**Title**

# Frequency And Number Of Ultrasound Lung Rockets (B-lines) Using A Regionally-based Lung Ultrasound Examination Named Vet BLUE (Veterinary Bedside Lung Ultrasound Exam) In Dogs With Radiographically Normal Lung Findings

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**Abstract**

Lung ultrasound is superior to lung auscultation and supine chest radiography for many respiratory conditions in human patients. Ultrasound diagnoses are based on easily learned patterns of sonographic findings and artifacts in standardized images. By applying the wet lung (ultrasound lung rockets or B-lines, representing interstitial edema) versus dry lung (A-lines with a glide sign) concept many respiratory conditions can be diagnosed or excluded. The ultrasound probe can be used as a visual stethoscope for the evaluation of human lungs because dry artifacts (A-lines) predominate over wet artifacts (ultrasound lung rockets or B-lines). However, the frequency and number of wet lung ultrasound artifacts in dogs with radiographically normal lungs is unknown. Thus, the primary objective was to determine the baseline frequency and number of ultrasound lung rockets in dogs without clinical signs of respiratory disease and with radiographically normal lung findings using an 8-view novel regionally-based lung ultrasound examination called Vet BLUE. Frequency of ultrasound lung rockets were statistically compared based on signalment, body condition score, investigator and reasons for radiography. Ten left-sided heart failure dogs were similarly enrolled. Overall frequency of ultrasound lung rockets was 11% (95% confidence interval, 6-19%) in dogs without respiratory disease vs. 100% (95% confidence interval, 74-100%) in those with left-sided heart failure. The low frequency and number of ultrasound lung rockets observed in dogs without respiratory disease and with radiographically normal lungs suggests that Vet BLUE will be clinically useful for the identification of canine respiratory conditions.

## Introduction

Lung ultrasound has higher sensitivity than lung auscultation and supine chest radiography for many acute and potentially life-threatening respiratory conditions in people.[1-5] Fundamental principles of lung ultrasound in acute respiratory conditions generally center around the observation of ultrasonographic artifacts based on the dry lung (A-lines with a glide sign) versus wet lung (ultrasound lung rockets or B-lines) concept. Ultrasound does not transmit through aerated lung and the presence of ultrasound lung rockets (wet lung artifact) primarily represent forms of interstitial edema.[6-10] In normal human lungs, ultrasound lung rockets are infrequent and dry lung artifacts predominate.[1,5,8] Thus, when ultrasound lung rockets are present, their regional distribution can be used as an evidence-based tool in addition to traditional means of lung auscultation and supine chest radiography.[1,5,8,9,11-14] Normal ultrasound findings and artifacts are readily teachable[6-9,12,13] and an international consensus statement by lung ultrasound experts has supported their use for diagnosing many respiratory conditions.[5] Other lung ultrasound findings have also been defined (shred sign, tissue sign, nodule sign [signs of consolidation])[15,16,22] but are not expected to be present in dogs with radiographically normal lungs.

No data are currently available regarding the frequency and number of ultrasound lung rockets in dogs without respiratory disease and with radiographically normal lung findings. The Thoracic FAST (Thoracic Focused Assessment with Sonography for Trauma [TFAST]) protocol , despite detecting other lung pathology, is the only standardized lung ultrasound examination currently described for use in small animals.[9,17] However, the Thoracic FAST protocol has limited scope because only a single lung view, called the chest tube site, is examined (1 view bilaterally [2 total acoustic windows]).[14,16] A more comprehensive lung ultrasound survey has been developed and named Vet BLUE.[a,14,16,18] This novel lung survey employs 4 bilaterally applied lung views (8 total acoustic windows).[a,14,16,18]

The purposes of this study were to (1) determine the overall frequency and number of ultrasound lung rockets in dogs without clinical signs of respiratory disease and with radiographically normal lung findings receiving the Vet BLUE examination; and (2) identify any significant predictors for the presence of ultrasound lung rockets in dogs without respiratory signs and with radiographically normal lung findings; and (3) determine the frequency and number of ultrasound lung rockets in a limited number of dogs with left-sided heart failure.

We hypothesized that ultrasound lung rockets would be uncommon in dogs without respiratory disease and with radiographically normal lung findings but frequent in dogs with left-sided heart failure and there would be no significant differences in age, sex, breed, body weight, body condition score, investigator and reasons for thoracic radiography between dogs with and without ultrasound lung rockets.

## Materials and Methods

Dogs without clinical signs of respiratory disease presenting at 2 private veterinary referral centers were prospectively enrolled over a 22-month period (September 2010- July 2012) after obtaining informed consent from owners. All dogs received the Vet BLUE examination within 30 minutes prior to digital thoracic radiography. A minimum of 2-view thoracic radiography was performed to rule-out respiratory disease and only dogs without clinical signs of respiratory disease and with radiographically normal lung findings were included. Radiographs were reviewed in DICOM format by board-certified veterinary radiologists that were blinded to lung ultrasound findings. A limited number of dogs with radiographically diagnosed left-sided heart failure and with radiographically evident cardiogenic pulmonary edema were similarly enrolled and evaluated for comparison.

The regionally-based lung ultrasound examination was performed identically to the previously described lung examination performed at the chest tube site view of Thoracic FAST. The chest tube site view has been previously defined as the highest point on the thoracic wall over lung directly dorsal from the xiphoid approximating the 8$^{th}$ and 9$^{th}$ intercostal spaces[9,17]; and was the starting point for the Vet BLUE examination. All dogs were evaluated in sternal recumbency or in standing position.

Each lung view was evaluated as a stationary, horizontally-held ultrasound probe position as previously described (Fig. 1).[9,17] Standard orientation consisted of the observation of the previously described “gator sign (alligator)” represented by two rib heads (the gator’s eyes) with an interposed intercostal space (gator’s bridge of nose) likened to a partially submerged alligator (gator) peering over the water at the sonographer (Fig. 2).[14,16] The proximal hyperechoic (bright white) line along the intercostal space is referred to as the pulmonary-pleural line.[9,17] Dry lung (glide sign) is ultrasonographically recognized by the to and fro motion along the pulmonary-pleural line with air reverberation artifact called A-lines.[9] A-lines are defined as equidistant parallel lines extending from the pulmonary-pleural line (Fig. 3).[1,5,8,9,15] Wet lung is recognized by ultrasound lung rockets also called B-lines (Fig. 4).[1,5,6,9,12-16] Other lung ultrasound findings have been described for consolidation (shred, tissue, nodule[s] sign)[15,16,22] but these are unexpected in our study population of dogs with radiographically normal lungs.

