Thoracic Imaging

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November 2, 2016

Thoracic imaging

What other cavity do we routinely image when there are no referable signs?

- Metastasis checks
- Pre-anesthesia screens

Our utilization of thoracic radiography in “normal” patients gives us a broader experience with “normal” findings, with wide anatomic/physiologic variations, and with non-clinical lesions.

This experience is a mixed blessing, in that it give us a broader understanding of patient variety, but it also increases the number of potentially “normal” or at least non-clinical findings that we have to consider when trying to assess clinical patients

Thoracic imaging

Image optimization

Interpretation paradigms

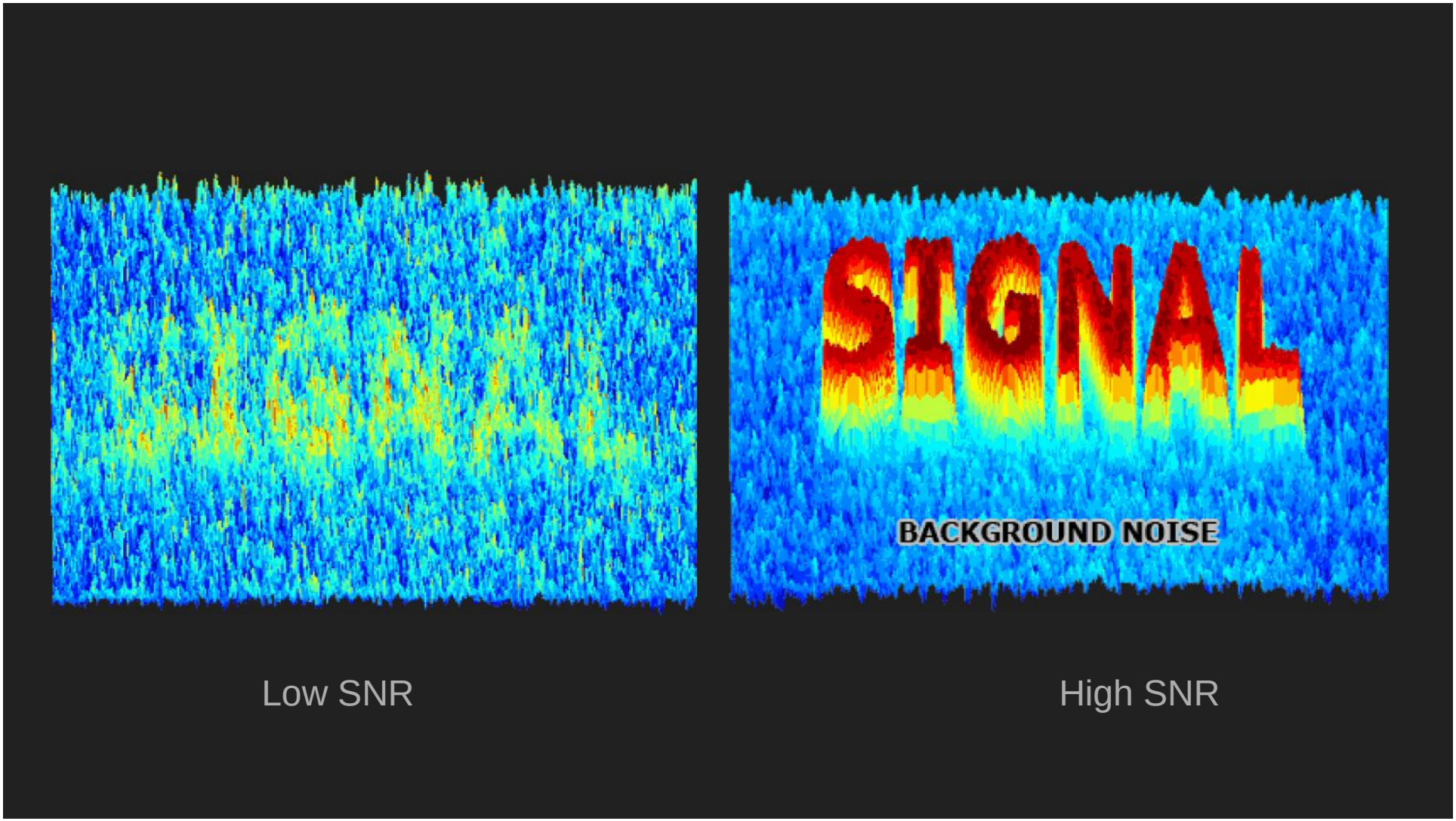
Case examples

Image optimization

Signal to noise ratio (SNR)

The ratio of usable information (“signal”) to unusable, interfering “noise”

Goal is to maximize signal and minimize noise to gain the most possible information from the test


SIGNAL
BACKGROUND NOISE
Low SNR
High SNR


JPG
Low
SNR
DICOM
High
SNR

SNR in thoracic radiographs

Noise: any condition that decreases detail in the image resulting in reduced clarity and reduced conspicuity of normal anatomy and potential lesions

Sources of noise in thoracic radiographs

- Technique
  - Exposure factors
  - Collimation
  - Digital imaging algorithm
- Inherent imaging modality factors
  - Spatial resolution
  - Image format/compression
- Positioning
- Phase of respiration
- Anesthesia
- Motion
- Normal anatomic variations

Sources of noise in thoracic radiographs

Things you **can** control

- Technique
- Positioning
- Phase of respiration
- Anesthesia
- Motion

Things you **cannot** control

- Inherent imaging modality factors
- Phase of respiration
- Motion
- Normal variations

Noise: Technique

kVp, mAS

Underexposure

Overexposure

Collimation and scatter radiation

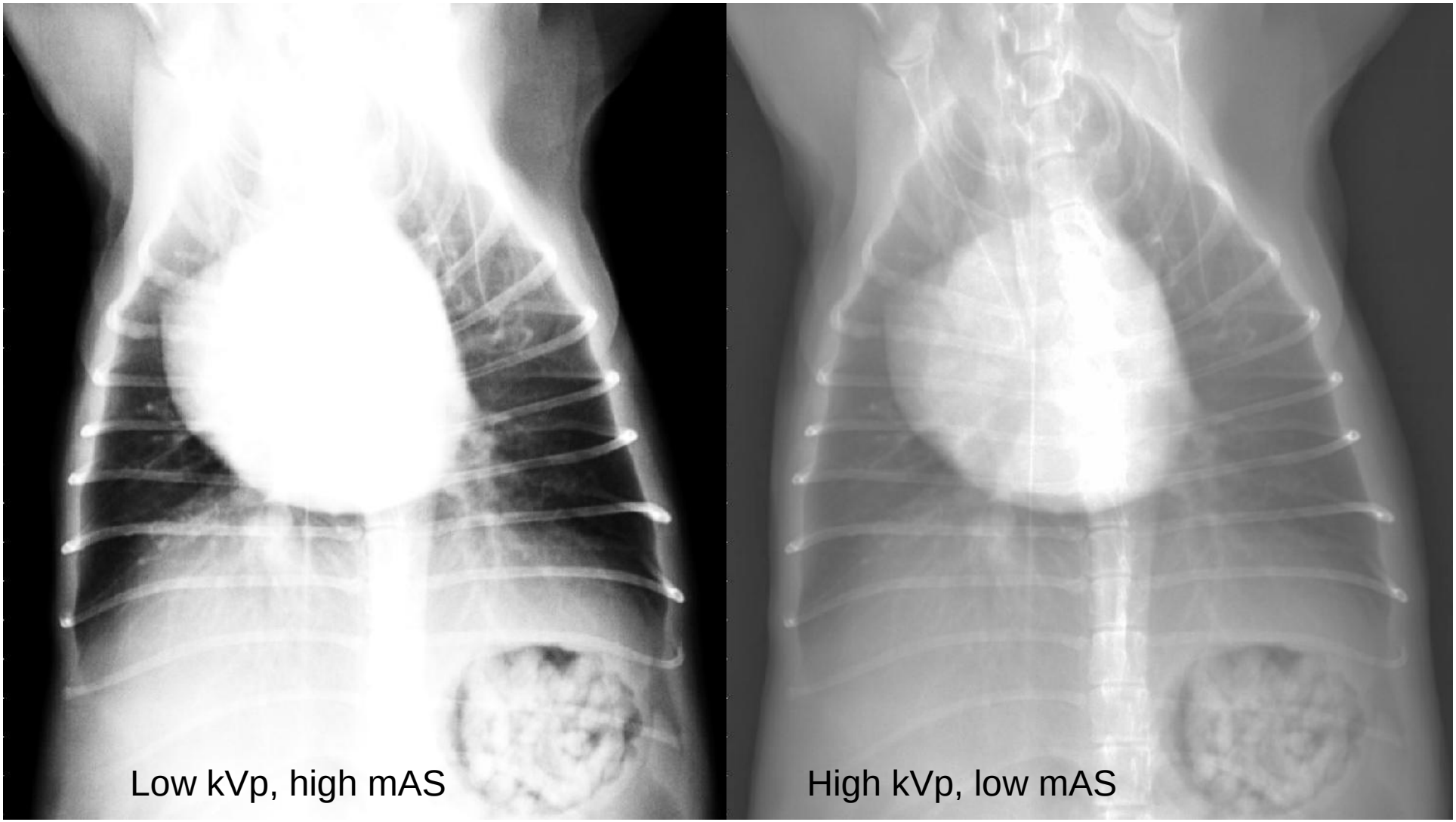
Filter algorithm

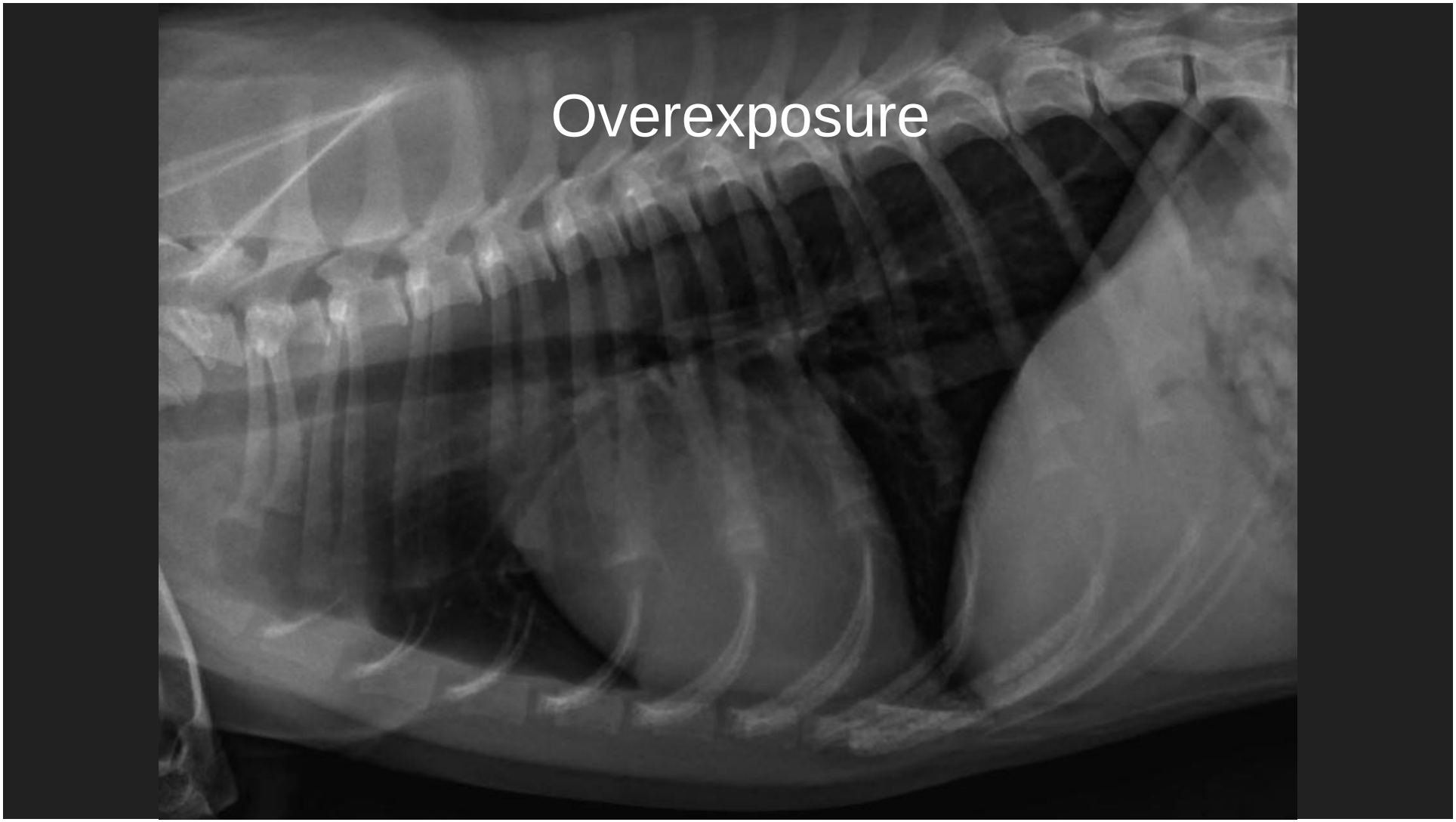
kVp, mAS

Low kVp, high mAS = high contrast

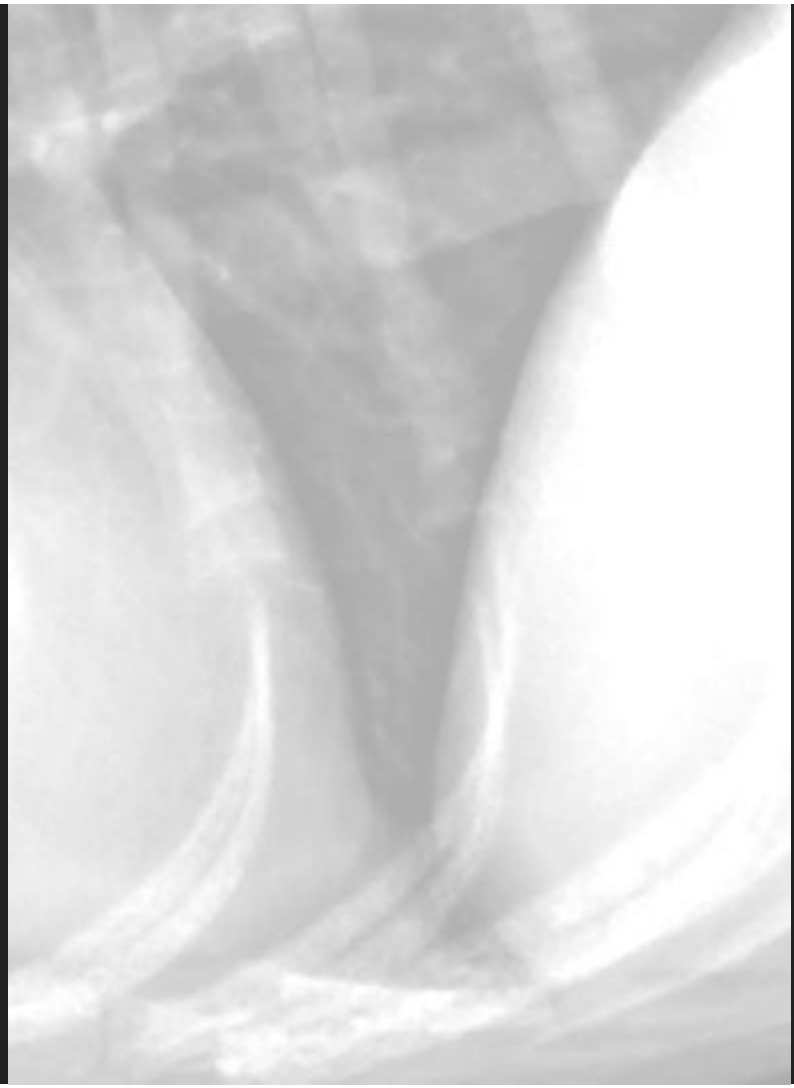
High kVp, low mAS = low contrast

“The higher the K, the higher the Gray”

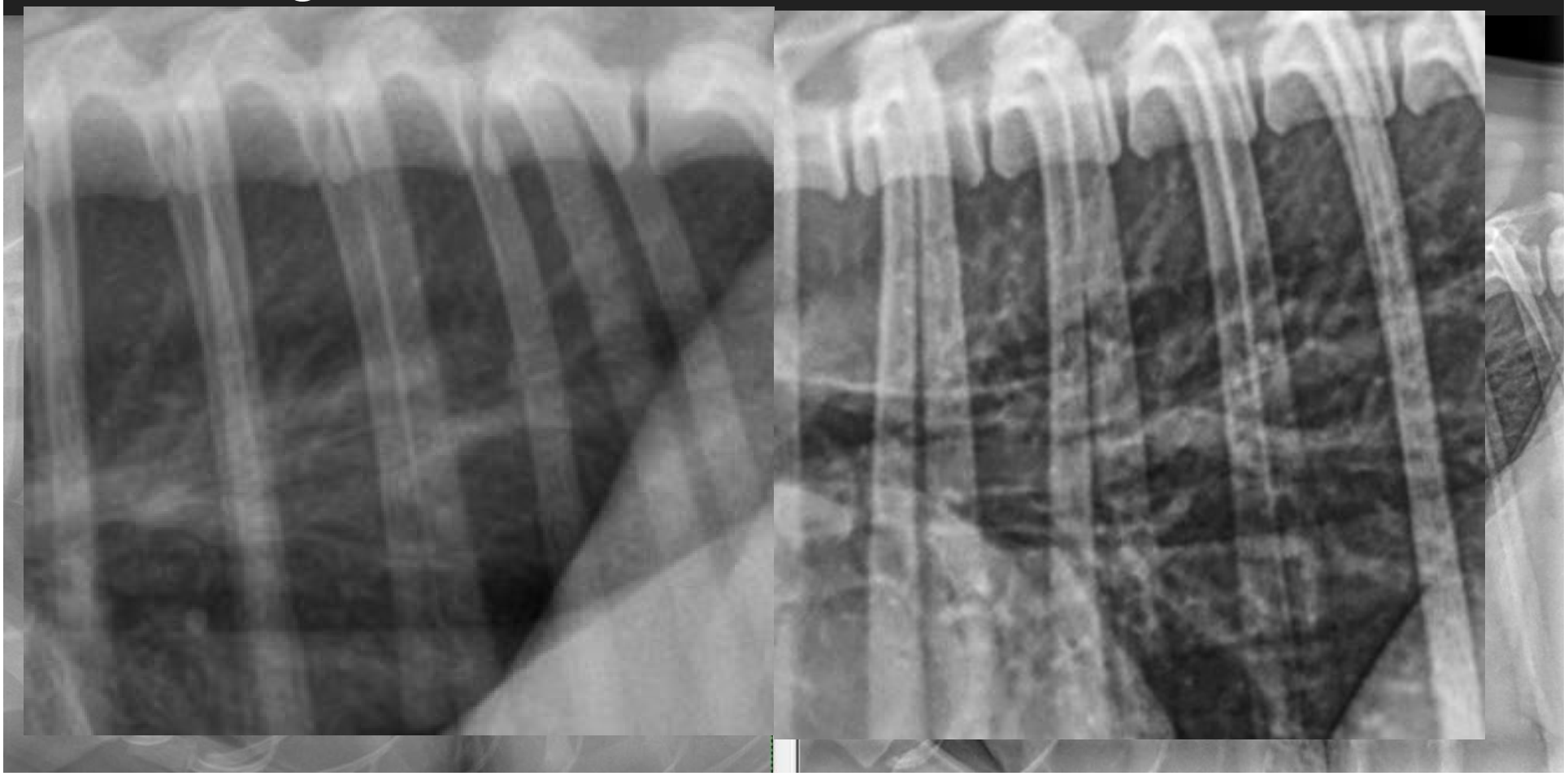

Low kVp, high mAS
High kVp, low mAS


Overexposure

Overexposure



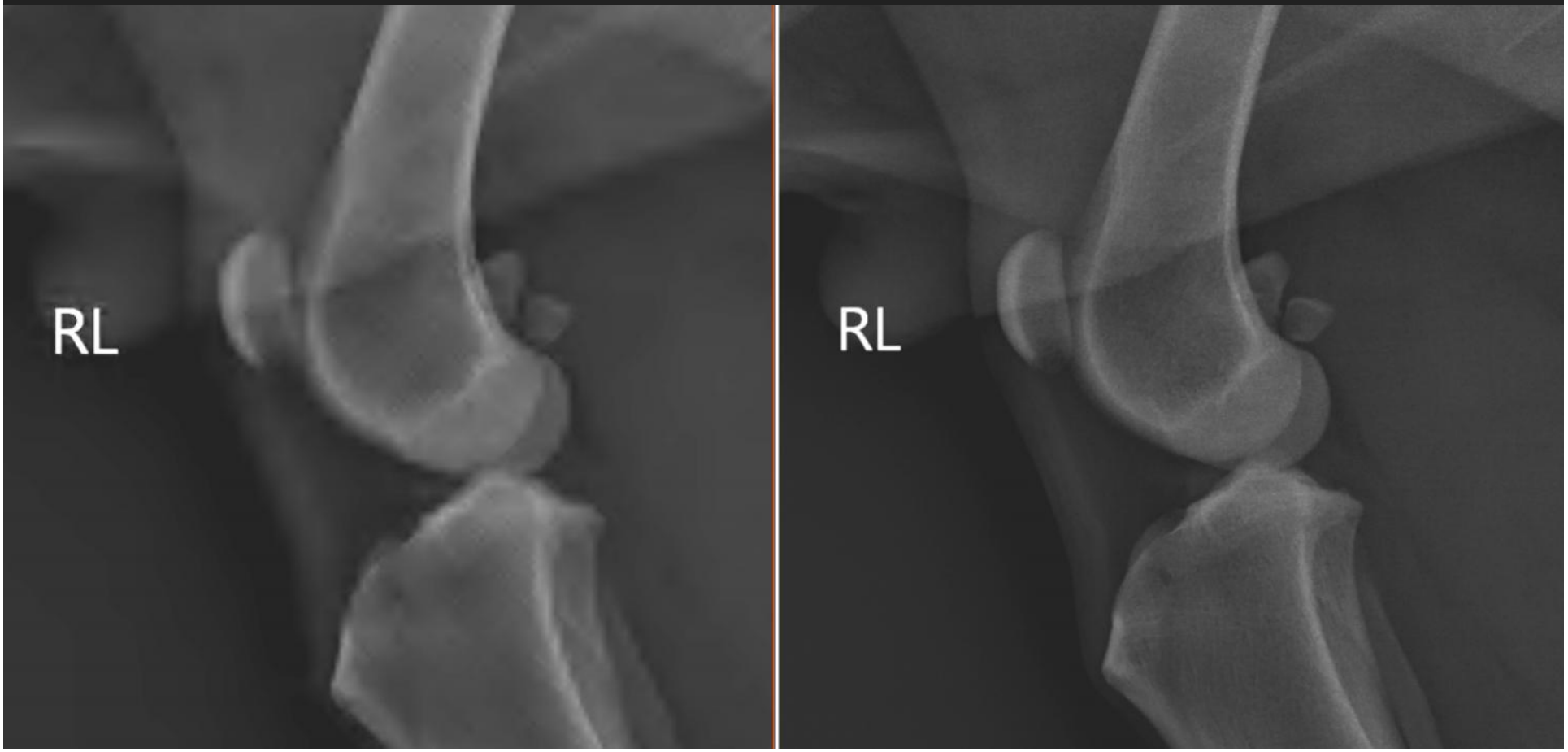
Filter algorithm



Noise: Modality factors

- CCD vs. CR vs. DR
  - DR highest resolution and latitude followed by CR then CCD
  - DR=$$$, CR=$$, CCD=$
- Post processing filters
  - All systems apply filters that you cannot control, important to be happy with the images before you buy a unit. The company should be able to provide you with samples pre-purchase.
- Compression
  - DICOM
  - JPEG
  - Other

