Respiratory Imaging- CT

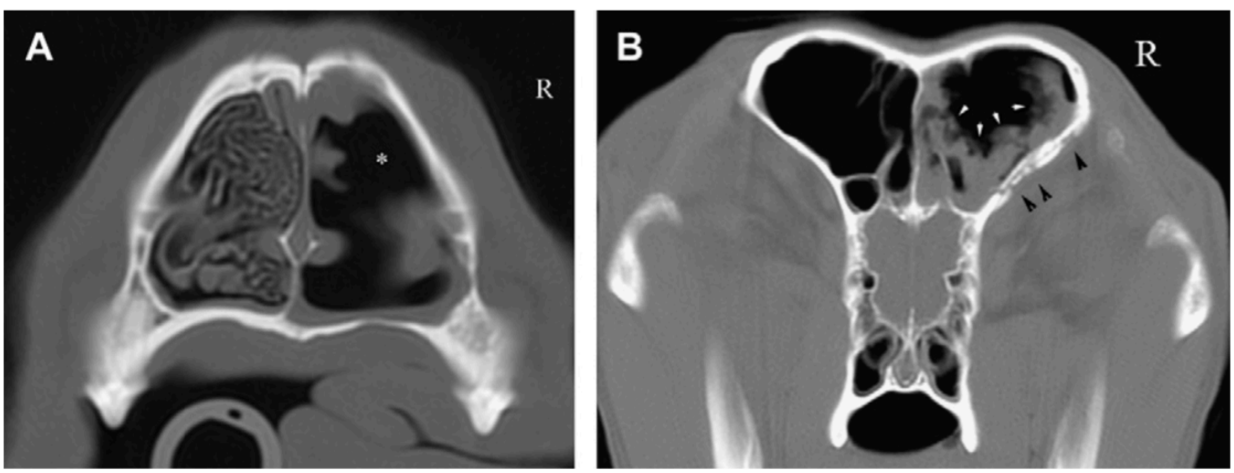
Johnson EG and Wisner ER. Advances in Respiratory Imaging. Vet Clin Small Anim. 2007. (37) 879-900

Fungal rhinitis

Loss of turbinate architecture, especially rostrally, and thickening of the frontal bone +/- frontal sinus involvement (soft tissue density within the frontal sinus)

Dogs → typically nasal **aspergillosis**; generally unilateral, especially early in disease

4yo mixed breed dog with unilateral mucoid nasal discharge. Destruction of the right nasal turbinates (*) with soft tissue opacity in the right nasal passage; (B) at level of frontal sinus – thickened mucosa and gas/ soft tissue opacity within the right frontal sinus. Floor of sinus has destructive boney changes



Cats → typically **cryptococcus neoformans.** Produces hyperplastic rather than destructive rhinitis. Feline aspergillosis is rare but produces a destructive rhinitis similar to canine aspergillosis

Nasal neoplasia

Adenocarcinoma (most common), sarcoma (chrondrosarcomas, osteosarcomas, STS), or lymphoma (rare in dogs, higher incidence in cats)

Not able to differentiate carcinomas from sarcomas on CT; lymphoma generally has less aggressive appearance

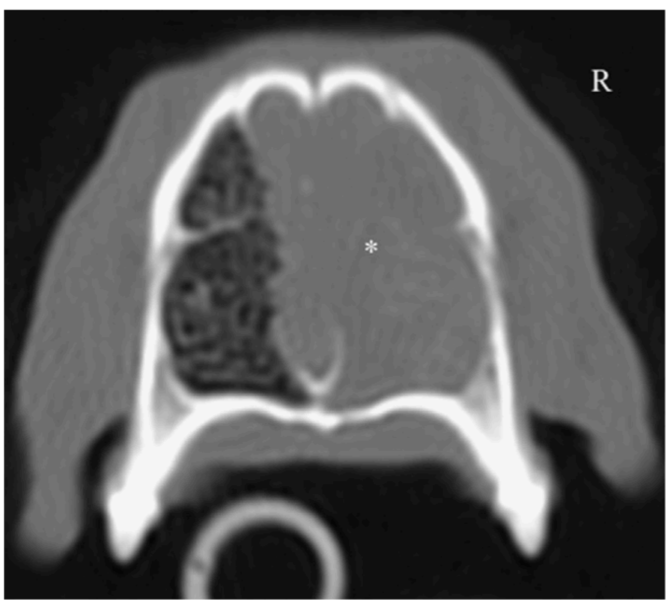
Imaging in dogs can lead to presumptive diagnosis of nasal neoplasia with high degree of confidence

