**Original Research Article**

**Evaluation and Treatment of Lower Respiratory Bacterial Infection in Dog**

**ABSTRACT:**

A research study was conducted between October 2022 and June 2023, on 30 dogs suffered with respiratory tract infections were considered based on radiographic changes in bronchial and alveolar patterns. Three groups comprising of 10 dogs each were administered ceftriaxone sodium, doxycycline hydrochloride and enrofloxacin for a period of 10 days. One control group was kept to study the radiographic lung pattern. The results showed significant reductions in bronchial and alveolar patterns after antibiotic treatment in all groups, with no significant changes in pleural effusion. Ceftriaxone sodium was found most effective in treating respiratory tract infection in dogs. The study also highlighted the occurrence of cardiomegaly in 10% of the dogs. This research contributes to the understanding of radiographic changes associated with canine respiratory infections and their response to different antibiotic treatments, potentially providing an important aid in clinical decision-making and patient care for veterinary practitioners.

*Keywords:**Alveolar pattern, Bacterial infection, Bronchial pattern, Dog, Thoracic radiography*

**1. INTRODUCTION:**

Dog (*Canis familiaris*) is the first domesticated animal and has interaction with human beings (Freedman and Wayne, 2017). In a research study by Pescini *et al.* (2019) explained that dogs as well as human both release oxytocin and they inferred that oxytocin is the main reason for creating a strong social bond between human being and pet animal. Since dogs are living with human in close contact, they are quite frequently exhibiting respiratory tract infections. Anatomically respiratory tract is broadly classified into upper respiratory tract (nose, nasal sinus, larynx) and lower respiratory tract (trachea, bronchi, bronchiole, alveoli and lungs) (Chakrabarti, 2014). Dogs are affected by both infectious as well as non-infectious diseases such as rabies, leptospirosis, scabies, dermatophytosis, yersiniosis, cryptosporidiosis, MRSA etc. are a few diseases which can be transmitted from dogs to humans and cause serious life threatening illness in personnel with specific medical conditions like immunodeficiency, chronic illness, pregnancy etc. In canine practice, among the various causes of respiratory tract infections (RTI) bacterial involvement is one of the common reasons. Qekwana *et al*. (2020) and Mavrides *et al.* (2021) found that in RTI of dogs, various kind of bacteria are involved *viz. Staphylococcus* spp., *Streptococcus* spp., *Escherichia coli*, *Pasteurella* spp., *Klebsiella* spp*., Pseudomonas* spp*., Bordetella bronchiseptica* etc. Hence, to render proper treatment, accurate diagnosis is highly recommended to attain a significant recovery. Diagnosing RTI in dogs includes advanced imaging techniques like thoracic radiography is very much helpful apart from the PCR to identify specific infectious agents; culture of upper respiratory secretion, nasal swab and trans tracheal wash; antibiotic sensitivity test and complete blood count etc. are also play significant role. In thoracic radiography, alveolar and bronchial infiltrates are found in bacterial pneumonia (Viitanen *et al*.,2017). Considering the importance, present study was undertaken to determine the thoracic radiographical changes in bacterial respiratory tract infection in dogs.

**2. MATERIALS AND METHODS:**

**2.1. Place of work and source of animal:** Dogs (n=30) presented to the Veterinary Clinical Complex (VCC), College of Veterinary Science, Assam Agricultural University, Khanapara from different parts of Assam and neighbouring states of the North-Eastern Region during the period from October, 2022 to June, 2023 were considered for the study.

**2.2. Physical examination, grouping and treatment of suspected dogs:** Dogs presented in the VCC with a history of coughing, sneezing, presence of nasal discharge, respiratory distress including clinical symptoms *viz.* pattern of nasal discharge, types of coughing, rectal temperature, sneezing, auscultation of lungs etc. were recorded during clinical examination. After radiographic confirmation the dogs were rendered treatment. Dogs were equally divided into three groups based on therapeutic trial viz. Group B, Group C and Group D and were treated with doxycycline hydrochloride (10 mg/kg body weight i/v or orally) daily for 10 days, enrofloxacin (5 mg/kg body weight i/m or s/c or orally), ceftriaxone sodium (20 mg/kg body weight i/v) respectively along with other supportive therapy (nebulization, proteolytic enzymes, mucolytic, diuretics, anti-inflammatory dugs, anti allergic drug etc.) for 10 days. Supportive therapy was given based on the requirements of the affected animals. One control group *i.e.* Group A was kept to study the thoracic radiographical changes.

