

Occurrence of Pneumonia based on histopathology in domestic ruminants - A seasonal record

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ABSTRACT

A total of 120 fallen ruminants (64 cattle, 09 buffaloes, 15 sheep and 32 goats), received for necropsy at the Division of Pathology, ICAR-IVRI, Izatnagar were included in the study. Among animals, higher mortality rate was observed in adult animals followed by 3 to 12 months old animals and young animals upto 3 months age. In the present study was conducted to assess the types of pneumonia in ruminants based on gross and histopathological findings. Further, C categorization of pneumonia was primarily based on histopathology finding of the lung tissue. Tissue sections were stained with special stains such as Periodic Acid Schiff (PAS), Masson Trichrome Stain (MTS) and Brown and Brenn (B&B) respectively for demonstration of goblet cell hyperplasia, fibrous tissue proliferation and bacteria, respectively. Histopathological examination of lungs tissue sections was carried out for 120/123 cases as due to autolytic changes in 3 cases. Histopathological examination revealed one or more lesions associated with pneumonia in 97.56% (120/123) cases. Bronchointerstitial pneumonia 65.831% (79/120) was the most common type followed by interstitial (16.66%, 20/120), bronchopneumonia 7.5% (9/120) and granulomatous pneumonia (0.83%, 1/120). Bronchointerstitial pneumonia included chronic (1.66%, 2/120), sub-acute (55.83%, 67/120) and acute forms (8.33%, 10/120). Interstitial pneumonia (16.66%, 20/120) was sub categorized into acute (4.16%, 5/120) and subacute interstitial pneumonia (12.5%, 15/120). The lesions of bronchopneumonia was diagnosed in 7.5% (9/120) animals, which included acute (0.83%, 1/120), fibrinous (0.83%, 1/120) and subacute bronchopneumonia 5.83% (7/120) and granulomatous pneumonia (0.83%, 1/120). Besides, miscellaneous conditions were diagnosed in 9.16% (11/120) animals, which included congestion and edema in 6/120 (5%) and emphysema in 5/120 (4.16%) cases. Other miscellaneous conditions like congestion, edema, emphysema, atelectasis, etc. were observed in 9.16% (11/120) animals.

Keywords: Bronchopneumonia, brown and brenn, Masson Trichrome, periodic acid schiff

INTRODUCTION

Pneumonia is an acute, subacute or chronic infection of the lungs characterized by the inflammation of the lung parenchyma and inflammatory cell infiltration into the alveoli and bronchioles¹. Bronchopneumonia, Interstitial pneumonia, Embolic pneumonia and Granulomatous pneumonia are the four major types of pneumonia based on the etiological factors, gross and microscopic abnormalities. Further, pneumonia is divided into three categories the include chronic, subacute and acute, based on duration, as well as pathogens such as bacterial, viral and mycoplasma based on etiology². Respiratory disease complex (RDC) is one of the primary causes of mortality in domestic animals contributing up to 20-40% of cases in India³. Bovine respiratory disease (BRD) is one of the most serious and costly illnesses affecting cattle around the world and symptoms generally appear soon after arrival in the feedlot⁴. The morbidity risk of respiratory illness cases in feedlot cattle is highest in the first 45 days after arrival and is highest in 1 to 3 weeks. Further, the morbidity decreases until the end of the 12-week period⁵. High temperature (about 40-41.5°C), depression, decreased appetite, nasal and ocular discharge, coughing and variable degrees of dyspnea are the most typical clinical symptoms that has been described. In young domestic animals, respiratory and digestive illnesses are the leading causes of death. Pneumonia, along with diarrhea is one of the leading causes of morbidity and mortality in dairy ranging from 17.1% to 39% and 43.2% to 58%, respectively. In feed-lot farms, calves mortality associated with respiratory illnesses has been found 10-61% in Canada and 44-67% in United States⁶. The combination

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of many respiratory pathogens, stress and the environment has a synergistic effect and disease severity increases in mixed infections⁷. In all respiratory diseases of ruminants, bacterial pneumonia has drawn much attention due to the variable clinical manifestations and severity of diseases⁸. Viruses are the most common pathogens, causing damage to the epithelium and cilia⁹, as well as increasing vulnerability to other diseases by impairing the host's immune system¹⁰ by suppressing or killing

Table 1. Details of samples collected.

Species	Place	No. of Samples	Sample Types
Cattle	PM Facility, IVRI	64	Lungs
Buffalo	PM Facility, IVRI	09	Lungs
Sheep	PM Facility, IVRI	15	Lungs
Goat	PM Facility, IVRI	32	Lungs
Total		120	

alveolar macrophages¹¹.

Bronchipneumonia is the most prevalent type of pneumonia in domestic animals is characterized by the consolidation of cranio-ventral pulmonary lobes and inflammation of the bronchi, bronchioles and alveolar lumen¹². Mainly pathogens enter through the airways, resulting in exudative lesions at the bronchiolar-alveolar junction¹³.

Viruses such as BRSV, BPI-3, BVDV, BCoV and BHV-1, as well as septicemia/toxemia, fungal spores, various chemical substances like 3-methylindole, migratory parasit larvae, immunological processes, toxic gases, hypersensitivity and possibly environmental factors cause interstitial pneumonia¹⁴.

Broncho-interstitial pneumonia is frequently complicated by secondary bacterial infection, concealing the original viral symptoms. As a result, right broncho-

interstitial pneumonia is occasionally reported¹⁵ for example, in a feedlot cow, broncho-interstitial pneumonia was found in only 3 of 214 (1.4%) and 25 of 112 pneumonic lungs respectively^{16,17}. However, 12.64% prevalence of broncho-interstitial pneumonia in pneumonic lungs of adult cattle in Punjab, India, has been reported¹⁸.

MATERIALS AND METHODS

Collection of lungs samples from dead/fallen domestic ruminants

During necropsy examination, tissue samples (lungs) were obtained from a total of 120 fallen animals (64 cattle, 9 buffaloes, 15 sheep and 32 goats). For histopathology, representative tissue samples (1 cm thick) from the affected areas of the lungs were collected in 10% NBF. These samples were used to identify various types of Histopathological pneumonia conditions. The carcasses were received at the Post Mortem Facility of Division of Pathology, ICAR-IVRI, Bareilly during the period from January to December 2022. Detail of the animals and the samples are listed in the Table 1.