Ultrasound lung rockets are hyperechoic laser-like streaks that extend from the pulmonary-pleural interface through the far field and oscillate in synchronization with inspiration and expiration (Fig. 4). [1,5,6,9,12-16] Ultrasound lung rockets are thought to be the radiographic equivalent of Kerley B-lines[1,8,19] and are created by a small amount of fluid being immediately adjacent to air at the outer 1-3 millimeters of lung.[19] The frequency of ultrasound lung rockets correlates with the degree of lung edema in humans.[5-8,12,19]

The Vet BLUE examination consisted of 4 bilaterally applied views (8 total acoustic windows) referred to as the caudodorsal lung lobe region, the perihilar lung lobe region, the middle lung lobe region, and the cranial lung lobe region as previously described (Fig. 5).[a,14,16,18] The caudodorsal lung lobe region (1) is directly dorsal to the xiphoid in the 8th -9th intercostal space near the highest point (upper 1/3 of thorax) over lung. The caudodorsal lung lobe region site is the same as the Thoracic FAST chest tube site view.[17] The perihilar lung lobe region (2) is the point mid-thorax (central 1/3 of thorax) between the 6th- 7th intercostal spaces approximating the perihilar region. The middle lung lobe region (3) is the lower thorax over the heart (lower 1/3 of thorax) in the 4th-5th intercostal spaces at the level of the costochondral junction. If the heart obscures the lung then the probe is moved an intercostal space(s) caudally for the middle lung lobe region view. The cranial lung lobe region (4) is the 2nd-3rd intercostal space cranial to the heart (lower 1/3 of thorax) at the level of the costochondral junction (the foreleg may need to be gently pulled forward to obtain this view). If the heart obscures the lung then the probe is moved an intercostal space(s) cranially for the cranial lung lobe region view (Fig. 6).

The maximum number of ultrasound lung rockets over a single intercostal space at each regional lung view was recorded on a standardized data sheet (Fig. 7). Ultrasound lung rockets were counted in B-mode as follows: 0, none seen; 1, a single discrete ultrasound lung rocket; 2, two discrete ultrasound lung rockets; 3, three discrete ultrasound lung rockets; and > 3, more than 3 discrete ultrasound lung rockets (Fig. 8). The standardized data sheet also collected patient identification number, age, sex, breed, body weight, body condition score (9 point scale), investigator and reason for thoracic radiography.

Two sonographers (GL, RF) performed the lung ultrasound examination studies using the same 8C-RS convex, 4-10.0 MHz, ultrasound probe (General Electric, Milwaukee, Wisconsin) with different ultrasound machines, Logic e Vet, General Electric (RF) and the Logic XP Note Book, by the same manufacturer (General Electric, Milwaukee, Wisconsin). The ultrasound frequency for all examinations was set at 8.0 MHz and the display depth ranged from 4 cm to 6 cm.

Categorical data were summarized as frequencies, proportions, and by calculating mid-P exact 95% confidence intervals (CI). Quantitative data were summarized as medians and inter-quartile ranges ($25^{th}$ to $75^{th}$ percentiles). Categorical data were compared between groups of dogs using chi-square and Fisher exact tests. Quantitative data were compared across groups using Mann-Whitney U tests. Observed ultrasound lung rockets were compared between left and right sides using Wilcoxon signed-rank tests. For statistical analysis, the reasons for thoracic radiography were categorized as trauma, lung metastasis examination, gastro-intestinal disease, cardiac disease, and other reasons. Categorical data analysis was performed using Epi Info, Version 6.04, (Center Disease Control, Atlanta, Georgia) and quantitative data were analysed using IBM SPSS Statistics, Version 21 software (International Business Machines Corporation, Armonk, New York). Results were interpreted at the 5% level of significance.

**Results**

Data from 98 dogs without clinical signs of respiratory disease and with radiographically normal lungs were collected during the study period. Dogs presented for trauma (n=27), lung metastasis examination (n=24), gastro-intestinal disease (n=21), cardiac disease (n=17), and one each from nine other reasons. The study population consisted of mixed breed dogs (n=23), Labrador retrievers (n=8), Chihuahua (n=6), Boston terriers (n=5), Jack Russell terriers (n=4), poodles (n=4), and 35 other breeds each with three or fewer dogs. There were 44 spayed females, 40 neutered males, 9 intact females, and 5 intact males. The median (range) age, weight, and body condition score was 7 years (3, 10), 9.9 kg (5.9, 23.5), and 5 (4.4, 6), respectively (Table 1). One investigator performed 67% (66/98) of the lung ultrasound examinations and the other performed the remainder. All thoracic radiographs consisted of the minimum of 2-views but 32 dogs were evaluated by standard 3-view thoracic radiography.

Ten dogs with left-sided heart failure were enrolled and the breeds consisted of poodles (n=3), Yorkshire terrier (n=2), and one each of Maltese terrier, miniature schnauzer, schnauzer, fox terrier and shih tzu. There were 4 spayed females, 4 neutered males, 1 intact female, and 1 intact male. The median (range) age, weight, and body condition score was 11.5 years (0.25, 13), 6.3 kg (4.8, 12), and 5 (3.5, 7), respectively.