**2.3. Thoracic radiography:** Thoracic radiographs were taken by using Type-ME 0610M (Tech-60. KV-100) X-ray machine (Siemen-Healthcare Pvt. Ltd., Mumbai 400079) from the selected clinical cases (n=30) on 0th day and after treatment (10th day). Therapeutic trial was conducted for 10 days according to Lappin *et al.* (2017) and Vientòs-plotts *et al.* (2021). Each case was assessed by the scoring system according to Kogan *et al*. (2008), the score was given on the basis of severity of the lung fields. For the bronchial pattern scoring system used was mild =1, moderate=2 and severe=3 and for the alveolar pattern, mild=4, moderate=5 and severe=6. The presence of pleural effusion in the thoracic radiography was scored as absent=0, mild=1, moderate=2 and severe=3 based on the severity according to Lynch *et al*. (2012). Based on Vertebral Heart Score, the cardiac size of selected clinical cases was assessed and evaluated for cardiovascular disorder according to Buchanan (2000) & Buchanan and Bucheler (1995). For statistical analysis Z test was done.

**3. RESULTS AND DISCUSSION:**

**3.1 Bronchial Pattern and alveolar pattern:** The radiographic interpretation of clinical cases revealed bronchial patterns in the lateral and ventro-dorsal view of the thoracic radiograph which is shown in Table 1 and Fig.1. In Group B (pre-treatment of Doxycycline) moderate bronchial pattern was found in six dogs and a severe bronchial pattern was found in four dogs. Post-treatment of Doxycycline in Group B, there was absence of a bronchial pattern in six dogs, a mild bronchial pattern in two dogs and a moderate bronchial pattern in one dog. In the result Z value was found to be 8.76 (*P*< 0.01), highly significant difference was found in Group B with Doxycycline. In Group C (pre-treatment of Enrofloxacin), there was a mild bronchial pattern in two dogs, a moderate bronchial pattern in four dogs and severe bronchial pattern in four dogs. In the result in Group C (post-treatment of Enrofloxacin), there was the absence of a bronchial pattern in five dogs, a mild bronchial pattern in two dogs and a moderate bronchial pattern in two dogs. In the result, Z value was found to be 8.18 (*P*< 0.01). Statistically the highly significant difference was found within Group C *i.e* pre and post-treatment of clinically affected dogs with Enrofloxacin. In Group D (pre-treatment of Ceftriaxone), there was the presence of a mild bronchial pattern in one dog, a moderate bronchial pattern in three dogs and a severe bronchial pattern in six dogs. In Group D (post-treatment of Ceftriaxone), there was the absence of a bronchial pattern in eight dogs, a mild bronchial pattern in one dog and a severe bronchial pattern one dog. In the result, Z value was found to be 8.96 (*P*< 0.01), highly significant difference was found within Group D pre and post-treatment of clinically affected dogs with Ceftriaxone.

The radiographic interpretation of clinical cases revealed an alveolar pattern in the lateral and ventro-dorsal view of the thoracic radiograph which is shown in Table 2 and Fig.2. In Group B (pre-treatment of Doxycycline) moderate and severe alveolar pattern was found in six and four dogs respectively. In Group B (post-treatment of Doxycycline), there was the absence of alveolar pattern in six dogs, a mild alveolar pattern in two dogs and a moderate alveolar pattern in one dog. In the result, Z value was found to be 3.49 (*P*< 0.01).The highly significant difference was found within Group B *i.e.* pre and post-treatment with Doxycycline. In Group C (pre-treatment of Enrofloxacin), there was the absence of alveolar pattern in one dog, mild alveolar pattern in two dogs, moderate alveolar pattern in three dogs and severe alveolar pattern in four dogs. In Group C (post-treatment of Enrofloxacin), there was absence of an alveolar pattern in seven dogs and a mild alveolar pattern in two dogs. In the result, Z value was found to be 3.53 (*P*< 0.01). The highly significant difference was found within Group C *i.e*. pre and post-treatment of clinically affected dogs with Enrofloxacin. In Group D (pre-treatment of Ceftriaxone), there was absence of alveolar pattern in one dog, mild alveolar pattern in two dogs, moderate alveolar pattern one dog and severe alveolar pattern six dogs. In Group D (post-treatment of Ceftriaxone), there was absence of alveolar pattern in five dogs, mild alveolar pattern in four dogs and severe alveolar pattern in one dog. In the result, Z value was found to be 2.2 (*P*< 0.05). The significant difference was found within Group D *i.e.* pre and post-treatment of clinically affected dogs with Ceftriaxone.