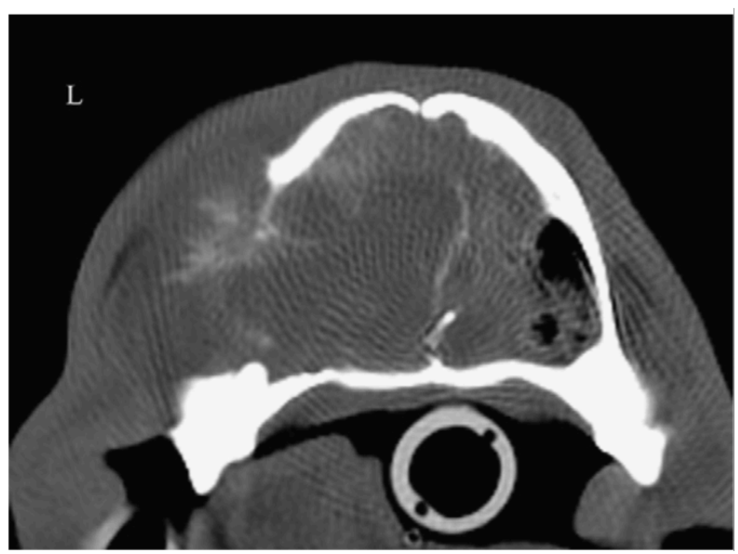
CT findings: ethmoid bone destruction, destruction of the nasal bone or maxilla, abnormal soft tissue opacity in the retrobulbar space, turbinate destruction, frontal sinus fluid and soft tissue accumulation, mass-like lesions within nasal cavity, patchy areas of increased attenuation within the soft tissue density

If tumor breaches paranasal bones, contrast may be helpful to delineate tumor margins, eg. Determining if frontal sinus opacity if due to tumor extension or fluid accumulation versus from obstructive rhinitis; or determining degree of extension past the cribiform plate into the calvarium

Carcinoma (left) – *10yo Sheltie with right nasal epistaxis. Mass lesion in right nasal cavity with destruction of the nasal septum and nasal turbinates.*

Osteosarcoma (right) – *7yo Pitbull with unilateral epistaxis and swelling of the left side of the muzzle. Primarily destructive lesion around the left nasal and maxillary bone. Soft tissue mass effect in the left nasal cavity that extends through the nasal septum into the right nasal passage.*

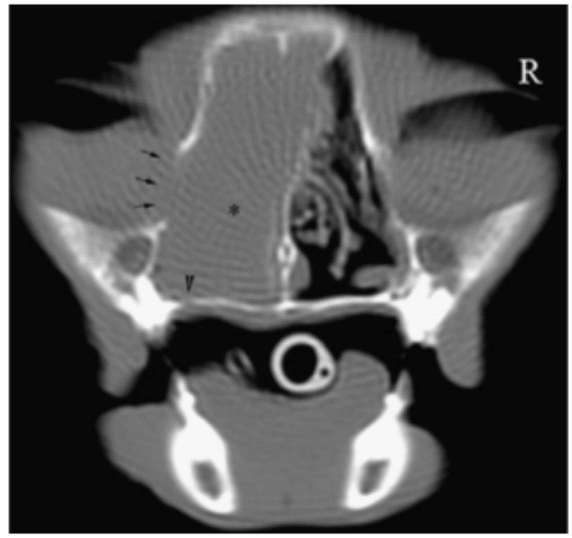




Canine Lymphoma (left) – *3yo Rhodesian Ridgeback dog. Hx sneezing, stertor, and nasal discharge. Soft tissue–attenuating material dissecting through the right ethmoturbinates and extending into the right frontal sinus. Mild osteolysis of the the frontal bone (black arrows). Soft tissue polypoid mass can be seen within the nasopharyngeal meatus (*)*

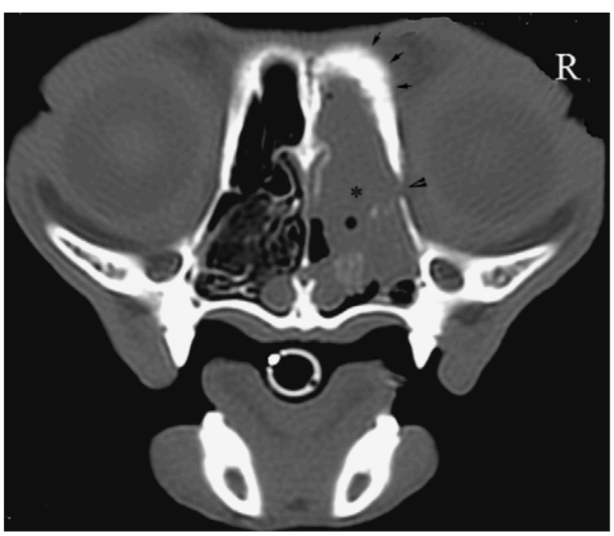
Feline Lympoma (right) – *13 yo DSH. Hx of nasal discharge and sneezing. Homogenous space-occupying mass with destruction of the nasal septum (*).*

Destruction at the junction of the maxillary, lacrimal, and frontal bones (arrows). Subtle destruction of the palatine bone (arrowhead).



Cats – CT findings in **chronic inflammatory nasal disease** is similar to nasal neoplasia. Both processes will cause deviation of the septum, cribiform plate destruction, turbinate destruction, frontal nasal sinus involvement, destruction of the paranasal bones, often both nasal cavities are affect

Chronic rhinitis – *Level of the orbits. 8yo Scottish Fold. Hx. chronic sneezing and nasal discharge. Soft tissue opacification of the right nasal passage with underlying turbinate loss (*). Hyperostosis of the dorsal maxillary bone (arrows) with osteolysis of bone at the junction of the maxillary bone with the lacrimal bone (arrowhead). → chronic neutrophilic and lymphoplasmacytic rhinitis*



Mediastinal Masses

Thoracic CT - best performed on heical machines with single-breath hold

Eg. Thymoma, lymphoma, cysts, rarely sarcomas.