**Tissues processing
Histopathology**

Tissue samples collected in 10% NBF were stored for 48 hours for proper fixation at room temperature. Further, 0.5 cm thick tissue sections were cut from the fixed tissues,

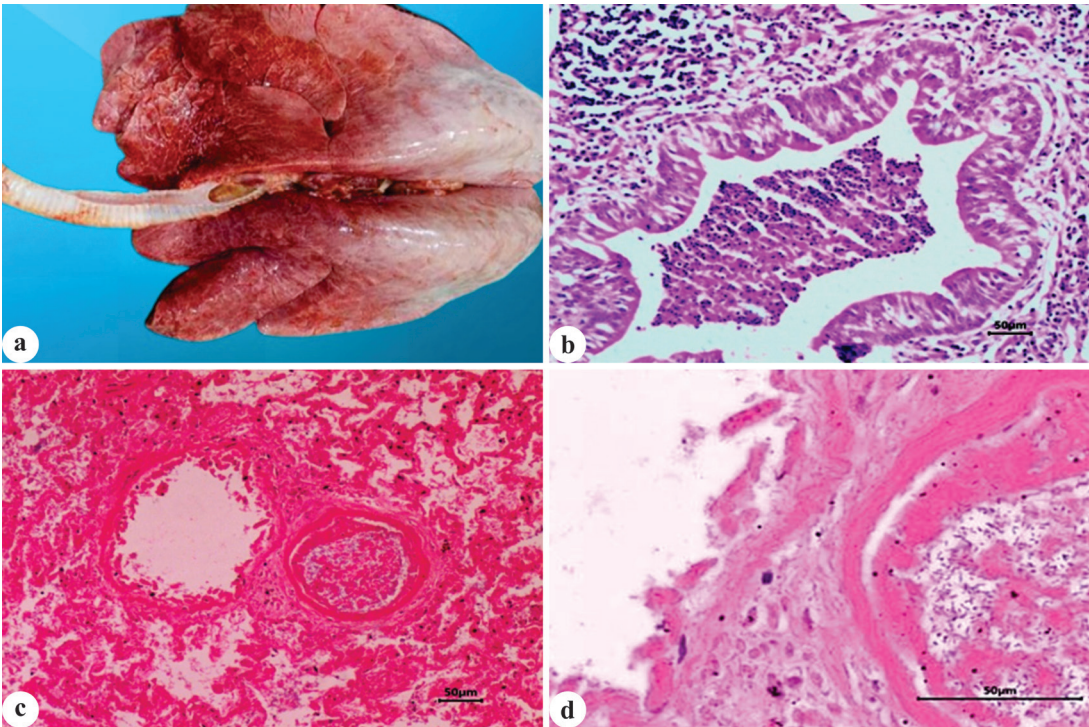


Fig. 1. Suppurative bronchopneumonia: Gross images of lungs **a.** Showing severe congestion and patchy consolidation in right cranial lobe; **b.** Microscopic image showing bronchiole with neutrophilic exudate (100x); **c.** Bronchiolar epithelial desquamation with bacteria in adjacent blood vessels (c) 40x and (d) H&E 400x/Lungs **a.** Severe congestion and patchy consolidation in right cranial lobe; **b.** Neutrophilic exudate in bronchiolar lumen (H&E Stain, bar = 50 µm); **c-d.** Bronchiolar epithelial desquamation with bacteria in adjacent blood vessels (H&E Stain, bar = 50 µm).

Table 2. Age wise mortality pattern in fallen animals.

Species	Cattle			Buffalo			Sheep			Goat		
Age (months)	0-3	3-12	>12	0-3	3-12	>12	0-3	3-12	>12	0-3	3-12	>12
Mortality ratio	9/64	15/64	40/64	1/9	2/9	6/9	1/15	0/15	14/15	2/32	11/32	19/32
% Mortality	14.06	23.43	62.5	11.11	22.22	66.66	6.66	0	93.33	6.25	34.4	59.37

and processed for routine histopathological examination. The cut section was dehydrated using ascending grades of the alcohol and cleared by two changes of the xylene. Further paraffin embedded tissue section was processed and 4 to 5 micron thick section was cut using semiautomatic microtome and taken on glass slide. The sections were stained using routine Haematoxylin and Eosin (H&E) staining following standard protocol¹⁹.

Special staining methods used in histopathology

To demonstrate goblet cell hyperplasia, fibrous tissue proliferation and bacteria in tissue sections Periodic Acid

Schiff (PAS), Masson Trichrome Stain (MTS) and Brown and Brenn (B&B) staining¹⁹ were performed, respectively.

RESULTS

A total of 120 ruminants, including cattle (64), buffalo (9), sheep (15) and goats (32) were received at the post-mortem facility of the Division of Pathology for necropsy examination. To determine the pattern of mortality in animals with respect to age, gender and season, the data was analyzed for different animals during the period between January to December 2022 (Table 2-4).