In case of healthy control group (Group A) there was absence of bronchial and alveolar pattern, so the radiographic score was zero.

On the 0th day, lateral and ventro-dorsal views of the thoracic radiograph revealed increased bronchial and alveolar patterns in Group B, Group C and Group D. On the 10th day after rendering treatment bronchial and alveolar patterns significantly reduced in all the groups. Similar findings were obtained by Peeters *et al*. (2000), Foster et al.(2004), Elgalfy *et al*. (2022) and Menard *et al*. (2022) who found the presence of alveolar and bronchial patterns in the respiratory tract of infected dogs. Similarly after administration of antibiotics Wayne *et al*. (2017) also found a resolution of radiographic pattern in a bacteria-associated pneumonia affected dog. In the present study, the bronchial pattern was revealed due to the infiltration of cells and fluids in the bronchial wall or the replacement of peri-bronchial cells by inflammatory cells or fluids. The alveolar pattern is revealed when the inspired air is present in the alveoli of the lung which later on is replaced by exudate or transudate (Spasov *et al*., 2018).

**3.2. Pleural effusion:** The radiographic observations of clinical cases revealed pleural effusion in the lateral and ventro-dorsal view of the thoracic radiograph which is shown in the Table 3 and Fig.3.In Group B (pre-treatment of Doxycycline), there was the absence of pleural effusion and severe pleural effusion in eight and two dogs respectively. In Group B (post-treatment of Doxycycline), there was absence of pleural effusion in seven dogs and mild pleural effusion in two dogs. In the result Z value was found to be 0.76 (*P*> 0.05) *i.e*. no significant difference was found within Group B *i.e.* pre and post-treatment with Doxycycline. In Group C (pre-treatment of Enrofloxacin), there was the absence of pleural effusion in four dogs, mild pleural effusion in two dogs and severe pleural effusion in four dogs. In Group C (post-treatment of Enrofloxacin), there was the absence of pleural effusion in nine dogs. In Group D (pre-treatment of Ceftriaxone), there was the absence of pleural effusion in eight dogs, mild pleural effusion in one dog and severe pleural effusion in one dog. In Group D (post-treatment of Ceftriaxone), there was the absence of pleural effusion in nine dogs and severe pleural effusion in one dog. In the result, Z value was found to be 0.15 (*P*> 0.05) *i.e*. no significant difference was found within Group D *i.e.* pre and post-treatment of clinically affected dogs with Ceftriaxone**.** In case of healthy control group (Group A) there was absence of pleural effusion, so the radiographic score was zero.

These present finding were in accordance to the report of Burnotte *et al*.(2023) who found pleural effusion present in the dogs which were suffered from bacteria-associated pneumonia. Pleural effusion may develop due to inflammation of the pleura which in turn increases the permeability of vascular endothelium (Yang *et al.,* 2017) or may be due to a cardiac issue (left-sided heart failure, dilated cardiomyopathy) or hypoalbuminemia (Sherding and Birchard, 2006) or may be secondary to bacterial pneumonia.

**3.3. Cardiomegaly:**The radiographic observations of clinical cases also revealed cardiomegaly in the lateral and ventro-dorsal views of thoracic radiographs in three out of thirty dogs showing the percentage of cardiomegaly as 10.00% (Fig.4.). Guglielmini *et al.* (2009) reported that the dogs having cough with cardiac and mixed origin had a higher vertebral heart score than the dogs having cough with non-cardiac origin. The incidence of cardiomegaly is more in dilated cardiomyopathy (Martin and Pereira, 2013).