JPEG compression



Noise: Positioning

Forelimbs

Positional atelectasis

Head positioning

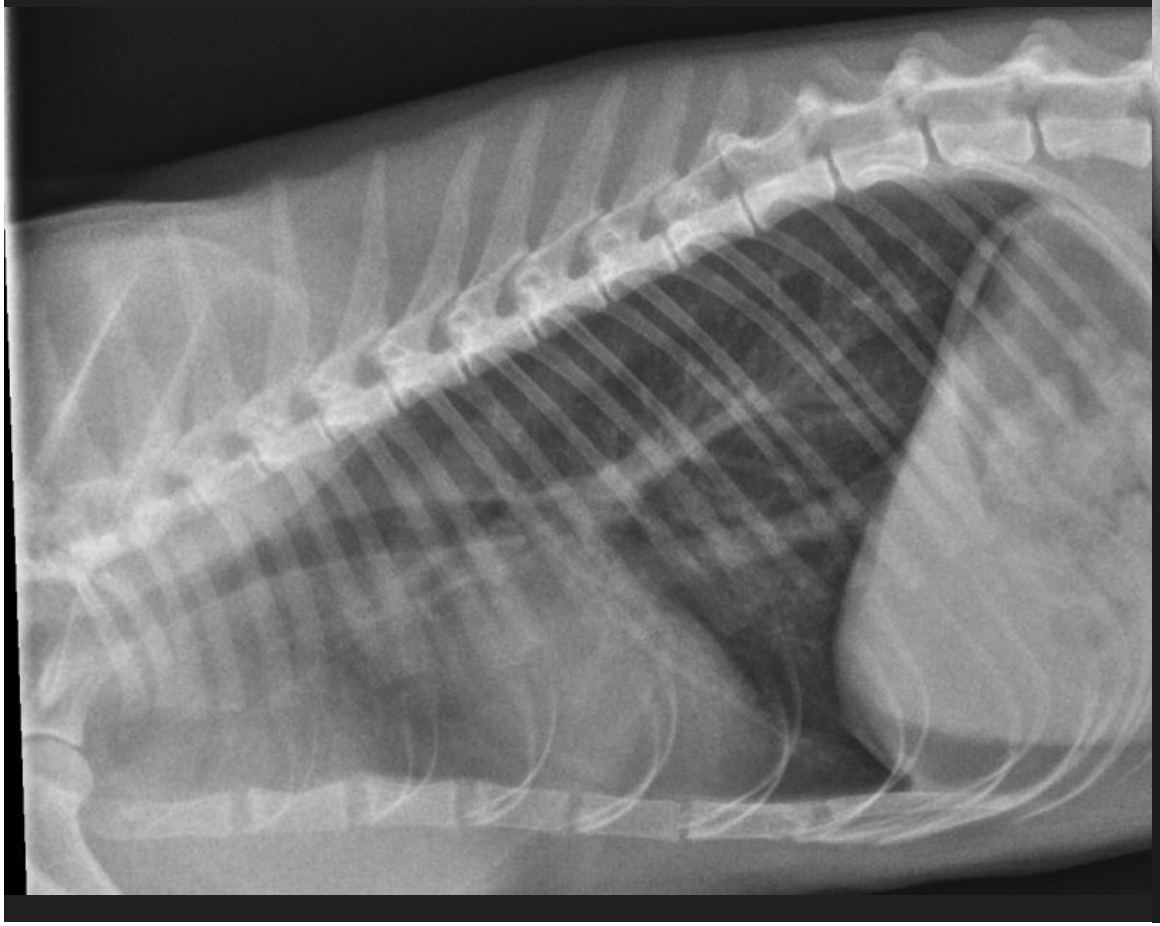
Rotation

Beam geometry

Forelimbs

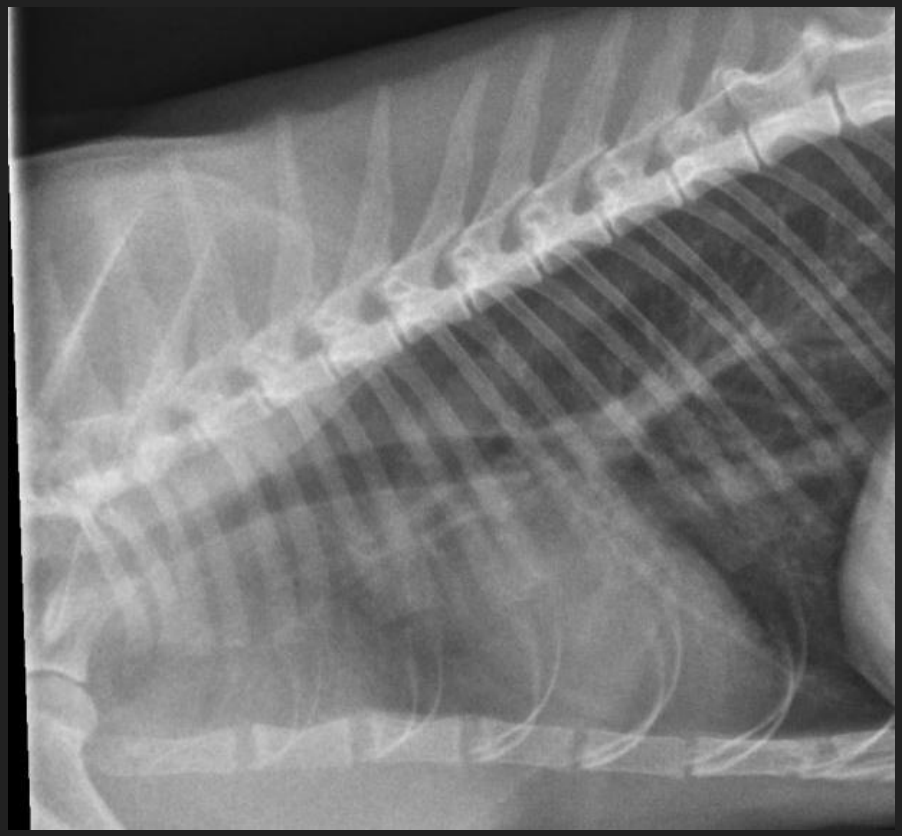
Forelimb positioning

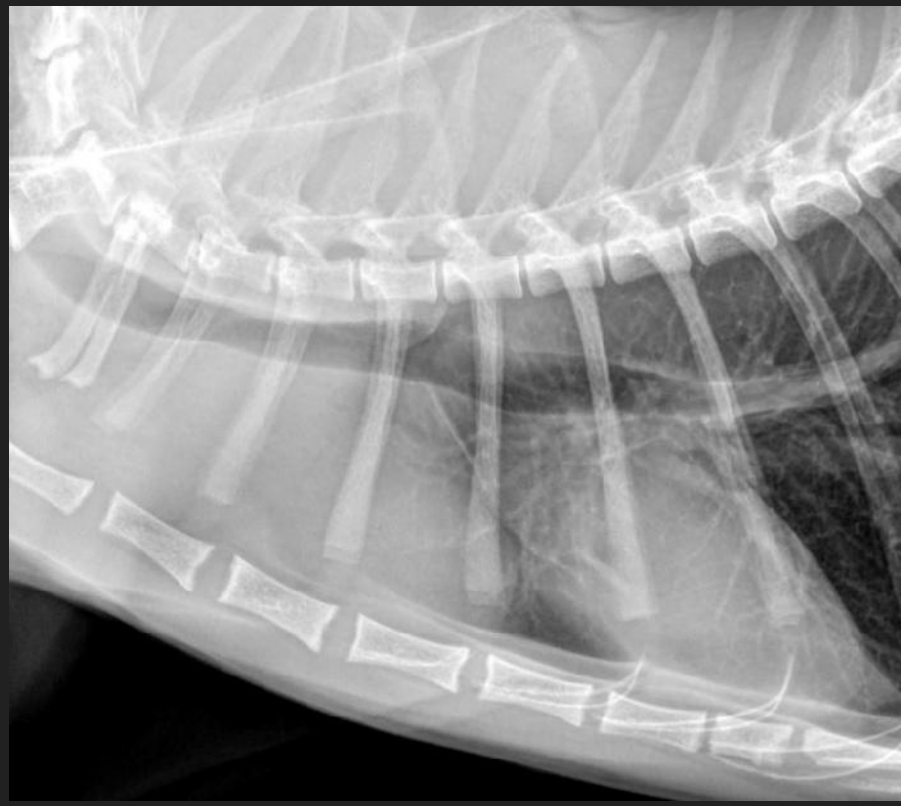
Forelimb positioning



Wide Cranial mediastinum: mass

Malpositioned forelimbs





Positional atelectasis

Contrast provided by air surrounding soft tissue structures

The less air, the less visible those soft tissue structures are as distinct objects

The dependent lung deflates

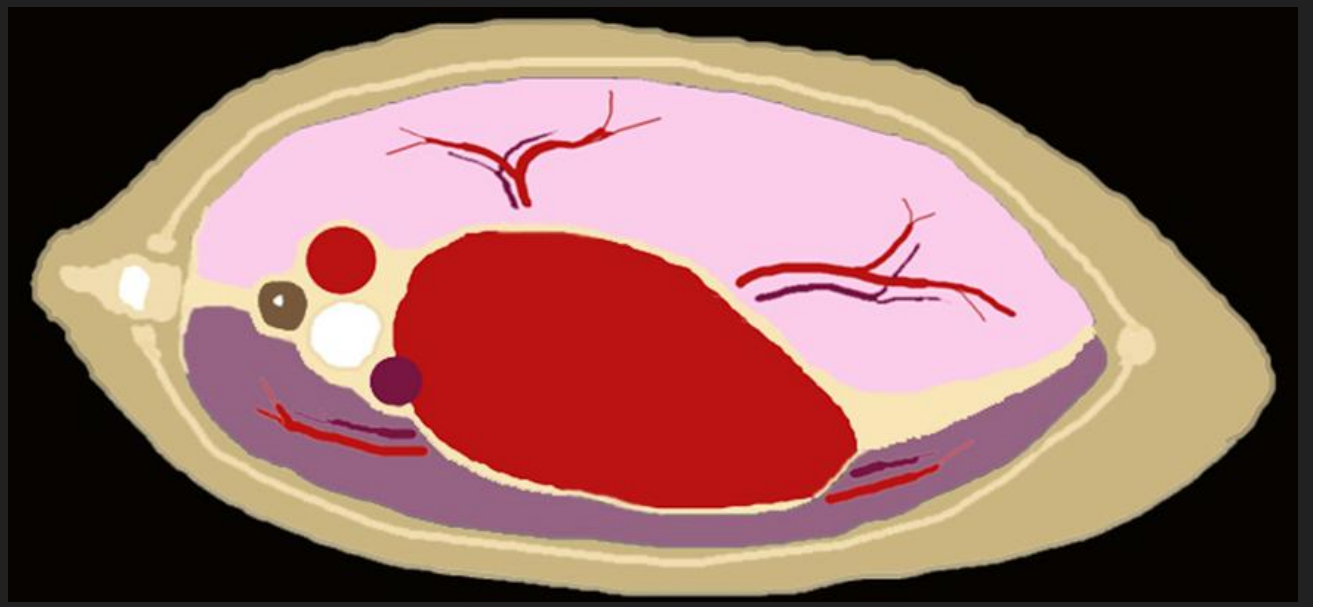
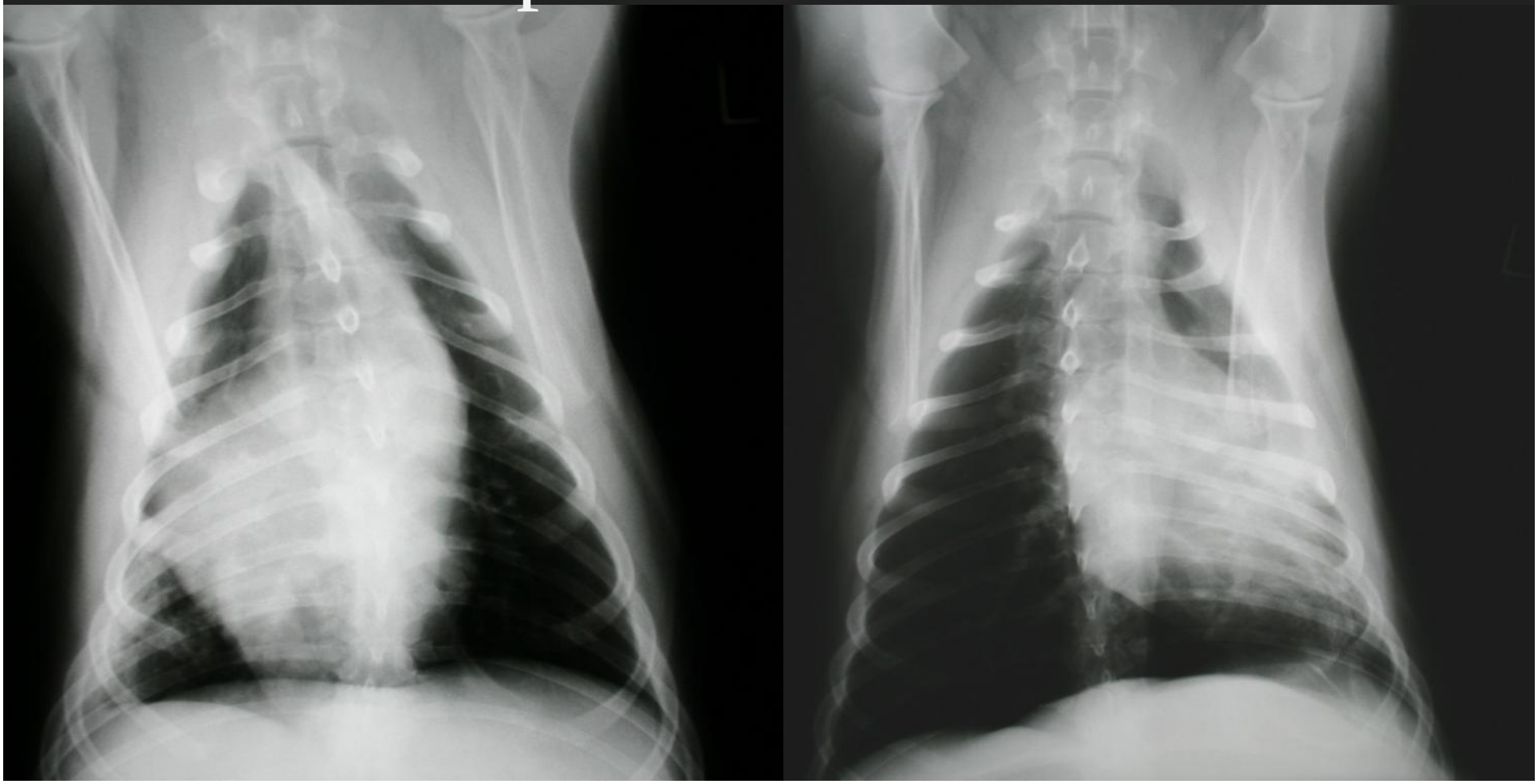
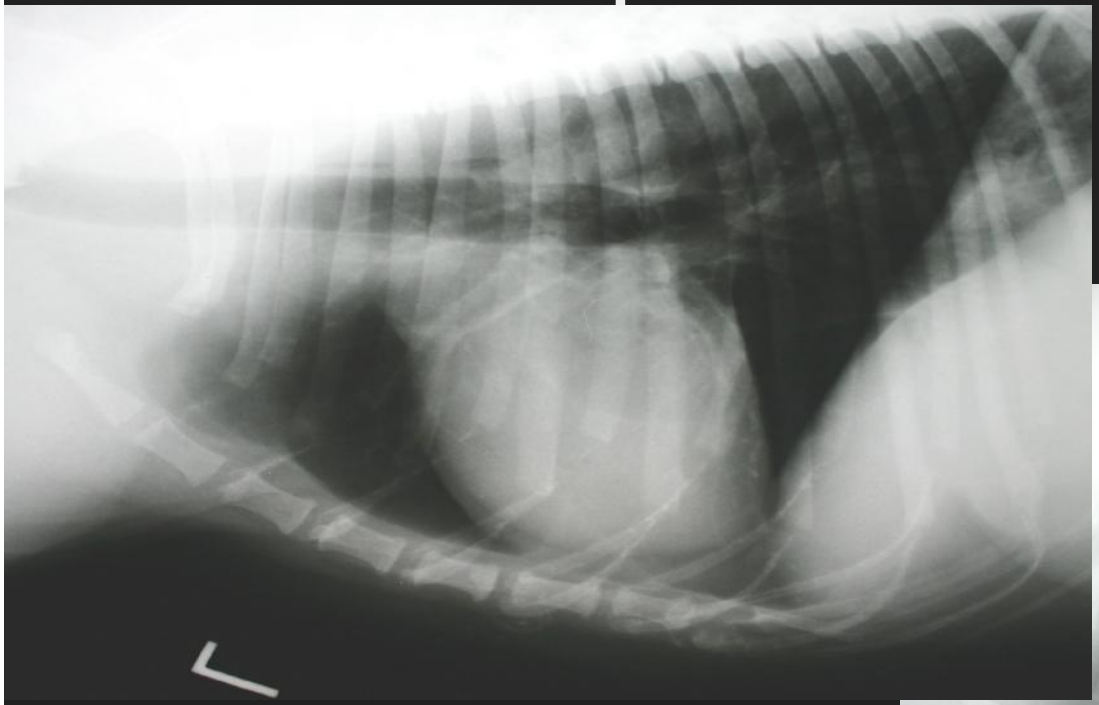