Overall frequency of ultrasound lung rockets was 11% (95% CI, 6-19%) in dogs without clinical signs of respiratory disease and 100% (95% CI, 74-100%) in dogs with left-sided heart failure. The majority of dogs without respiratory disease and with ultrasound lung rockets were observed to have them at only a single location (10/11); and a single dog had recognized ultrasound lung rockets at 2 sites (a single ultrasound lung rocket at each site). Of the 10 dogs with a single ultrasound lung rocket-positive site, the majority had only a single ultrasound lung rocket (8/10); and the other 2 dogs had two and three ultrasound lung rockets at the specific positive site (Table 2). Ultrasound lung rockets in dogs without respiratory disease were more frequently observed in neutered males (Table 1; P = 0.007). They were also more frequently observed on the left side (8/11 versus 4/11 on the right side) but the difference was not significant (Table 2; P = 0.131). The majority of ultrasound lung rockets were observed in the less aerated ventrally located middle and cranial lung lobe regions (8/12). In comparison, dogs with left-sided heart failure had ultrasound lung rockets more frequently at all Vet BLUE sites (Table 2).

**Discussion**

Overall frequency and number of detected ultrasound lung rockets using Vet BLUE was low at 11% for radiographically normal lungs. The majority of dogs without clinical signs of respiratory disease were observed to have ultrasound lung rockets at a single location (10/11). Of these dogs with ultrasound lung rockets at a single location, the majority had only a single ultrasound lung rocket (8/10). The single dog with 2 positive sites had only a single ultrasound lung rocket observed at each. In contrast, dogs with left-sided heart failure had a higher frequency (100%) and larger number of ultrasound lung rockets per positive view. The number and frequency of ultrasound lung rockets has been used to reliably rule-in and rule-out left-sided heart failure in people.[1,5,8,12,13,20]

Of the compared parameters, the only statistically significant difference between dogs without respiratory disease with and without ultrasound lung rockets was their sex with ultrasound lung rockets being more frequent in neutered male dogs (P = 0.007). This finding may be due to the small sample size or due to neutered males having disease conditions that were more likely to cause ultrasound lung rockets in the absence of respiratory disease. However, none of the evaluated categories regarding reasons for thoracic radiography had a significantly higher frequency of ultrasound lung rockets. The two investigators also recognized a different frequency and number of ultrasound lung rockets even though the difference was not statistically significant. Investigator A observed ultrasound lung rockets in 6% (2/32) of dogs in contrast to Investigator B that identified ultrasound lung rockets in 14% (9/66) dogs. This discrepancy may be due to differences in the clinical reasons for performing thoracic radiography. Investigator A is employed at a speciality referral center that includes an oncology unit. Thus many dogs examined by Investigator A were not ill but rather having follow-up radiographic metastasis checks. In contrast, Investigator B is employed at a referral emergency and critical care center so many dogs were in fact ill or symptomatic for a disease or condition most commonly minor trauma and gastro-intestinal disease. Also, the case population examined by Investigator A had 3 -view thoracic radiography performed in contrast to the 2 -view thoracic radiography performed at Investigator B's practice. Thus, 3- view thoracic radiography may have more accurately assessed lung as truly normal. If lung ultrasound proves more sensitive than thoracic radiography as shown in humans and non-canine research models for some forms of interstitial edema,[5,10,19,21] then occult radiographic disease deemed normal by 2-view thoracic radiography might have been detected by lung ultrasound (or excluded from the study by 3-view thoracic radiography). Although not statistically significant, more ultrasound lung rockets were observed at the more ventral, less aerated middle and cranial lung lobe regions, compared to the more aerated dorsal caudodorsal and perihilar lung lobe regions as would be intuitively expected in dogs without clinical signs of respiratory disease in sternal recumbency or standing position. In contrast, dogs with left-sided heart failure had ultrasound lung rockets in more than half their views and at higher numbers.

There were some limitations to our clinical study. The prospective study reported here enrolled dogs that were free of respiratory disease. However, many presented for other illnesses rather than being clinically normal dogs. On the other hand, the use of this subset of patients may make the frequency of ultrasound lung rockets even more valuable since our study establishes that the frequency of ultrasound lung rockets in ill dogs without respiratory signs is low. Another limitation involved the inclusion of both 2- and 3-view thoracic radiographs. The authors feel that the contrast between 2- and 3-view thoracic radiography and the finding that there was no statistically significant difference in frequency and number of ultrasound lung rockets suggests that this information is still valuable. The comparative findings in left-sided heart failure dogs appears to support our hypothesis, however, a larger sample size is necessary to make valid inferences. Finally, the imaging principles and limitations in the use of lung ultrasound that has been described for human patients are applicable to our veterinary patients. First, identification of abnormal lung ultrasound findings (B-lines) relies on respiratory conditions with pathology that extends to the lung periphery and has been primarily associated with the presence of pulmonary edema.[1,5-8,10,15,19,20-22] Conversely, more isolated disease states such as masses (neoplastic, granulomatous, infectious [abscesses]), consolidated lung, and early interstitial diseases may not initially extend to the lung periphery.[1,5,10,15,19,21,22] In such cases, lung pathology will be missed using ultrasound alone. However, it has been shown that many acute forms of interstitial edema and lung consolidation in human patients and animals do in fact extend to the lung periphery and are readily recognized by lung ultrasound.[1,5-8,10,15,19,20-23] Importantly, ultrasound lung rockets (B-lines) are an easily recognizable and quantifiable “all or none” lung ultrasound artifact serving as an objective evaluation unaffected by environmental and patient noise or auscultation skills.[9,12,13,24]

In conclusion, the low frequency and number of ultrasound lung rockets in dogs without clinical signs of respiratory disease and with radiographically normal lung findings presented here suggest that use of a standardized, pattern-based approach like Vet BLUE will be clinically useful for the identification of dogs with certain respiratory conditions.

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**Footnotes**

[a] Lisciandro GR. Lung Ultrasound: The Vet BLUE: Case-Based Applications of Vet BLUE "L"ung Scan for Trauma, Triage, and Tracking (Monitoring). International Veterinary Emergency and Critical Care Symposium Proceedings, 2012, San Antonio, Texas.