**Table 1. Bronchial pattern of affected dogs in pre and post-treatment days**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Attributes** | | | **Absent** | **Mild** | **Moderate** | **Severe** | **Total score** | **Average score** | **Z-value** |
| Assigned score  Groups | | | 0 | 1 | 2 | 3 | - | - | **-** |
| **B** | **Doxycycline**  **(Pre-treatment)** | Frequency | 0 | 0 | 6 | 4 | - | - | **8.76\*\*** |
| Score | 0 | 0 | 12 | 12 | 24 | 2.40 |
| **Doxycycline**  **(Post-treatment)** | Frequency | 6 | 2 | 1 | 0 | - | - |
| Score | 0 | 2 | 2 | 0 | 4 | 0.44 |
| **C** | **Enrofloxacin**  **(Pre-treatment)** | Frequency | 0 | 2 | 4 | 4 | - | - | **8.18\*\*** |
| Score | 0 | 2 | 8 | 12 | 22 | 2.20 |
| **Enrofloxacin**  **(Post-treatment)** | Frequency | 5 | 2 | 2 | 0 | - | **-** |
| Score | 0 | 2 | 4 | 0 | 6 | 0.67 |
| **D** | **Ceftriaxone**  **(Pre-treatment)** | Frequency | 0 | 1 | 3 | 6 | - | - | **8.96\*\*** |
| Score | 0 | 1 | 6 | 18 | 25 | 2.50 |
| **Ceftriaxone**  **(Post-treatment)** | Frequency | 8 | 1 | 0 | 1 | - | - |
| Score | 0 | 1 | 0 | 3 | 4 | 0.40 |

\*\*: *P*< 0.01 (highly significant); \*: *P*< 0.05 (significant), NS: *P*> 0.05 (non-significant)

**Table 2. Alveolar pattern of affected dogs in pre and post-treatment days**

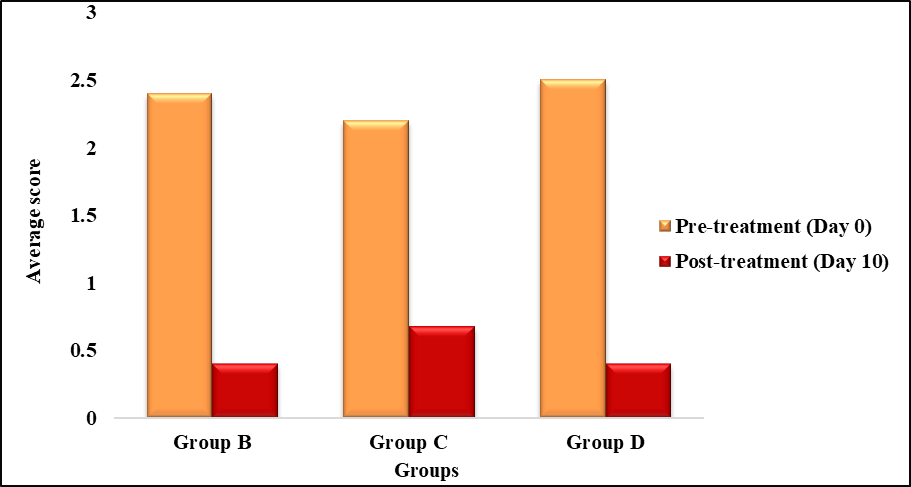
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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Attributes** | | | **Absent** | **Mild** | **Moderate** | **Severe** | **Total score** | **Average score** | **Z- value** |
| Assigned score  Groups | | | 0 | 4 | 5 | 6 | - | - | **-** |
| **B** | **Doxycycline**  **(Pre-treatment)** | Frequency | 0 | 0 | 6 | 4 | - | - | - |
| Score | 0 | 0 | 30 | 24 | 54 | 5.40 | **3.49\*\*** |
| **Doxycycline**  **(Post-treatment)** | Frequency | 6 | 2 | 1 | 0 | - | - |
| Score | 0 | 8 | 5 | 0 | 13 | 1.40 |
| **C** | **Enrofloxacin**  **(Pre-treatment)** | Frequency | 1 | 2 | 3 | 4 | - | - | **3.53\*\*** |
| Score | 0 | 8 | 15 | 24 | 47 | 4.70 |
| **Enrofloxacin**  **(Post-treatment)** | Frequency | 7 | 2 | 0 | 0 | - | - |
| Score | 0 | 8 | 0 | 0 | 8 | 0.90 |
| **D** | **Ceftriaxone**  **(Pre-treatment)** | Frequency | 1 | 2 | 1 | 6 | - | - | **2.2\*** |
| Score | 0 | 8 | 5 | 36 | 49 | 4.90 |
| **Ceftriaxone**  **(Post-treatment)** | Frequency | 5 | 4 | 0 | 1 | - | - |
| Score | 0 | 16 | 0 | 6 | 22 | 2.20 |

\*\*: *P*< 0.01 (highly significant); \*: *P*< 0.05 (significant), NS: *P*> 0.05 (non-significant)

