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Original

# Anatomopathological characterization of pneumonia in guinea pig produced by Streptococcus pneumoniae in intensive breeding

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## ABSTRACT

**Objective.** Characterize macroscopically and microscopically the lesions caused by *Streptococcus pneumoniae* in samples of guinea pig lung (*Cavia porcellus*) of intensive breeding in Lima. **Materials and methods.** The necropsy of 138 guinea pigs with clinical signs of pneumonia was performed, and the sample of the affected lungs was taken. Bacterial isolation was performed for the identification of *Streptococcus pneumoniae*, using blood agar and biochemical tests; Histopathological processing was performed using the hematoxylin eosin (HE) staining of tissue samples preserved in 10% formalin. **Results.** Of the total lungs diagnosed with pneumonia at necropsy, 17.4% (24/138) was positive for *Streptococcus pneumoniae*. Of these, 75% (18/24) showed macroscopic characteristics of interstitial pneumonia and 20.87% (5/24) macroscopic characteristics of suppurative bronchopneumonia and 4.17% (1/24) of fibrinous bronchopneumonia. In the microscopic evaluation it was found that 54.17% presented both interstitial bronchopneumonia, 37.50% interstitial pneumonia, and 8.33% of them correspond to bronchopneumonia. **Conclusions.** Interstitial bronchopneumonia, interstitial pneumonia and bronchopneumonia with a diagnosis of Streptococcus pneumoniae are lesion patterns found in intensive rearing systems in Lima.

**Keywords:** Bronchopneumonia; guinea pigs; infection; pneumonia; mortality; pathology (*Source: MeSH*).

## RESUMEN

**Objetivo.** Caracterizar macroscópica y microscópicamente las lesiones causadas por *Streptococcus pneumoniae* en muestras de pulmón de cuyes (*Cavia porcellus*) de crianza intensiva de Lima. **Materiales y métodos**. Se hizo la necropsia de 138 cuyes con signos clínicos de neumonía, y se tomó la muestra de los pulmones afectados. Se realizó el aislamiento bacteriano para la identificación de *Streptococcus pneumoniae,* utilizando agar sangre y pruebas bioquímicas; se realizó el procesamiento histopatológico utilizando la coloración hematoxilina eosina (HE) de

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las muestras de tejidos conservados en formol al 10%. **Resultados.** Del total de los pulmones diagnosticados con neumonía en necropsia, el 17.4% (24/138) resultó positivo a *Streptococcus pneumoniae*; De estos, el 75% (18/24) mostró características macroscópicas de neumonía intersticial y 20.87% (5/24) características macroscópicas de bronconeumonía supurativa y 4.17% (1/24) de bronconeumonía fibrinosa. En la evaluación microscópica se encontró que el 54.17% presentó tanto para bronconeumonía intersticial, 37.50% neumonía intersticial, y un 8.33% de ellas corresponden a bronconeumonía. **Conclusiones**. La bronconeumonía intersticial, neumonía intersticial y bronconeumonía con diagnóstico de *Streptococcus pneumoniae* son patrones lesionales encontradas en sistemas de crianza intensiva de Lima.

**Palabras clave:** Bronconeumonía; guinea pigs; infección; neumonia; mortalidad; patología (*Fuente: MeSH*).

## INTRODUCTION

Guinea pig breeding has become an industry of major economic importance for the country. Due to its importance as a production system and the development of populations in production, it is affected by various external and internal factors, such as inadequate management of temperature, humidity, airflow, over animal density, animal house hygiene, poorly balanced diets, hypovitaminosis C, making these animals susceptible to stress, affecting their immune response, favoring the presentation of various diseases (1,2); where pneumonias, enteritis, dermatophytosis, pseudotuberculosis, lymphadenitis and conjunctivitis are caused by multiple etiology (3,4).

Pneumonia is an important disease for this species, because it produces high morbidity and mortality (5) and can be caused by: bacteria, fungi, parasites, viruses, and/or toxic gases. Bacterial agents are considered secondary pathogens since they require a preceding deterioration of the defense mechanisms for their colonization at the lung level (6,7). Some studies report the presentation of pneumonia; cows presented 43.2% (8), rabbits 12.8% (9), alpacas 4%, (10), 3.95% in goats of pneumonia (11).

Animals have microorganisms that constitute the microbiota of different tissues, Streptococcus pneumoniae is part of the upper respiratory tract of the guinea pig (5,12,13); however, it is also considered a subclinical carrier, since it has been reported as a pathogen in the upper respiratory tract with a high prevalence, with a frequency greater than 50% in some populations, this explains the sporadic epizootics that occur when animals are stressed or malnourished (4).

Epizootics occur more frequently in winter; younger and pregnant animals are more frequently affected; other predisposing factors include changes in environmental temperature, inadequate nutrition (4,14), and environments with excessive or deficient ventilation, which is more critical in times of seasonal change (13,15). Transmission is mainly by aerosol, by direct contact with infected animals (including humans), or vertically during parturition (4).

Pneumonia is considered to be an inflammatory lesion in the lungs and is associated with several etiological agents, which can produce one type of pneumonic lesion; however, the concomitant presentation of more than one type of pneumonia is possible (7). Lesions associated with Streptococcus pneumoniae in laboratory guinea pigs are fibrinopurulent bronchopneumonia and suppurative bronchopneumonia (4); on the other hand, interstitial and bronchointerstitial pneumonia can have a coexistent presentation.