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**Table 1.** Comparison of factors between dogs with ultrasound lung rockets (ULRs) and those without within 98 dogs without respiratory disease enrolled from two emergency referral practices.

| | Overall | | ULRs | | No ULRs | |
|---|---|---|---|---|---|---|
| **Variable** | **PE (n)** | **95% CI or range*** | **PE (n)** | **95% CI or range*** | **PE (n)** | **95% CI or range*** |
| Presenting complaint | | | | | | |
| Trauma | 0.28 (27) | 0.19, 0.37 | 0.27 (3) | 0.07, 0.58 | 0.28 (24) | 0.19, 0.38 |
| Metastasis | 0.23 (23) | 0.16, 0.33 | 0.09 (1) | 0.00, 0.37 | 0.26 (23) | 0.18, 0.36 |
| Gastro-intestinal | 0.21 (21) | 0.14, 0.30 | 0.27 (3) | 0.07, 0.58 | 0.21 (18) | 0.13, 0.30 |
| Cardiac | 0.17 (17) | 0.11, 0.26 | 0.18 (2) | 0.03, 0.48 | 0.17 (15) | 0.10, 0.26 |
| Other | 0.09 (9) | 0.05, 0.16 | 0.18 (2) | 0.03, 0.48 | 0.08 (7) | 0.04, 0.15 |
| Sex | | | | | | |
| FS | 0.45 (44) | 0.35, 0.55 | 0.18 (2) | 0.03, 0.48 | 0.48 (42) | 0.38, 0.59 |
| FI | 0.09 (9) | 0.05, 0.16 | 0.00 (0) | 0.00, 0.24 | 0.10 (9) | 0.05, 0.18 |
| MN | 0.41 (40) | 0.31, 0.51 | 0.82 (9) | 0.52, 0.97 | 0.36 (31) | 0.26, 0.46 |
| MI | 0.05 (5) | 0.02, 0.11 | 0.00 (0) | 0.00, 0.24 | 0.06 (5) | 0.02, 0.12 |
| Breed | | | | | | |
| Mix | 0.23 (23) | 0.16, 0.33 | 0.27 (3) | 0.07, 0.58 | 0.23 (20) | 0.15, 0.33 |
| Labrador | 0.08 (8) | 0.04, 0.15 | 0.00 (0) | 0.00, 0.24 | 0.09 (8) | 0.04, 0.17 |
| Chihuahua | 0.06 (6) | 0.03, 0.12 | 0.00 (0) | 0.00, 0.24 | 0.07 (6) | 0.03, 0.14 |
| Boston terrier | 0.05 (5) | 0.02, 0.11 | 0.09 (1) | 0.00, 0.37 | 0.05 (4) | 0.01, 0.11 |
| Investigator | | | | | | |
| A | 0.33 (32) | 0.24, 0.42 | 0.18 (2) | 0.03, 0.48 | 0.34 (30) | 0.25, 0.45 |
| B | 0.67 (66) | 0.58, 0.76 | 0.82 (9) | 0.52, 0.97 | 0.66 (57) | 0.55, 0.75 |
| Outcome | | | | | | |
| Discharged | 0.93 (91) | 0.86, 0.97 | 1.0 (11) | 0.76, 1.0 | 0.92 (80) | 0.85, 0.96 |
| Died/euthanized | 0.07 (7) | 0.03, 0.14 | 0.00 (0) | 0.00, 0.24 | 0.08 (7) | 0.04, 0.15 |
| Age (yrs) | 7 (98) | 3, 10 | 6 (11) | 2, 10 | 7 (87) | 2, 10 |
| Weight (kg) | 9.9 (98) | 5.9, 23.5 | 8.1 (11) | 6.2, 27.5 | 11.4 (87) | 5.8, 23.1 |
| BCS | 5 (98) | 4.4, 6 | 5 (11) | 4, 6 | 5 (87) | 4.5, 6 |

PE = point estimate as proportion or median. BCS = body condition score. CI = confidence interval.

*95% CI for categorical and inter-quartile range for quantitative data.

†Based on Chi-square or Fisher exact tests for categorical data and Mann-Whitney U tests for quantitative data comparing dogs with ULRs to those without ULRs.

**Table 2.** Frequency of ultrasound lung rockets (ULRs) based on specific lung lobe regions within 98 dogs without respiratory disease and 10 dogs with heart failure enrolled from two emergency referral practices.

| | | **Normal dogs** | | **Heart failure dogs** | | |
|---|---|---|---|---|---|---|
| **Side** | **Lung lobe** | **Max** | **Proportion (95% CI)** | **Max** | **Proportion (95% CI)** | **P value*** |
| Left | Dorsal | 3 | 0.02 (0, 0.07) | >3 | 0.30 (0.08, 0.62) | 0.005 |
| | Perihilar | 2 | 0.01 (0, 0.05) | >3 | 0.80 (0.48, 0.97) | <0.001 |
| | Middle | 1 | 0.03 (0.01, 0.08) | >3 | 0.80 (0.48, 0.97) | <0.001 |
| | Cranial | 1 | 0.02 (0, 0.07) | >3 | 0.40 (0.14, 0.71) | <0.001 |
| | Sum (all) | 3 | 0.08 (0.04, 0.15) | >3 | 1.0 (0.74, 1.0) | <0.001 |
| Right | Dorsal | 0 | 0 (0, 0.03) | >3 | 0.70 (0.38, 0.92) | <0.001 |
| | Perihilar | 0 | 0 (0, 0.03) | >3 | 1.0 (0.74, 1.0) | <0.001 |
| | Middle | 1 | 0.03 (0.01, 0.08) | >3 | 0.60 (0.29, 0.86) | <0.001 |
| | Cranial | 1 | 0.01 (0, 0.05) | >3 | 0.60 (0.29, 0.86) | <0.001 |
| | Sum (all) | 1 | 0.04 (0.01, 0.10) | >3 | 1.0 (0.74, 1.0) | <0.001 |
| Both | Dorsal | 3 | 0.02 (0, 0.07) | >3 | 0.80 (0.48, 0.97) | <0.001 |
| | Perihilar | 2 | 0.01 (0, 0.05) | >3 | 1.0 (0.74, 1.0) | <0.001 |
| | Middle | 1 | 0.06 (0.03, 0.12) | >3 | 0.80 (0.48, 0.97) | <0.001 |
| | Cranial | 2 | 0.02 (0, 0.07) | >3 | 0.70 (0.38, 0.92) | <0.001 |
| | Sum (all) | 3 | 0.11 (0.06, 0.19) | >3 | 1.0 (0.74, 1.0) | <0.001 |