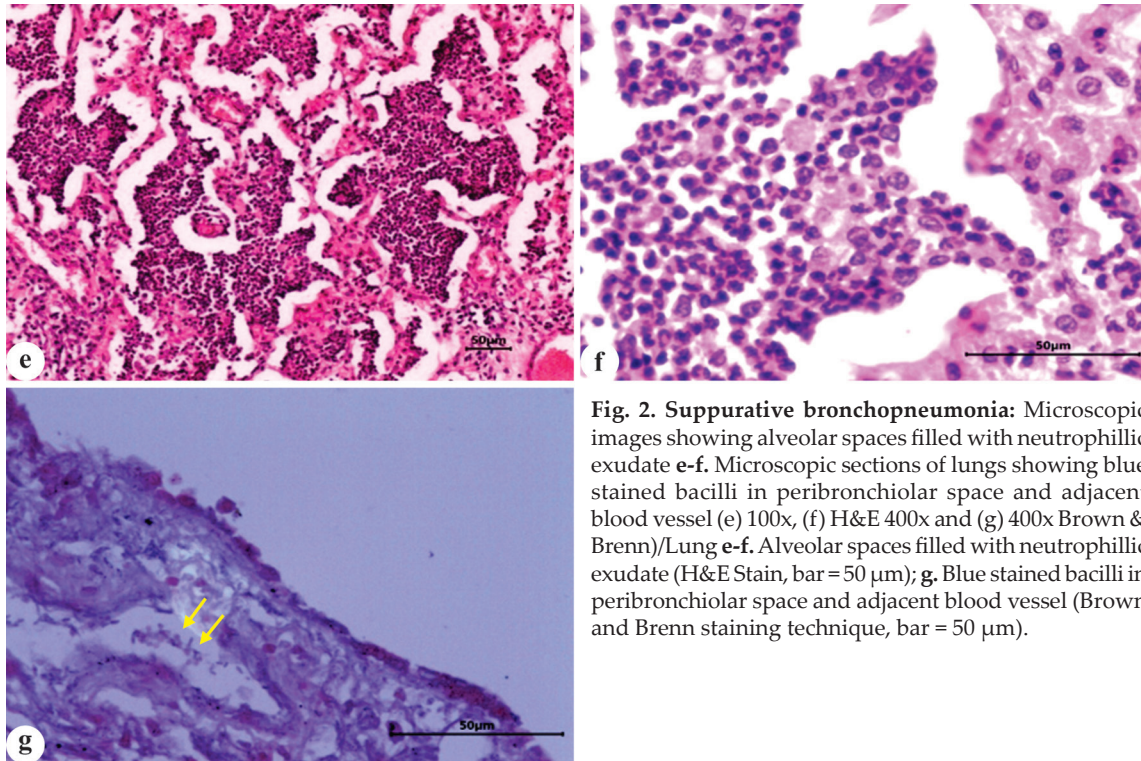


Fig. 2. Suppurative bronchopneumonia: Microscopic images showing alveolar spaces filled with neutrophilic exudate **e-f**. Microscopic sections of lungs showing blue stained bacilli in peribronchiolar space and adjacent blood vessel (**e**) 100x, (**f**) H&E 400x and (**g**) 400x Brown & Brenn)/Lung **e-f**. Alveolar spaces filled with neutrophilic exudate (H&E Stain, bar = 50 µm); **g**. Blue stained bacilli in peribronchiolar space and adjacent blood vessel (Brown and Brenn staining technique, bar = 50 µm).

The mortality rate in cattle was higher in males 67.18% (43/64) as compared to 32.82% (21/64) in female. Animals older than one year had a higher mortality rate (62.5%, 40/64), followed by 3 to 12 months old animals (23.43%, 15/64) and young animals upto 3 months age (14.06%, 9/64). Cattle mortality was highest during the

post-monsoon (42.18%, 27/64) season, followed by the monsoon (29.68%, 19/64) and summer (18.75%, 12/64), and winter (9.37%, 6/64) season.

Among buffaloes, mortality was higher in female (77.77%, 7/9) than male buffaloes (22.22%, 2/9) received

Table 3. Sex wise mortality pattern in fallen animals.

Species/Sex	Cattle		Buffalo		Sheep		Goat	
	M	F	M	F	M	F	M	F
Mortality ratio	43/64	21/64	2/9	7/9	6/15	9/15	19/32	13/32
% Mortality	67.18	32.82	22.22	77.77	40	60	59.38	40.62

Table 4. Season wise mortality pattern in fallen animals.

Species/Sex	Monsoon			Post-Monsoon			Winter			Summer		
	Male	Female	Total %	Male	Female	Total %	Male	Female	Total %	Male	Female	Total %
Cattle	15	4	29.68	15	12	42.18	3	3	9.37	9	3	18.75
Buffalo	0	1	11.11	1	2	33.33	1	2	33.33	0	2	22.22
Sheep	1	1	13.33	5	3	53.33	0	3	20	0	2	13.33
Goat	4	3	21.87	5	3	25	5	3	25	5	4	28.15

for necropsy. The post monsoon and winter season (33.33, 3/9) had the highest and identical mortality rates, followed by summer (22.22%, 2/9) and monsoon season (11.11%, 1/9).

Mortality was higher in male goats (59.38%, 19/32) than females (40.62%, 13/32) during the study period. Animals older than 12 months had the highest mortality rate (59.37%, 19/32), followed by grower animals (34.4%, 11/22) and young animals (6.25%, 2/32). The summer season had the highest mortality rate (28.15%, 9/32),

followed by the post monsoon and winter seasons (28%, 8/32). Lowest mortality (21.87%, 7/32) was observed during monsoon season.

In sheep, higher mortality was observed in female animals (60%, 9/15) than males (40%, 6/15). Animals older than 12 months had the highest rate of mortality (93.33%, 14/15), followed by those younger than 3 months (6.66%, 1/15) and no mortality was recorded in grower animals (3-12 months). Seasonal mortality showed that post-monsoon (53.33%, 8/15) had the highest rate,