Radiographs generally diagnostic for presence of mass, however CT is helpful for assessing invasion of local structures and surgical planning

Chylothorax

Radiographs – pleural effusion, reduction in lung lobe volume, rounding of lobar margins, pleural thickening

CT advantageous for pre-surgical planning for imaging of the thoracic duct – surgical catheterization of intestinal lymphatic vessel and injection of contrast or direct lymphangiography by injection of mesenteric lymph node (by ultrasound guidance)

4-year-old Rottweiler at the level of the second sternebral segment after mesenteric lymph node injection with iodinated contrast material. Opacification of dilated cranial mediastinal lymphatic vessels consistent with idiopathic cranial mediastinal lymphangiectasia. Contrast material is present in the pleural space surrounding the left cranial lung lobe consistent with leakage from a mediastinal lymph vessel or vessels (arrows).

Pyothorax

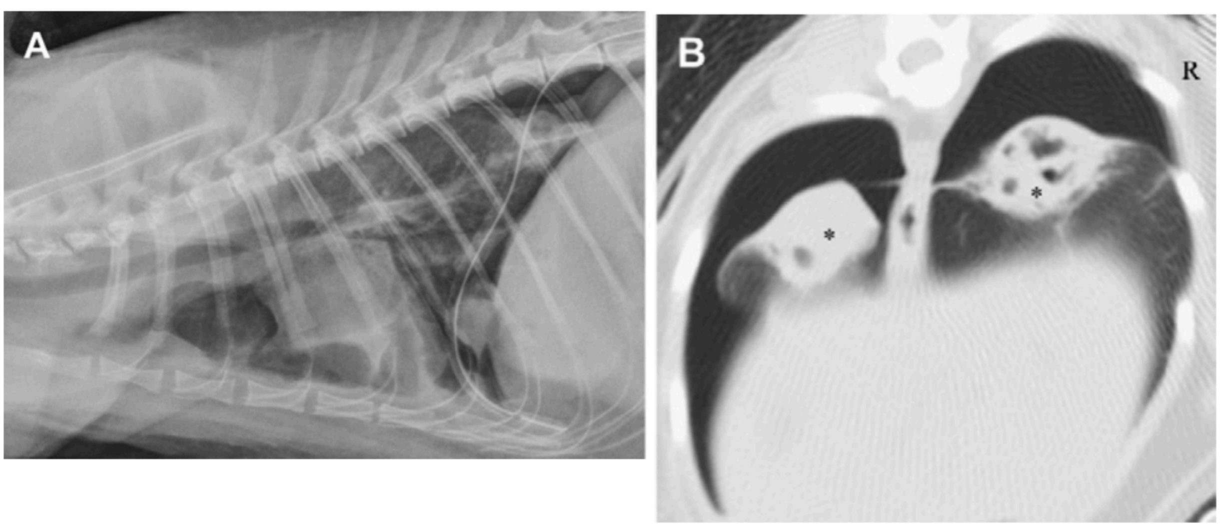
Radiographs – pleural effusion, reduction of lung volume, rounding or thickening of pleural margins +/- pleural adhesions. Pulmonary infiltrates if there is foreign body migration, abcessation or atelectasis

CT generally pursued when abscess or foreign body is suspected

Mediastinal fluid accumulation, pleural abscess (encapsulated fluid accumulation), thickening and rounding of pleural margins and mediastinal pleural, lymphadenopathy, pulmonary atelectasis, alveolar infiltrates +/- pleural adhesions

Pleural surfaces are often contrast enhancing because of thickening, hyperemia and increased vascular permeability of the pleura

2yo cat. Hx. pyothorax that was nonresponsive to chest tube placement and antibiotic therapy. (A) Right lateral thoracic radiograph – thickening of the pleural surface with small regions of plural fluid accumulation and a small volume of free pleural gas. Multifocal areas of alveolar opacity. (B) Two well-circumscribed alveolar densities with central gas opacities in the left and right caudal lung lobes (*). Thickening of the adjacent pleural surfaces and pneumothorax.

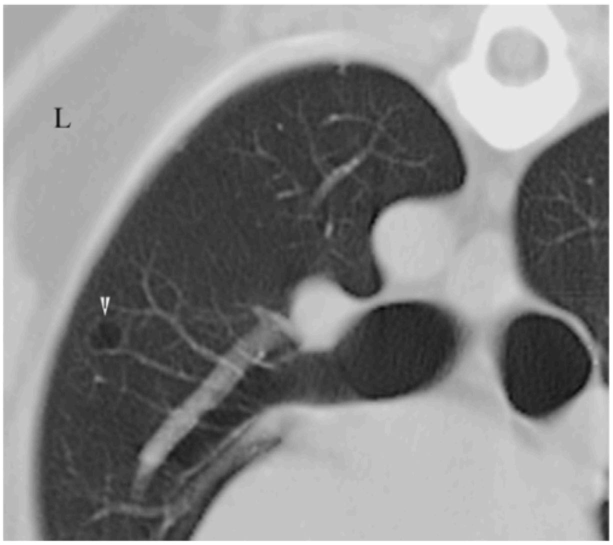


Pneumothorax

Readily diagnosed by radiographs. CT may be indicated to look for underlying cause.