*Based on Fisher exact tests

**Figure Legends**

Fig. 1. Standard probe positioning for all lung ultrasound shown externally on a dog. The probe is held stationary and horizontally to maximize the interface between its echoes and the pulmonary-pleural interface. The probe positioning shown is at the caudodorsal lung lobe (cdll) region which is the starting point for Vet BLUE and the same view as the chest tube site of Thoracic FAST. *With permission Lisciandro GR, In: Focused Ultrasound Techniques for the Small Animal Practitioner, Wiley-Blackwell, 2014.*

Fig 2. A) Still B-mode image of standard ultrasound orientation for all lung ultrasound and consists of the probe being held horizontally, stationary, and perpendicular to the ribs for the observation of lung within the interposed intercostal space(s). B) Same B-mode image as in A) however with an overlay of the gator sign. The standard orientation for all lung ultrasound is likened to an alligator (gator) partially submerged with its eyes (rib heads) and the bridge of its nose (intercostal space) above the water peering at the sonographer. The bridge of the nose is where the proximal hyperechoic (bright white) pulmonary-pleural line (PP-line) is observed for lung ultrasound findings. *With permission Lisciandro GR, In: Focused Ultrasound Techniques for the Small Animal Practitioner, Wiley-Blackwell, 2014. Courtesy of Nancy Place, M.S., A.M.I., San Antonio, Texas.*

Fig. 3. The glide sign with A-lines represents dry lungs. The line drawing to the left illustrates proper orientation of the gator sign and correlates with the B-mode still image to its right. The proximal hyperechoic (bright white) pulmonary-pleural line (PP-line) is where the to and fro motion of lung gliding along the thoracic wall (arrows) is observed. Distal to the

pulmonary-pleural line (PP-line) are air reverberation artifacts called A-lines that are parallel and equidistant from the pulmonary-pleural line (PP-line). *With Permission, Lisciandro GR, J Vet Emerg Crit Care 2011 21(2). Courtesy of Nancy Place, M.S., A.M.I., San Antonio, Texas.*

Fig. 4. Ultrasound lung rockets or B-lines represent wet lung. These are created when small amounts of fluid are immediately adjacent to air within the outer 1-3 millimetres of peripheral lung. They oscillate like a swinging pendulum in synchrony with inspiration and expiration and do not fade while extending through the far field as hyperechoic laser-like lines obliterating A-lines. The line drawing on the left correlates with the B-mode still image on the right. *With Permission, Lisciandro GR, J Vet Emerg Crit Care 2011 21(2). Courtesy of Nancy Place, M.S., A.M.I., San Antonio, Texas.*

Fig. 5. A) Vet BLUE shown externally on a dog beginning with the stationary, horizontal placement of the ultrasound probe at caudodorsal lung lobe (cdll) region (shown as probe and horizontal bar). The starting point for Vet BLUE is the same point referred to as the chest tube site in Thoracic FAST. Similarly, lung is observed at the perihilar (phll), middle (mdll), and cranial lung lobe (crll) regions (arrows and circles). During the Vet BLUE each of these views is observed for basic lung ultrasound artifacts using the wet versus dry lung principle. B) The correlating lateral thoracic radiograph illustrating where lung is regionally viewed during the Vet BLUE with arrows representing the order of the examination. *With permission Lisciandro GR, In Focused Ultrasound Techniques for the Small Animal Practitioner, Wiley-Blackwell, 2014. Courtesy of Nancy Place, M.S., A.M.I., San Antonio, Texas.*

Fig. 6. A) Schematic of Vet BLUE showing how data is recorded at each of the regional lung views as follows: 0, no ultrasound lung rockets are observed; 1, a single ultrasound lung rocket is observed; 2, two individual ultrasound lung rockets are observed; 3, three individual

ultrasound lung rockets are observed; >3, more than 3 ultrasound lung rockets are observed. The >3 finding is further subdivided as ∞ (infinity) when >3 are no longer recognized as individuals but rather are confluent or blended together (not shown on the data sheet). This ultrasound lung finding has also been referred to as white lung (see Fig. 7). The maximum number of ultrasound lung rockets counted in B-mode over a single intercostal space in that specific lung lobe region is recorded. B) Correlating lateral thoracic radiographs depicting Vet BLUE sites. C) Correlating lateral thoracic radiographs depicting lung anatomy emphasizing that Vet BLUE is a regionally-based lung ultrasound examination. *With permission Lisciandro GR, In: Focused Ultrasound Techniques for the Small Animal Practitioner, Wiley-Blackwell, 2014. Courtesy of Nancy Place, M.S., A.M.I., San Antonio, Texas.*

Fig. 7. Examples of ultrasound lung rockets. A) A single ultrasound lung rocket. B) Greater than 3 (>3) ultrasound lung rockets that may still be recognized individually. C) Confluent lung rockets occur when so many ultrasound lung rockets are present they blend together. The finding is also referred to as white lung and represented by the infinity symbol (∞ ). *With permission Lisciandro GR, In: Focused Ultrasound Techniques for the Small Animal Practitioner, Wiley-Blackwell, 2014. Courtesy of Nancy Place, M.S., A.M.I., San Antonio, Texas.*

