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Retrospective Evaluation of the Radiographic Pulmonary Patterns in Small Animals in Ahmadu Bello University Veterinary Teaching Hospital, Zaria from 2017-2024

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ABSTRACT

Radiographic examination of the lung parenchyma is crucial in the clinical diagnosis of respiratory diseases and its interpretation can be challenging. The radiographic pattern of pulmonary diseases assists because these patterns can be strategized into various forms for specific differential diagnoses. This study aimed to evaluate the radiographic pulmonary patterns in small animals presented at Ahmadu Bello University Veterinary Teaching Hospital, Zaria with complaints of respiratory diseases from 2017 to 2024. Two-dimensional thoracic radiographs of small animals were obtained as primary data from the archive of selected cases in the Diagnostic Imaging Center of Ahmadu Bello University Veterinary Teaching Hospital, Zaria. A total of 70 thoracic radiographs were collected using a random sampling method, out of which, only 30 radiographs were observed with radiographic patterns in both dogs and cats. Of the 30 cases, 25 (83.3%) were dogs and 5 (16.7%) were cats. The pulmonary patterns observed in dogs were bronchial 7 (23.3%), alveolar 6 (20%), vascular 5 (16.7%), interstitial 2 (6.7%) and mixed patterns 5 (16.7%). While, the pulmonary patterns observed in cats were alveolar 2 (6.7%), vascular 1 (3.3%), and mixed patterns 2 (6.7%). From the results of this study's radiographic pulmonary patterns, bronchial pattern was the most common radiographic pulmonary pattern in dogs. While alveolar and mixed patterns were the most common radiographic pulmonary pattern in cats.

Keywords: Radiographic Pulmonary Patterns; Thoracic Radiographs; Small Animals

INTRODUCTION

Radiographic examination of the lung parenchyma is very crucial in the clinical diagnosis of respiratory diseases (Spasov *et al*., 2018), but its interpretation is quite challenging (Seiler, 2010). The radiographic patterns of pulmonary diseases are being considered as solution to this strenuous challenge, because these patterns have been strategized into various forms of specific differential diagnoses (Myer, 1979). Important information from the patient's history, clinical signs and laboratory evaluations has to correlate with the radiographic findings in order to have definitive diagnosis (Seiler, 2010). Pulmonary patterns utilized in assessment of the lung parenchyma include alveolar, bronchial, interstitial, vascular and combination of one or more of these, which assist radiologists or clinicians to make an accurate diagnosis of lung diseases in veterinary practice (Spasov *et al*., 2018).

Lung diseases include influenza (Secrest and Sharma, 2016), pneumothorax, pulmonary oedema, pneumonia, and chronic obstructive pulmonary disease cause by parasites, infectious agents, allergy, congenital, trauma, toxic agents (Tan *et al*., 2020), neoplastic and degenerative conditions (Teja-Rani *et al*., 2023). Clinical signs include cough, dyspnea, tachypnoea, syncope, exercise intolerance, cyanosis (Kirberger and Lobetti, 1998; Koster and Kirberger, 2016) anorexia, lethargy, weight loss, nasal discharge and fever (Secrest and Sharma, 2016). Diagnostic approaches to pulmonary conditions include physical examination, clinical signs, and thoracic radiography (left-right lateral, right-left lateral, and ventrodorsal views). Respiratory pathways sampling such as bronchoalveolar lavage (Norris *et al*., 2002) or trans-tracheal aspiration (McMillan and Taylor, 2008) well as fine needle aspiration or biopsy of the lung parenchyma (Wood *et al*., 1998) for cytological, microbiological and histological evaluations. Proper management and a favourable prognosis are product of rapid and accurate diagnosis, and early interventions (Sumner and Rozanski, 2013).

Pulmonary diseases in our small animal practice are majorly intervened without consideration to the radiographic pulmonary patterns because they are complex and difficult to study (Nykamp *et al*., 2002). However, understanding this pattern model can be helpful in categorizing these conditions into a list of differential diagnoses (Larsen, 2008). The aim of this study was to evaluate the radiographic pulmonary patterns in small animals presented at Ahmadu Bello University Veterinary Teaching Hospital, Zaria with complaint of respiratory distress such as cough, dyspnoea, tachynea, rhinorrhoea, exercise intolerance and wheezing from 2017 to 2024.