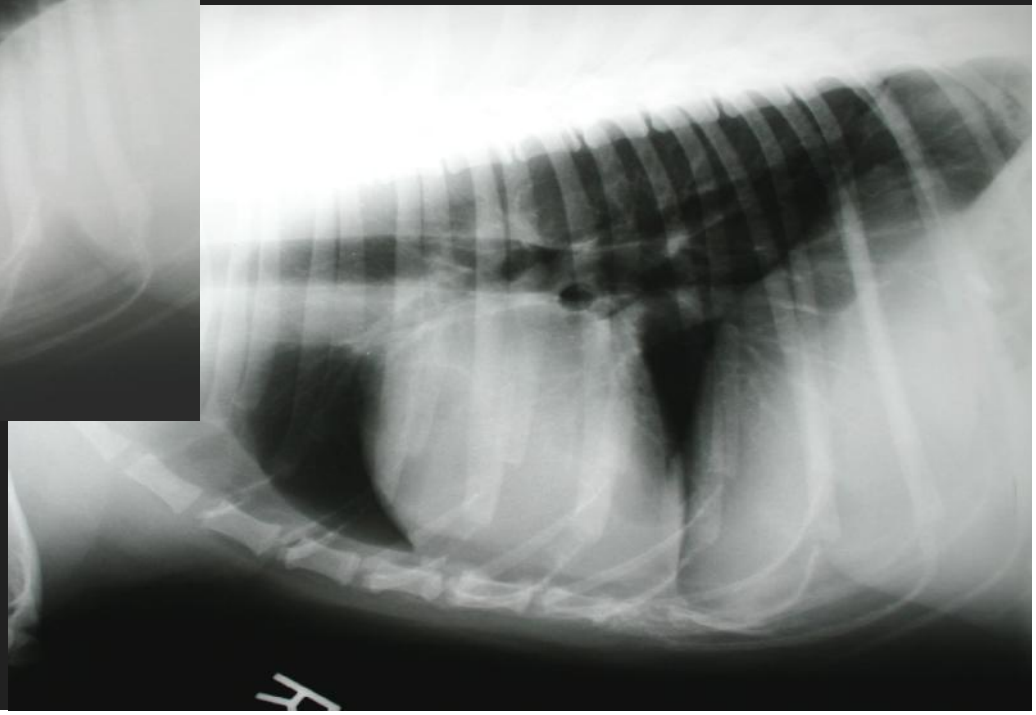
Diagram by Marc Andre d’Anjou

Dependent atelectasis

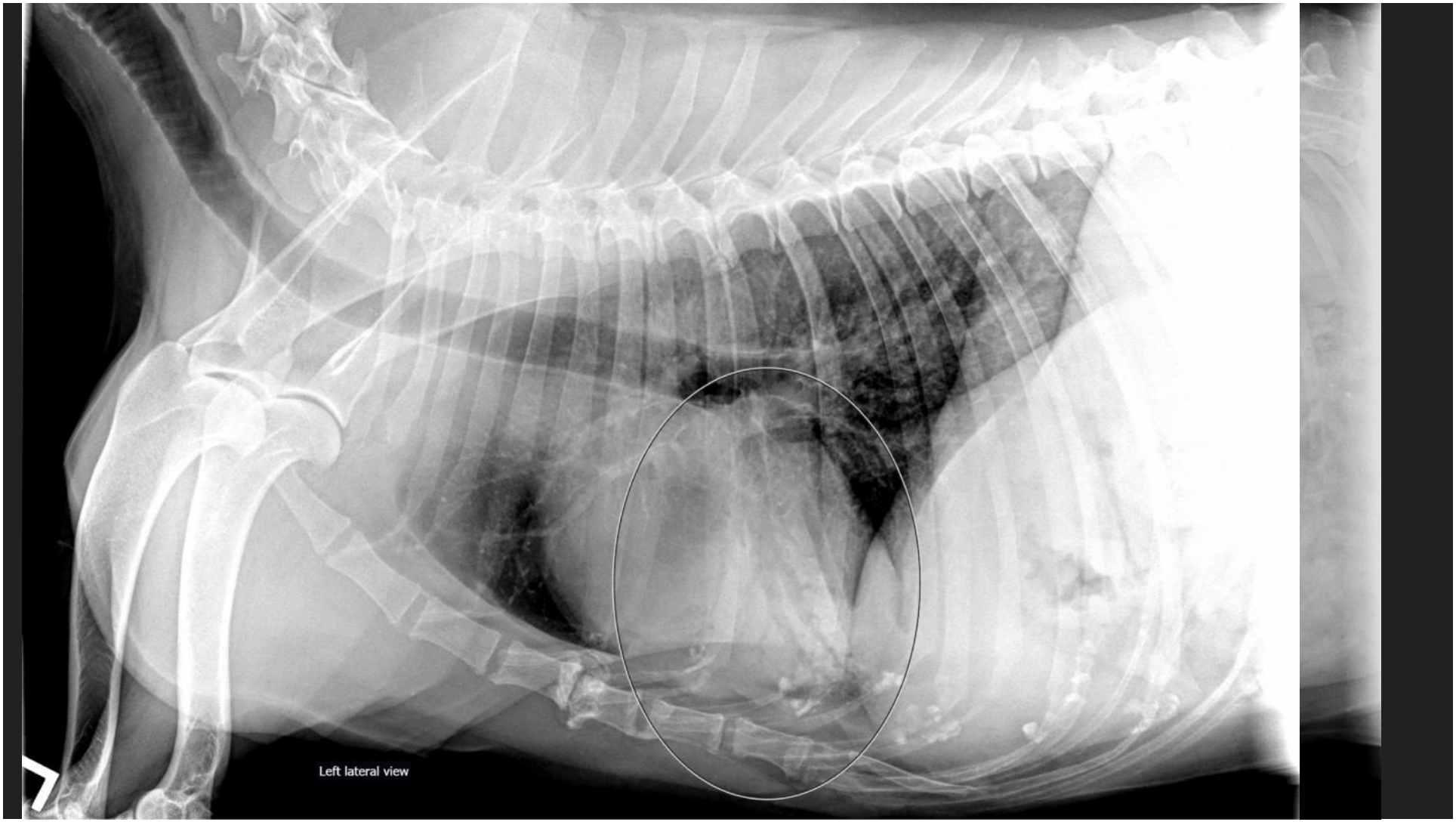


Dependent atelectasis





- 10Y GSD, skin nodule removal
- Pre-anesthesia thorax

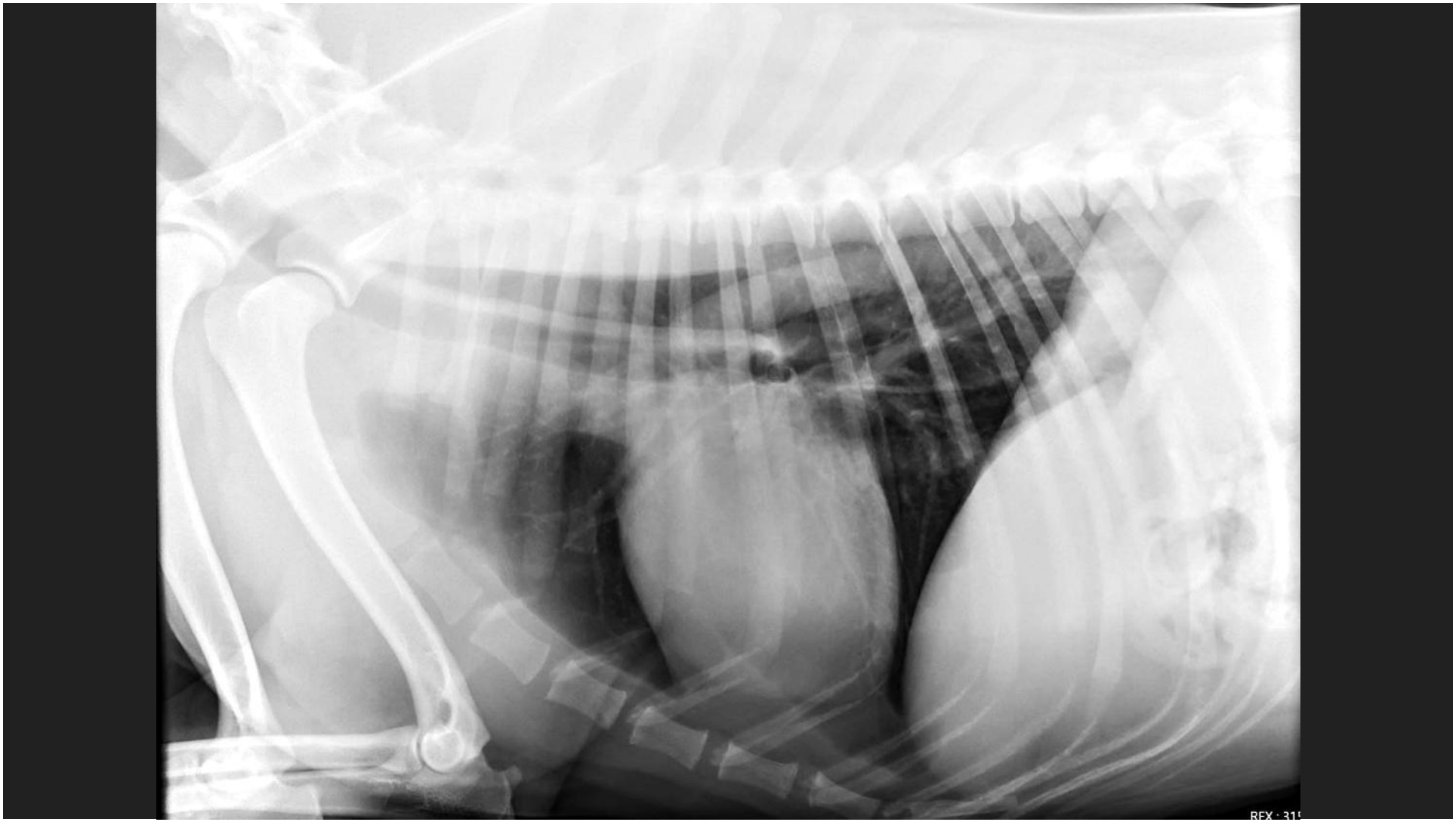

Left lateral view

Anesthesia

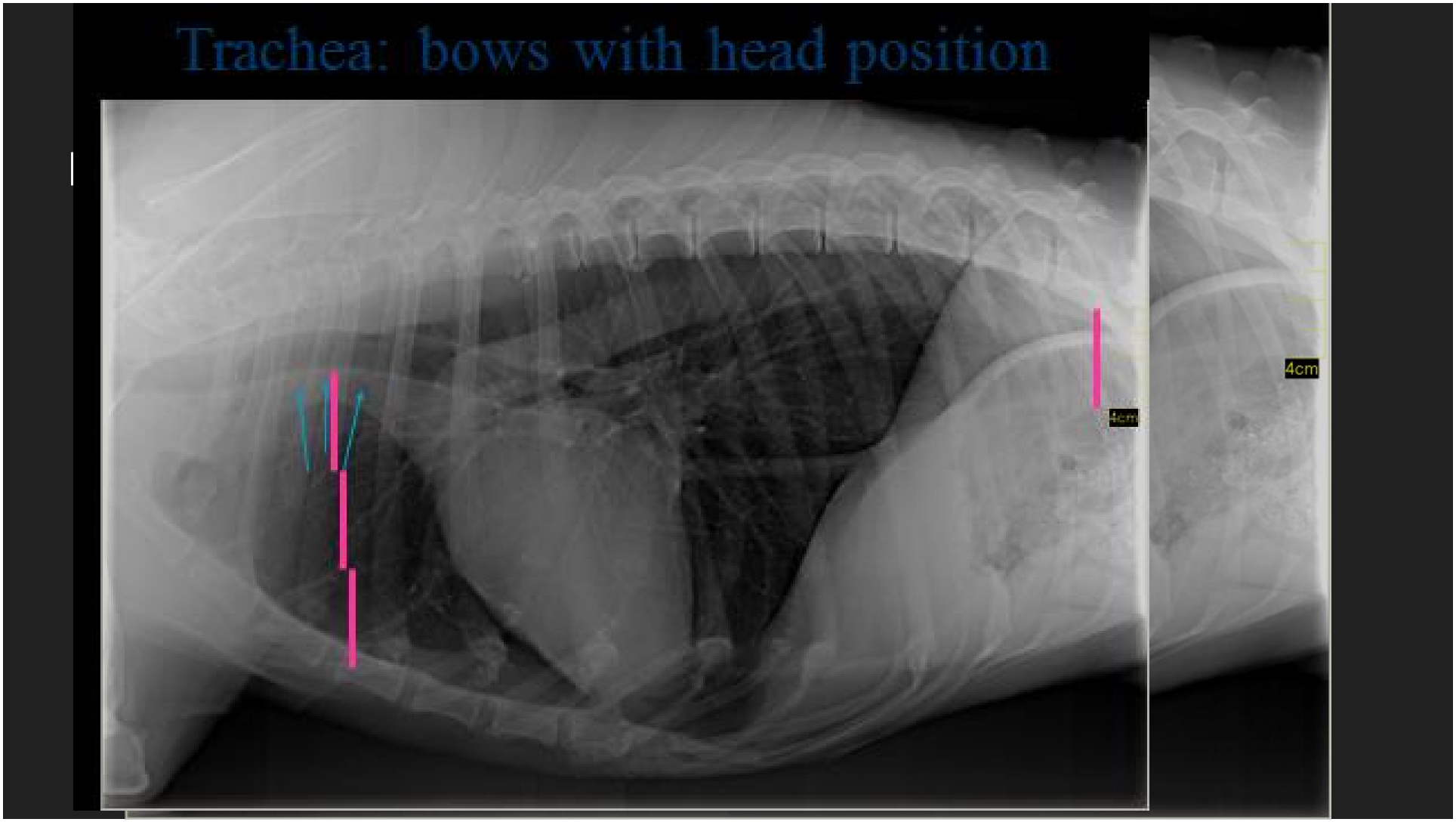
Exaggerates atelectasis

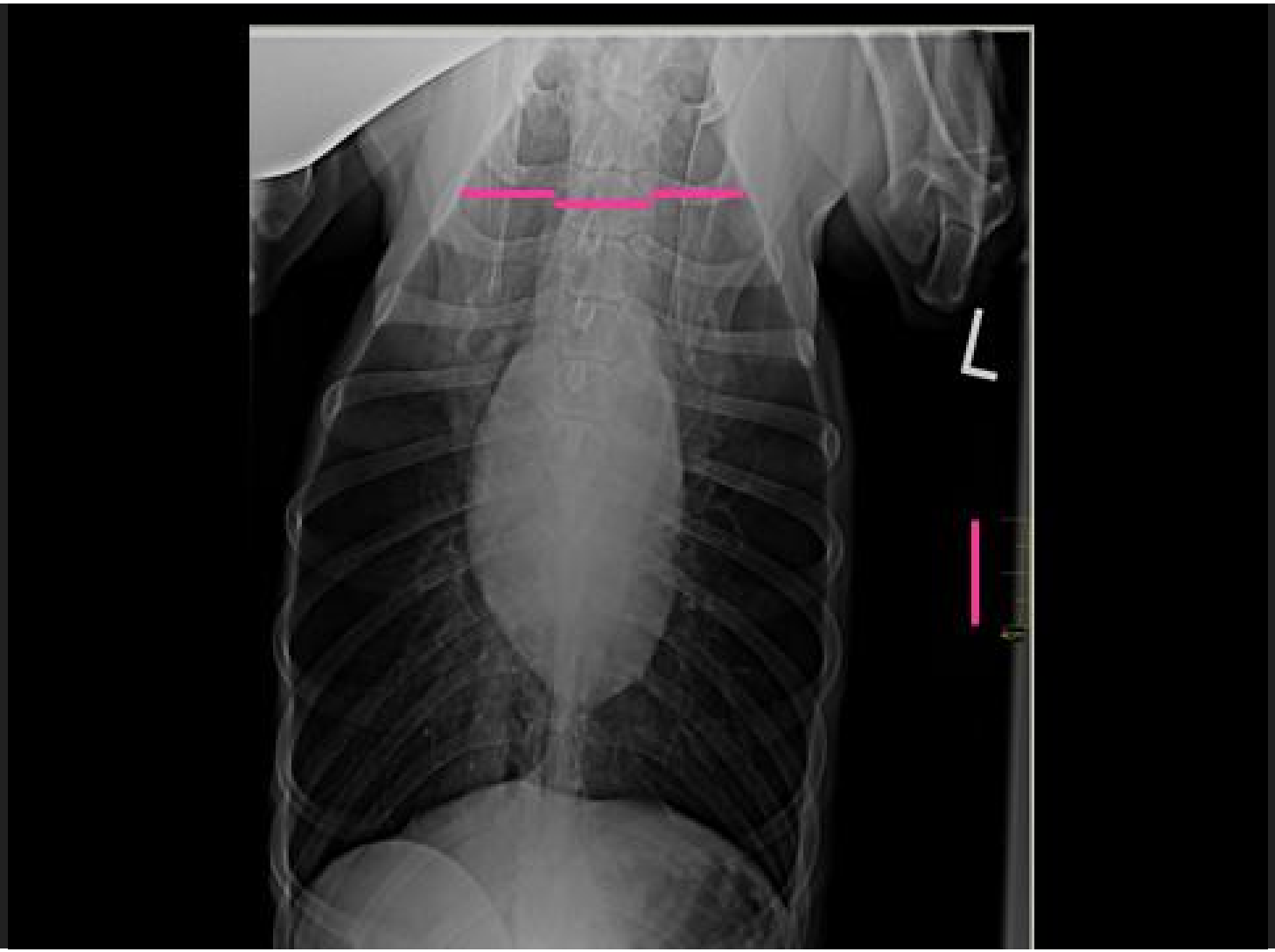
Poor lung inflation overall

Esophageal dilation



Trachea: bows with head position

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Rotation

Noise: beam geometry

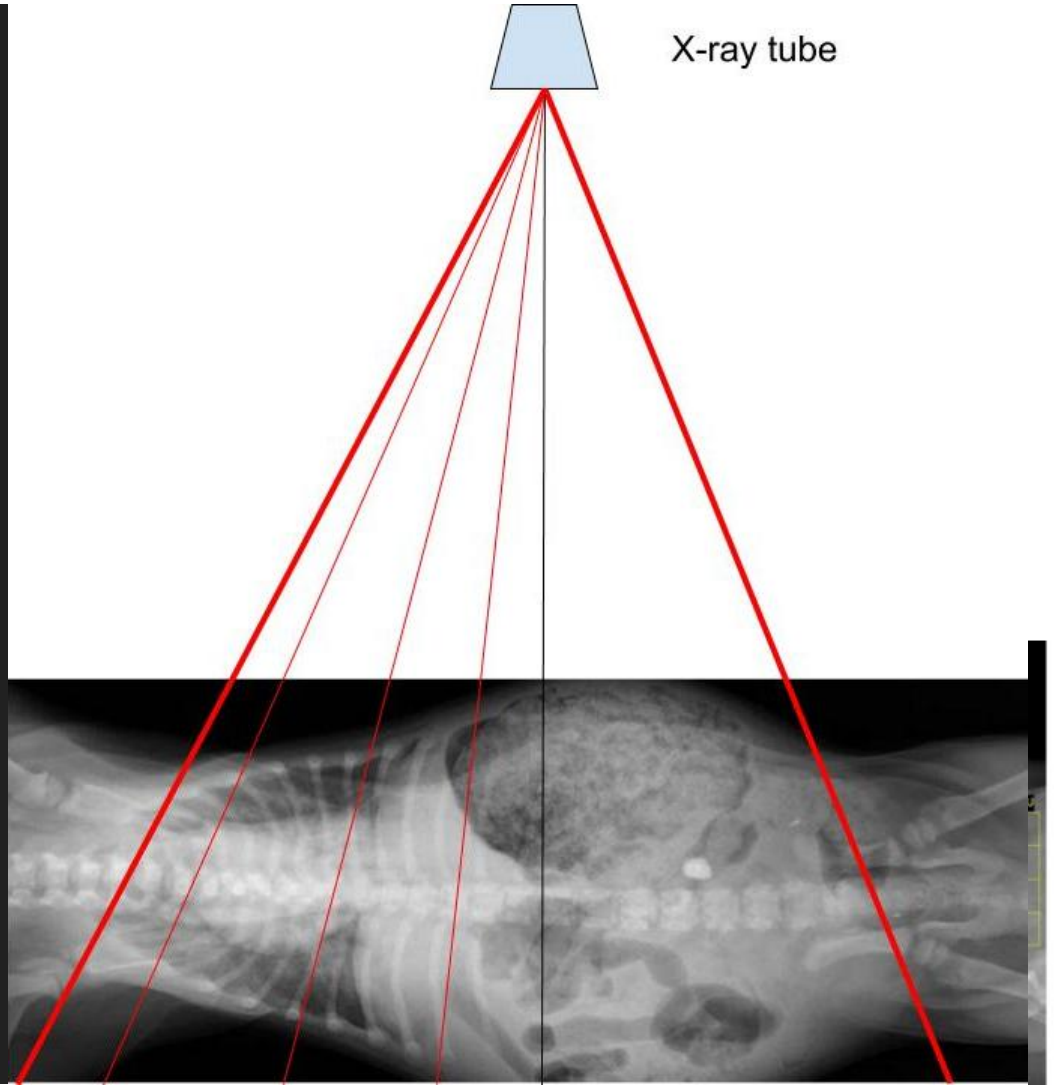
Whole body images

Thorax projected at an angle

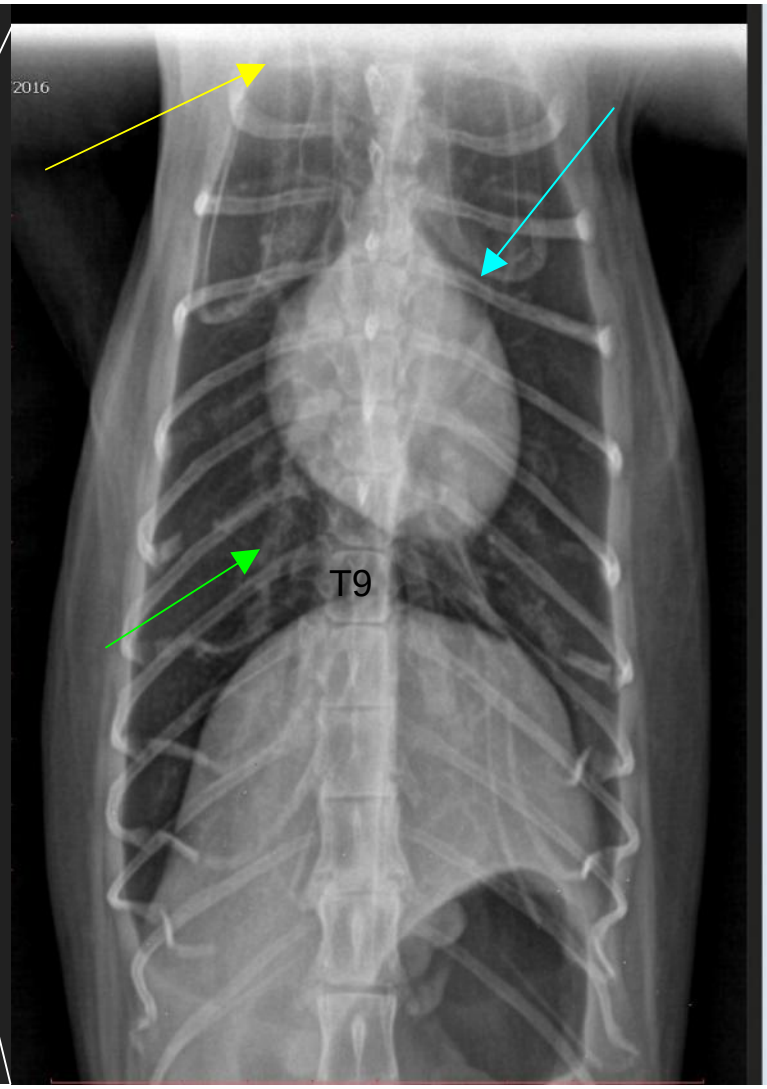
Foreshortens lung fields

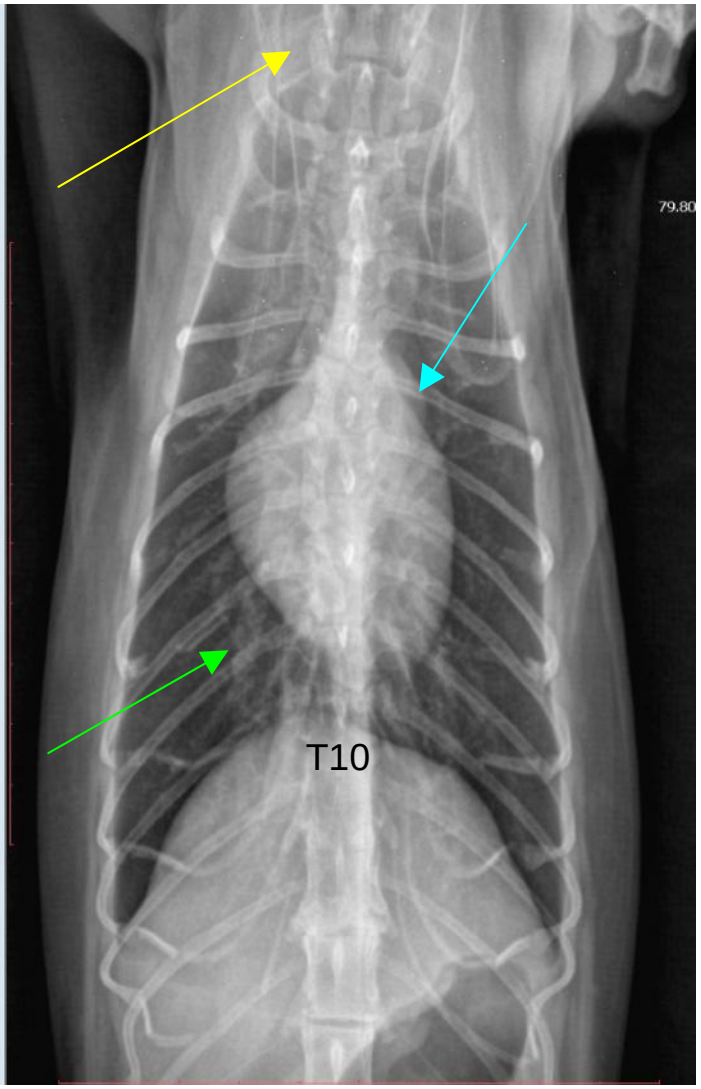
Foreshortens and rounds heart

Displaces pulmonary vasculature relative to landmarks



Noise: beam geometry





Noise: Phase of respiration

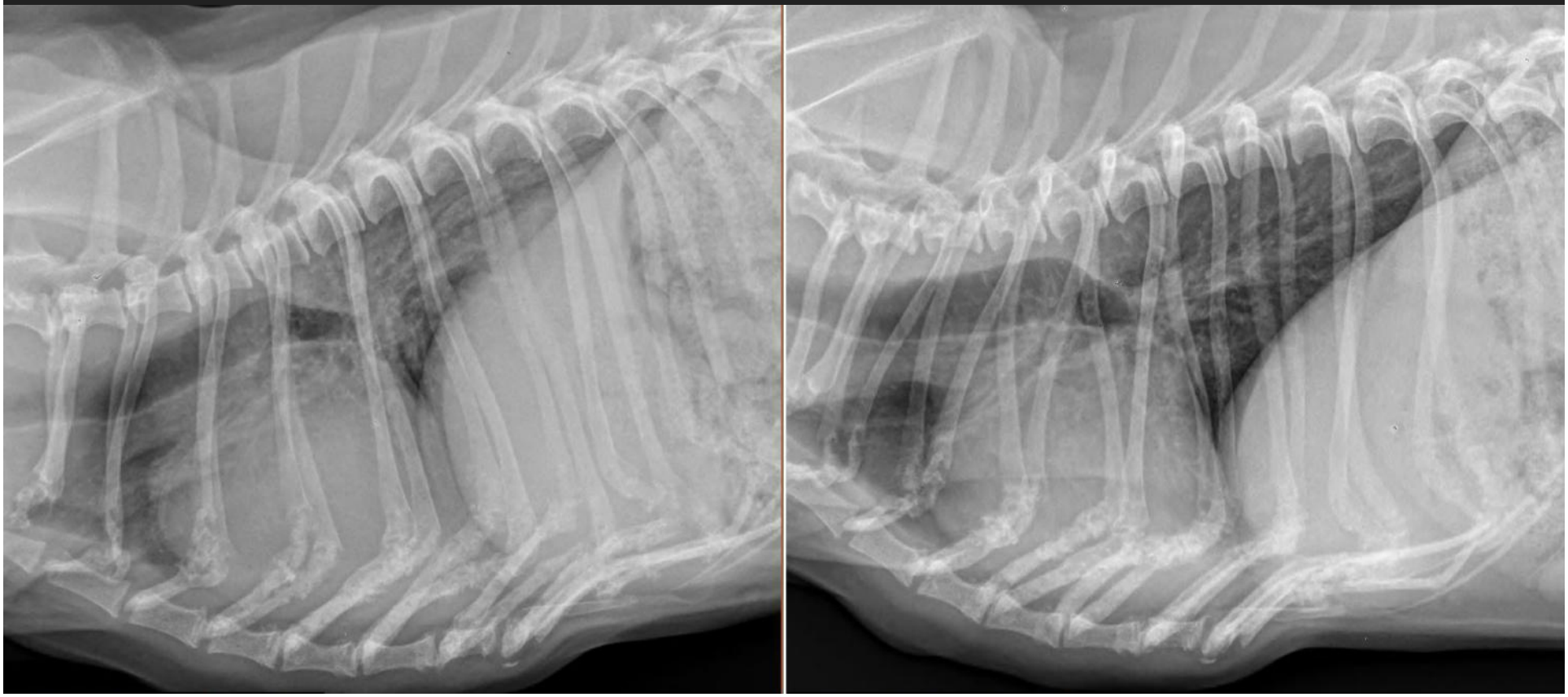
Contrast in the lung fields provided by gas separating and highlighting the soft tissue structures

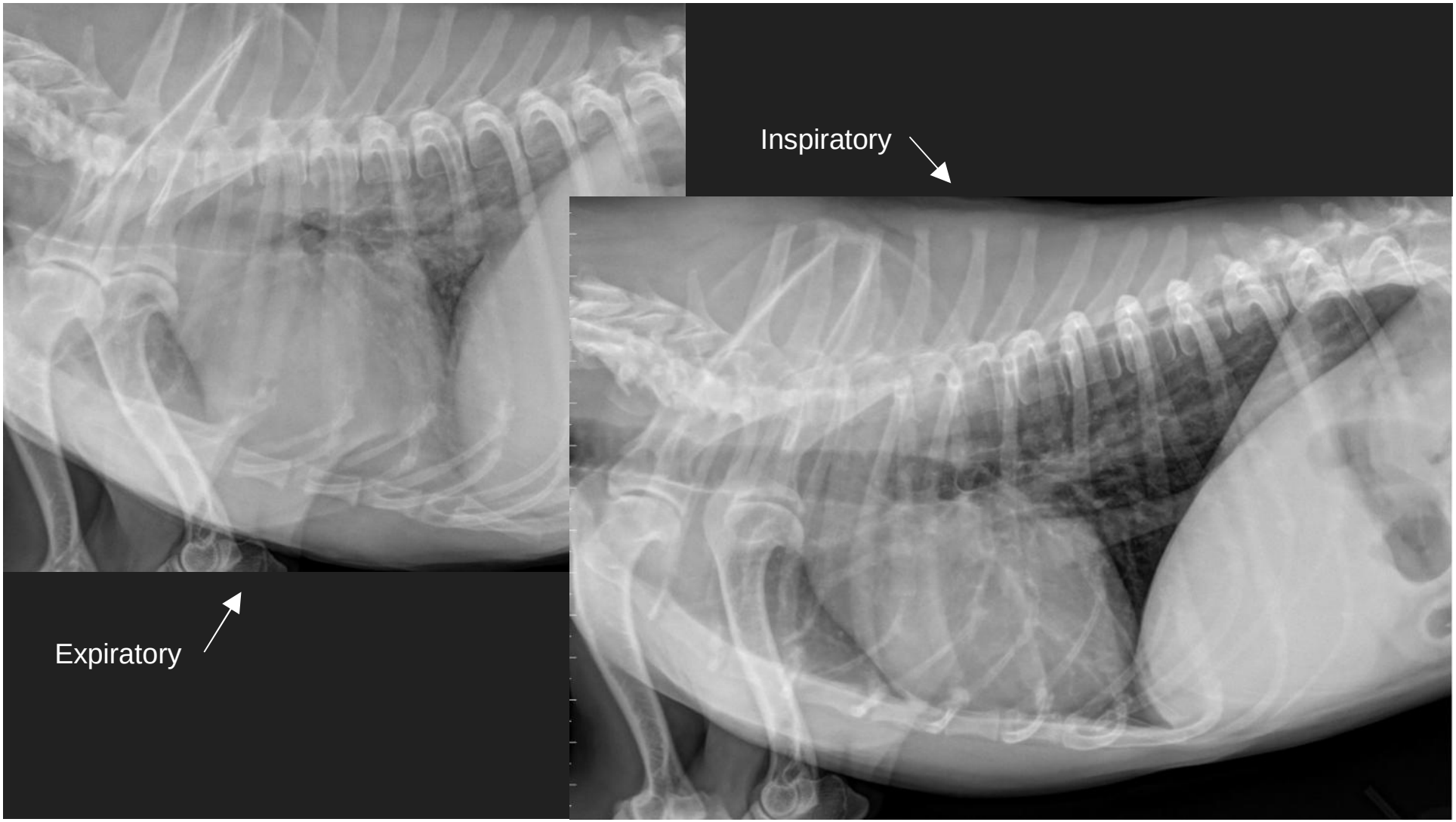
Less gas = less contrast

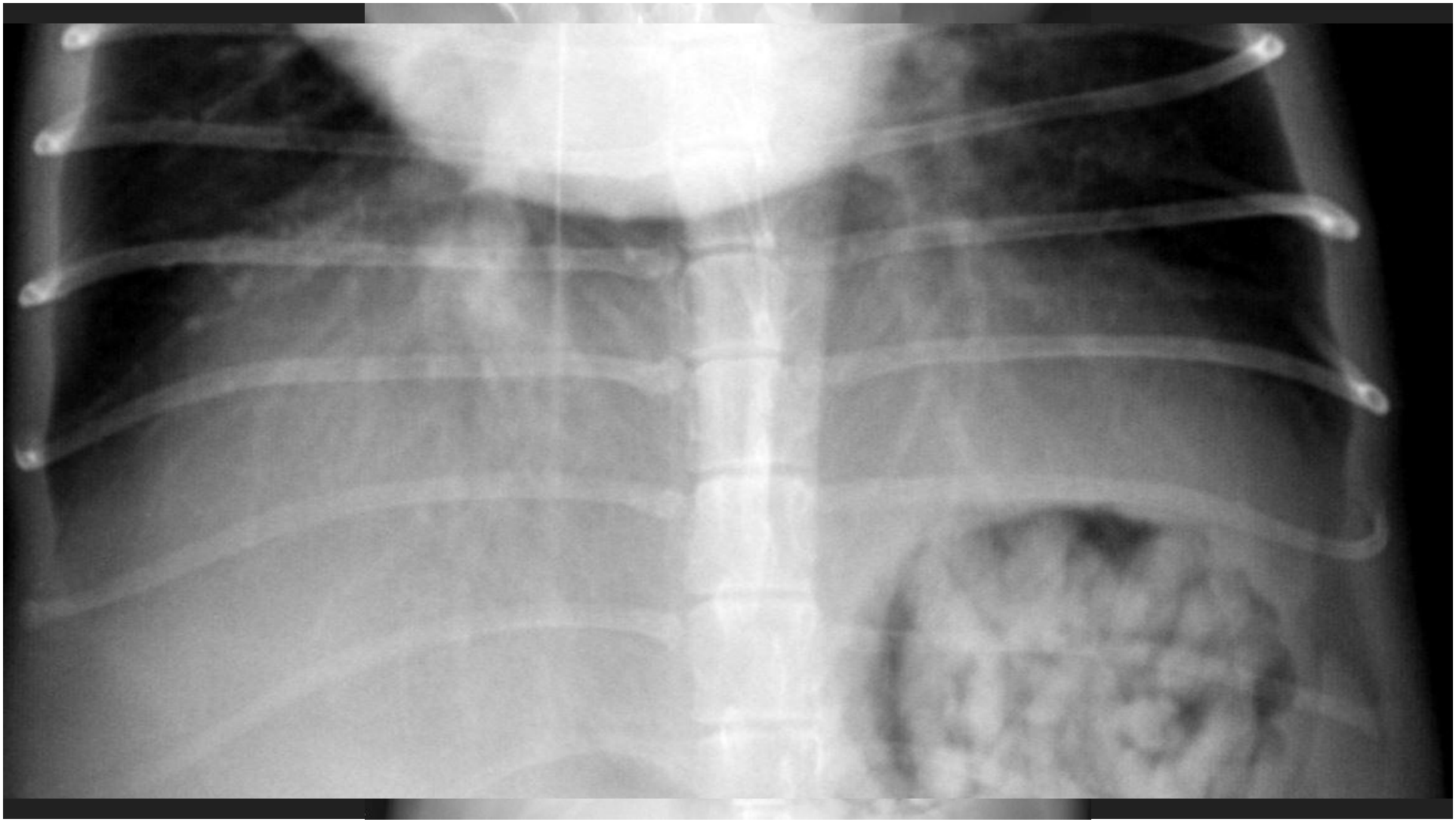
Less gas = relatively more soft tissue, mimics pathology