Figure 1

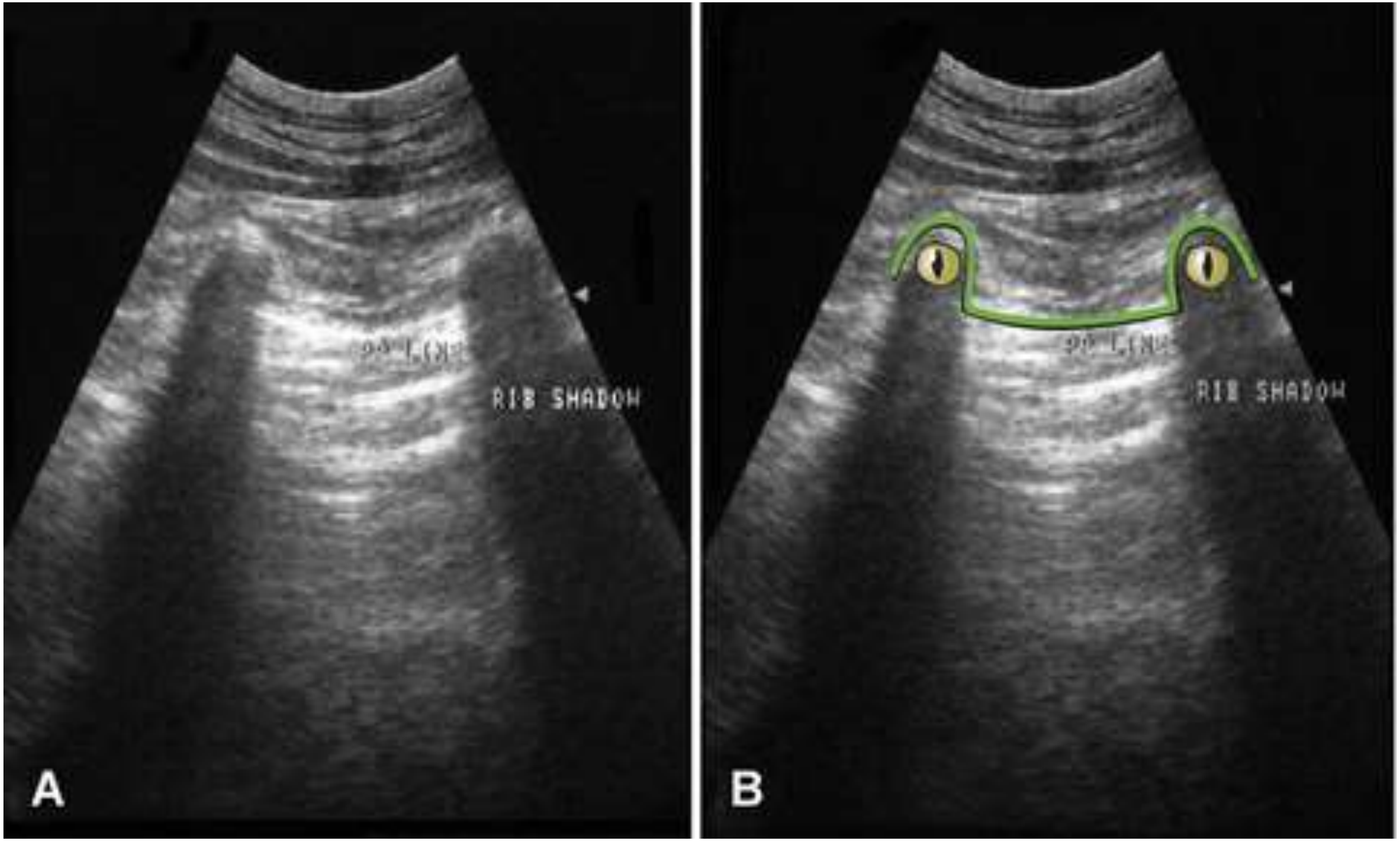



Figure 2

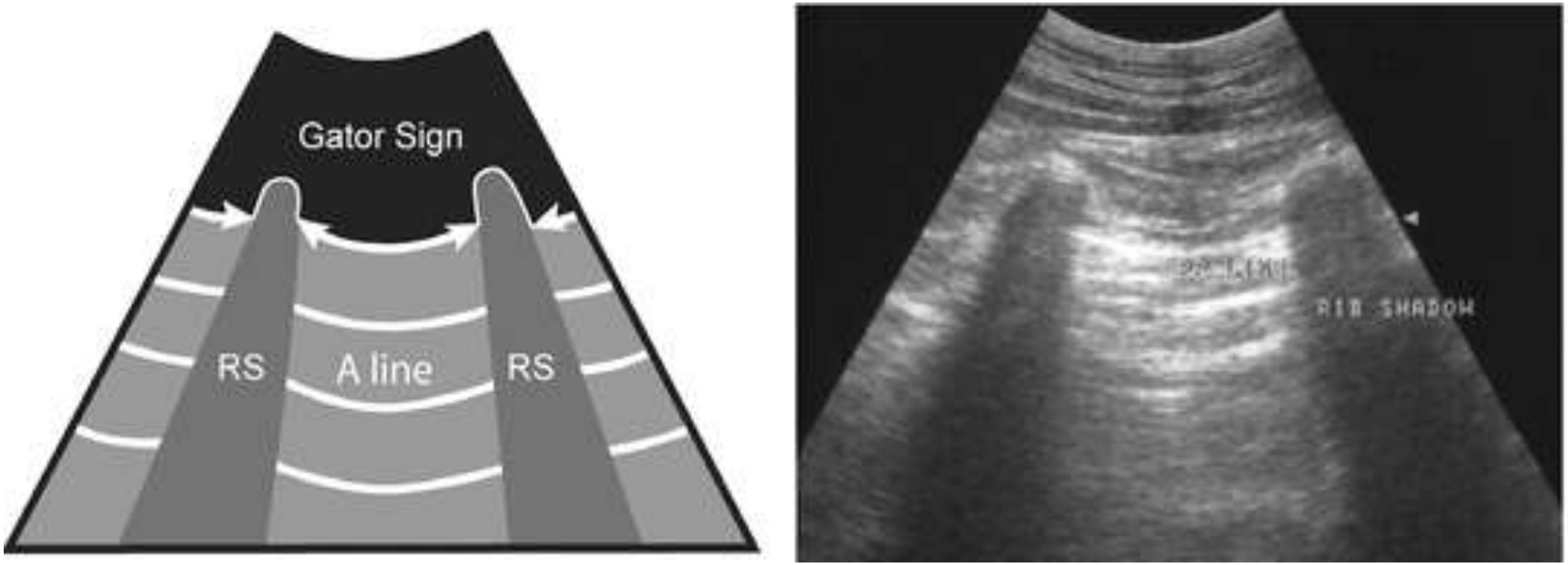
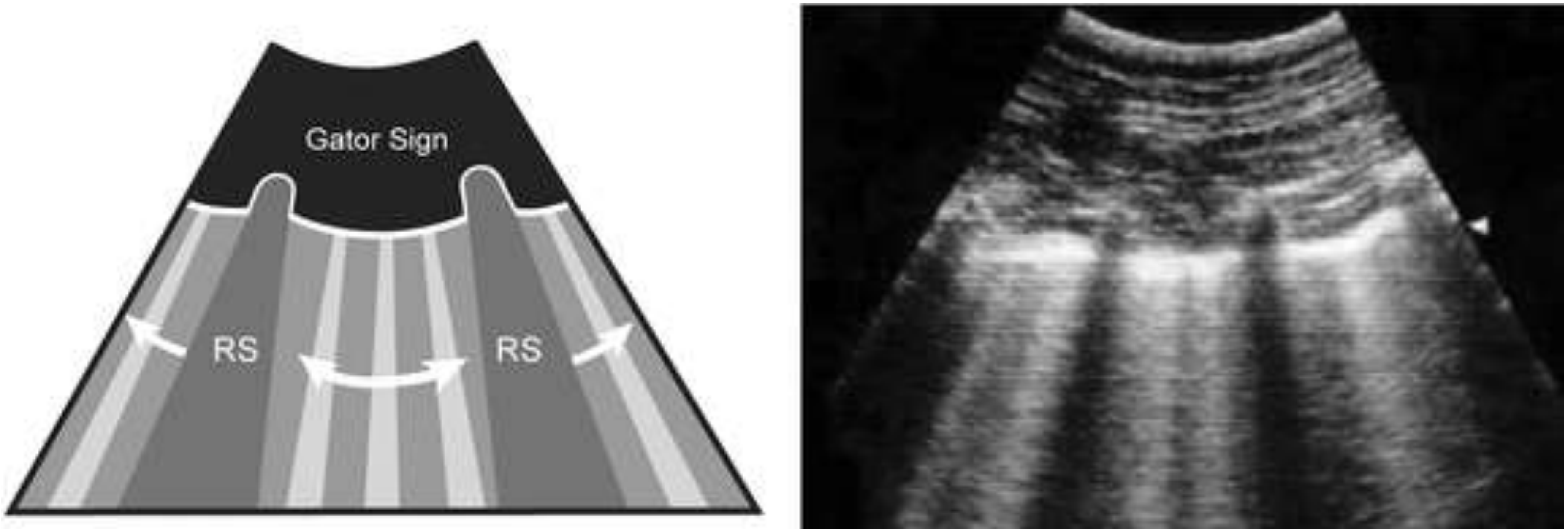