MATERIALS AND METHODS

Two-dimensional thoracic radiographs of small animals (dogs and or cats) were obtained as primary data from the archive of selected cases in the Diagnostic Imaging Center of Ahmadu Bello University Veterinary Teaching Hospital, Zaria from 2017 to 2024 based on the technical quality such as mild to moderate artifacts on radiographs, avoiding underexposed radiographs and radiographs with exposure at inspiration. A total of 70 of radiographs were collected using a random sampling method, and viewed using a single x-ray viewing box made of lights mounted transparent screen providing backlighting for radiographic images.

Lateral views were placed on the viewing box for interpretation with the subject's dorsum at uppermost and the rostral towards the viewer's left hand-side. For ventro-dorsal and dorso-ventral views, radiographs were placed with the subject's rostral uppermost and then subject's left side at the viewer's right hand-side and the subject's left side at the viewer's left hand-side, retrospectively.

Radiographic findings were recorded by adopting the radiographic pulmonary pattern model as described below by Thrall (2018):

Bronchial Pattern: The radiographic feature usually revealed as increased opacity of the bronchus leading to increase in number of ring shadows and tram lines of the bronchial tree.

Alveolar Pattern: The radiographic features may include air bronchograms characterised by air-filled bronchus within the area of increase opacity and lobar sign which revealed as a sharp demarcation of increase radiographic opacity of abnormal lobe along the edge of a normal radiolucent lobe of the lungs. There is also border effacement of the heart.

Interstitial Pattern: Radiographic features can be structured which are characterized by localised linear interstitial changes in the form of nodule or multiple nodules of approximately4-5 mm in diameter. While, the radiographic features of unstructured interstitial pattern revealed a diffuse increase opacity with a hazy appearance of the lung tissues.

Vascular Pattern: The radiographic features revealed increase opacity of enlarged blood vessel and change in the direction of the vessel. The cranial blood vessels were compared to the 4th rib, while the caudal blood vessels were compared to the 9th rib.

Mixed Pattern: When there is combination of two or more of these patterns.

Also recorded were anatomic distribution of radiographic findings as described below by Myer (1979) and Lo *et al*. (2021):

Anatomic location: The anatomic location of the radiographic features of the pulmonary patterns are considered as cranioventral, perihilar, caudodorsal and caudoventral in lateral view, and as hilar (A), intermediate (B), and peripheral (C) areas of the lung field in either ventrodorsal or dorsoventral views.

Data Analysis

The data obtained from this study was presented in Tables and Plates. Chi-square test was used to evaluate the distribution probability of the pulmonary patterns between canine and feline species.

RESULTS

Thirty (30) out of the seventy (70) radiographs selected were observed with radiographic patterns in both dogs and cats. Of the 30 cases, 25 (83.3%) were dogs and 5 (16.7%) were cats. The pulmonary patterns observed in dogs were bronchial 7 (23.3%), alveolar 6 (20%), interstitial 2 (6.7%), vascular 5 (16.7%), and mixed patterns 5 (16.7%). While, the pulmonary patterns observed in cats were alveolar 2 (6.7%), vascular 1 (3.3%), and mixed patterns 2 (6.7%) as shown in Table 1. The data from this study has showed that the distribution of pulmonary patterns between the canine and feline species were a chance. However, there was no statistically significant (P = 0.313) and evidence that the null hypothesis of distribution was not rejected.

Table 1: Radiographic pulmonary patterns in small animal from Ahmadu Bello University Veterinary Teaching Hospital, Zaria.