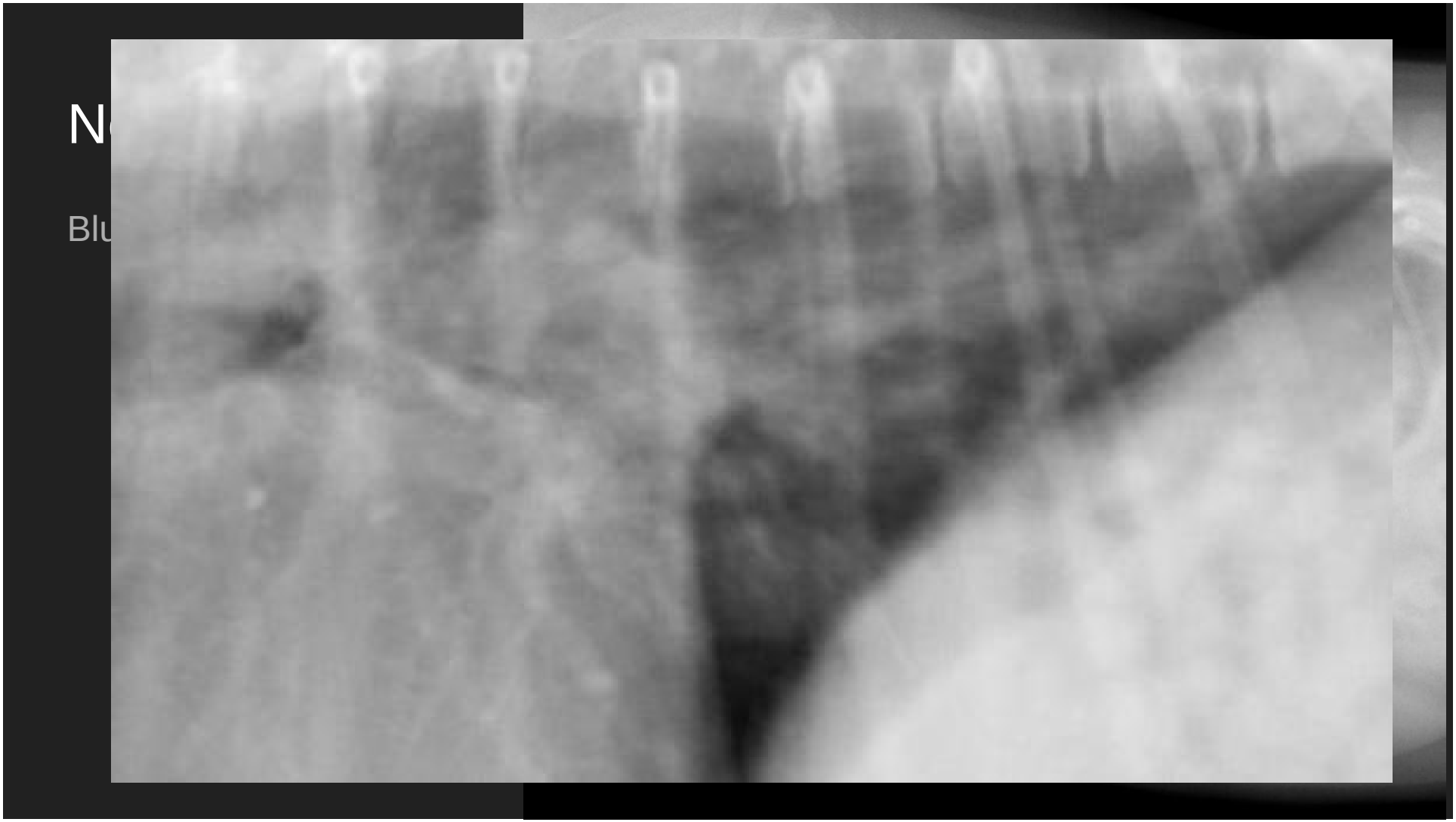
Expiration

Inspiration




Inspiratory
Expiratory





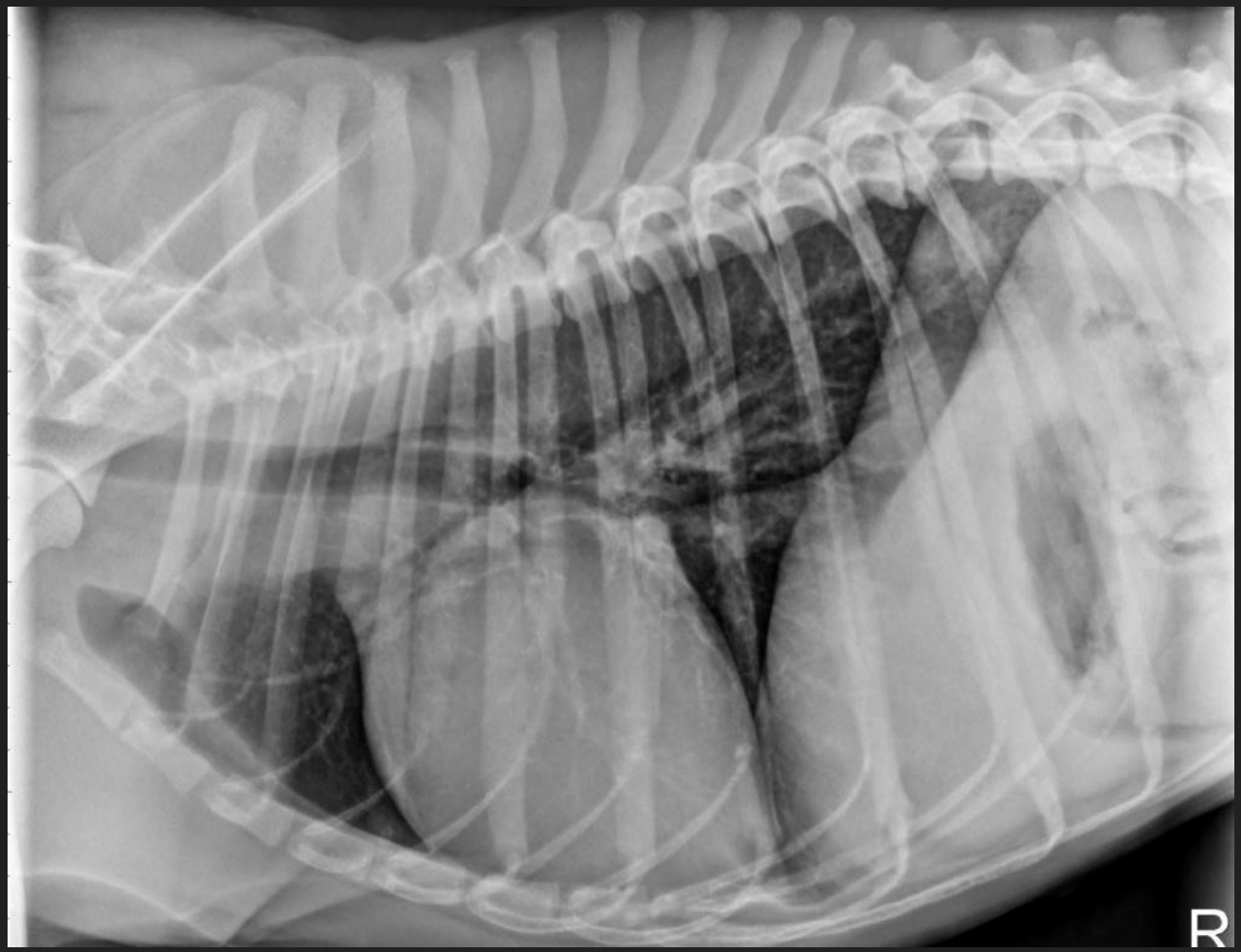
Noise: Normal anatomic variation

Breed/body conformation

Fat

Age

“Normal” Dog



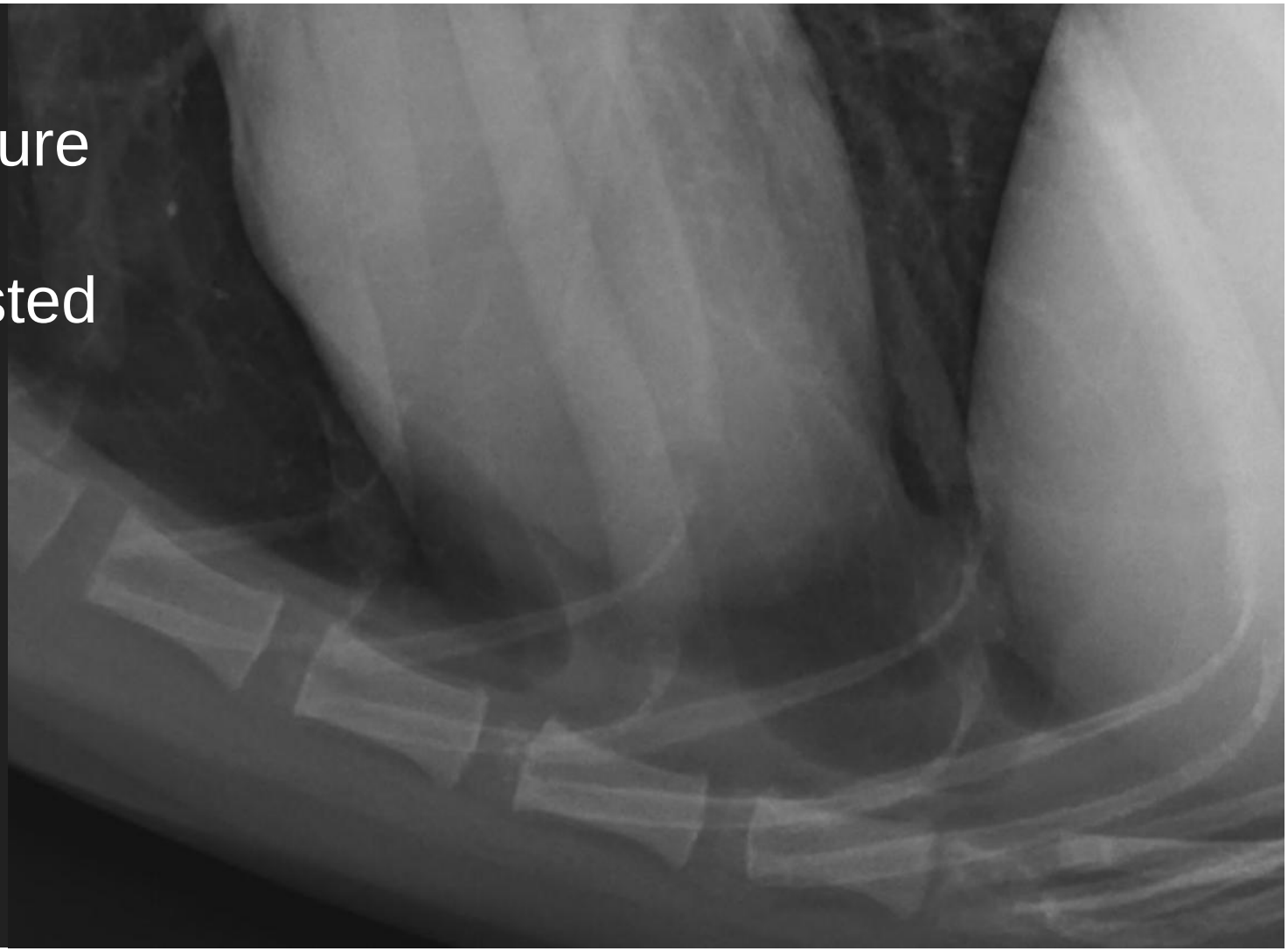
“Normal” Dog


EDR3 Digital Radiography System
32715 Patient: MILTON, GABBY

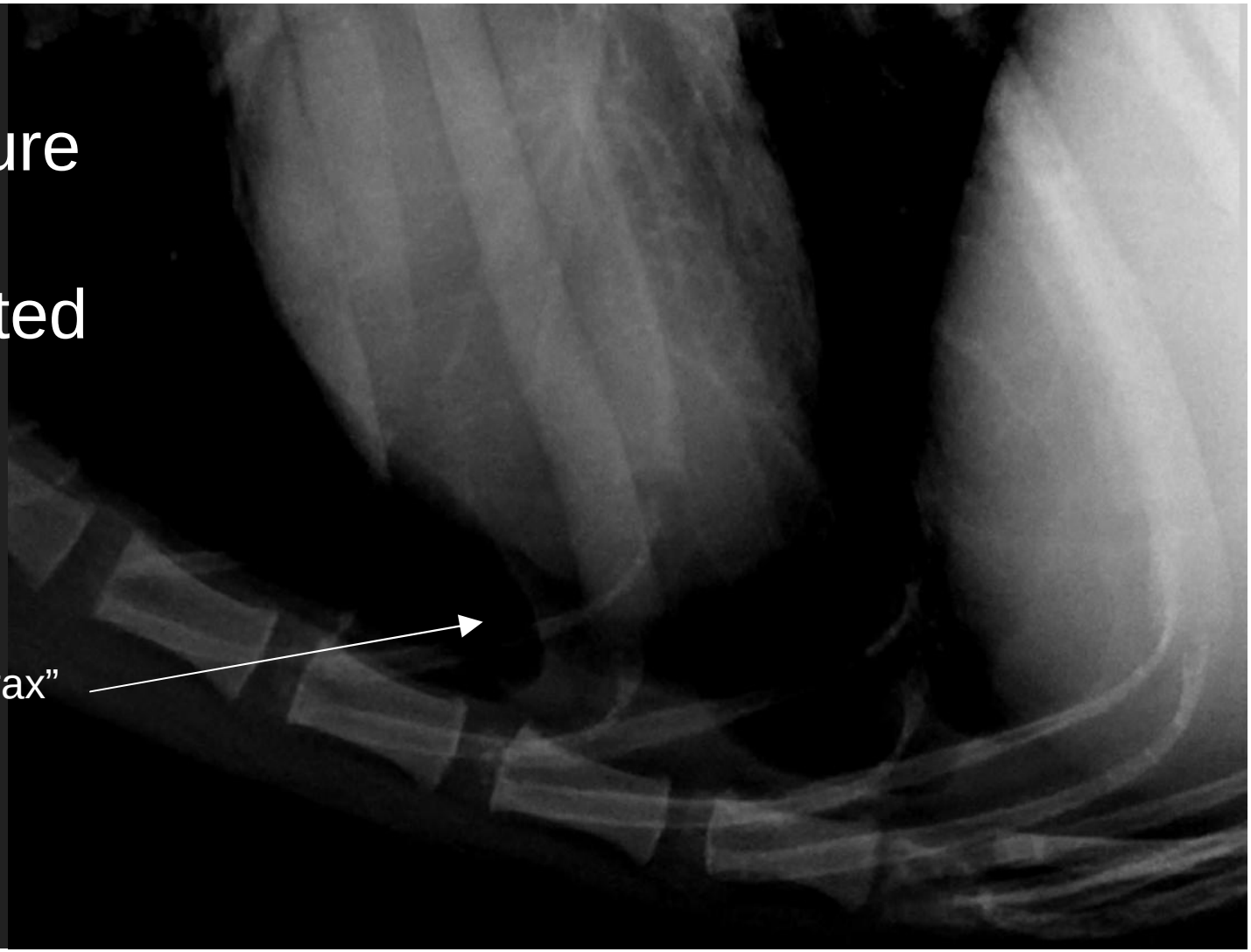
“Deep Chested”

- Lungs “Bigger” and more lucent
- Heart longer and thinner in lateral, Rounder in VD
- Separation between heart and sternum

Overexposure
And
Deep Chested

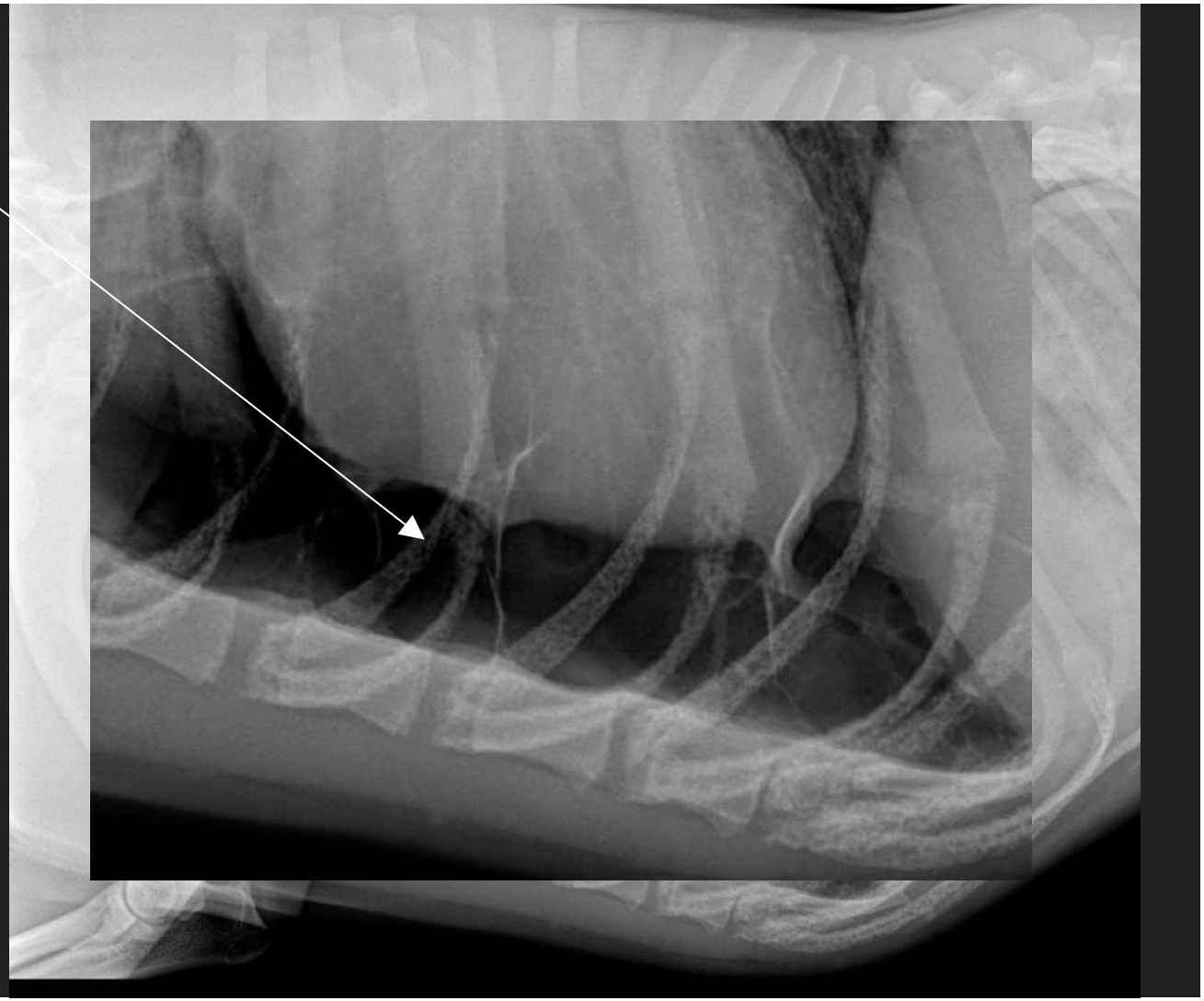


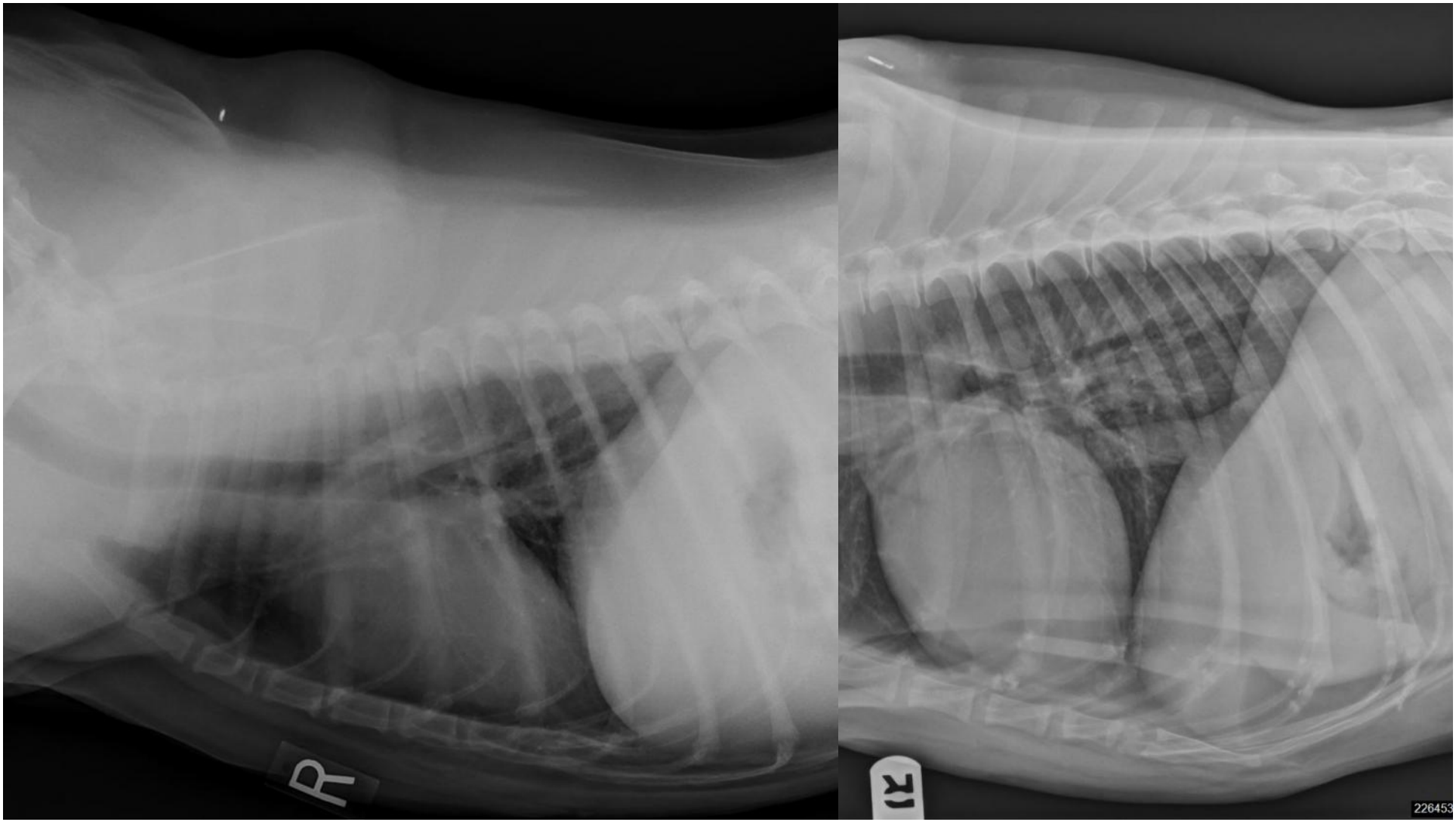
Overexposure
And
Deep Chested



“Pseudopneumothorax”

True pneumothorax

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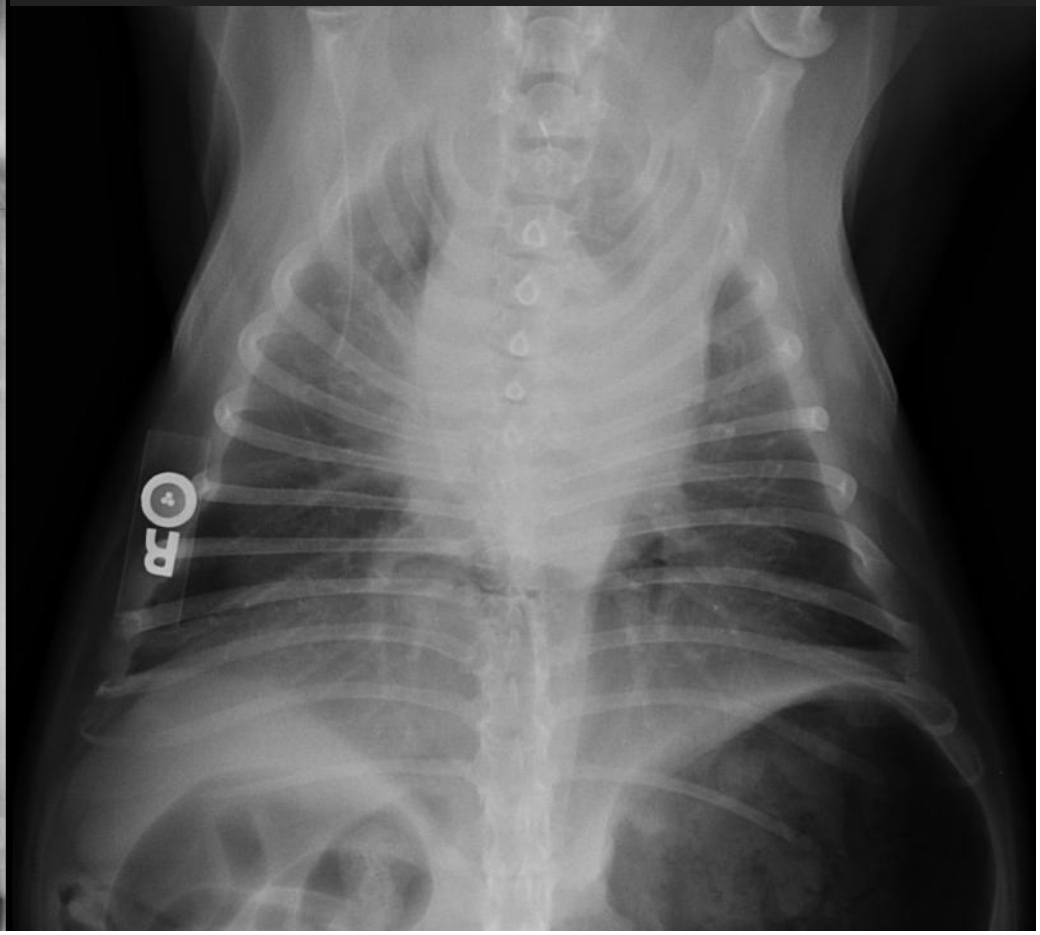
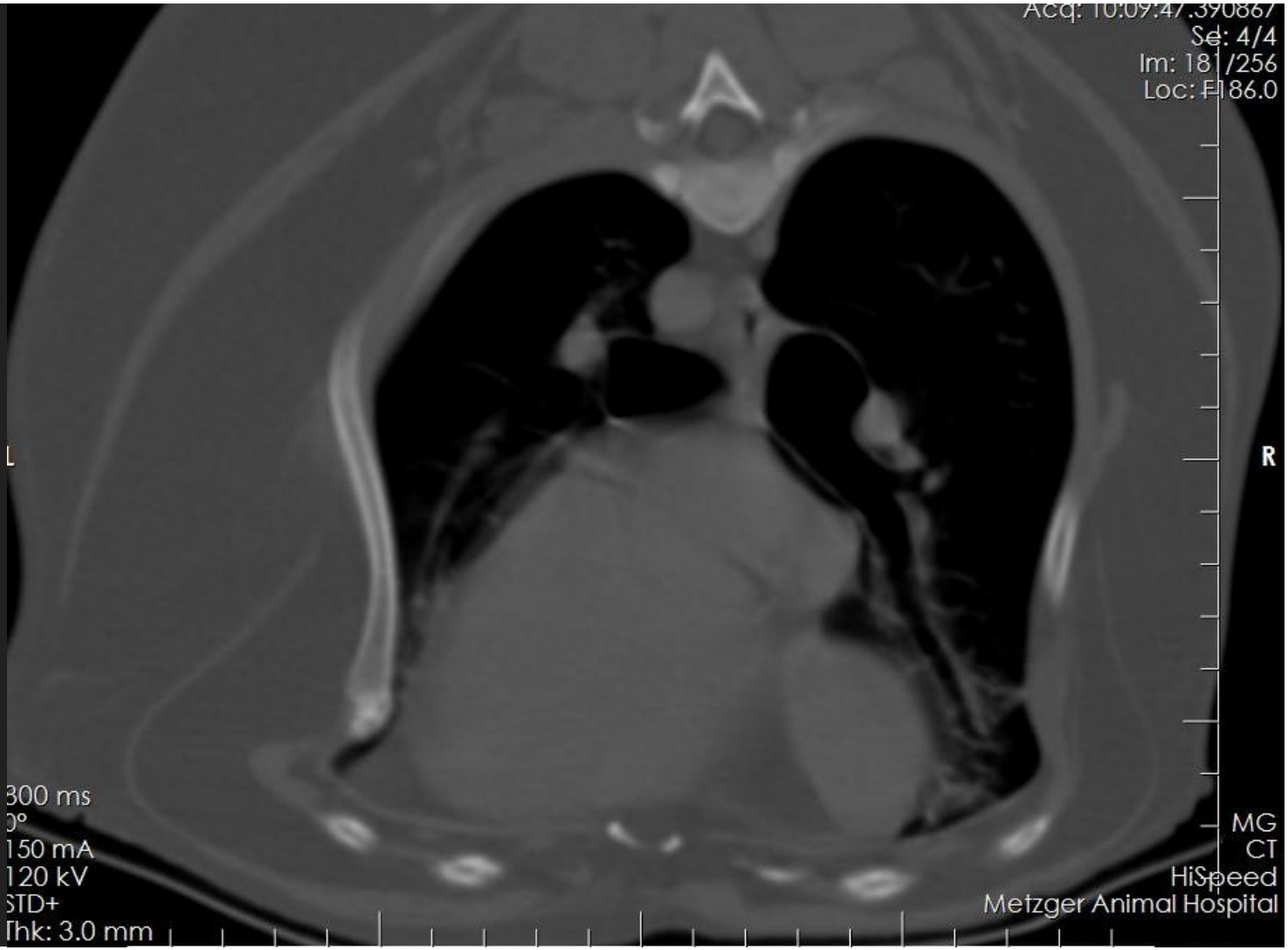
226453