Marked lung lobe atelectasis decreased pulmonary density, making it harder to identify lung pathology. Evacuate pleural space first.

Adult mixed-breed dog presented for a pulmonary mass. Incidental finding - pulmonary bulla in the caudal subsegment of the left cranial lung lobe. Disrupted vasculature with a central region of hypoattenuation typical of pulmonary bullae (arrowhead).



Canine Bronchial disease

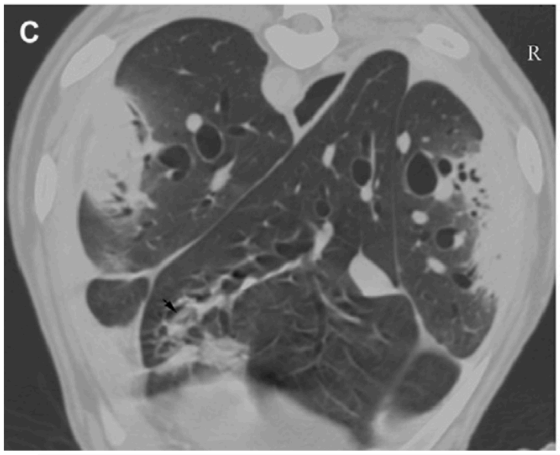
Acute bronchitis or tracheobronchitis typically doesn't cause enough edema or cellular infiltration to see significant changes on radiographs or CT

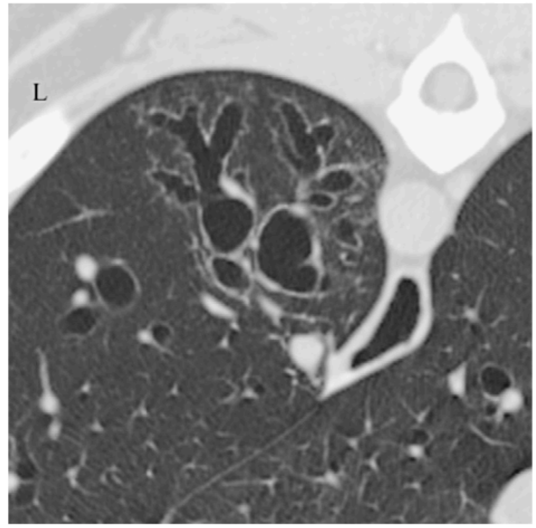
Chronic bronchitis will result in bronchial pattern +/- bronchiectasis and interstitial infiltrates. Radiographic accuracy is 65-74% for diagnosis. CT may be more accurate?

Bronchiectasis -> persistent airway dilation (dilated without tapering at periphery) often with suppuration. Radiographs are not able to identify this until late in the disease
In humans diagnosis is made by CT measurements of bronchial to pulmonary arterial diameter ratios

LEFT – 3yo GSP. Multifocal regions of alveolar infiltrates within the right and left caudal lung lobes and accessory lung lobe. Multiple focal regions of bronchiectasis. Foreign body within distal aspect of the accessory lung lobe (arrow). Bronchoscopy revealed multiple grass awns within the airways and associated bronchiectasis.

RIGHT – 8yo Lab. Hx. chronic cough and recurrent left caudal lung lobe infiltrates reveals focal bronchiectasis in the left caudal lung lobe with an irregular contour to the bronchial walls → traction bronchiectasis. Ground-glass–like appearance is present next to dilated bronchi.





Feline Airway Dz

Similar radiographic findings to dogs – thickening of bronchial walls, increased peribronchial radiodensity, soft tissue accumulation in the airways (mucus plugs), hyperinflation, collapse of the right middle lung lobe, occasional bronchiectasis

CT is more sensitive. May see multifocal to coalescing interstitial opacities with ground glass appearance – represents active aleolitis or fibrosis in people

5 yo cat. Hx. chronic coughing. Large soft tissue density in the right cranial lung lobe bronchus consistent with an intraluminal mucus plug (*). Ground-glass pulmonary opacities present in the dorsal aspect of the right cranial lung → active alveolitis or fibrosis