Pulmonary patterns	Dogs	Cats	Anatomic locations within lung fields
Bronchial	7 (23%)	---	caudo-dorsal
Alveolar	6 (20%)	2 (6.7%)	cranio-ventral, caudo-dorsal, and perihilar
Interstitial	2 (6.7%)	---	caudo-dorsal, and hilar, immediate and peripheral
Vascular	5 (16.7%)	1 (3.3%)	caudo-dorsal
Mixed	5 (16.7%)	2 (6.7%)	caudo-dorsal and cranio-ventral, and perihilar and cranio-ventral

In bronchial pattern, all the 7 cases observed revealed tram lines and ring shadows as the radiographic features and caudo-dorsal was the anatomic location of the lesions in lateral view as demonstrated in Figure 1. Alveolar pattern was radiographically characterized by a focal increased opacity in all cases. The radiographic features include border effacement of the cardiac silhouette in 2 cases, air bronchogram in 2 cases, and lobar sign in 2 cases. The anatomic location of the lesions in lateral view includes cranio-ventral in 4 cases, caudo-dorsal in 2 cases. In ventro-dorsal view, perihilar as the anatomic location of the lesions were observed in 2 cases of the lung field.

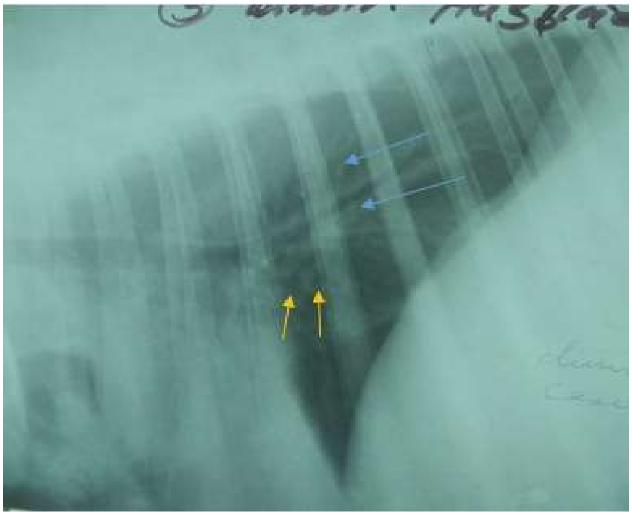

Figure 1: Bronchial radiographic pattern with its tram lines (blue arrows) and shadow rings (yellow arrows) on lateral view in a dog.

The interstitial pattern was observed in 1 case with structured increase opacities located at caudo-dorsal region in lateral view and another case with unstructured increase opacity with hazy appearance located within hilar, immediate and peripheral region of the lung field in ventro-dorsal view as shown in Figure 2.

Figure 2: Unstructured (interstitial) increase opacity and hazy appearance (blue arrows) at hilar, immediate and peripheral lung field on ventro-dorsal view in a dog.

The vascular pattern was observed as enlarged caudal blood vessels as compared to the 9th rib with increase opacity in 6 cases which were located at caudo-dorsal region of the lungs in lateral view as demonstrated in Figure 3.

In mixed pulmonary pattern we observed combination of bronchial and alveolar in 7 cases with radiographic features of bronchial located at caudo-dorsal and cranio-ventral regions in lateral view, while the alveolar was observed at the perihilar and cranio-ventral regions in lateral view in 4 and 3 cases retrospectively as demonstrated in Figure 4.

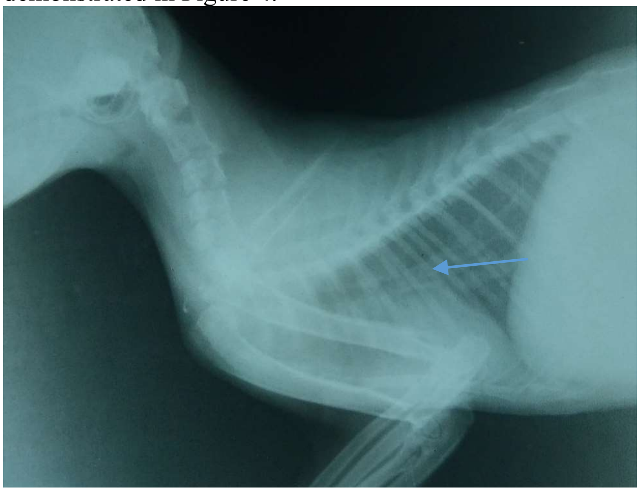

Figure 3: Vascular pattern with enlarged and radio-opaque blood vessels on a lateral view in a cat.