Figure 3

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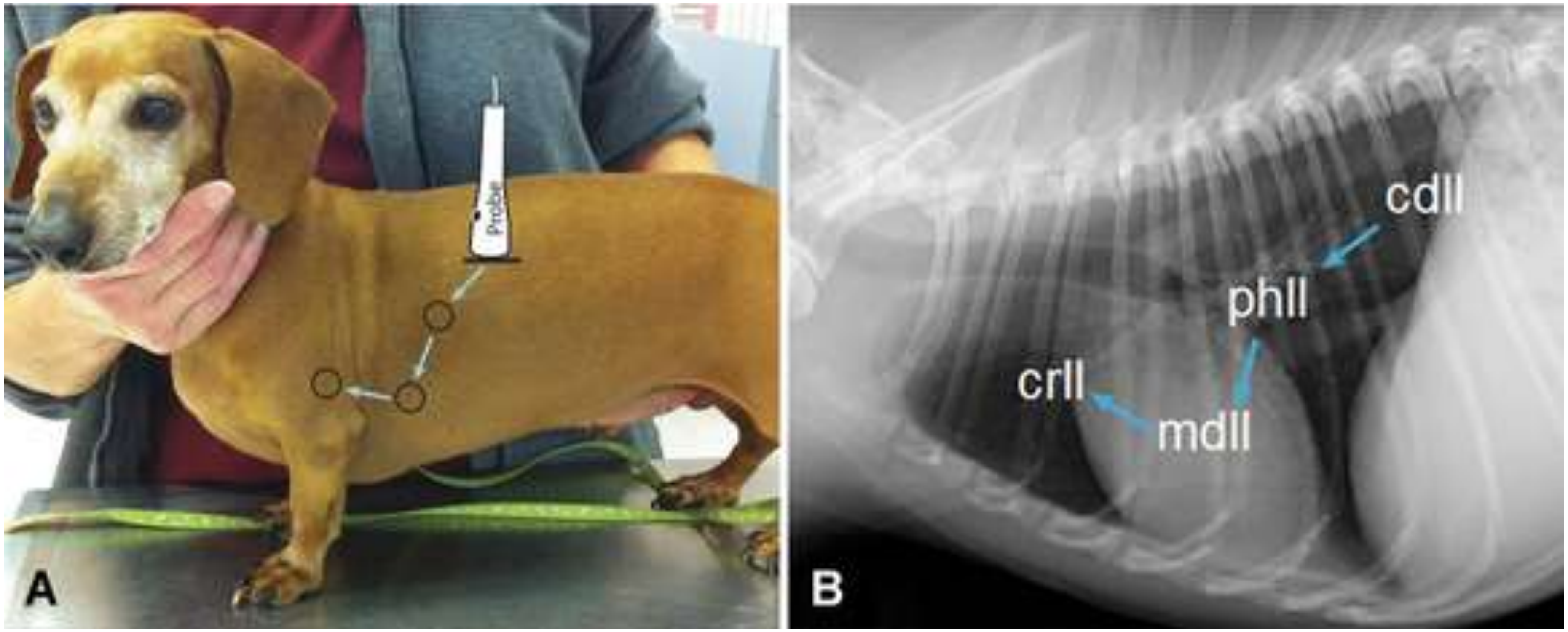