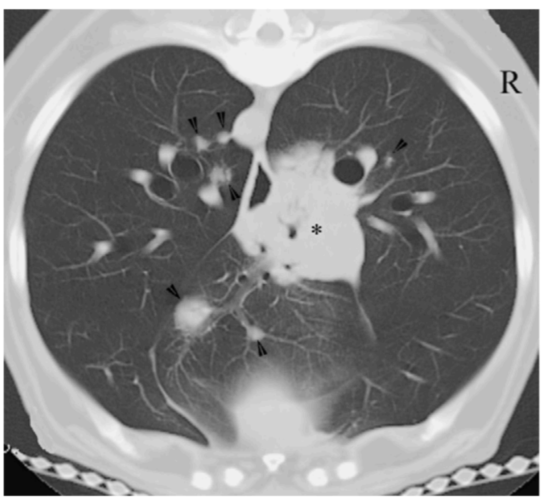
Pulmonary masses

Radiographs are generally able to identify pulmonary masses. CT helpful in localizing area of thorax affected, and may help differentiate inflammatory from neoplastic mass, and assess for LN involvement

CT more sensitive than radiographs for detection of pulmonary metastatic disease in people and dogs. Nodules must reach 7 to 9 mm before detection on radiographs

LEFT – 11yo mixed-breed dog with a solitary pulmonary massat the junction of the right caudal lung lobe bronchus and the accessory lung lobe bronchus (*). Several other pulmonary nodules are visible in multiple lung fields (arrowheads). → pulmonary adenocarcinoma with intrapulmonary metastases.

RIGHT – 12yo Collie with a bleeding splenic mass demonstrates multiple soft tissue nodules within the pulmonary parenchyma (arrows)



Pulmonary Edema

Radiographs – air bronchograms, soft tissue opacification of the lung, lobar consolidation, silhouetting of adjacent soft tissue structures

CT may be helpful for looking for underlying cause if not apparent, eg. Pulmonary masses obscured by fluid

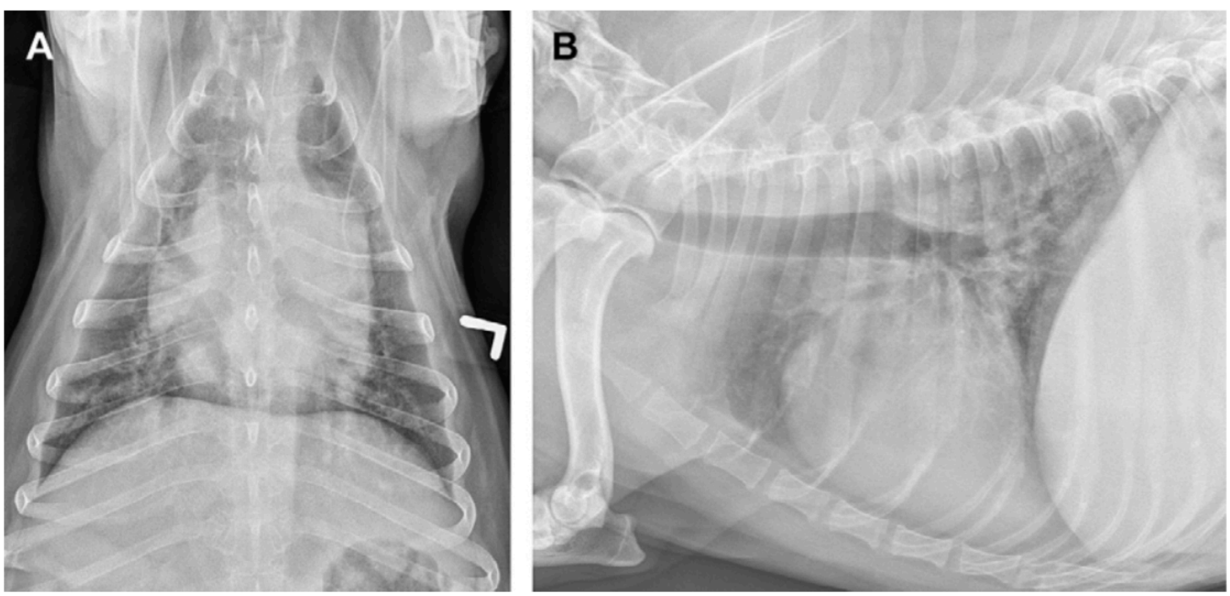
<u>Pulmonary Fibrosis</u>

Canine Idiopathic pulmonary fibrosis – West Highland Terriers

Radiographs - diffuse interstitial pattern, sometimes miliary, hypoinflated lung fields (decreased pulmonary compliance) +/- right heart enlargement and pulmonsry arterial enlargement from secondary pulmonary hypertension

Use of CT in these patient is currently limited – ground glass opacity (does not obscure underlying vessels), traction bronchiectasis (bronchial dilation with irregular contour from traction on wall from fibrosis), interstitial thickening, honeycombing (cystic air-filled spaces)

13yo Terrier. Hx. tachypnea. Diffuse heavy interstitial pattern with a mild un-derlying bronchial pattern. Hypoinflated, suggesting decreased pulmonary compliance. Moderate right heart enlargement with mildly enlarged pulmonary arteries. → primary interstitial pulmonary fibrosis with right heart hypertrophy suggesting secondary pulmonary hypertension



Keyserling CL, Buriko Y, Lyons BM et al. Evaluation of thoracic radiographs as a screening test for dogs and cats admitted to a tertiary-care veterinary hospitalfor noncardiopulmonary disease. Vet Radiol Ultrasound. 2017; 58: 503-511