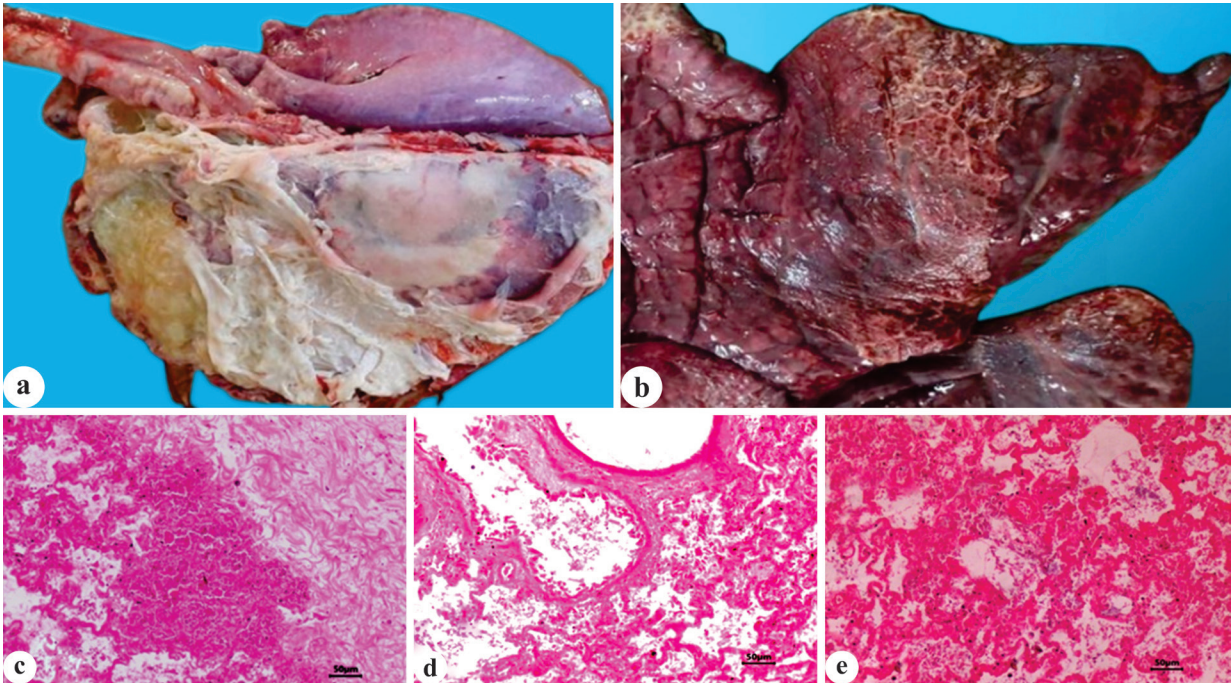


Fig. 3. Fibrinous bronchopneumonia: **a-b.** Gross images showing deposition of light yellowish layer of fibrinous exudate over the congested and consolidated lobes; **c-e.** Microscopic images of lungs showing eosinophilic fibrin strands in pleura, bronchiolar lumen and alveoli (c-e) H&E 100x/Lungs **a-b.** Deposition of light yellowish layer of fibrinous exudate over the congested and consolidated lobes; **c-e.** eosinophilic fibrin strands in pleura, bronchiolar lumen and alveoli (H&E Stain, bar = 50 μm).

followed by winter (20%, 3/15) and summer and monsoon (13.33%, 2/15) had similar rates.

Classification of Pneumonia

Tissue samples collected from all the necropsied carcasses during the period as well as few archived samples were processed for the morphological and pathological diagnosis. Tissue

Table 5. Types of Pneumonia and frequency of their occurrence.

Type of Pneumonia	Frequency of Occurrence	Percentage Frequency (%)
Bronchopneumonia	9	7.50
Bronchointerstitial pneumonia	79	65.83
Interstitial pneumonia	20	16.66
Granulomatous pneumonia	1	0.83
Miscellaneous conditions	11	9.16
Total	120	

Table 6. Histological classification of Pneumonia and their occurrence.

Types of Pneumonia		Cattle	Buffalo	Sheep	Goat	Total	Total %
Bronchopneumonia (BP) 7.5% (9/120)	Acute BP	1	0	0	0	1/120	0.83
	Sub acute BP	3	1		2	7/120	5.83
	Fibrinous BP	1	0	0	0	1/120	0.83
Bronchointerstitial pneumonia (BISP) 65.83% (79/120)	Acute BISP	5	1	2	2	10/120	8.33
	Sub acute BISP	34	5	7	21	67/120	55.83
	Chronic BISP	2	0	0	0	2/120	1.66
Interstitial pneumonia (ISP) 16.66% (20/120)	Acute ISP	4	1	0	0	5/120	4.16
	Sub acute ISP	10	0	1	4	15/120	12.5
Granulomatous pneumonia 0.83% (1/120)	-	0	1	0	0	1/120	0.83
Miscellaneous conditions 9.16% (11/120)	Congestions & Oedema	4	0	2	0	6/120	5
	Emphysema	0	0	2	3	5/120	4.16
	Total	64	9	15	32	120/120	

samples of a total of 123 animals were examined histopathologically and out of which 120 cases were classified into different types of pneumonia and other miscellaneous lesions based on the histopathological lesions and nature of exudate in the airways and parenchyma. Microscopically, three cases were found to be in advance stage of autolysis. The lung lesions were categorized as bronchopneumonia, broncho-interstitial pneumonia, interstitial pneumonia, granulomatous pneumonia and miscellaneous conditions (Table 5).

Classification of pneumonic lungs was done based

on cellular infiltration, into acute suppurative broncho-pneumonia, chronic bronchopneumonia (cBP), fibrinous pneumonia, acute bronchointerstitial pneumonia (aBISP), subacute bronchointerstitial pneumonia (saBISP), chronic bronchointerstitial pneumonia (cBISP), acute interstitial pneumonia (aISP), chronic interstitial pneumonia (cISP), acute bronchointerstitial pneumonia (aBISP), sub acute bronchointerstitial pneumonia, granulomatous pneumonia and bronchitis. The miscellaneous conditions such as congestion, haemorrhages and congestion, edema, congestion and edema, emphysema and atelectasis, haemorrhages and emphysema, etc. were