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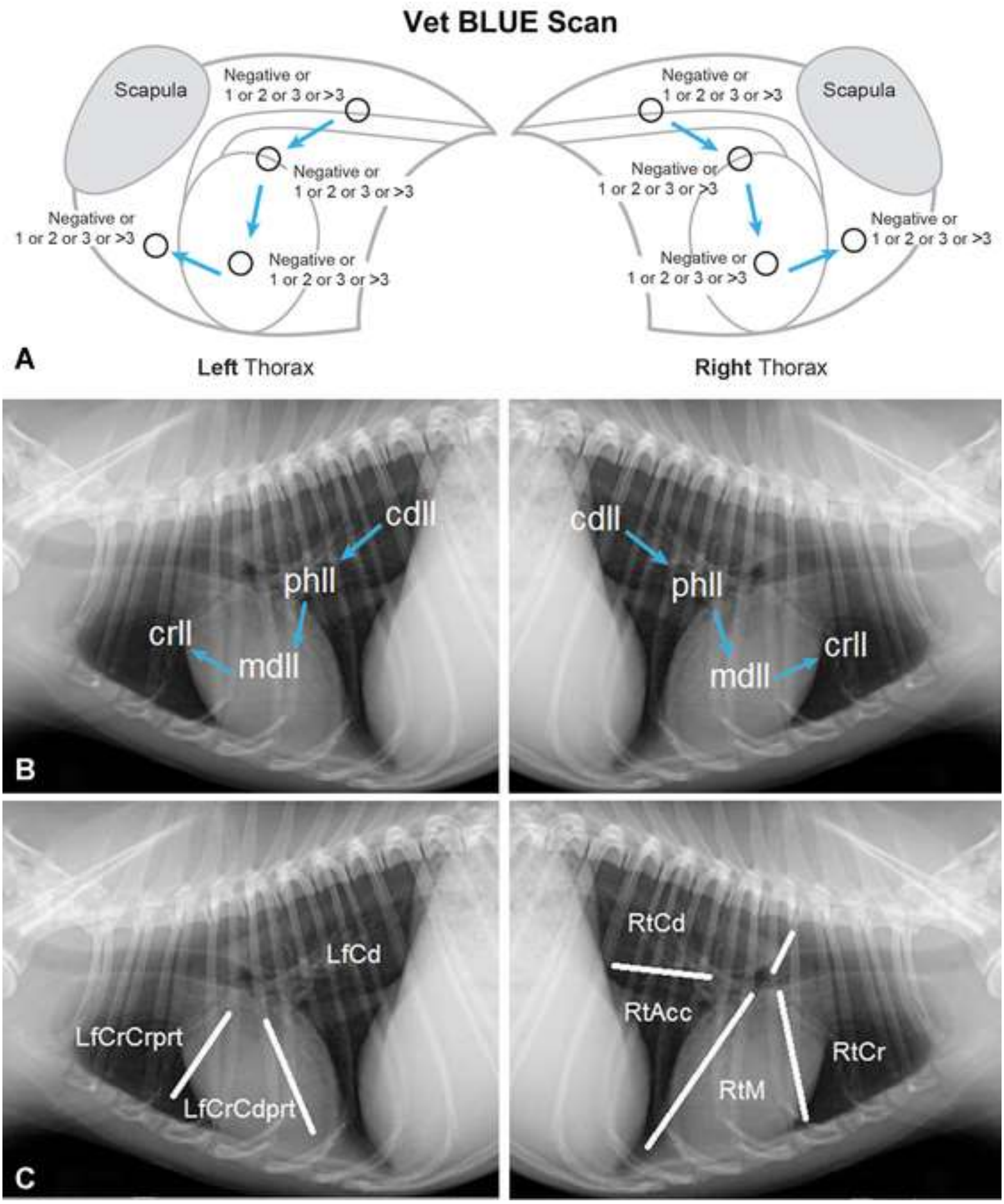
Vet BLUE Scan
Scapula
Negative or
1 or 2 or 3 or >3
A
Left Thorax
Right Thorax
cdll
phll
crll
mdll
B
LfCd
LfCrCrprt
LfCrCdprt
C
RtCd
RtAcc
RtM
RtCr

Figure 6

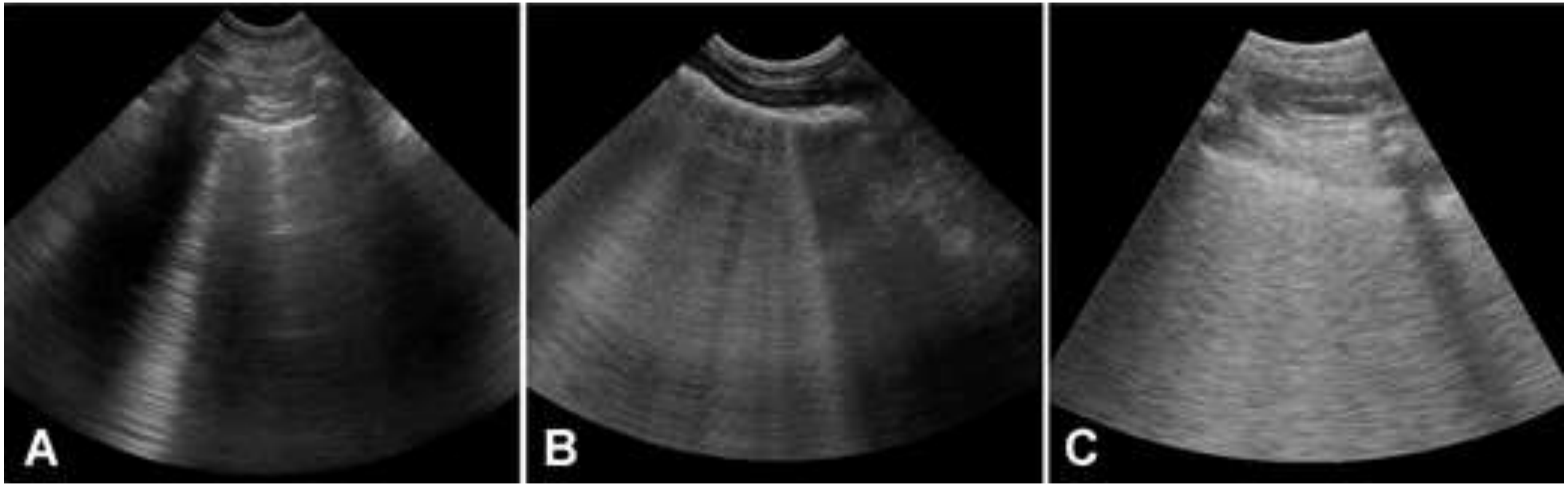


Figure 7