1. Thoracic radiographs often used for screening purposes in dogs and cats with no clinical signs associated with thoracic disease
    a. Eg. Geriatric wellness, pre-anesthesia, general assessment of systemic illness
    b. Initially used in humans to looks for subclinical tuberculosis; however trend has remained even as tuberculosis has become less common
    c. One study showed only 4/294 routine films identifying thoracic disease
2. Objective
    a. Do certain populations have a higher proportion of radiographic abnormalities?
    b. Do these abnormalities affect patient hospitalization and outcome?
3. Retrospective observational study at AMC
4. Exclusion criteria: prior diagnosis of primary respiratory or cardiac disease, malignant neoplasia or clinical findings of dyspnea/ inc resp effort/ crackles or wheezes
5. Results
    a. 231 radiographs
    b. 57% radiographs taken for general screening; 21% for pre-anesthetic purposes, 6% for heart murmur or gallop, 3.6% for trauma, 3% for esophageal disease, 3% for pyrexia
    c. 28% of dogs and 45% of cats had abnormal thoracic radiographs

TABLE 1 Overall proportions and 95% confidence intervals of abnormal and normal thoracic radiographs

	Dog	Cat	All patients
NR	120/166 (72.3%, 95% CI: 65–79%)	36/65 (55.4%, 95% CI: 43–68%)	156/231 (67.5%, 95% CI: 61–74%)
AR	46/166 (32.3%, 95% CI: 21–35%)	29/65 (44.6%, 95% CI: 32–57%)	75/231 (32.5%, 95% CI: 27–39%)

    d. 42% had lactate measured within 24 hours of the radiographs → significantly higher in abnormal radiograph group
    e. Feline patients with abnormal radiographs were more likely to be anemic or have a low-normal hematocrit
    f. No significant difference in BCS, PCV/TS, BG, temperature, blood pH, length or cost of hospitalization or outcome

TABLE 3 Listed reasons for obtaining screening thoracic radiographs in dogs and cats

Reason for obtaining radiographs (number of patients)	Dogs with NR (120)	Dogs with AR (46)	Changed clinical plan (8)
Dogs			
General screening (95)	70	25	7
Preanesthesia (35)	26	9	0
Heart murmur or gallop ausculted (11)	7	4	1
Unknown (9)	6	3	0
Trauma (6)	4	2	0
Suspect esophageal disease (5)	4	1	0
Pyrexia (5)	3	2	0
Total (166)	120	46	8
Cats			
Reason for obtaining radiographs (number of patients)	**Cats with NR (36)**	**Cats with AR (29)**	**Changed clinical plan (7)**
General Screening (41)	21	20	4
Unknown (7)	6	1	1
Heart murmur or gallop ausculted (7)	4	3	1
Preanesthesia (6)	3	3	0
Trauma (4)	2	2	1
Total (65)	36	29	7

NR, normal radiographs; AR, abnormal radiographs.

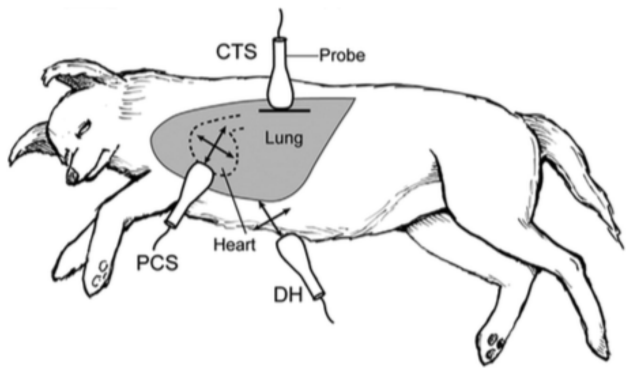
6. Discussion
    a. Larger percentage of abnormal radiographs than expected
        i. Broad inclusion criteria?
        ii. More difficultly than in humans to identify thoracic disease?
    b. Difficult to determine if adjustments in clinical plan resulted in benefit to patients
    c. Preanesthetic patients that had abnormalities -> clinical plan never adjusted
7. Conclusion: Screening radiographs may be justified to obtain a complete clinical picture, but it does not seem to have an influence of duration or cost of hospitalization

TFAST

Boysen SR and Lisciandro GR. The Use of Ultrasound for Dogs and Cats in the Emergency Room AFAST and TFAST. Vet Clin Small Anim 43 (2013) 773-797.