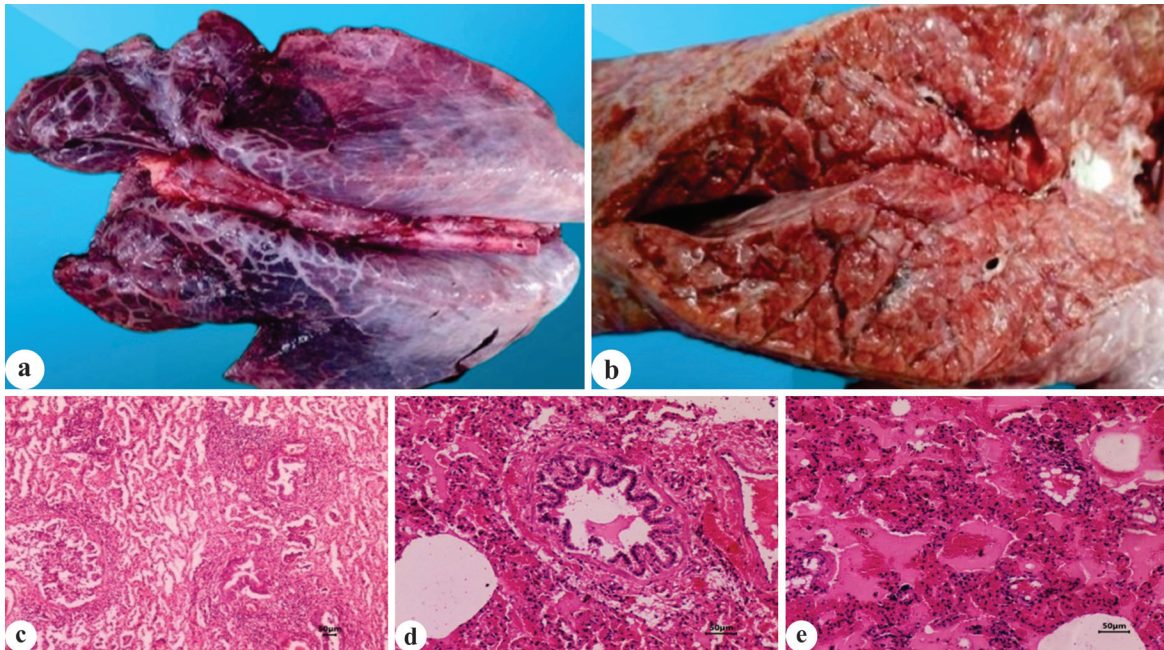


Fig. 4. Subacute bronchointerstitial pneumonia: **a.** Gross images of lungs showing severe congestion and consolidation cranio-ventral lobes with thickened and emphysematous interlobular septa; **b.** Cut section showing oedematous interlobular septa; **c-e.** Microscopic images of lungs section showing moderate to severe bronchiolar desquamation, peri-bronchiolar infiltration of MNCs, alveolar oedema and thickened alveolar septa (c) 4x and (d-e) H&E 10x/Lungs **a.** Severe congestion and consolidation cranio-ventral lobes with thickened and emphysematous interlobular septa; **b.** Cut section showing oedematous interlobular septa; **c-e.** Lungs: Moderate to severe bronchiolar desquamation, peri-bronchiolar infiltration of MNCs, alveolar oedema and thickened alveolar septa (H&E Stain, bar = 50 μ m).

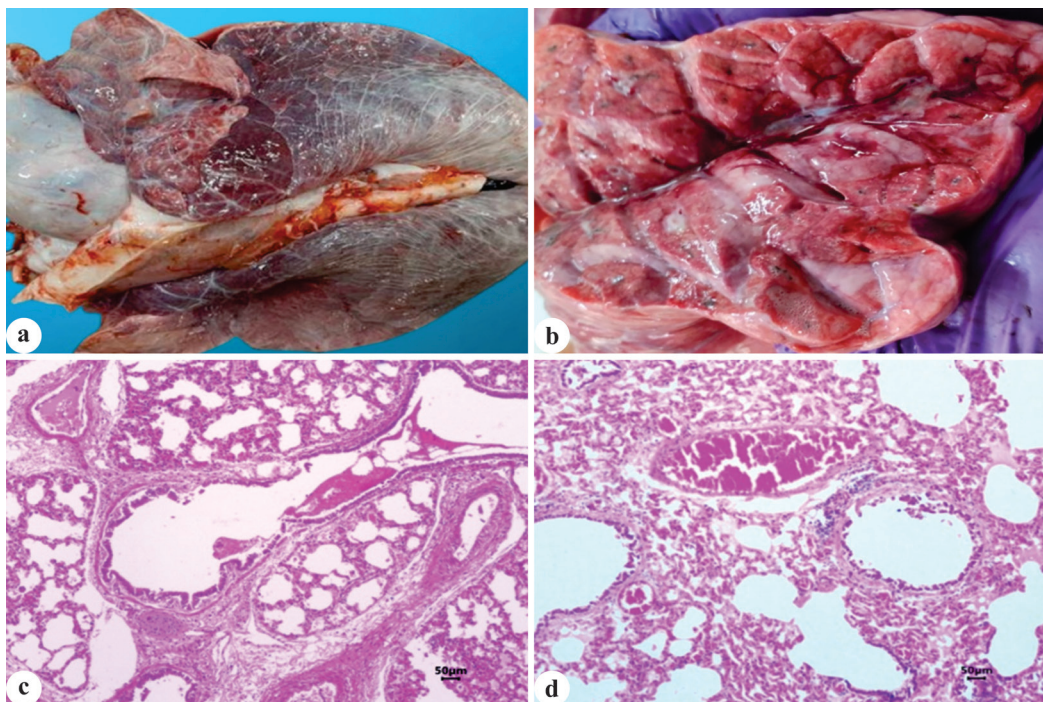


Fig. 5. Acute bronchointerstitial pneumonia: **a.** Gross images showing congestion and consolidation of pulmonary lobes with mild thickening of visceral pleura over the caudal lobes; **b.** Cut section showing thickening of interlobular septa and congested lobules; **c-d.** Microscopic images showing mild desquamation of bronchi and bronchioles with thickened alveolar septa (c-d) H&E 100x/Lungs **a-b.** Congestion and consolidation of pulmonary lobes with mild thickening of visceral pleura over the caudal lobes; **b.** Cut section showing thickening of interlobular septa and congested lobules; **c-d.** Mild desquamation of bronchi and bronchioles with thickened alveolar septa (H&E Stain, bar = 50 µm).

also identified (Table 6).

Suppurative Bronchopneumonia

Four out of 120 pneumonic cases had lesions suggestive of suppurative bronchopneumonia, one of which was acute and three of which were of sub acute nature. None of the cases had lesions suggestive of chronic bronchopneumonia. The affected lobes in acute suppurative bronchopneumonia were reddish or brown-grey in color, with mild to moderate interlobular edema (Table 6).

Gross examination of the lobes revealed firm texture and cranioventral consolidation. The majority of cases had consolidation in the left and right cranial lung lobes, with only a few cases having consolidation in the cranioventral aspect of the diaphragmatic lobes (Fig. 1a). A lobular pattern was observed, with oedema and hyperemia in the affected areas, as well as a mosaic of normal and affected lobules. When the affected lobes were cut open, the sections revealed mucopurulent exudate of a hemorrhagic type from the airways in areas that were both pale and dark in colour.

Histopathological examination of the affected lungs tissues revealed engorged alveolar capillaries with minor haemorrhages. The lumen of the bronchi and bronchioles, as well as in the alveolar spaces, had cellular exudate

containing mostly neutrophils with denuded cellular debris and a few macrophages (Fig. 2e). The alveolar spaces were filled with a uniform pinkish edema fluid.

Some of the bronchioles and bronchi had necrosis and denudation of the epithelium. Acute bronchiolitis was observed, with suppurative exudates plugging the bronchiolar lumen and inflammatory cells infiltrating the peribronchiolar space.

The lungs had liver-like firmness and grayish to red consolidated areas in the right and left anterior lobes in the case of subacute suppurative bronchopeumonia; the cut surface had a nodular appearance, with purulent exudate oozing from the airways.

Pleural thickening was observed, as well as cellular infiltrates primarily composed of neutrophils and to a lesser extent, mononuclear cells (MNCs). Mild fibrocellular proliferation around the bronchi and bronchioles, as well as thickened alveolar interstitium were observed as a result of MNC infiltration.