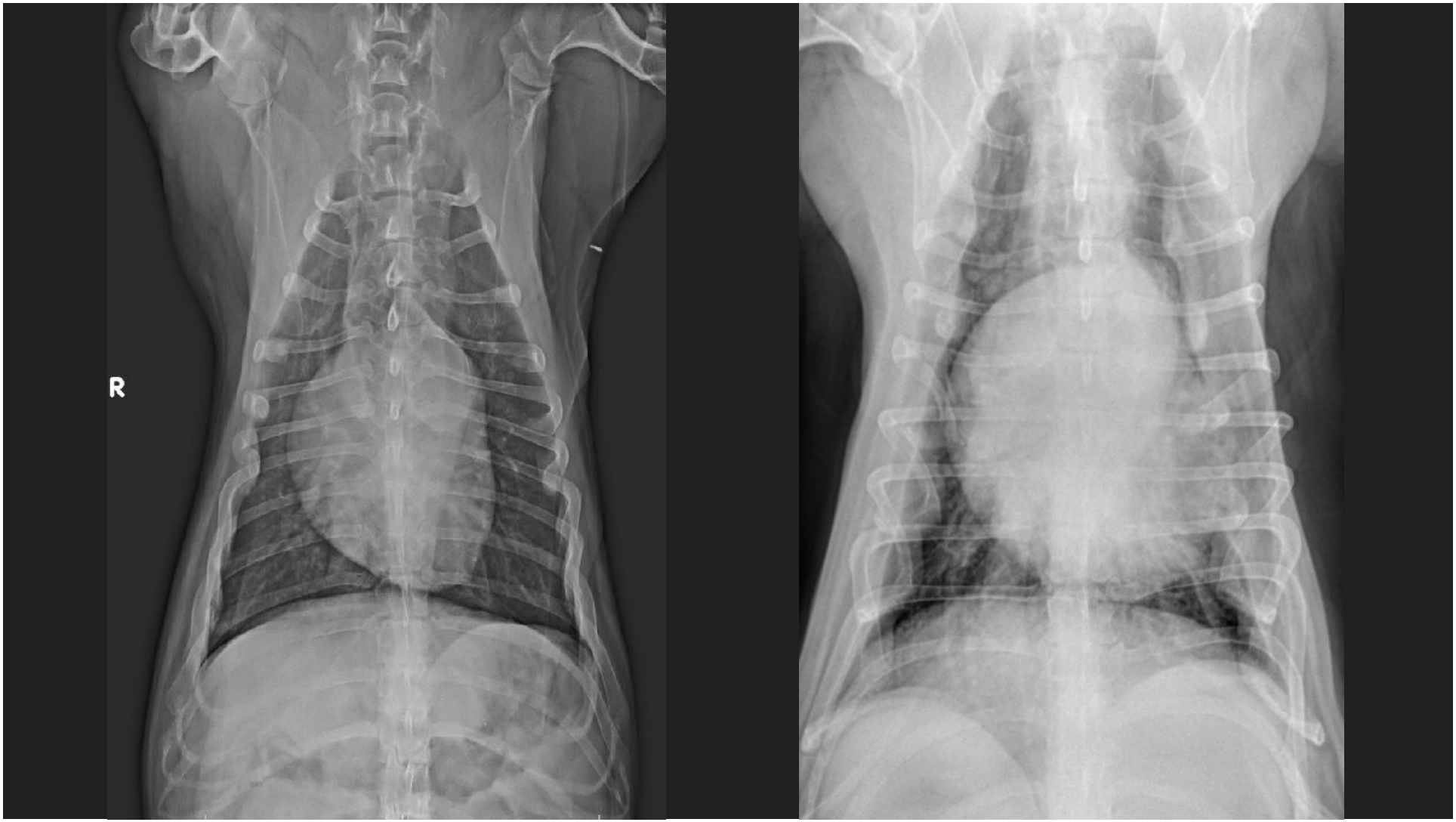
“Normal” French Bulldog



“Normal”
Basset Hound

“Normal”
Basset Hound

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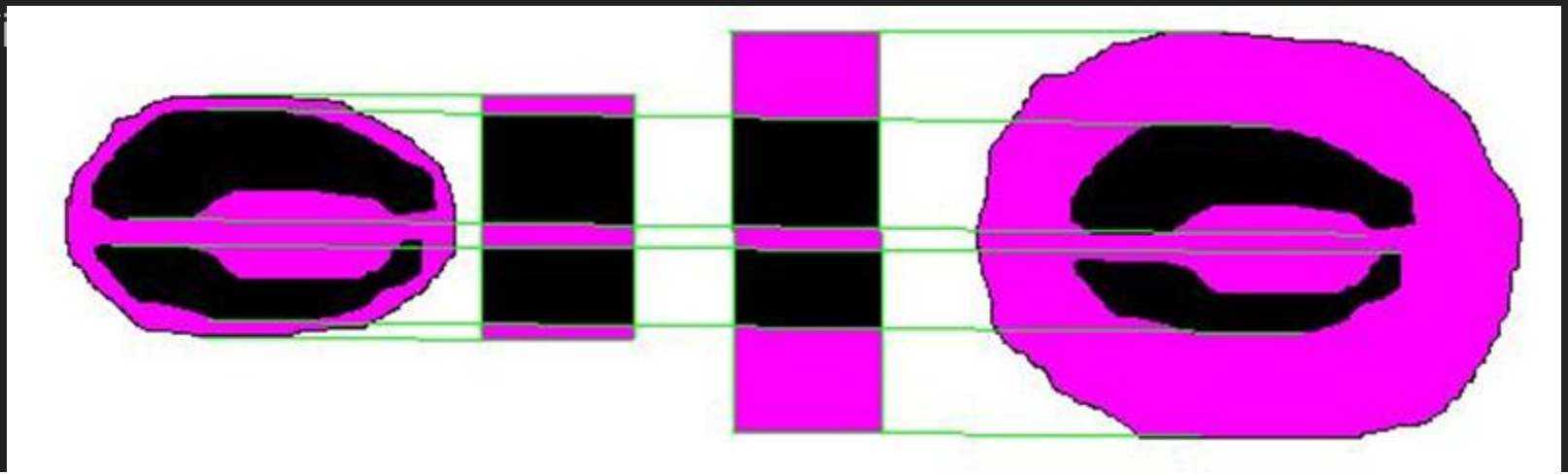
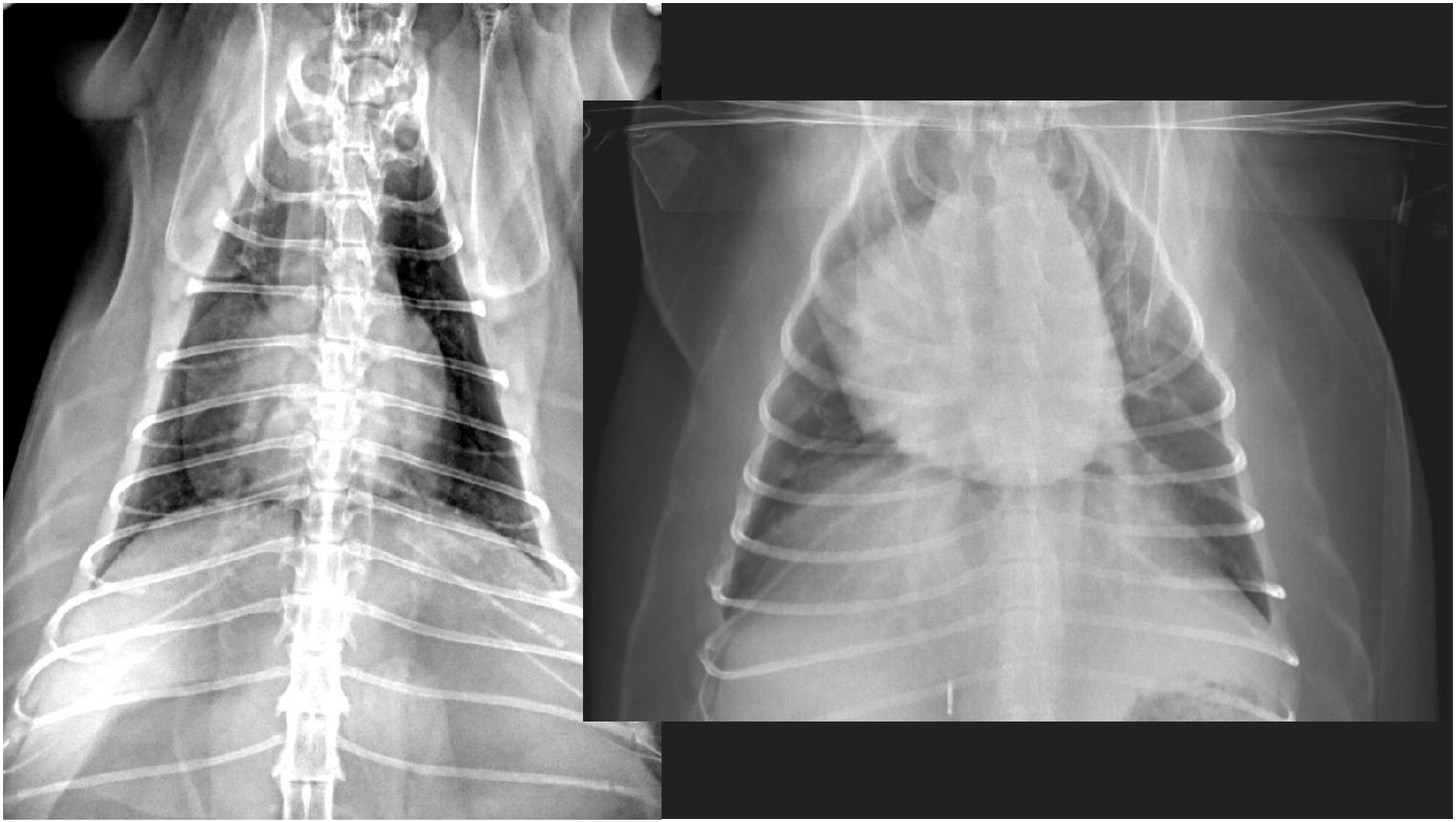
Effects of fat

- Increases lung opacity
  - Decreased lung expansion
  - Summation
- Expands pleural space
- Augments and changes the shape of the cardiac silhouette

Wi






Fat

Normal aging changes

Dogs

Interstitial pattern

Airway mineralization

Tracheal ring and laryngeal cartilage mineralization

Pneumolithiasis

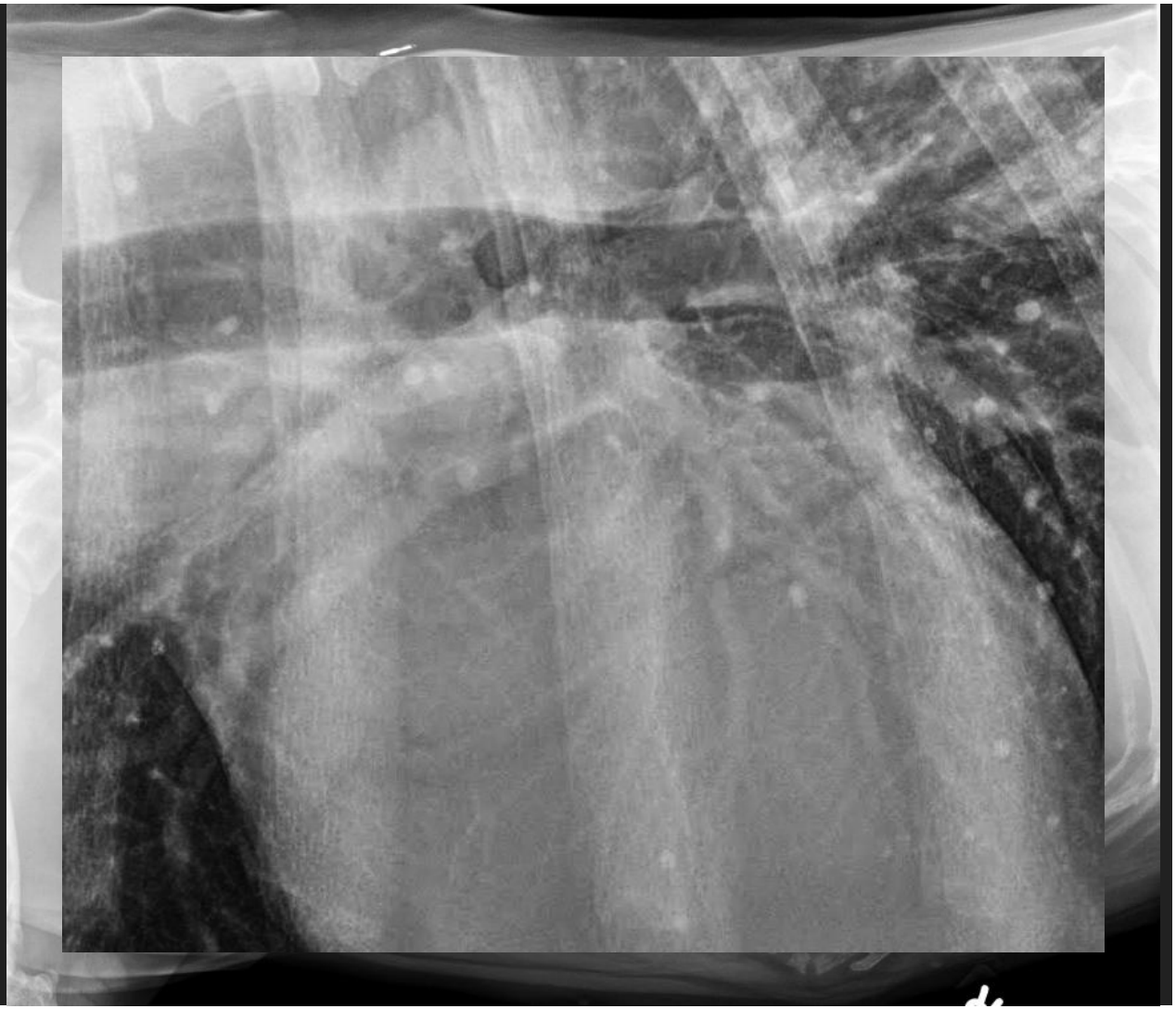
Cats

Bronchointerstitial pattern

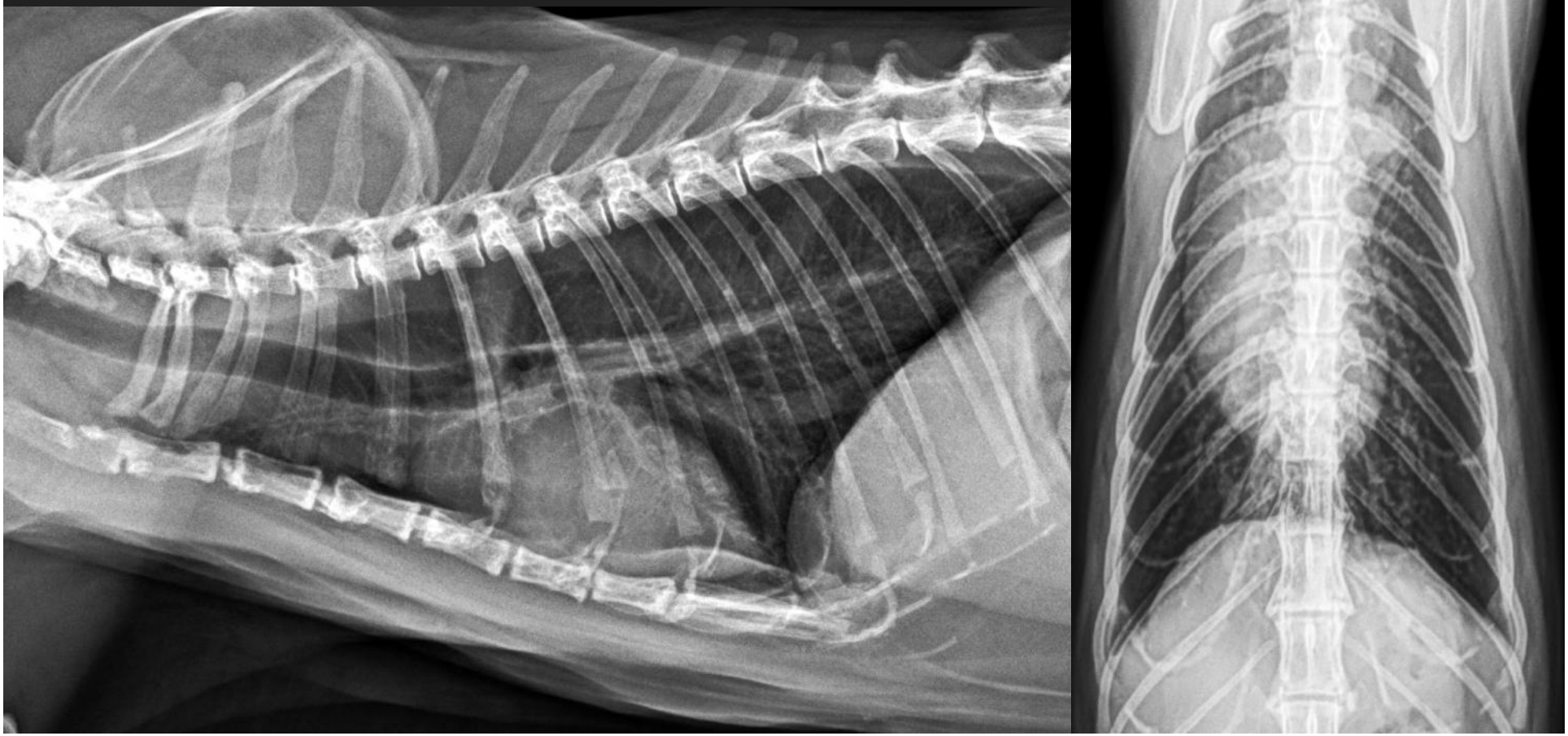
“Horizontal Heart”

Redundant aorta

Normal Aging Changes: Dog



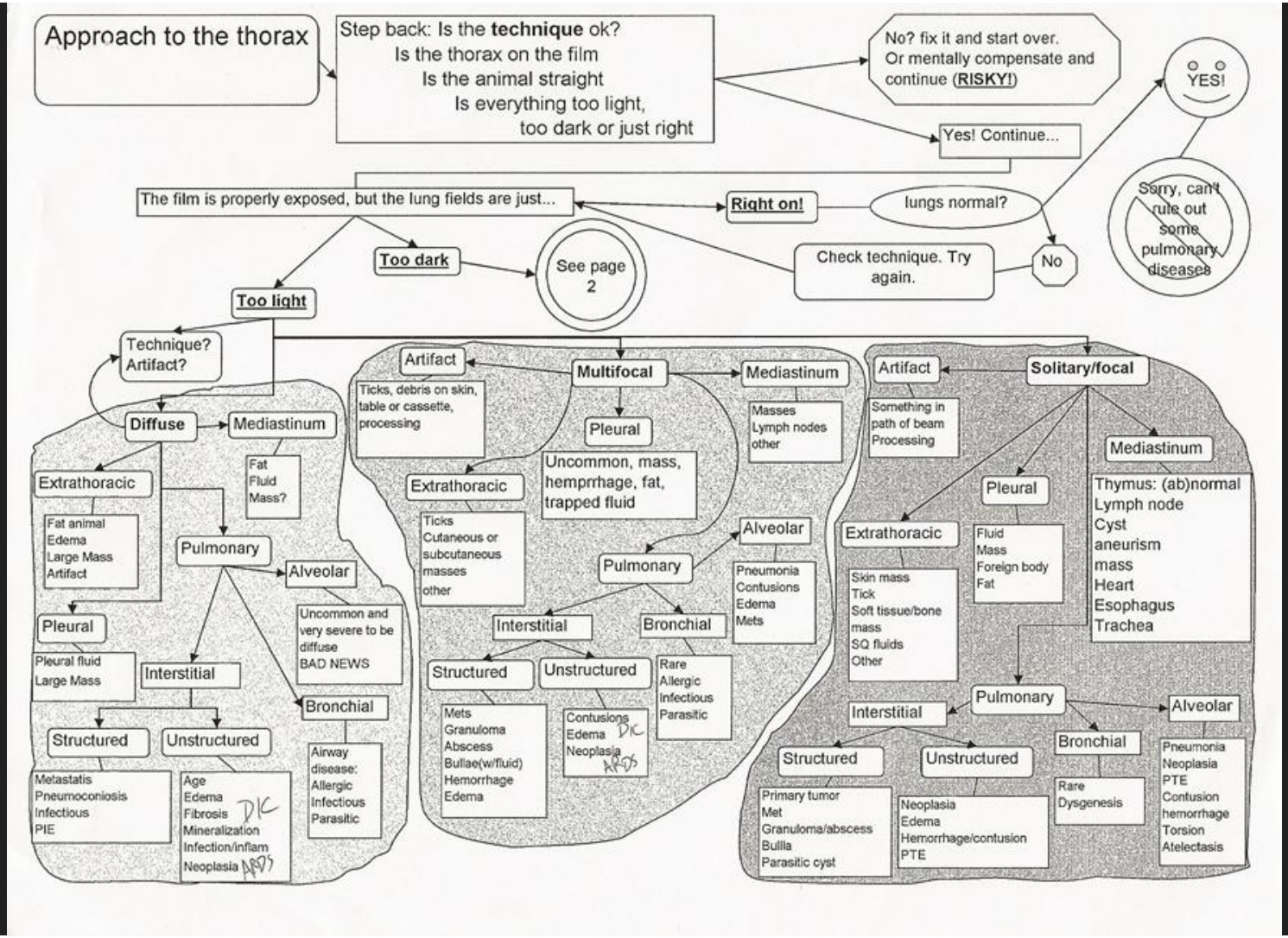
Normal aging changes: Cat



Redundant aorta

Diagnostic approach

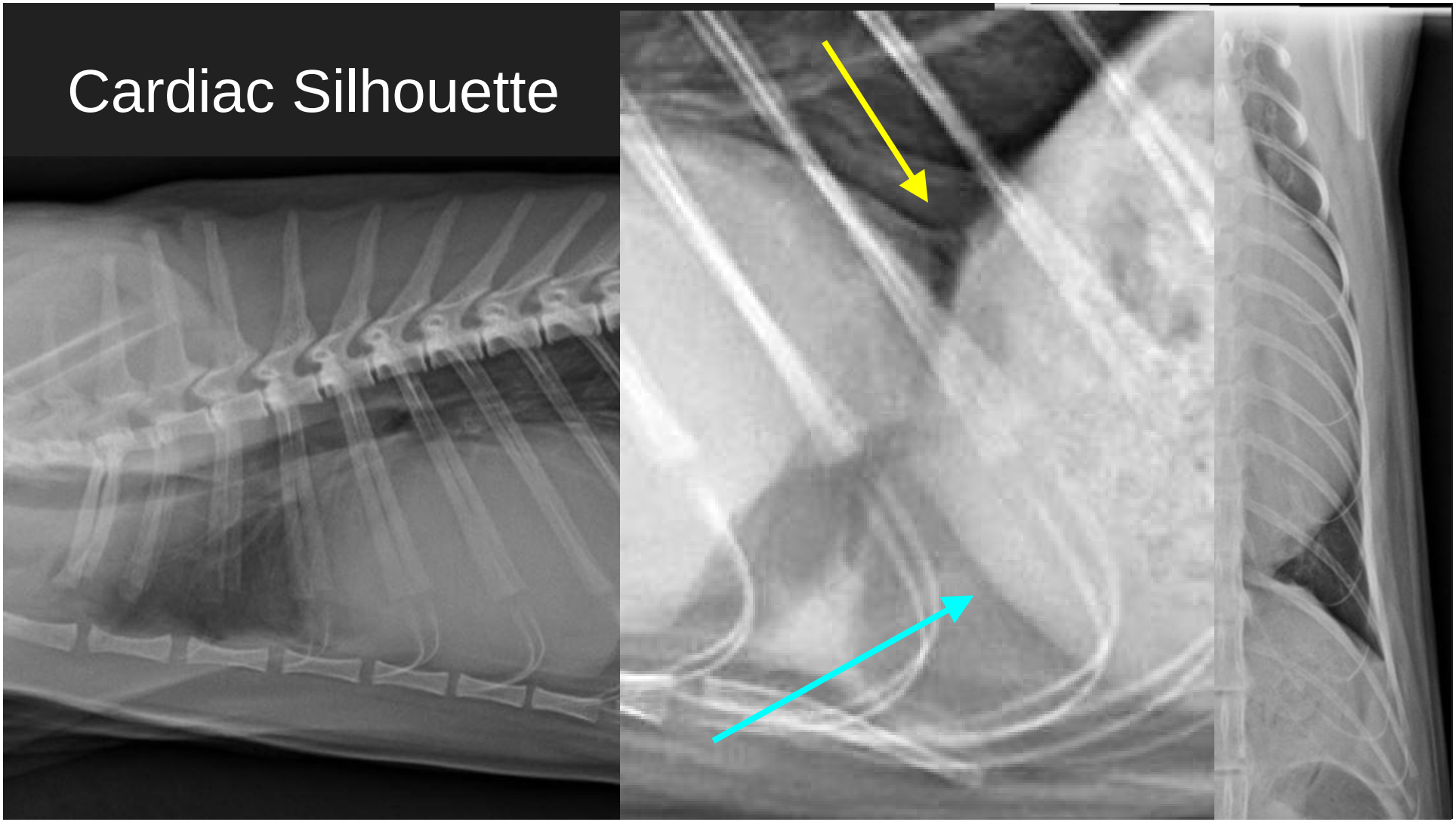
- Assessing SNR
- Regional/systems approach
  - Cardiac silhouette
  - Pulmonary vessels
  - Pulmonary parenchyma
  - Pleural space
  - Mediastinal space
  - Body wall
  - Musculoskeletal structures
  - Subcutaneous and cutaneous structures
  - Abdomen/neck