First line screening tool in patients with respiratory distress. In some cases, exceeds chest auscultation and radiography with a high sensitivity and specificity for pneumothorax, pleural effusion, lung consolidation and interstitial syndrome in humans

5-point scan:



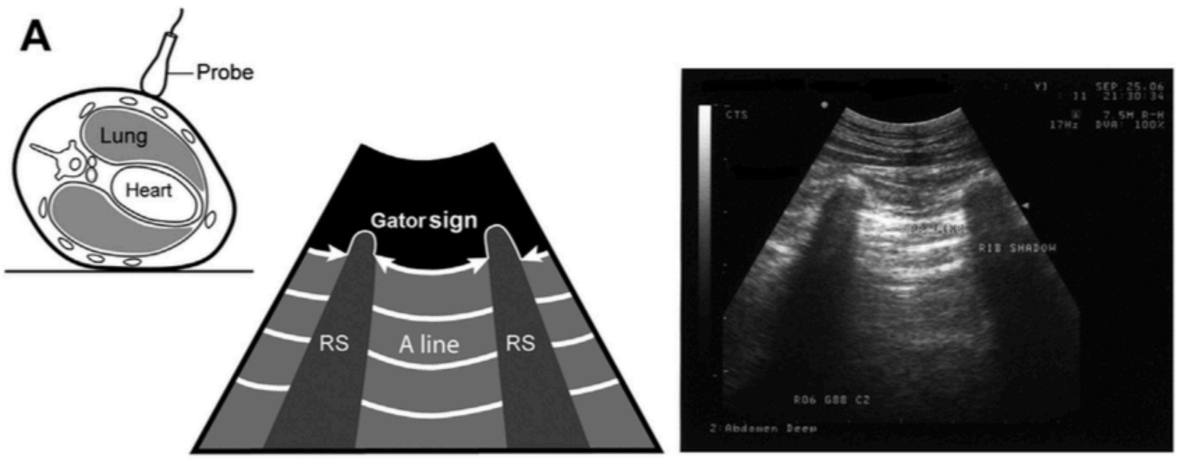
CTS – chest tube site → pneumothorax and lung pathology
PCS – pericardial site → pleural and pericardial effusion. Right PCS assesses for volume status (mushroom view), La:Ao
DH – diaphragmaticohepatic → pericardial effusion, assessment of size of caudal vena cava and hepatic venous distension

Glide sign – lung sliding along the thoracic wall. Absence indicative of pneumothorax

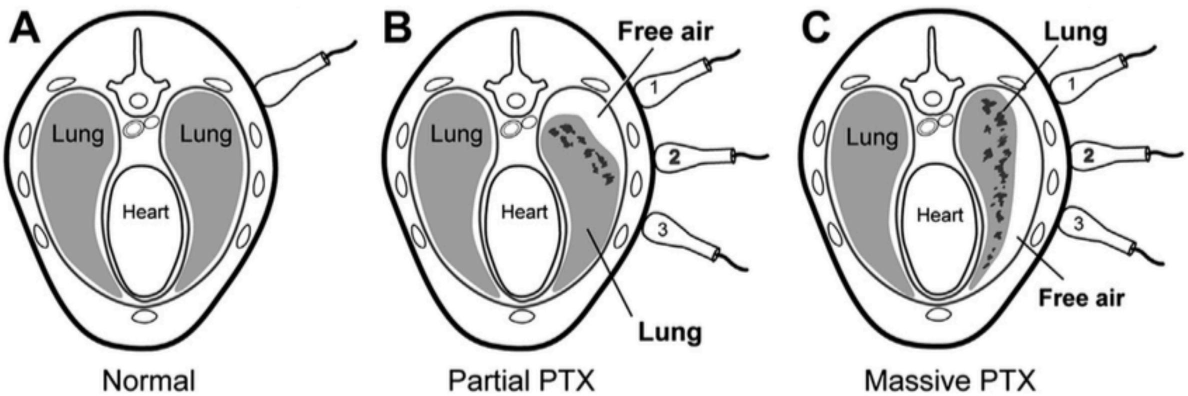
Presence of B lines (lung rockets) excludes pneumothorax

B-lines are hyperechoic laser-like streaks that do not fade and obliterate the A lines (air reverberation artifact)

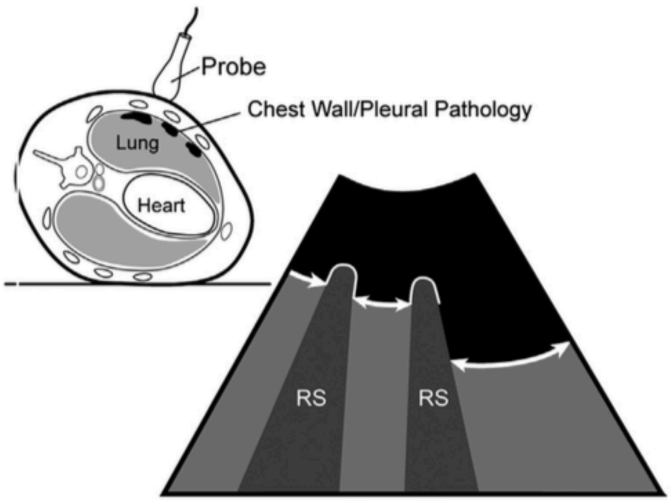
Can identify degree of pneumothorax by looking for lung point, i.e. point where glide sign or B-lines return, identifying that aerated lung is reaching the thoracic wall



Glide Sign with A-lines, Normal Dry Lung



Step sign: inconsistence along the pleural-pulmonary line, indicative of thoracic wall injury (eg. Intercostal tear, rib fractures, flail chest, subcostal hematoma), pleural effusion, lung consolidation or lung masses



Step Sign

Limitations of lung ultrasound: lung conditions must have reached anatomic periphery to be seen (deep lesions will not be identified)