Fibrinous Bronchopneumonia

One out of 120 cases one had typical fibrinous bronchopneumonia lesions (Table 6). The lungs were grossly covered with a thin straw-yellow layer of fibrin, as well as watery serous fluid in the thoracic cavity. Consolidation was seen as patchy to diffuse areas of

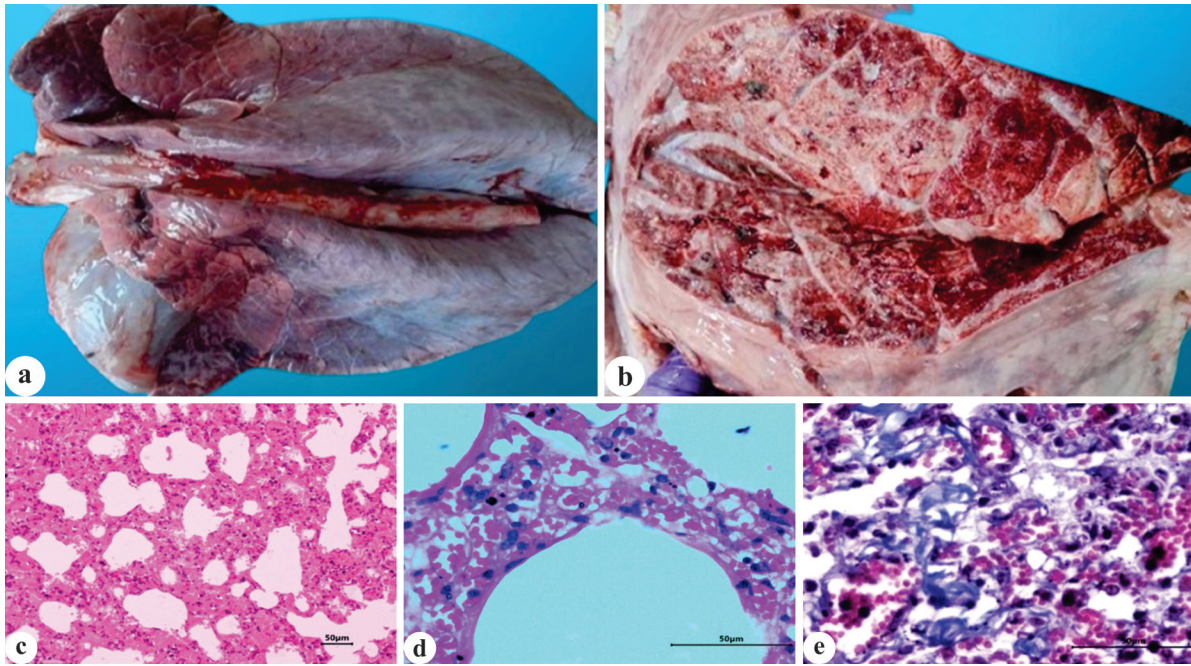


Fig. 6. Subacute interstitial pneumonia: **a.** Gross image of lungs with severe congestion of pulmonary lobes with prominent thickening of inter-lobular septa and visceral pleura; **b.** Cut-section showing widened interlobular septa; **c-d.** Microscopic images of lungs revealing severe thickening of interstitium as a result of congested capillaries and infiltration of MNCs (c) 100x and (d) H&E 400x; **e.** Lung section with thickened interstitium due to deposition of collagen fibres, stained blue (400x MTS)/Lungs **a.** Severe congestion of pulmonary lobes with prominent thickening of inter-lobular septa and visceral pleura; **b.** Cut-section showing widened interlobular septa; **c.** Lungs with severe thickening of interstitium as a result of congested capillaries and infiltration of MNCs (H&E Stain, bar = 50 μ m); **d.** Thickened interstitium due to deposition of collagen fibres, stained blue (Masson Trichrome Stain, bar = 50 μ m).