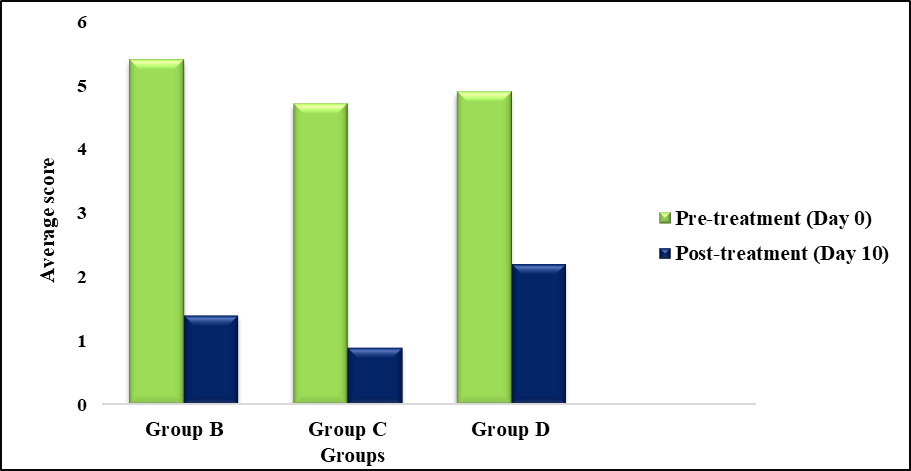
**Table 3. Pleural effusion of affected dogs in pre and post-treatment days**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Attributes** | | | **Absent** | **Mild** | **Moderate** | **Severe** | **Total score** | **Average score** | **Z-value** |
| Assigned score  Groups | | | 0 | 1 | 2 | 3 | - | - | **-** |
| **B** | **Doxycycline**  **(Pre-treatment)** | Frequency | 8 | 0 | 0 | 2 | - | - | **0.76NS** |
| Score | 0 | 0 | 0 | 6 | 6 | 0.60 |
| **Doxycycline**  **(Post-treatment)** | Frequency | 7 | 2 | 0 | 0 | - | - |
| Score | 0 | 2 | 0 | 0 | 2 | 0.22 |
| **C** | **Enrofloxacin**  **(Pre-treatment)** | Frequency | 4 | 2 | 0 | 4 | - | - | **-** |
| Score | 0 | 2 | 0 | 12 | 14 | 1.40 |
| **Enrofloxacin**  **(Post-treatment)** | Frequency | 9 | 0 | 0 | 0 | - | - |
| Score | 0 | 0 | 0 | 0 | 0 | 0 |
| **D** | **Ceftriaxone**  **(Pre-treatment)** | Frequency | 8 | 1 | 0 | 1 | - | - | **0.15NS** |
| Score | 0 | 1 | 0 | 3 | 4 | 0.40 |
| **Ceftriaxone**  **(Post-treatment)** | Frequency | 9 | 0 | 0 | 1 | - | - |
| Score | 0 | 0 | 0 | 3 | 3 | 0.30 |

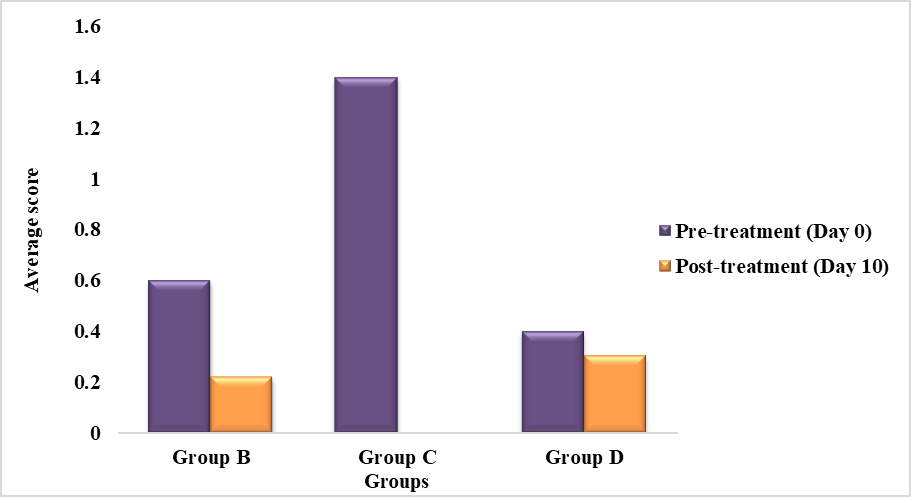
\*\*: *P*< 0.01 (highly significant); \*: *P*< 0.05 (significant), NS: *P*> 0.05 (non-significant)