Approach to the thorax
Step back: Is the technique ok?
Is the thorax on the film
Is the animal straight
Is everything too light,
too dark or just right
No? fix it and start over.
Or mentally compensate and continue (RISKY!)
Yes! Continue...
YES!
Sorry, can't rule out some pulmonary diseases
The film is properly exposed, but the lung fields are just...
Right on!
lungs normal?
Too dark
See page 2
Check technique. Try again.
No
Too light
Technique?
Artifact?
Diffuse
Mediastinum
Extrathoracic
Fat animal
Edema
Large Mass
Artifact
Fat
Fluid
Mass?
Pulmonary
Alveolar
Pleural
Pleural fluid
Large Mass
Interstitial
Uncommon and very severe to be diffuse
BAD NEWS
Bronchial
Structured
Unstructured
Metastatis
Pneumoconiosis
Infectious
PIE
Age
Edema
Fibrosis
Mineralization
Infection/inflam
Neoplasia
DIC
Airway disease:
Allergic
Infectious
Parasitic
Artifact
Ticks, debris on skin, table or cassette, processing
Multifocal
Mediastinum
Masses
Lymph nodes
other
Pleural
Uncommon, mass, hemprrhage, fat, trapped fluid
Extrathoracic
Ticks
Cutaneous or subcutaneous masses
other
Alveolar
Pulmonary
Pneumonia
Contusions
Edema
Mets
Interstitial
Bronchial
Structured
Unstructured
Rare
Allergic
Infectious
Parasitic
Mets
Granuloma
Abscess
Bullae(w/fluid)
Hemorrhage
Edema
Contusions
Edema
Neoplasia
DIC
Artifact
Something in path of beam
Processing
Solitary/focal
Mediastinum
Thymus: (ab)normal
Lymph node
Cyst
aneurism
mass
Heart
Esophagus
Trachea
Pleural
Fluid
Mass
Foreign body
Fat
Extrathoracic
Skin mass
Tick
Soft tissue/bone mass
SQ fluids
Other
Pulmonary
Alveolar
Interstitial
Bronchial
Structured
Unstructured
Rare
Dysgenesis
Pneumonia
Neoplasia
PTE
Contusion
hemorrhage
Torsion
Atelectasis
Primary tumor
Met
Granuloma/abscess
Bullla
Parasitic cyst
Neoplasia
Edema
Hemorrhage/contusion
PTE

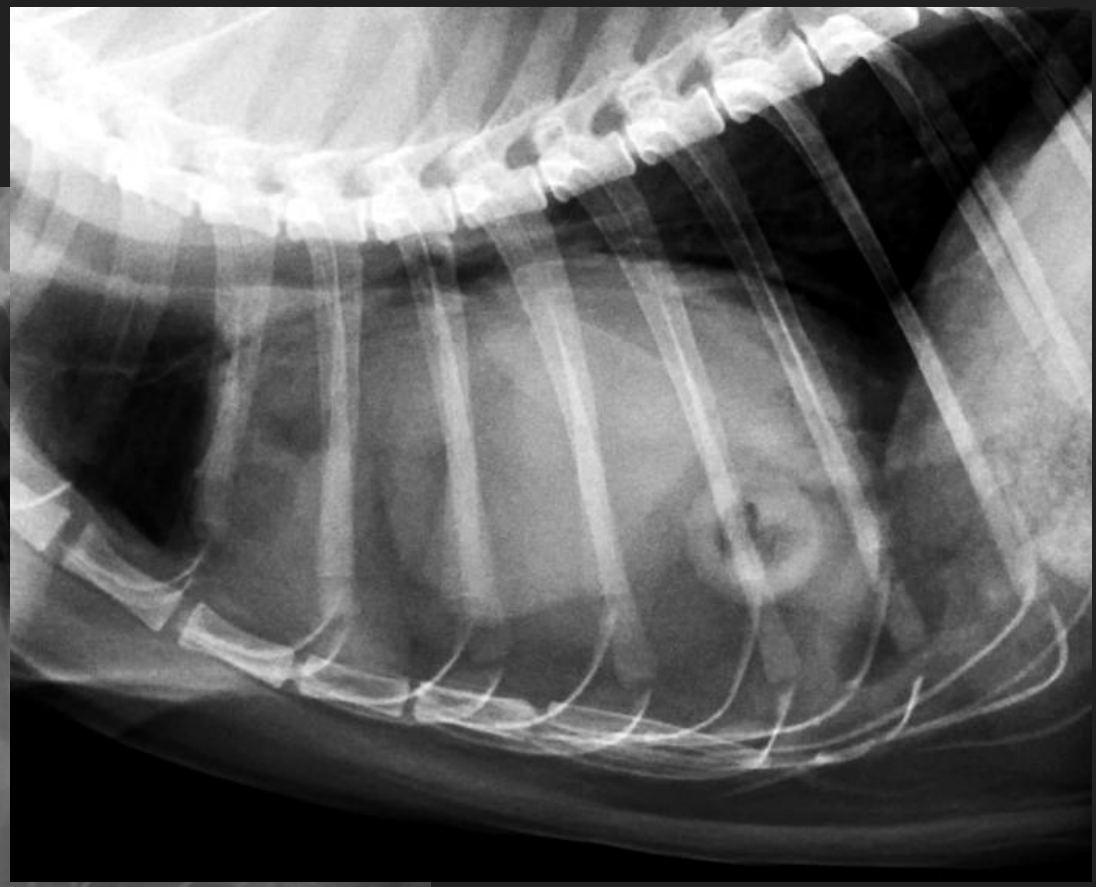
Cardiac silhouette

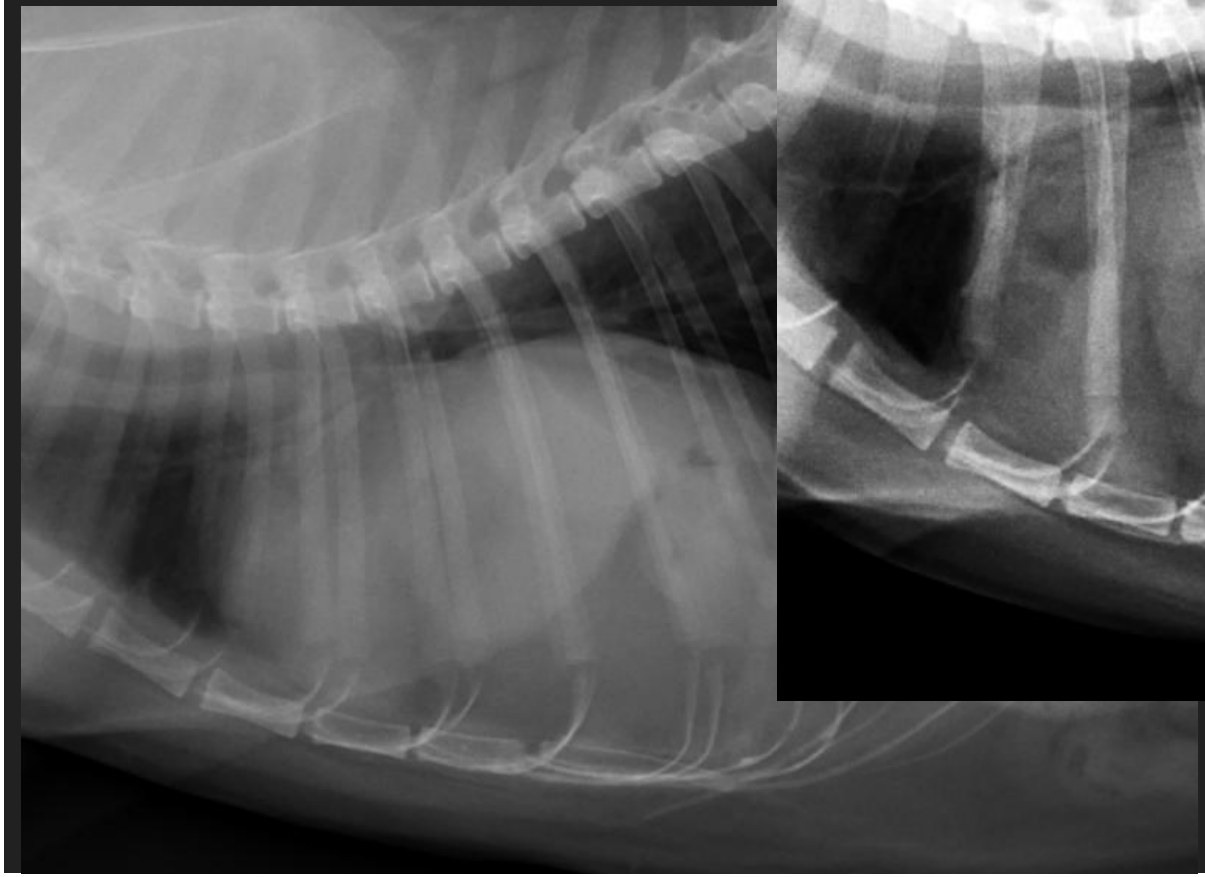
Not just “seeing the heart”
Includes
pericardial space
cardiac muscle
valves
cardiac chambers
aortic and pulmonic artery roots
+/- carinal lymph nodes

Cardiac Silhouette



Cardiac Silhouette





Pulmonary vasculature

- Too large
  - Congested
    - Volume overload
    - Downstream blockage
      - Heart failure
      - PTE (chronic)
      - Idiopathic pulmonary hypertension (IPH)
    - Overload from upstream
      - L->R shunts
      - AV fistulas
  - Wall thickened
    - Heartworm disease
    - IPH
- Too small
  - Underperfused
    - Hypovolemia
    - Hypovolemia
    - Hypovolemia
    - Heart failure (rt sided)
    - PTE (acute)
    - R->L shunts
- Artery/vein symmetry
- Diffuse vs regional abnormalities

Pulmonary vasculature

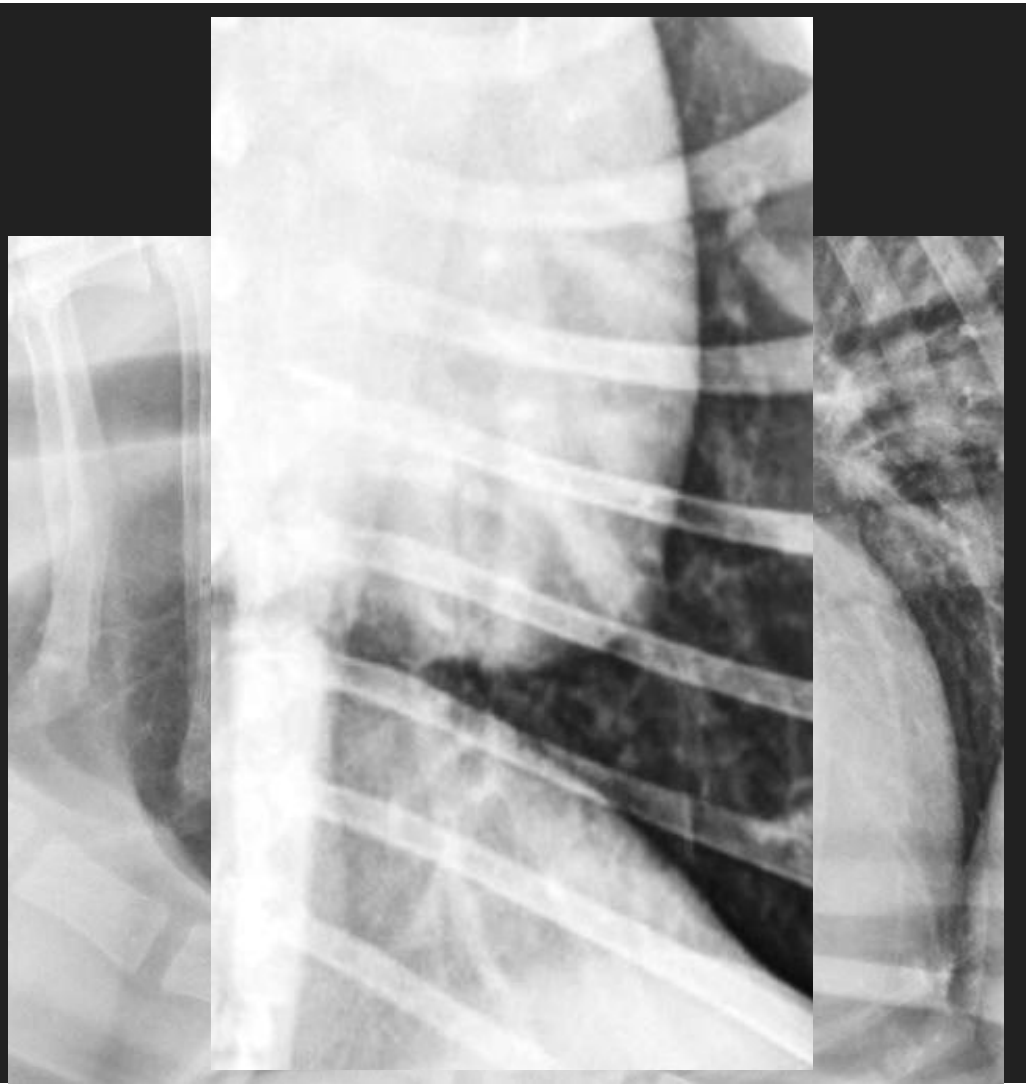
Normal rule of thumb

A and V symmetrical

</= proximal 4th rib in lateral

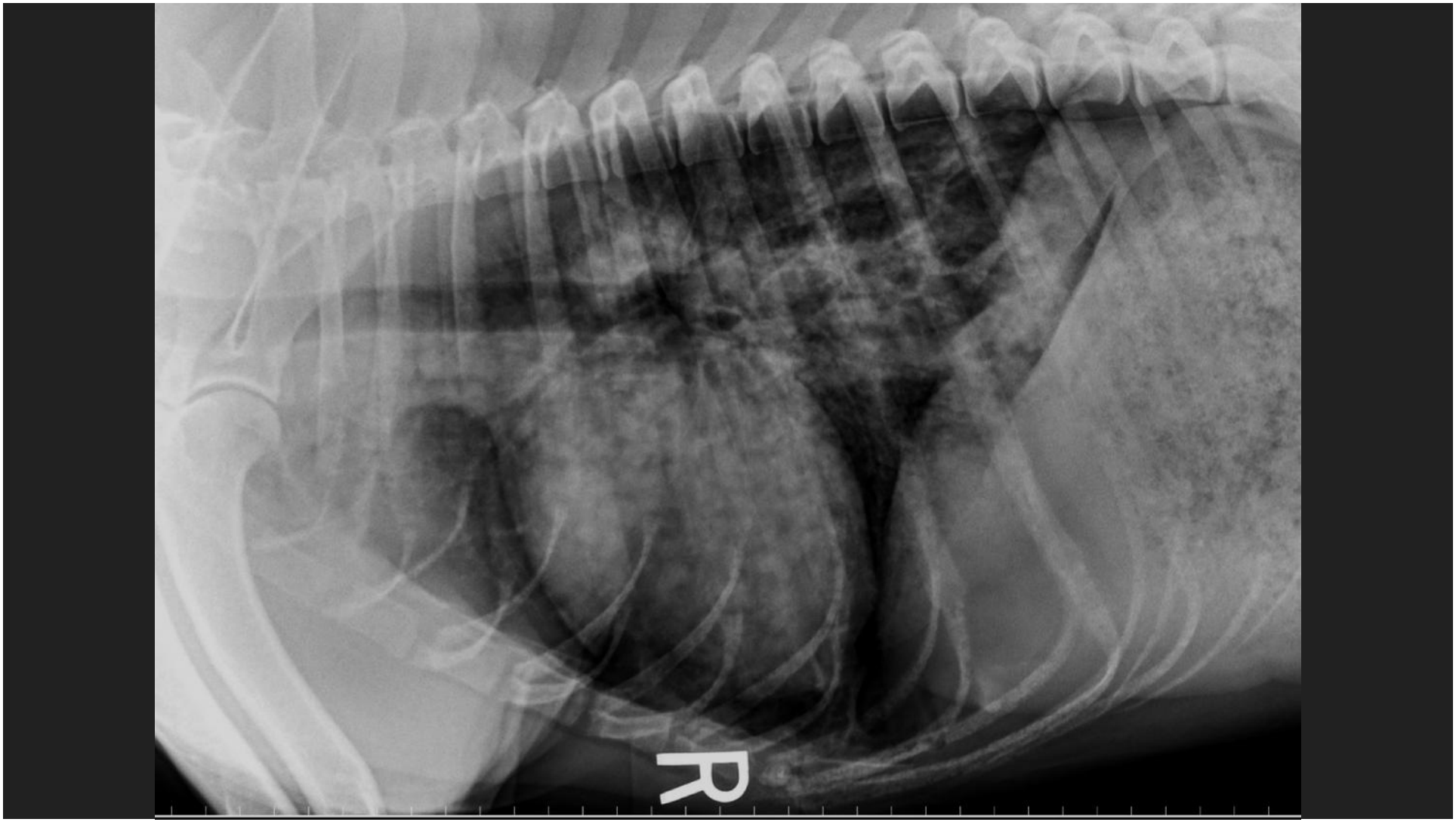
</= 9th rib in VD

VERY UNRELIABLE, esp in whole body images



Pulmonary parenchyma: Distribution

- Diffuse
  - “Normal” - fat, old, brachycephalic, prev. infl.
  - Airway inflammation
    - Allergic
    - Infectious
    - Parasitic
  - Neoplasia
  - Pathologic fibrosis
    - “Westie fibrosis”
    - Chronic interstitial pneumonia
  - Systemic infection/illness
    - Lepto/neospora/Toxo
    - Capillaria/Aleurostrongylus
    - Fungal
  - Non-infectious inflammatory: EB/PIE
- Patchy
  - Hemorrhage
  - Neoplasia
  - Infectious/inflammatory
- Focal
  - Caudodorsal
    - Edema
      - Cardiogenic
      - Non-cardiogenic
    - Embolic pneumonia
    - PTE
    - Neoplasia
    - Non-infectious inflammatory
    - Torsion (less common)
    - Airway obstruction
  - Ventral
    - Pneumonia
    - Hemorrhage
    - Neoplasia
    - Non-infectious inflammatory
    - Torsion (more common)
    - Airway obstruction
    - Severe edema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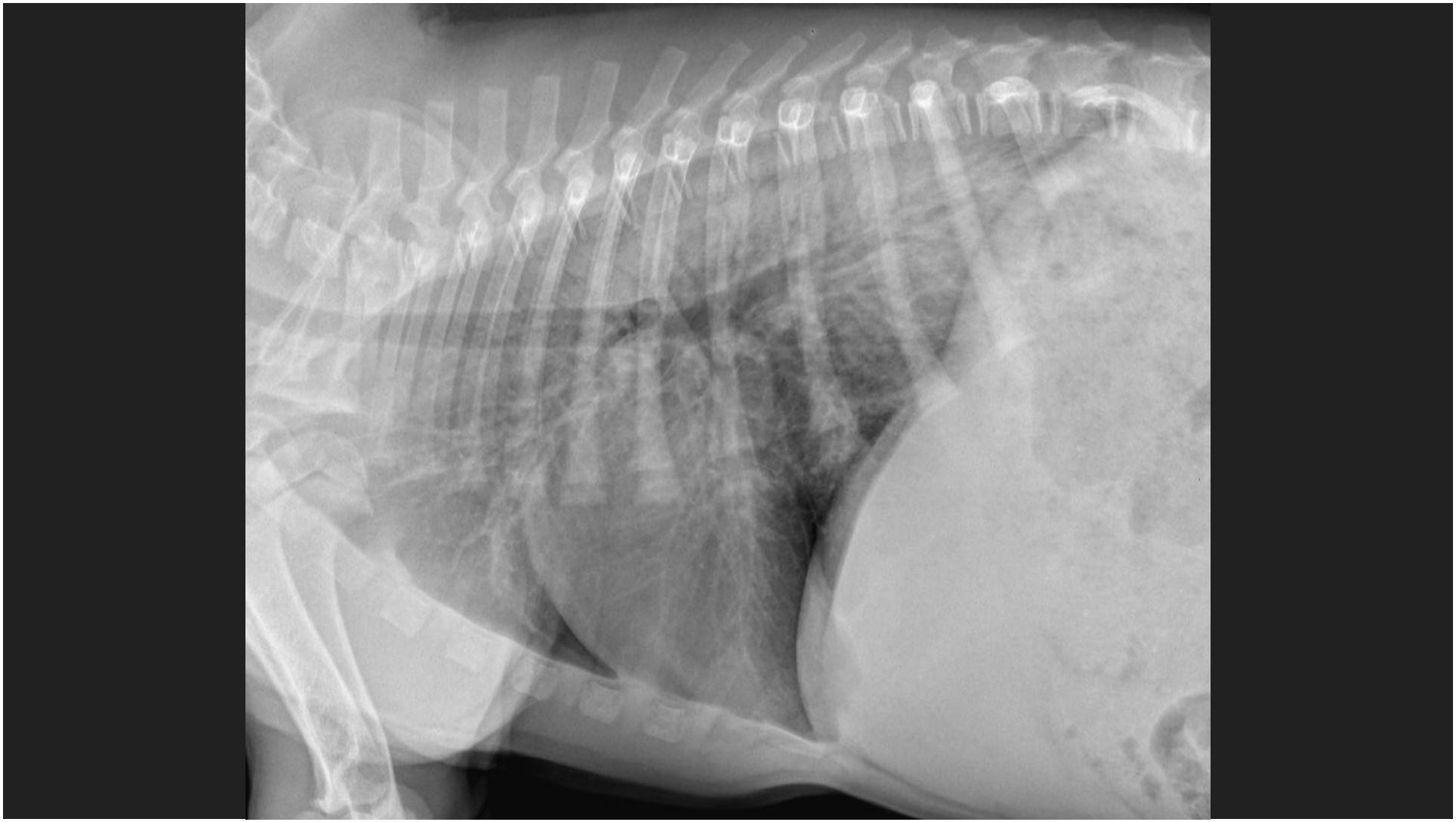
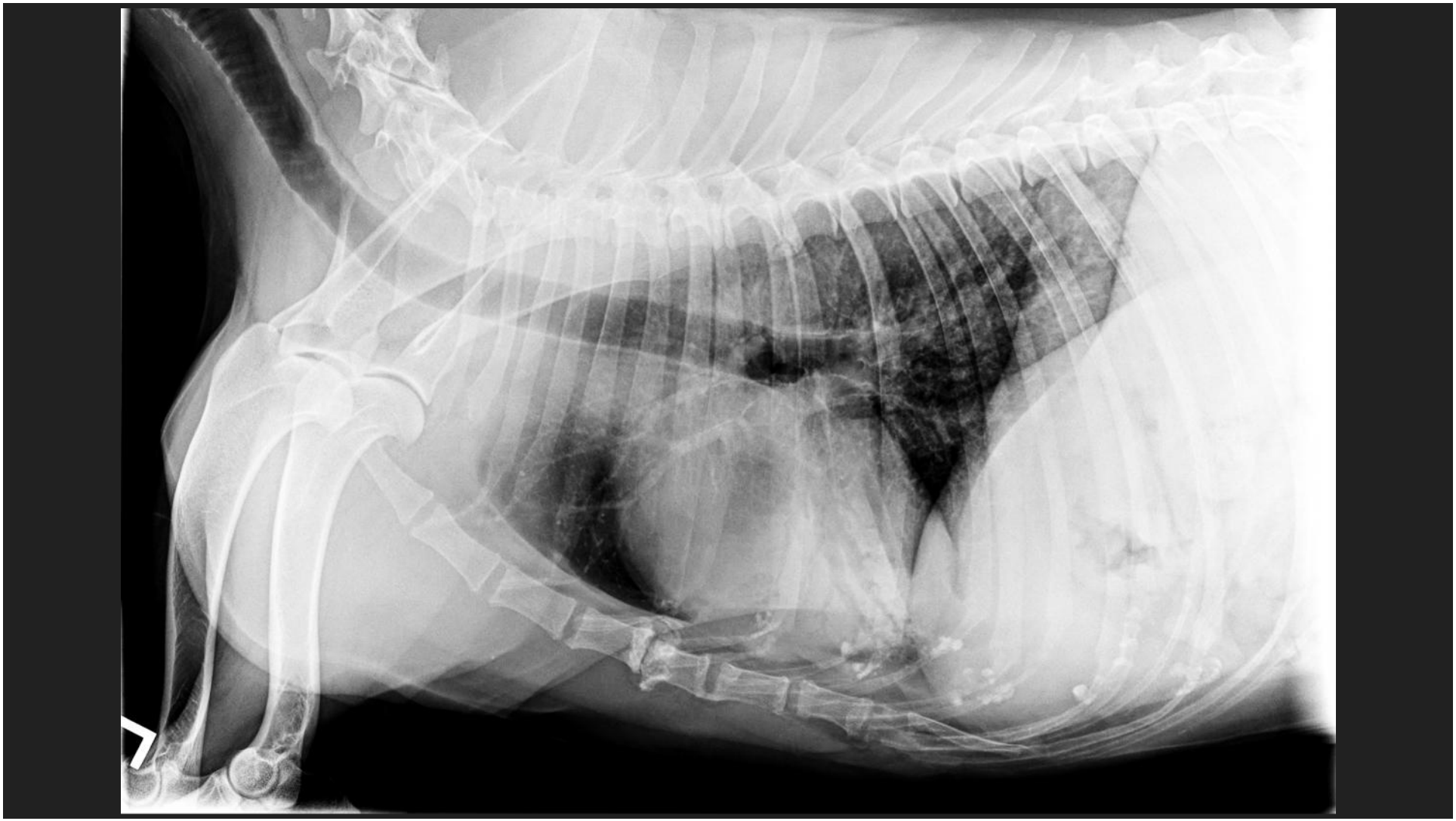




Pulmonary parenchyma: Patterns

Interstitial

Bronchial

Alveolar

Vascular?