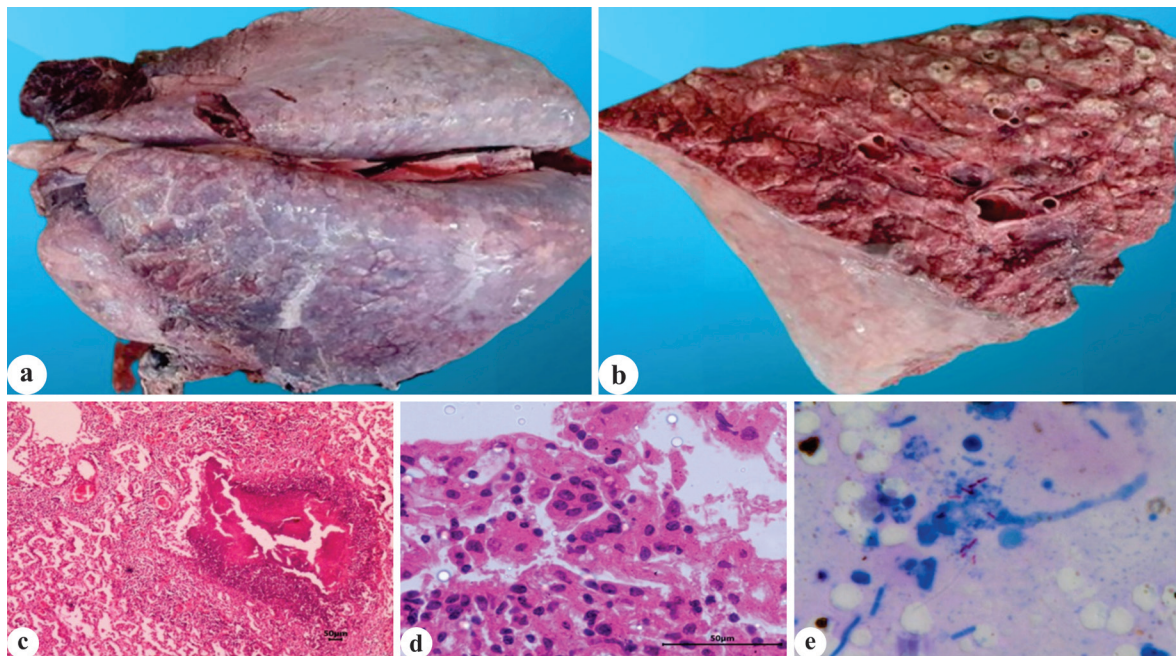


Fig. 7. Granulomatous pneumonia: **a.** Gross image of lungs showing inflated lobes with diffused nodules (2-4 cm diameter) over the surface; **b.** Cut section showing presence of diffused nodules and caseous exudate within bronchial lumen; **c-d.** Microscopic image of lungs showing granuloma with eosinophilic central necrotic debris surrounded by macrophages, MNCs and giant cells (c) 40x and (d) H&E 400x; **e.** Lungs impression smear showing red acid-fast bacilli (1000x, Modified Z-N Stain)/Lungs **a.** Inflated lobes with diffused nodules (2-4 cm diameter) over the surface; **b.** Cut section showing presence of diffused nodules and caseous exudate within bronchial lumen; **c-d.** Note the presence of granuloma with eosinophilic central necrotic debris surrounded by macrophages, MNCs and giant cells (H&E Stain, bar = 50 μ m); **e.** Impression smear from cut surface of affected lungs showing red acid-fast bacilli (Modified Z-N Stain, bar = 10 μ m).

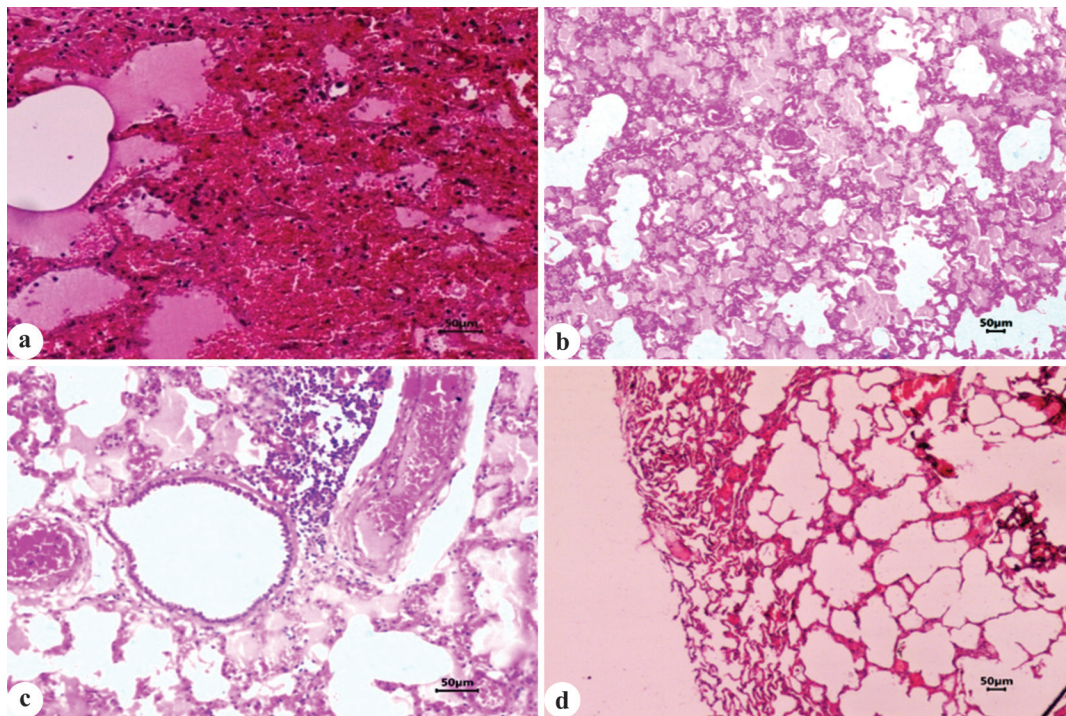


Fig. 8. Miscellaneous affections of lungs: **a.** Tissue section showing alveolar airspaces with erythrocytes and interstitial congestion (H&E 100x); **b-c.** Section showing congested pulmonary vessels with adjacent alveolar airspaces (b) 4x and (c) H&E, 100x; **d.** Thin, enlarged and ruptured alveoli indicating bullous emphysema and atelectasis (100x, H&E 4x)/Lungs **a.** Tissue section showing diffuse alveolar hemorrhages obliterating alveolar airspaces and interstitial congestion (H&E Stain, bar = 50 µm); **b-c.** Section showing marked congestion of pulmonary vessels adjacent alveolar airspaces and edema (H&E Stain, bar = 50 µm); **d.** Thin, enlarged and ruptured alveoli indicating bullous emphysema and atelectasis (H&E Stain, bar = 50 µm).

distribution, primarily in the anterioventral portion of the lungs, which were reddish-enlarged and liver-like in consistency. The parietal pleura was found to be adherent to the visceral pleura and diaphragm. The cut surface of the lungs revealed focal to diffuse lesions, as well as firm, hard-consolidated areas (Fig. 3a & b).

Microscopic examination revealed the thickening of pleura with fibrinocellular exudate. The infiltration of fibrinous and cellular exudates enlarged the interlobular septae. The bronchi and bronchioles' lumens showed epithelial desquamation with cellular exudate containing MNCs and a few neutrophils. In the bronchioles and alveolar spaces, fibrinous exudate mixed with neutrophils was observed (Fig. 3c-e).

Bronchointerstitial Pneumonia

Bronchointerstitial pneumonia (BISP) was diagnosed histopathologically in 79 cases (65.83%) (Table 6). The majority of the cases revealed lungs with cranio-ventral distribution of lesions, with affected lobes exhibiting dark reddish to brown coloured consolidated areas. The majority of the cases had consolidated lesions in the left and right cranial lobes, as well as the right middle lobes. Further, the caudo-dorsal lobes were frequently distended with lobular, inter-lobular or sub-pleural edematous and emphysematous lesion. In severe cases, one or more entire lobes were involved and

were consolidated with multifocal area to diffuse type of distribution. On palpation, atelectic areas revealed a rubbery consistency in some cases.

Necrosis and denudation of bronchiolar and bronchial epithelium were observed along with MNC infiltration around the bronchi, syncytia formation, type II pneumocyte hyperplasia and proliferative or exudative alveolitis. Fibrinous exudate containing RBCs and macrophages accumulated in the subpleura and interlobular septa, leading to the thickening of the septae.

Out of 48 cases, acute, sub-acute and chronic broncho-interstitial pneumonia (BISP) were diagnosed in 10 (8.33%), 67 (55.83%) and 2 (1.66%) cases, respectively.