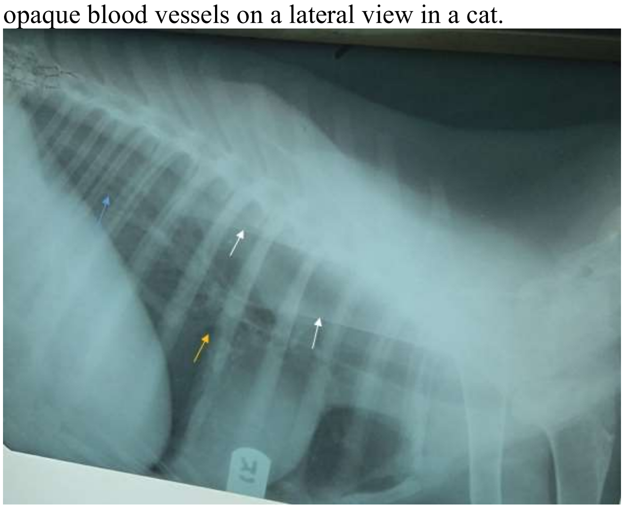

Figure 4: Mixed of bronchial (blue and yellow arrows) and lobar signs of alveolar patterns (white arrows) on a lateral view in a dog.

DISCUSSION

The thoracic radiographs used in this study were from patients with signs of respiratory distress and the radiographs were of good quality, well positioned and adequately exposed at the peak of inspiration. This measure will ensure optimal diagnostic image quality which usually leads to accurate and precise interpretation of thoracic radiographs (Dennis, 2008a; Huguet *et al*., 2023).

Bronchial pulmonary pattern observed in this study was characterized by radiographic tram lines and ring shadows at the caudo-dorsal lung field. These radiographic findings were similarly reported by other researchers (Spasov *et al*., 2018; Tavakoli *et al*., 2018; Thrall, 2018; Tan *et al*., 2020). It is stated that, the caudo-dorsal lung field is the most common location of bronchial pattern (Dunworth, 1993; Lo *et al*., 2021). From this study, bronchial pattern was reported with the highest occurrence in dogs (23%), this finding was similarly observed by Tan *et al*. (2020). This could be attributed to the fact that bronchial pattern can be observed without evidence of respiratory disease as noticed in geriatric animals due to bronchial mineralization (Berry and Graham, 2017). Therefore, age is an important factor that is associated with this pattern (Tan *et al*., 2020).The bronchial pattern resulted from the thickening of the bronchial wall due to cellular fluid infiltration of the bronchial wall or immediate peribronchial space and this suggest that patients in this category could be diagnosed with allergy, parasitic infestation (heartworms and lungworms), bronchiectasis, chronic bronchitis (irritant), eosinophilic bronchpneumopathy or feline asthma (Spasov *et al*., 2018; Kaur *et al*., 2021).

Alveolar pattern was characterized by increased radiographic density accompanied with features such as border effacement of the cardiac silhouette, air bronchogram, and lobar sign. The consolidation was located at cranio-ventral, caudo-dorsal, and perihilar lung fields. These radiographic findings concur with the findings of Berry (2010), Sen*et al*. (2015), Spasov *et al*. (2018), Thrall (2018), Tan *et al*. (2020) and Koster *et al*. (2023). The anatomic locations of alveolar pattern were caudo-dorsal, perihilar and cranio-ventral as the most common lung field (Dear, 2020; Eom *et al*., 2006), the right side of the lung is more susceptible due to passive aspiration (Eom *et al*., 2006). However, alveolar pattern was in the past considered as the most common in small animal (Lord, 1976) and from this study, alveolar pattern in both dogs and cats constitutes the highest percentage than the other pulmonary patterns. Alveolar pattern is a situation when the air in the alveoli of the lungs compete with fluid, haemorrhage, exudate or oedema resulting in the lung with increased radiographic opacity (Seiler, 2010; Thrall, 2018). The conditions that could arise from this pattern include bacterial pneumonia, primary tumour, haemorrhage due to trauma, oedema (cardiogenic and non-cardiogenic), and atelectasis (Spasov *et al*., 2018; Teja-Rani *et al*., 2023).