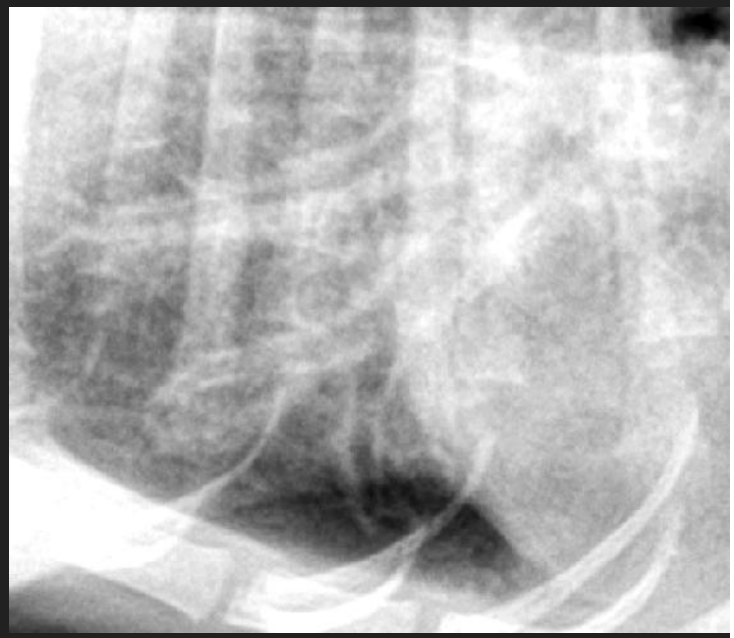
Bullous/vesicular?

Combination (most common)

Not good correlation between radiographic pattern and histopathology.

Norris et. Al. JAAHA, 2002, vol 38

–63% agreement between rads and histopath.



Don’t Overthink It!

Pleural space

- Increased opacity
  - Fat
  - Fluid: blood, pus, water, chyle
- Decreased opacity
  - Air
    - Traumatic: external penetration vs. lung rupture
    - Infectious

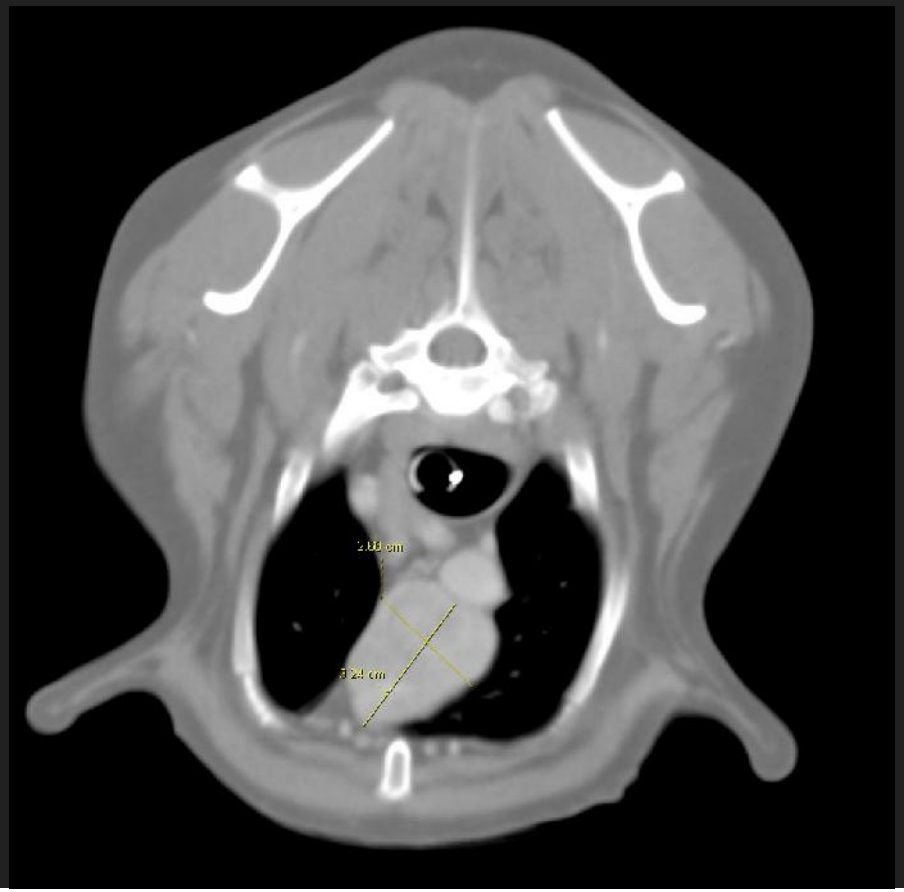
- Pleural margins
  - Smooth and angular: acute
  - Rounded and irregular: pleural restrictive disease
    - Chronic
    - Inflammatory
    - Neoplastic
    - Secondary to chronic lung disease

Mediastinal space

- Widened: in VD, extends beyond margins of overlying spine
  - “Normal”: fat, brachycephalic
  - Mass: discrete mass or rounded margins, “bulging” appearance
  - Fluid: hemorrhage, mediastinitis
  - Esophageal dilation
- Increased definition of mediastinal structures: pneumomediastinum
  - Cervical wounds (including cervical venipuncture!)
  - Direct penetrating trauma
  - Tracheal laceration/rupture
  - Pleural or pulmonary leakage

Wide Cranial mediastinum: mass

Cranial mediastinal mass



Body wall

Hernia

Mass

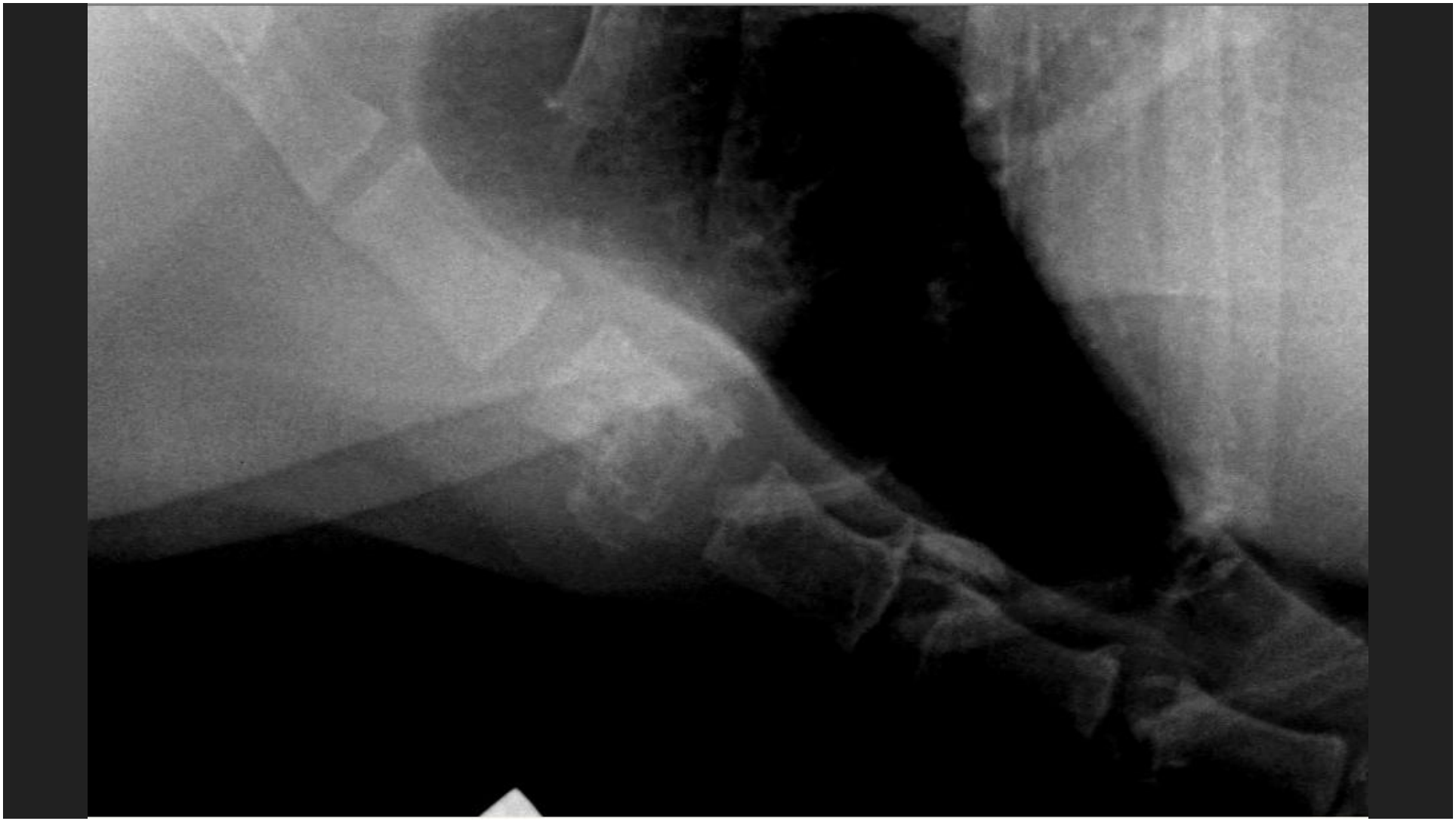
Penetrating trauma

Incidental disease

Body wall herniation

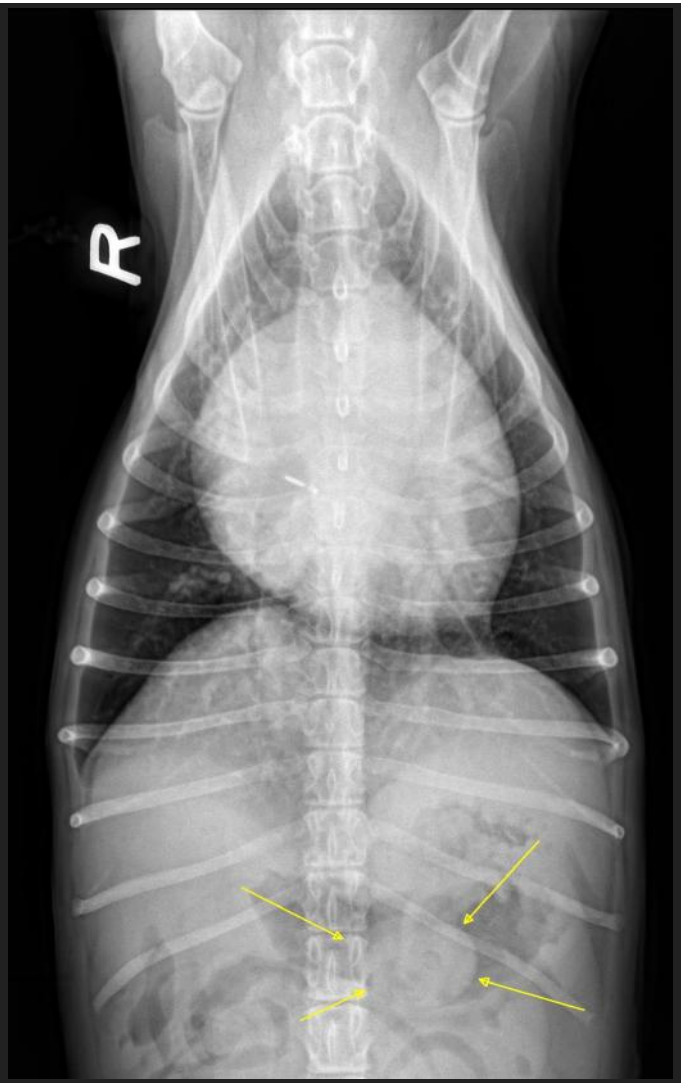
Musculoskeletal

Degenerative changes
Trauma
Neoplasia
Congenital deformity
Osteomyelitis



Neck/abdomen

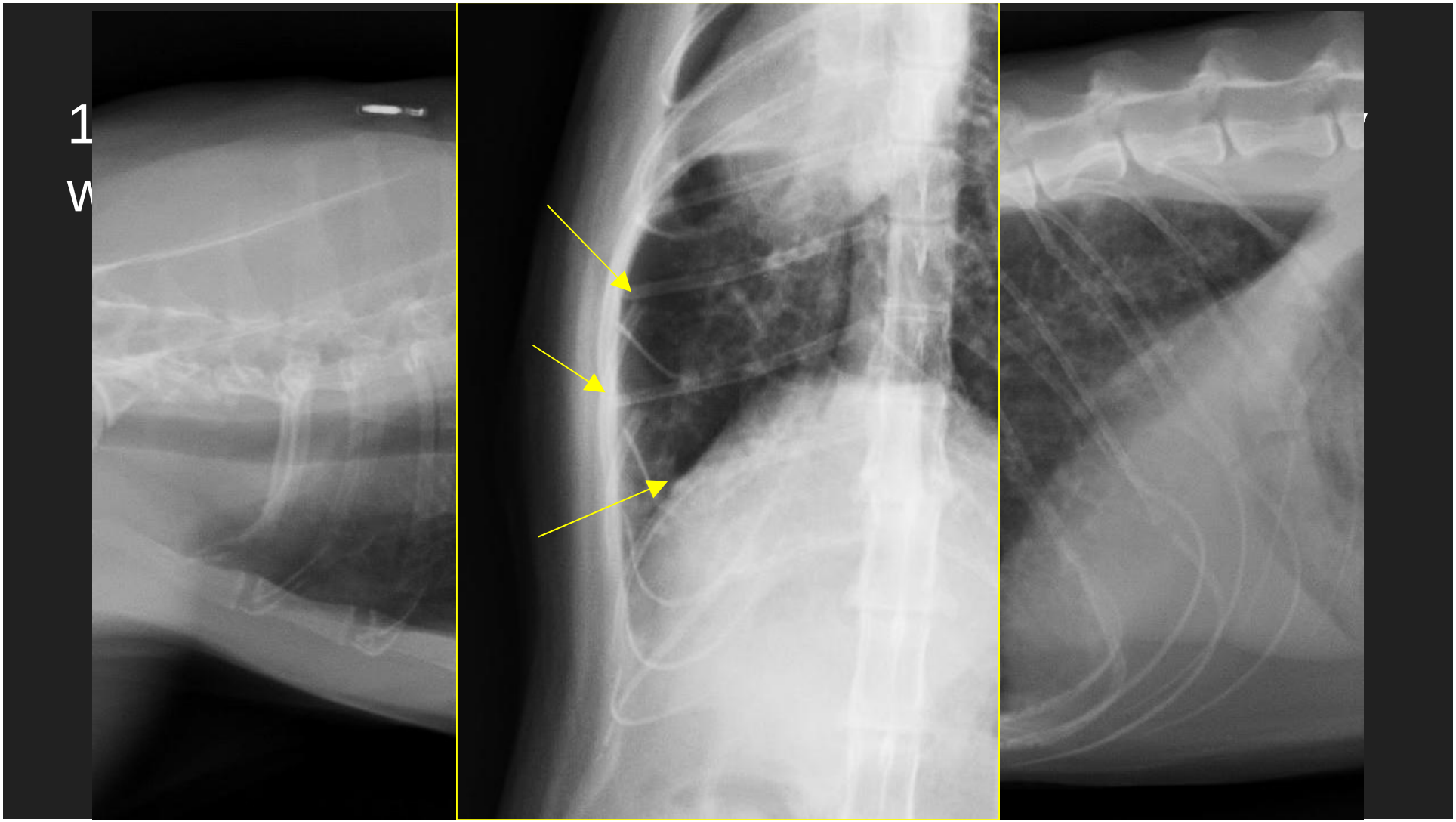
Don’t forget to look at these regions to catch those incidental but important lesions such as the incidental gastric foreign body or the cervical aggressive lesion