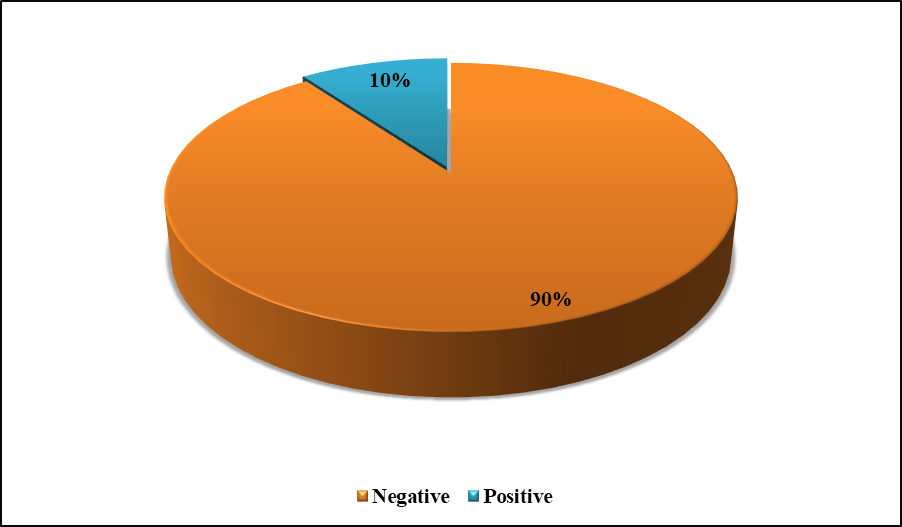
**Graph.1. Bar diagram showing bronchial pattern of affected dogs in pre and post-treatment days**

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**Graph.2. Bar diagram showing alveolar pattern of affected dogs in pre and post-treatment days**

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**Graph.3. Bar diagram showing pleural effusion of affected dogs in pre and post treatment day**

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**Graph.4. Pie chart depicting percentage of dogs showing cardiomegaly**

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**A B**

**Fig. 1a: Ventro-dorsal (B) and lateral (A) view revealed presence of moderate alveolar and bronchial pattern (pre-treatment, Group B) Arrow mark suggested presence of alveolar and bronchial pattern**

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**A**   **B**

**Fig. 1b: Ventro-dorsal (A) and lateral (B) view revealed absence of alveolar and bronchial pattern (post-treatment, Group B with doxycycline hydrochloride)**

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**Fig. 2a: Lateral (A) and ventro-dorsal (B) revealed severe alveolar and bronchial pattern (pre-treatment, Group C) arrow mark suggested severe alveolar and bronchial pattern**

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**Fig. 3a: Lateral (A) and ventro-dorsal (B) marked alveolar and bronchial pattern and presence of marked pleural effusion (pre-treatment, Group D) arrow mark suggested severe pleural effusion and that’s why cardiac silhouette not distinct properly.**

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**4. CONCLUSION**

In the study there was significant reductions in bronchial and alveolar patterns after rendering treatment with antibiotics and supportive therapy. The study revealed that ceftriaxone sodium was found most effective followed by doxycycline hydrochloride and enrofloxacin based on thoracic radiographs.

**Ethical approval**

The work was approved by the Institutional Animal Ethics Committee (Approval no: 770/GO/Re/S/03/CPCSEA/FVSc/AAU/IAEC/22-23/1039).

**5. ACKNOWLEDGEMENT**

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**6. COMPETING OF INTERESTS**

The authors have declared no competing interest exist.   **7. Importance of the Manuscript for the Scientific Community**

The initial changes in respiratory tract infection takes place mostly in lung parenchyma. It is always bit cumbersome to collect sample properly, process it for bacterial culture and study the antimicrobial sensitivity towards the specified antibiotic as it takes good amount of time. Radiography is non invasive, quick and least expensive methods which most of veterinarian can adopt in order to render treatment immediately. Moreover, the evaluation of recovery based on clinical improvement of signs and radiographic interpretation can be the most accurate to determine the drug efficacy and to decide the stop of medication by veterinarian. Hence the present study mostly stressed on this particular imaging technique

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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