Interstitial Pneumonia

Microscopic examination of lungs tissues revealed interstitial pneumonia (ISP) in 20 (16.66%) cases, of which 5 (4.16%) were diagnosed as acute interstitial pneumonia and 15 (12.5%) as sub-acute interstitial pneumonia (Table 6).

Grossly, bilateral deflation of the lungs, particularly the diaphragmatic lobes, was observed, along with varying degrees of interlobular emphysema and/or edema. In some cases, the caudo-dorsal portion of the lungs showed rubbery to firm dark red areas interspersed with pale pink areas (Fig. 6a & b). The dorsal surface

of inflated emphysematous lungs had rib impressions. Consolidation of the cranial lobes was associated with serous to mucopurulent exudate from the smaller airways in some cases. In some cases, pleuritis with focal to diffuse fibrin and adhesions to the adjacent thoracic wall was observed. Few cases had petechial haemorrhages on the surfaces of the lobes and the thoracic wall.

Microscopically, thickening of inter-alveolar septa due to the infiltration of variable numbers of neutrophils, MNCs and fibroblast cells (Fig. 6c & d) and in few cases inter-alveolar septa had hyperemia, oedema partial to complete hyperplasia of type 2 pneumocytes. In most of the cases, proliferative lesions were observed in sections of lungs. Interstitium showed macrophages with basophilic bacterial colonies. MTS staining revealed lung section with thickened interstitium due to deposition of blue stained collagen fibers (Fig. 6e).

Granulomatous Pneumonia

Granulomatous pneumonia was found in 1 (0.83%) out of 120 affected lungs examined. During gross examination, the affected lungs showed inflated lobes with diffused nodules (2-4 cm) over the surfaces and cut section showed presence of diffused nodules and caseous exudates within bronchial lumen (Table 6). There were numerous granulomas of varying sizes all over the surface of the lung. A number of small granulomas merged to form a larger granuloma with central caseating material. Pyogranuloma was focally extensive and limited to both cranial lobes in one case. Chronic granulomatous nodules of this type were also found in the parietal and visceral pleura. There was severe enlargement and caseation of the mediastinal and tracheobronchial lymph nodes (Fig. 7a & b).

Microscopically, granulomas were composed of a central eosinophilic necrotic area surrounded by epithelioid cells, lymphocytes, macrophages and characteristic Langhans type of giant cells with horse shoe nuclei and an outer zone of proliferating fibrous connective tissue. In the center and periphery of granulomatous lesion, slender acid-fast bacilli were demonstrated by using Ziehl and Neelsen staining. Impression smear from the granulomatous lesion also revealed presence of acid-fast bacteria (Fig. 7c, d & e).

Congestion and Pulmonary Oedema

In 5% (6/120) of the cases, pulmonary congestion and edema were observed (Table 6). Grossly, the lungs had scattered regions of haemorrhage and congestion. When the thorax was opened, the lungs were pale and heavy and failed to collapse. Following the incision, frothy edematous fluid was observed in the lumen of trachea, bronchi and bronchioles.

Histopathological examination of the sections indicated blood vessel engorgement in the interalveolar,

interlobular septa and peribronchiolar regions. Erythrocytes partially or totally filled the alveoli and interalveolar septa. In the alveoli and interlobular septa, homogeneous, eosinophilic fluid was found.

Emphysema and atelectasis

Five out of 120 cases (4.16%) of cases revealed atelectasis and emphysema (Table 6). Grossly, prominent foci of pale and large emphysematous regions in one or more pulmonary were detected. These areas were slightly raised from the nearby unaffected areas and showed depression and crepitation on applying pressure. Large emphysematous bullae were seen in the form of open distended alveoli in lungs sections that have breached alveolar interstitium. Dark reddish to bluish-grey discoloured, firm textured areas depressed below than the normal lobular surface were marked as atelectasis in one or more lobes. On microscopic examination, atelectatic lesions with foci of emphysema nearby and collapsed alveoli that resembled a slit-like constricted lumen (Fig. 8). Alveolar walls looked parallel and in apposition and neither the alveoli nor the interstitium displayed any signs of inflammation.

DISCUSSION

The incidence of pneumonia in the present study was higher (97.56%) in comparison to the previous report, 89.13% in small and large ruminants by²⁰, 63.23% by²¹, 64.7% in large ruminants by²² and 14.82% in small ruminants by²³. The differences in the results of incidence of cases of pneumonia could be attributed to the variables in the temporal and spatial parameters taken up by different researchers during their investigation work. In cases of interstitial pneumonia, the inflammatory processes were primarily in the alveolar epithelium, endothelium and were contiguous with bronchiolar epithelium. Progression of inflammatory changes from interstitium towards the alveoli, bronchiole and bronchi lead to broncho-interstitial pneumonia²⁴. Bronchopneumonia are typically characterized by the cranio-ventral consolidation of the lobes and infiltration of inflammatory exudate within the lumen of bronchi, bronchioles and alveoli of different lobules was recorded in 6.7% (8/129) cases. The agents initially damage the broncho-alveolar epithelium and subsequently the inflammation spread distally and centrifugally, the earlier lesions being at the centre. Based on the vascular changes and type of predominant inflammatory cells, bronchopneumonia is arbitrarily categorized into acute, sub-acute, suppurative, fibrinous and chronic pneumonia. In the present study, the incidence of acute bronchopneumonia was recorded as 0.83% (1/120), which is in contrast to reports of higher incidence of upto 90%^{25,26} and 26.28% to 33.33%^{27,28}. Suppurative bronchopneumonia was observed in 3.3% (4/120) animals, wherein the gross

and microscopic lesions recorded were similar to those described in the literature^{12,24}. The affected lobes had consolidation with necrotic cellular debris admixed with neutrophilic exudate and occasional few macrophages in the air spaces. The lungs exhibited a varying range of consolidation in the affected lobes, fibrinous exudate over the pleura and the airways were filled with fibrinous exudate along with the presence of inflammatory and denuded epithelial cells. Miscellaneous affections of lungs were also diagnosed in 9.16 (11/120) animals in the current study, which included congestion and oedema in 5% (6/120) animals and emphysema in 4.16% (5/120) animals.

CONCLUSION

Occurrence of bronchointerstitial pneumonia was found to be highest with 65.83% (79/120) incidence followed by interstitial pneumonia with 16.66% (20/120) and bronchopneumonia 7.5% (9/120).

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