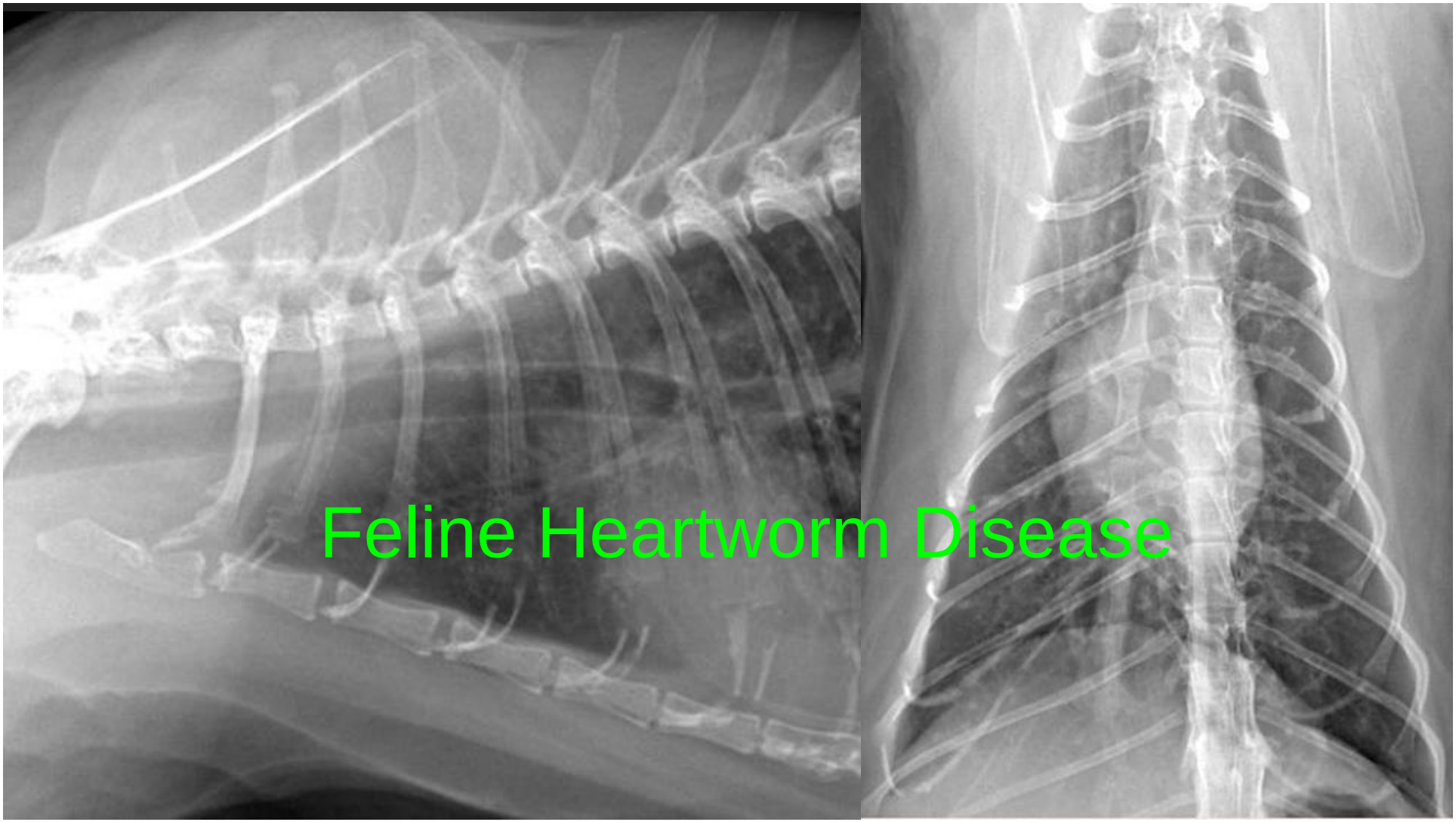


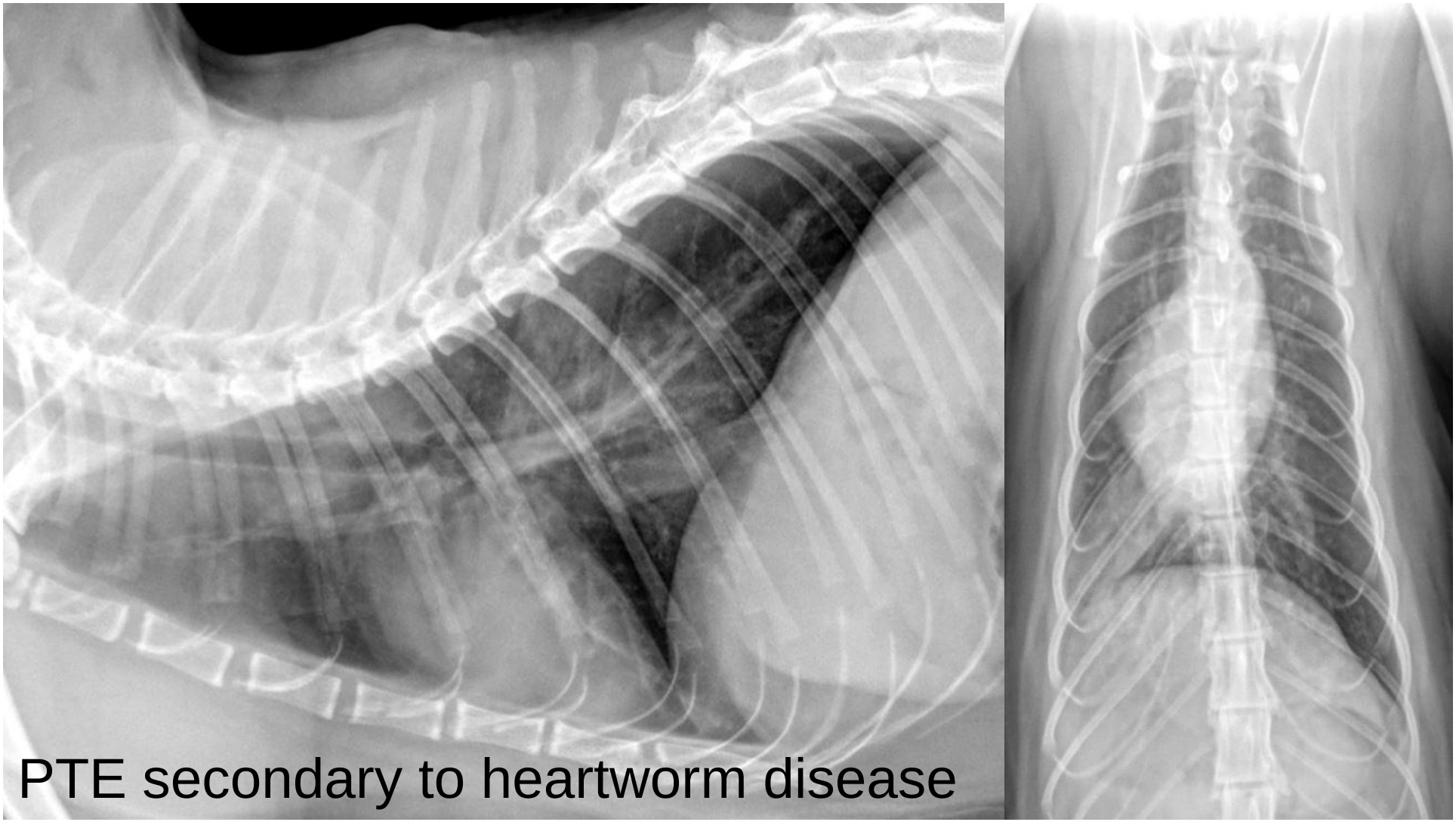
Cases

1

w




Feline Heartworm Disease


PTE secondary to heartworm disease

10y
mu

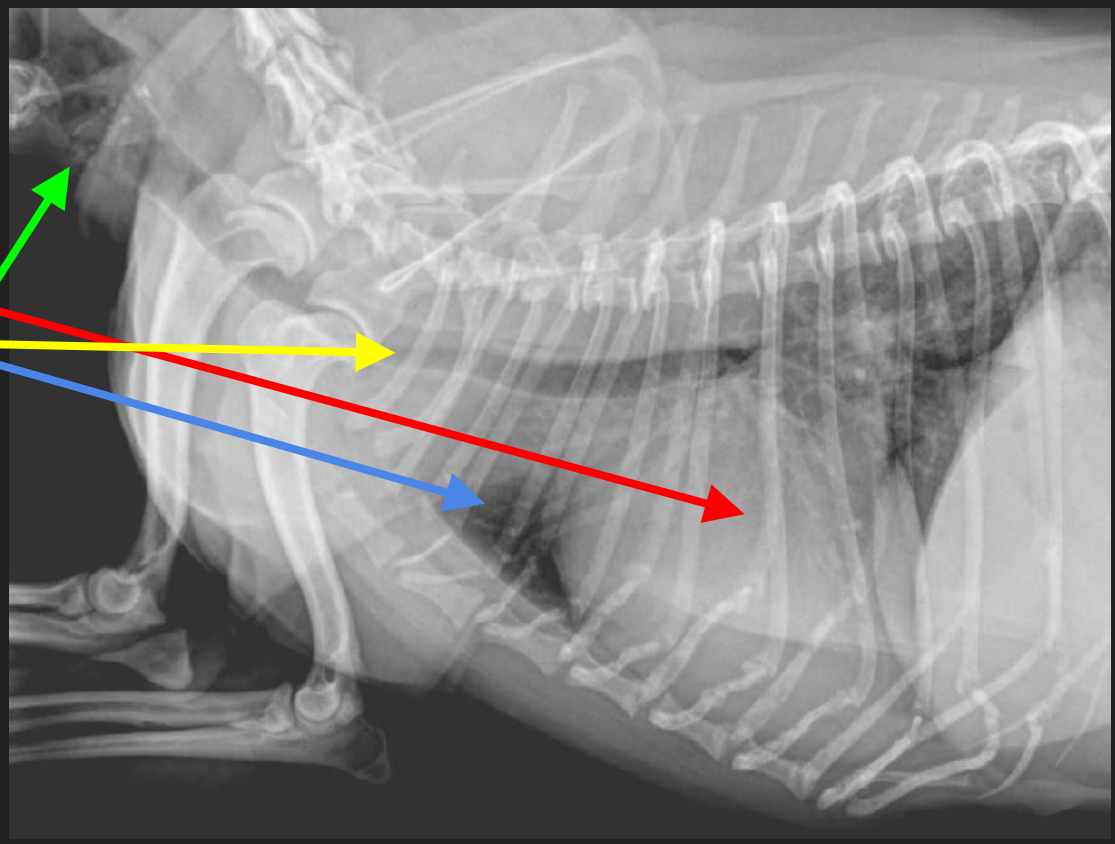
Little coughers with murmurs

Cardiac

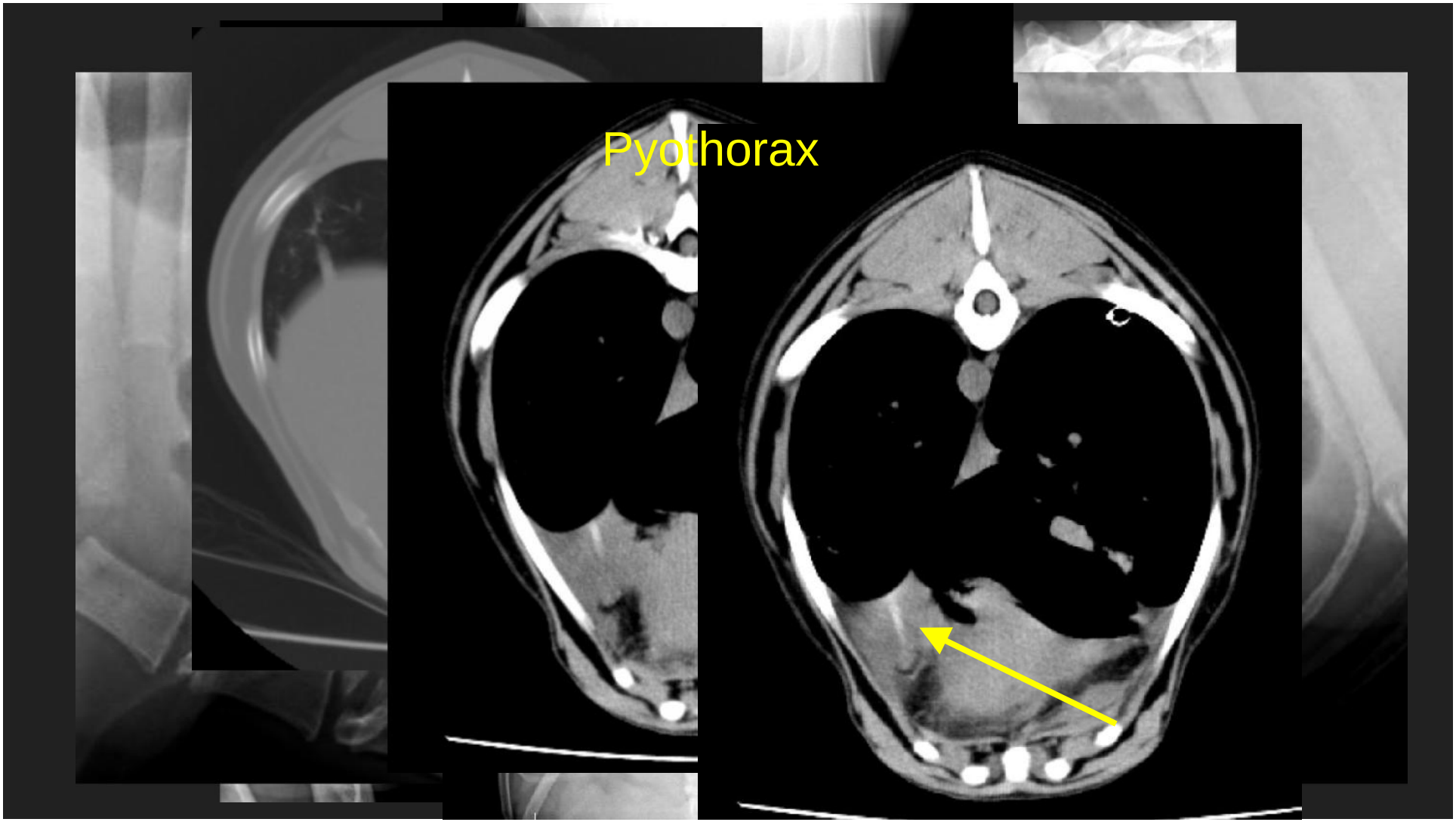
Pulmonary

Tracheal

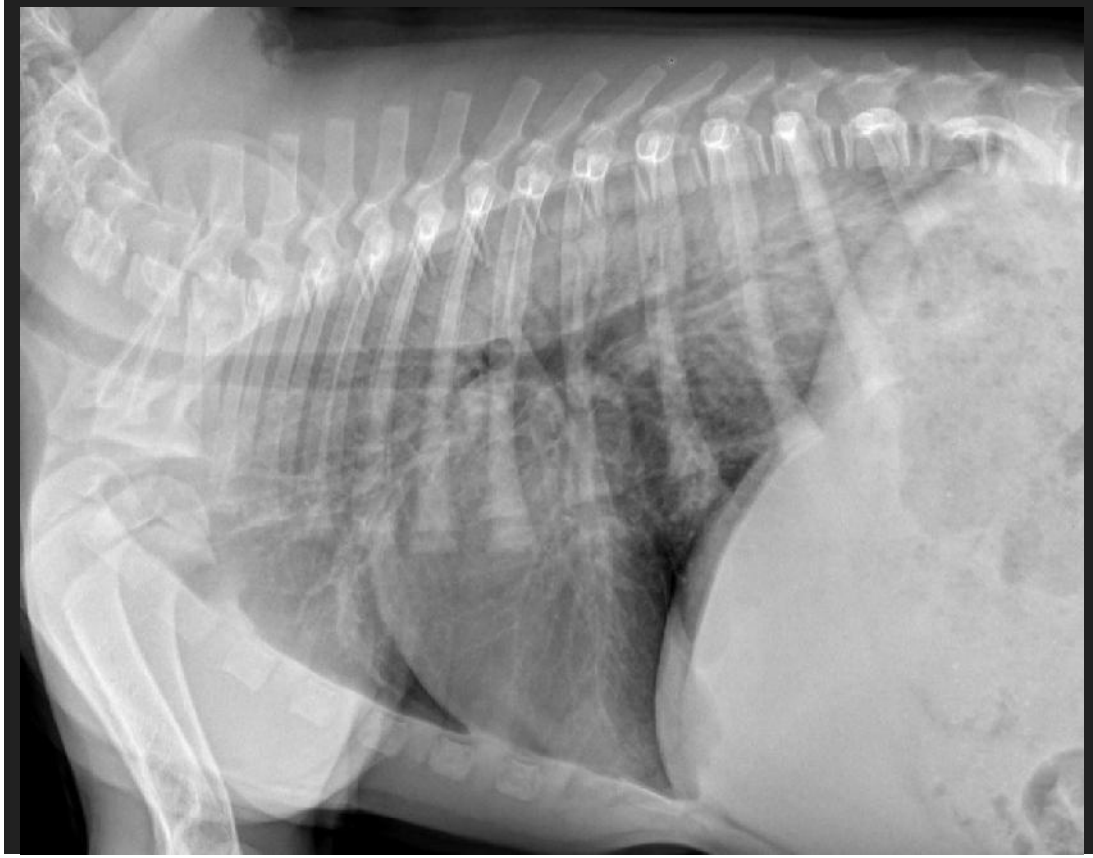
Laryngeal/pharyngeal

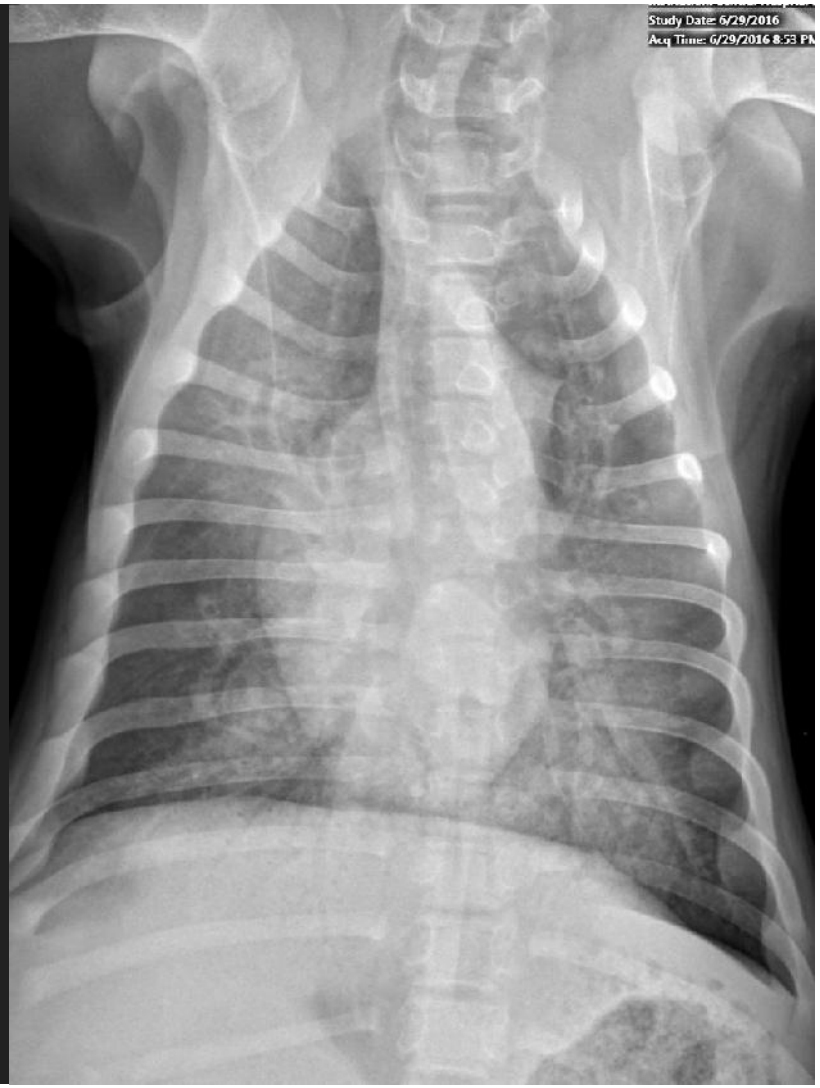


Don’t forget larynx/pharynx as potential cause for cough


Pyothorax

4m puppy found hanging by blind pull





Non-cardiogenic pulmonary edema

Asphyxiation: external compression, lar par, tracheal FB, etc.

Electrocution

Near-drowning

Seizure

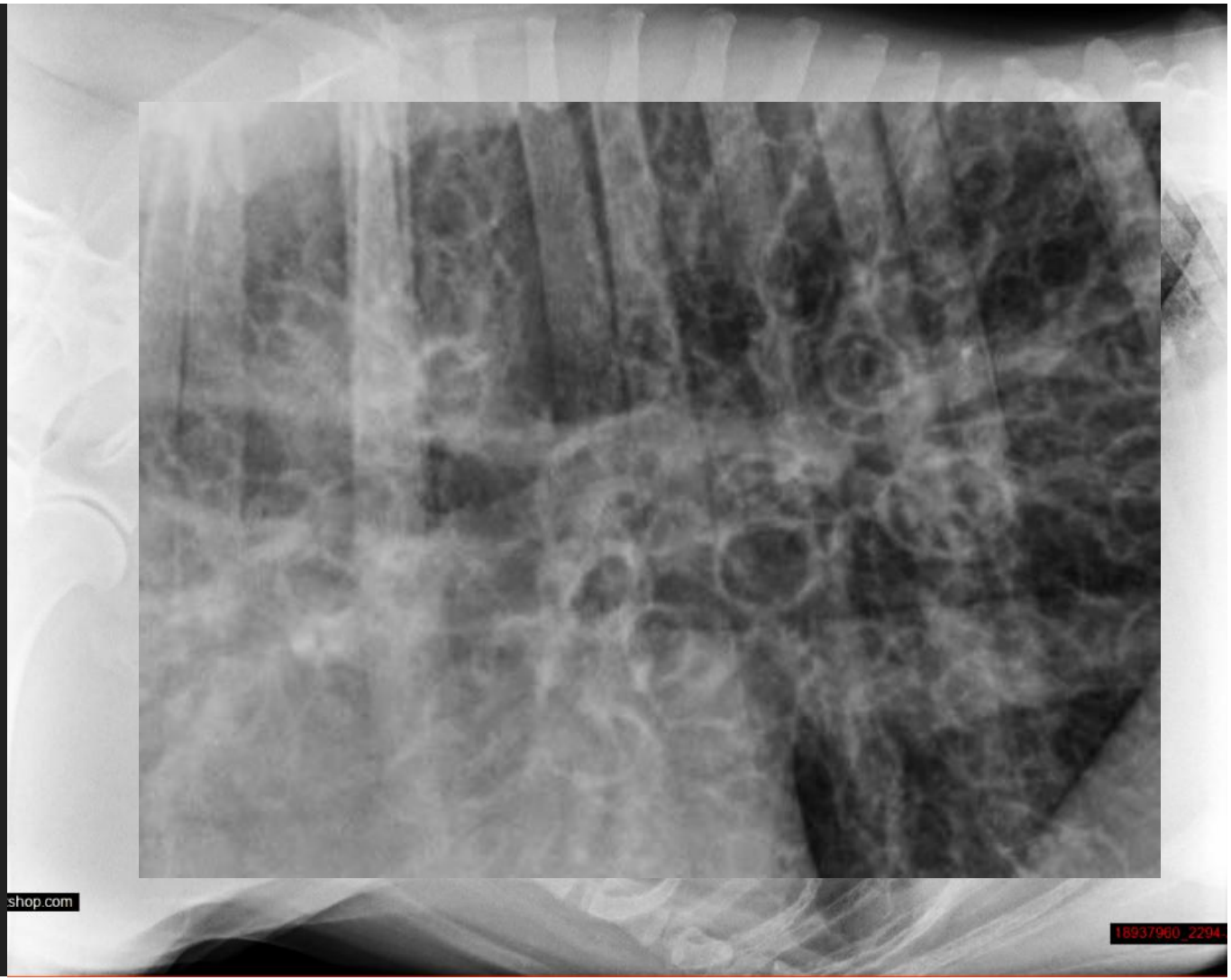
Head trauma

Smoke inhalation

ARDS/SIRS/MODS

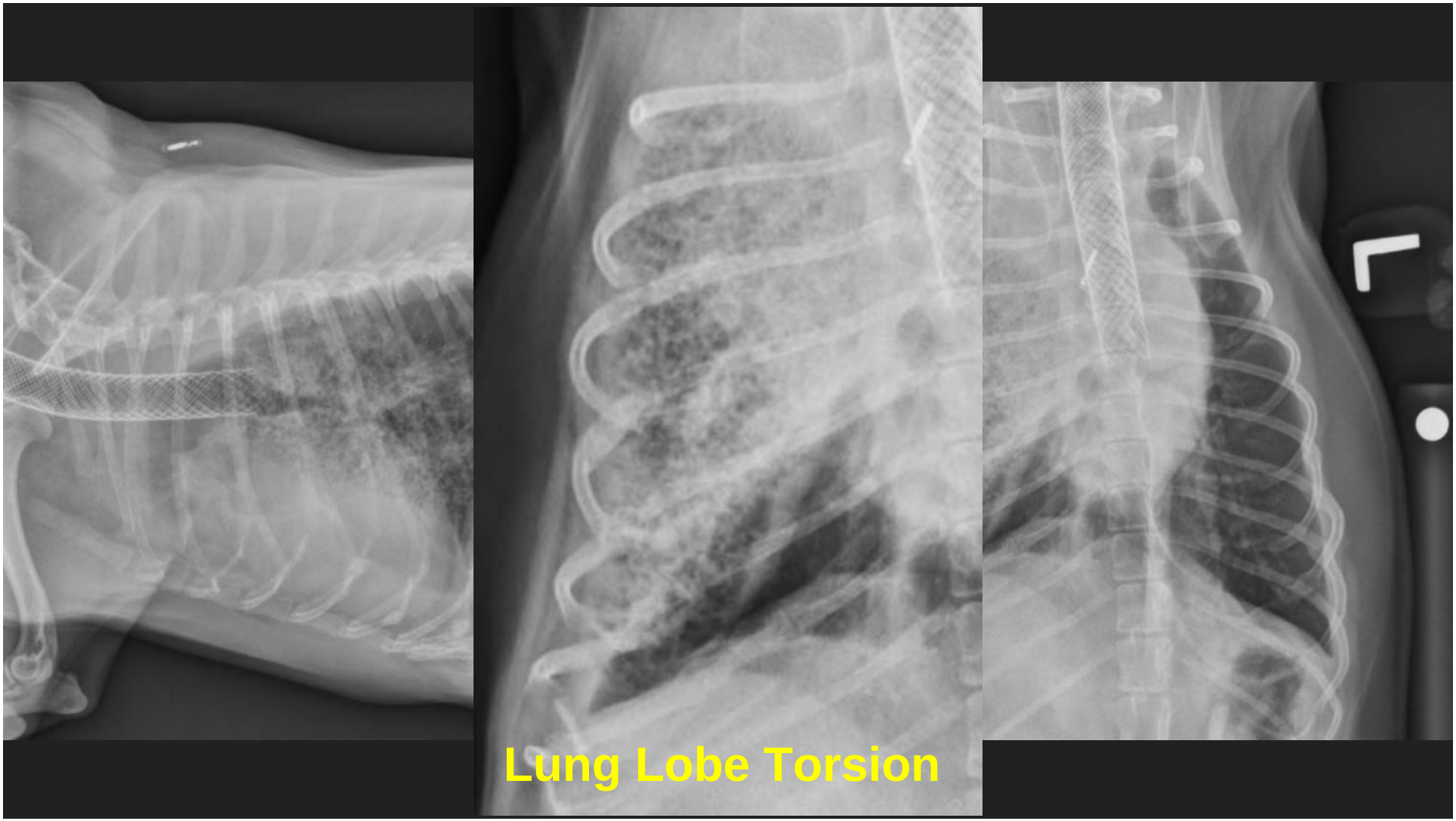
Paragonimus

-Crayfish

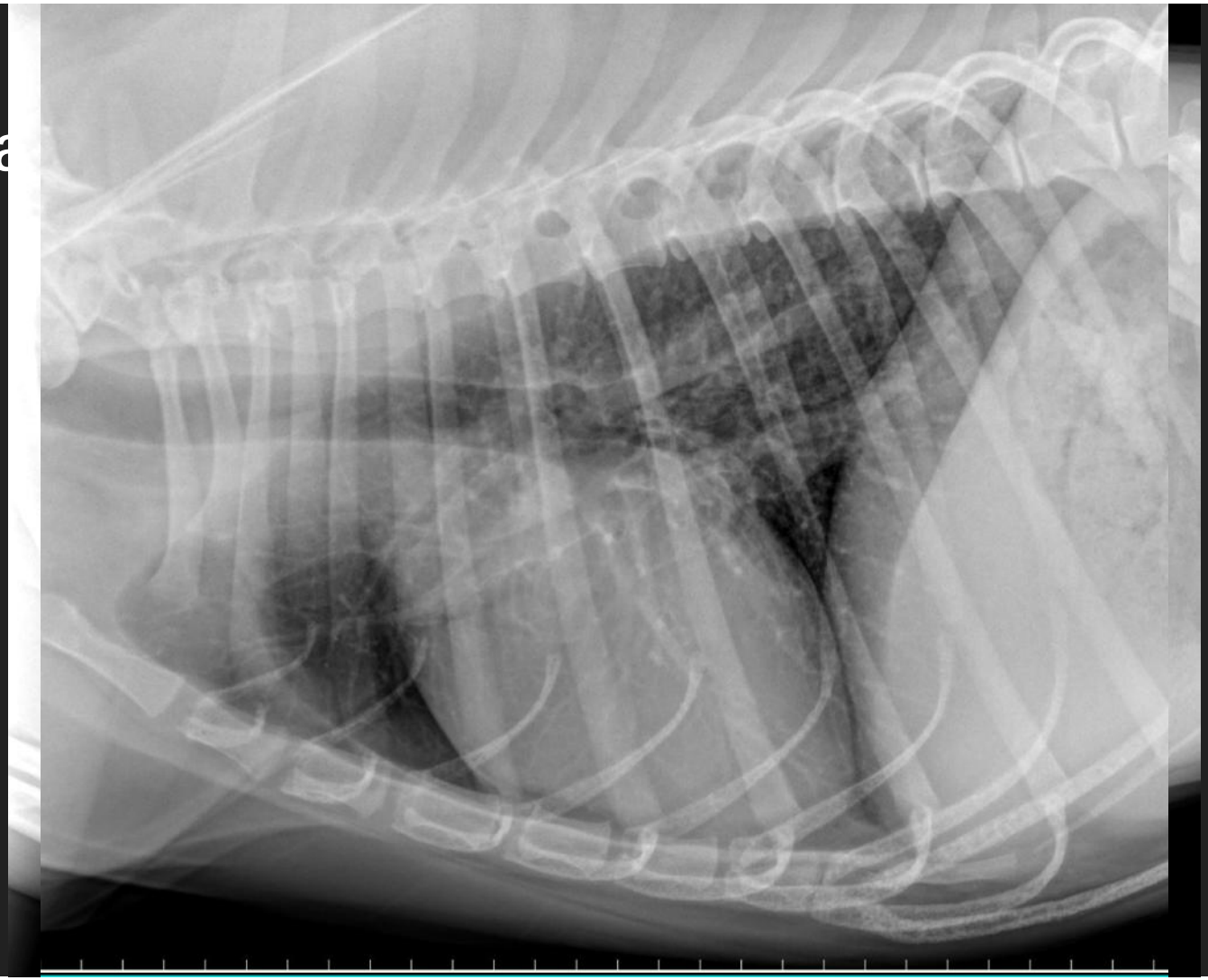


Bullous/vesicular changes in the lungs

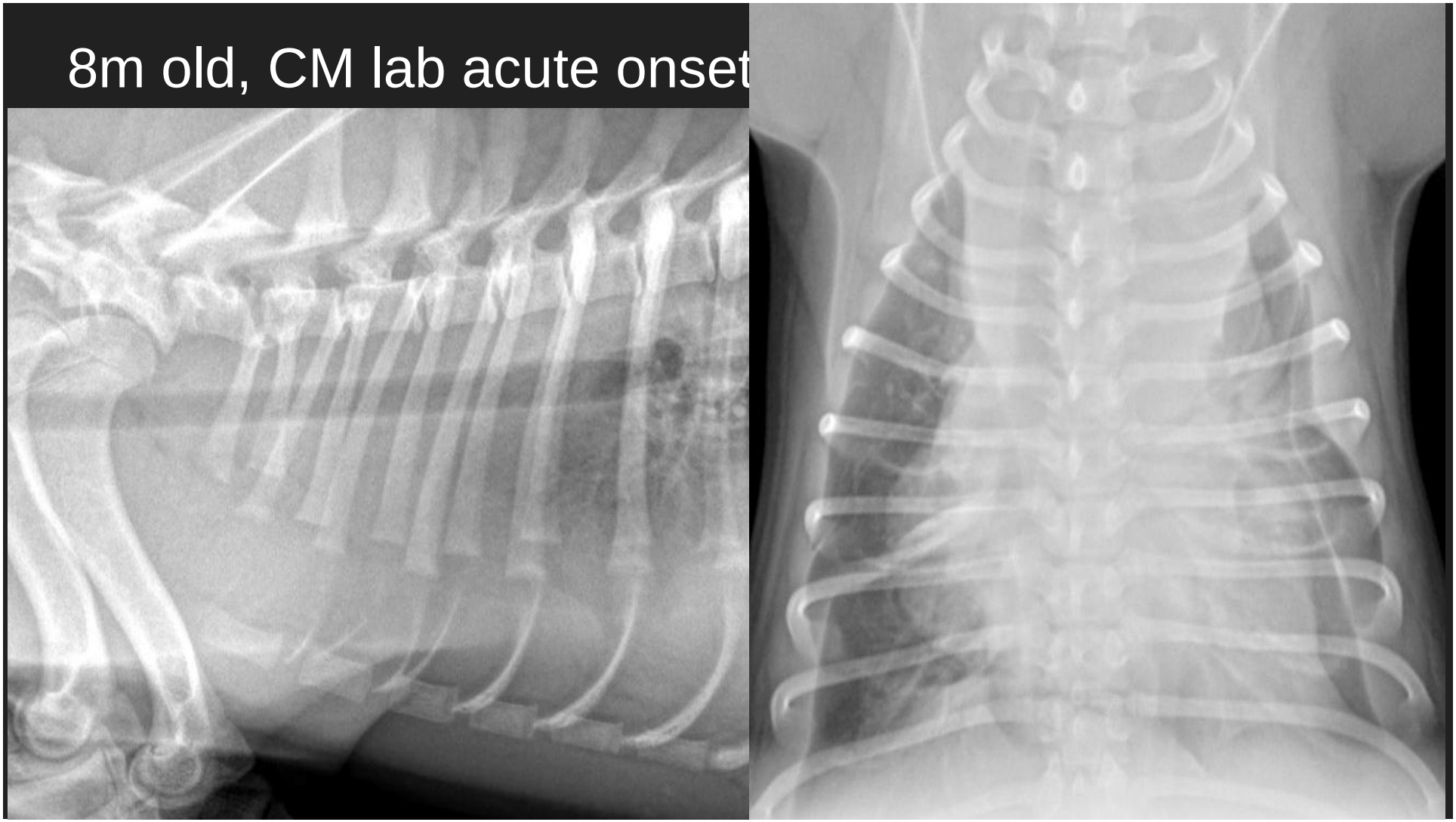
Bullae - idiopathic, traumatic, chronic airway disease (huskies?)
Emphysema/bronchiectasis - chronic inflammatory airway disease
Parasitic cysts - Paragonamus kellicotti
Abscess
Granuloma: fungal, parasitic, non-infectious inflammatory
Neoplasia with cavitation
Lung lobe torsion


Lung Lobe Torsion

9yr SF La
elevated



8m old, CM lab acute onset



Thoracic Imaging

Lance Rozear, DVM, DACVR

New Haven County Veterinary Medicine Association

November 2, 2016