Ward JL, Lisciandro GR, Keene BW et al. Accuracy of point-of-care lung ultrasonography for the diagnosis of cardiogenic pulmonary edema in dogs and cats with acute dyspnea. JAVMA. 2017; 250(6)

1. Humans:
    a. Cardiogenic from NCPE can be differentiated by lung ultrasound with a high sensitivity/ specificity
    b. Similar or greater PPV than NT-proBNP or thoracic radiographs
    c. Number of B lines is correlated with amount of lung water
2. Benefits of ultrasound over radiographs: sometimes radiograph results are equivocal, taking radiographs can exacerbate patient's respiratory distress
3. Prospective enrollment of 76 dogs and 24 cats from 2013-2015 at NC State
    a. All patients presented with dyspnea
    b. Lung-ultrasound (8 sites per patient – caudal, cranial, middle and perihilar) and thoracic radiographs performed
    c. Trauma patients and patients with moderate to severe pleural effusion excluded
4. Blinded examiners assessed saved images for number of B lines
    a. 0, 1, 2, 3, >3, or infinite

    b. >3 or infinite was scored as positive
    c. Lung ultrasound with at least 2 positive sites on each hemithorax were considered consistent with CPE; less than 2 positive sites on each hemithorax were consistent with non-cardiogenic cause of dyspnea (Volpicelli method)
5. Radiographs evaluated by radiologist and diagnosed as CPE, non-cardiogenic or undetermined. If uncertain, diagnosis of CPE would only be made if fit with echocardiographic findings, positive response to heart failure treatment, markedly high NT-proBNP or post-mortem exam
6. Results
    a. 61% diagnosed with CPE, 39% had non-cardiac disease
    b. Cardiac disease in dogs – MVD (35), DCM (8), endocarditis of the aortic valve (3)
    c. Cardiac disease in cats – HCM (13), unclassified (2)
    d. Noncardiac respiratory distress – pulmonary hypertension or thromboembolism (10), airways disease (4), pneumonia (4), heartworm pneumonitis (2), neurologic disease (2), right-to-left cardiac shunt (1)
    e. Noncardiac respiratory distress in cats – asthma (2), unknown diffuse pulmonary disease (2), upper airway obstruction (1), heartworm pneumonitis (1), pain by ATE (1)
    f. At least one positive site in…
        i. 55/61 CPE patients
        ii. 26/39 non-cardiogenic patients

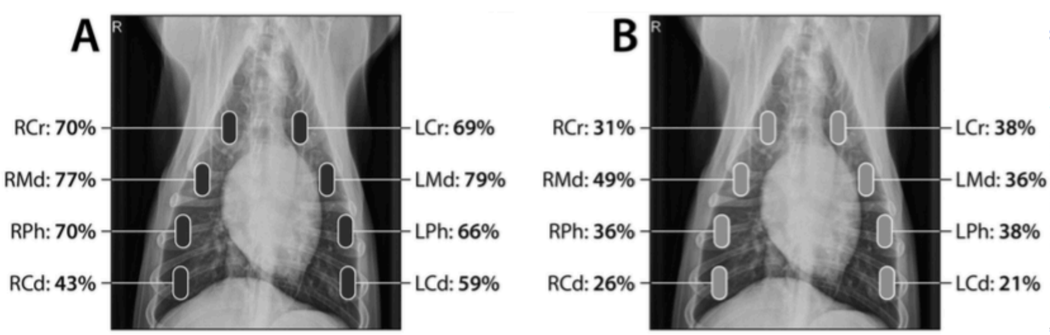


Table 1—Diagnostic accuracy of LUS* and thoracic radiography for the diagnosis of CPE in 76 dogs and 24 cats with acute dyspnea.

Diagnostic test	Species	Sensitivity (%)	Specificity (%)	Positive likelihood ratio†	Negative likelihood ratio†
LUS	Both	84	74	3.23	0.22
	Dogs	83	70	2.77	0.24
	Cats	87	89	7.91	0.15
Thoracic radiography	Both	85	87	6.54	0.17
	Dogs	85	87	6.54	0.17
	Cats	87	89	7.91	0.15

g. Sensitivity – 84%
    i. 6 patients (5 dogs, 1 cat) had a final diagnosis of CPE with no positive lung ultrasound sites, whereas in humans absence of B-lines essentially rules out CPE (94%) → differences in patient conformation or different distribution of edema?
h. Specificity - 74%
    i. Clinically normal dogs have very low numbers of B lines
    ii. False positives occurred with diffuse interstitial or alveolar disease (ARDS, neoplasia, pneumonitis, pulmonary hypertension – fibrosis, PTE)
    iii. Better specificity in humans (92%) – most common causes of respiratory distress in humans are CPE or COPD
i. Sensitivity and specificity are similar to thoracic radiography
j. Excellent interobserver agreement
k. Middle lung lobes most commonly affected, regardless of cardiogenic or non-cardiogenic

7. Conclusions: feasible diagnostic test causing minimal distress to patient, high interobserver agreement, fairly high accuracy (better in cats), with similar sensitivity to thoracic radiographs