The interstitial pattern observed in this study was one marginated structured nodule and another diffused unstructured increase opacities within the lung field. Radiographic finding of the interstitial pattern was similarly reported by other researchers (Myer, 1980a; Seiler, 2010; Thrall, 2018; Tan *et al*., 2020). When infiltration of cells or fluid occurs into the interstitial tissue of the lungs. The unstructured interstitial pattern is usually caused by accumulation of fluid, fibrin or cells within the tissue of the lung, and around the alveoli, blood vessels and bronchi that gives a generalized increase opacity with a hazy radiographic appearance of the lung field (Seiler, 2010). This pattern is usually seen in interstitial pneumonia due to fungal infection, viral interstitial pneumonia, and metastatic neoplasm (Myer, 1980a). The structured interstitial manifest as cluster of cells that progresses and compresses normal tissues of the lung. The structured interstitial pattern produces more homogenously increased opacity than focal areas in alveolar pattern (Dennis, 2008b). This feature is usually seen in primary neoplasia, paraquat poisoning, feline infectious peritonitis, and abscess (Myer, 1980a).

The vascular pattern was observed as enlarged blood vessels with increase opacity located at caudo-dorsal lung field. This radiographic feature of vascular pattern was similarly reported by Myer (1980b), and Teja-Rani *et al*. (2023). The features of vascular pattern include change in number, size, shape and opacity of the blood vessel, which the reduced in size is known to be hypovascular pattern (Dennis, 2008a). The enlargement of the pulmonary arteries leads to hypervascularity which means increase perfusion of the lung field, and this may be seen in conditions such as Dirofilariasis in dogs (Thrall *et al*., 1979), and Aelurostrongylus in cats (Myer, 1980b). The enlargement of the pulmonary veins signifies venous congestion, and may be common in conditions resulting in left heart failure such as canine cardiomyopathy and mitral valve insufficiency (Myer, 1980b). The enlargement of both the pulmonary arteries and veins are usually seen in pulmonary congestion, pulmonary hypertension, peripheral arteriosvenous fistula, iatrogenic fluid overload, chronic anaemia (Dennis, 2008a), and congenital anomalies of the heart resulting in left-to- right shunting of blood such as ventricular septal defects and patent ductus arteriosus (Myer, 1980b).

The mixed pulmonary pattern observed in this study was the combination of alveolar and bronchial patterns. Mixed pulmonary patterns is usually seen with appearance of more than one radiographic patterns (Kealy *et al*., 2010). Mixed pulmonary pattern occurs due to the complexity of the disease progression and the close relationship of the different tissues in the lung field (Dennis, 2008b). The dominant pattern is mostly considered as the aetiology and another rule of thumb stated that alveolar pattern should be considered the dominant pattern because it is reported to be most significant in any of its combinations followed by interstitial then bronchial (Dennis, 2008b). Alveolar and bronchial combination is the most common type of mixed pulmonary pattern (Dennis, 2008b). Alveolar pattern was considered the dominant pattern in this study. This mixed pulmonary pattern is usually seen in bronchopneumonia (Dennis, 2008b).

Conclusion

It was concluded that bronchial pattern was the most common radiographic pulmonary pattern in dogs followed by alveolar pattern. The alveolar and mixed patterns (alveolar and bronchial) were the most common radiographic pulmonary pattern in cats followed by vascular pattern. The knowledge of this radiographic pulmonary patterns can assist in categorizing the various lung conditions into appropriate differentials to assist in diagnoses.

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Conflict of Interest

The authors have no conflict of interest to declare.

Author Contribution

MNB conceived the idea and designed the experiment. LIS, SI and NJC collected samples and together with MNB and LM run the radiographic interpretation. MNB wrote the first draft and was revised by BAA, MS and BG performed the statistical analysis. All authors read and endorsed the revised manuscript.

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