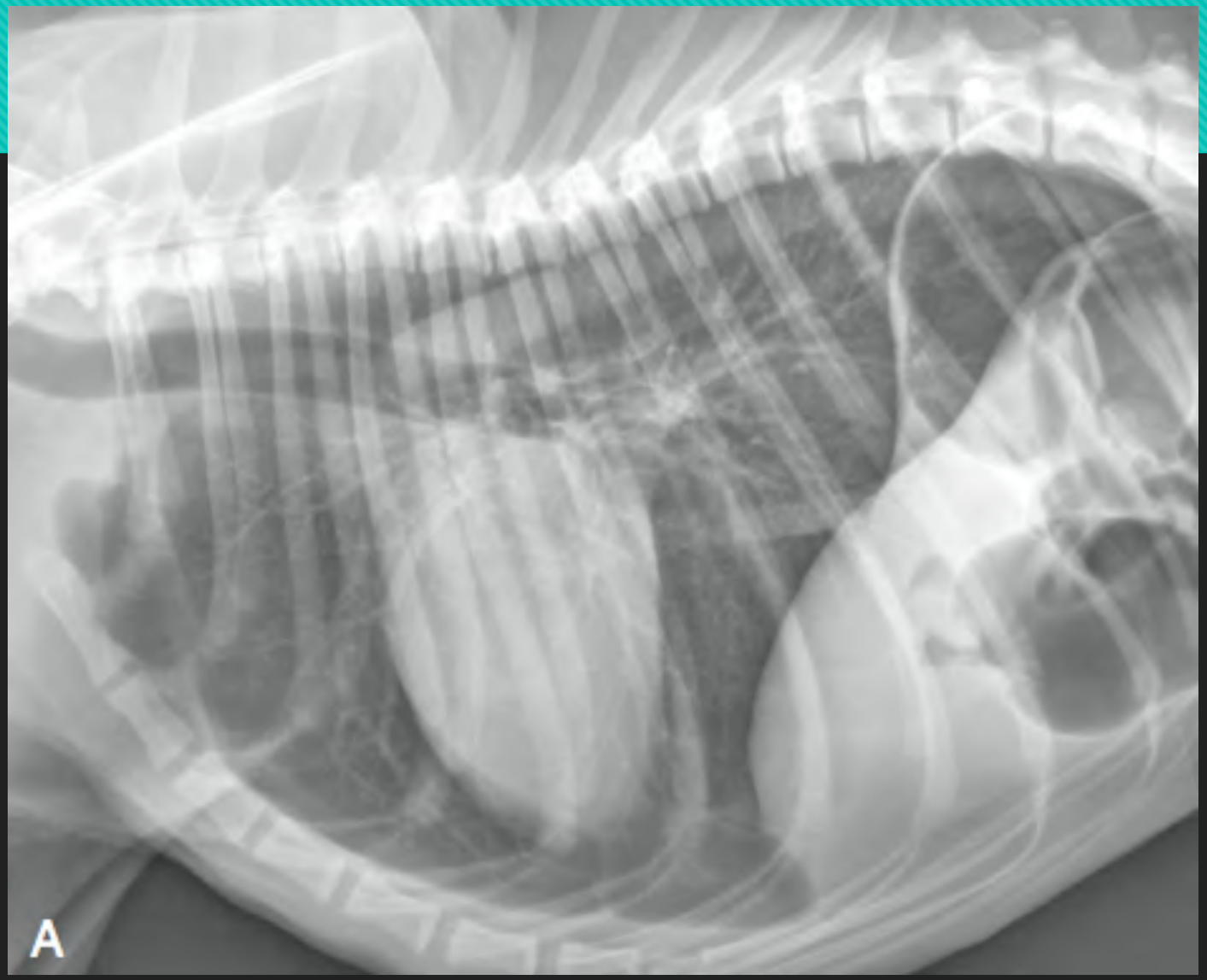
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Tricuspid Dysplasia