Macroscopic lesions in the case of bronchopneumonia are evidenced with cranioventral consolidation, while interstitial pneumonia evidence collapse failure with diffuse distribution, which is difficult to characterize (7); in the case of bronchointerstitial pneumonia it is associated with cranioventral consolidation (4), however, other authors associate it with congestion (16).

Finally, in conditions of intensive production system, it has not yet been characterized against any etiological agent, therefore the objective of the present study is to determine an anatomopathological lesion pattern in the lungs with pneumonia caused by Streptococcus pneumoniae in guinea pigs (Cavia porcellus) from intensive breeding systems in Lima.

## MATERIALS AND METHODS

**Place of Study.** The sampling was carried out in a commercial farm for intensive guinea pig breeding, located in Manchay, which is at 590 m.a.s.l. in the district of Pachacamac, located south of the city of Lima. Its latitude is 12°4¨11.8" S - 12°8¨33" S and longitude 76°53¨33.1" W- 76°51¨22.7" W; with an average temperature of 18°C (maximum 27°C and minimum 15°C).

This study is descriptive because it describes the occurrence of the event and does not influence it; it is prospective because it is evaluated based on sampling; transversal because the individuals were observed only once. Convenience sampling was carried out.

Animals. A total of 138 animals were used for histopathological and bacteriological studies. The animals came from an intensive breeding farm that reported mortality due to respiratory processes, and where the inclusion criteria were the affected lungs of guinea pigs, with different signs such as nasal secretions, decreased appetite, dyspnea and rales.
The guinea pigs were destined for slaughter until the established number of samples was completed, using the physical method of cervical dislocation (17,18).

**Macroscopic Pathological Study.** Postmortem examination focused on the lungs using the necropsy technique described by Astaiza et al (19). The extent and location of the lesions were noted on a necropsy card.

Macroscopic alterations were classified according to the evidence of lesions observed at necropsy, as described by Zachary (7). Suppurative bronchopneumonia, fibrinous bronchopneumonia, interstitial pneumonia, embolic pneumonia and granulomatous pneumonia. If in microscopy lesion in bronchus and interstitium is observed, use interstitial bronchopneumonia.

Sampling. Exudate samples were taken from the lung parenchyma using sterile swabs after a cut with a sterile scalpel in a characteristic pneumonic area. Samples were deposited in sterile Falcon tubes containing Stuart transport medium and transported under refrigeration at 4°C within 24 hours to the Microbiology laboratory.

Lung parenchyma samples were collected using sterile swabs by making a cut with a sterile scalpel in a pneumonic area.

Lung samples of approximately 1 cm3 were taken from the cranial lobes for histopathology analysis and preserved in 10% formalin flasks. The diagnosis was made in the laboratory of Veterinary Anatomopathology of the Universidad Científica del Sur.

**Isolation and Bacteriological Identification**. Samples contained in Stuart transport medium were seeded on Blood Agar and incubated in aerobiosis for 24 hours at 37°C. For the identification of Streptococcus pneumoniae, colony characteristics on blood agar, Gram staining and biochemical tests (catalase, oxidase, raffinose, trehalose, mannitol, sorbitol, glucose, sucrose and lactose), similar to those described by Markey et al (12), were considered. Also, a KB005A streptococcus differentiation kit KB005A HiStrep™ Identification Kit was used.

**Histopathological study.** Lung samples were processed by a conventional histological technique using kerosene embedding and hematoxylin-eosin (HE) staining to describe microscopic lesions.

For the microscopic study, the histological characteristics described by Barthold et al (4) were used as references. On the other hand, to classify the histopathological changes, the description of pneumonias by Zachary (7) was taken as a reference.

**Statistical analysis.** For the analysis of the data, descriptive statistics were used and frequency and average tables were established with the Excel program to determine the percentage of types of pneumonia in guinea pigs positive for Streptococcus pneumoniae in intensive breeding systems.

**Ethical aspects.** The described sacrifice technique was approved by the Institutional Animal and Biodiversity Research Ethics Committee of the Southern Scientific University (CIEI-AB-CIENTÍFICA), with registration code 053-2018-PRE16.

## RESULTS

Of the lungs with pneumonia evaluated, 17.4% (24/138) tested positive for Streptococcus pneumoniae.

Of these, 75% (18/24) showed macroscopic features of interstitial pneumonia and 25% (6/24) showed macroscopic features of bronchopneumonia (Table 1).

**Table 1.** Macroscopic characteristics of each type of pneumonia of lungs of 24 Streptococcus pneumoniae-positive guinea pigs (2019).

| Diagnosis of pneumonia | Feature | F | P (%) |
|---|---|---|---|
| Interstitial pneumonia | Diffuse distribution | 17 | 94.44 |
| | Red color | 15 | 83.33 |
| | Elastic texture | 7 | 38.89 |
| | Hemorrhage foci | 7 | 38.89 |
| | No collapse | 7 | 38.89 |
| | Mottled red color | 3 | 16.67 |
| | Subtotal cases | 18 | 100.00 |
| Suppurative bronchopneumonia | Consolidated texture | 5 | 100.00 |
| | Distribution craneoventral | 4 | 80.00 |
| | Dark red color | 5 | 100.00 |
| | Suppurative foci | 5 | 100.00 |
| | Hemorrhage foci | 3 | 60.00 |
| | Red color | 1 | 20.00 |
| | Subtotal cases | 5 | 100.00 |
| Fibrinous bronchopneumonia | Consolidated texture | 1 | 100.00 |
| | Distribution craneoventral | 1 | 100.00 |
| | Hemorrhage foci | 1 | 100.00 |
| | Red color | 1 | 100.00 |
| | Subtotal cases | 1 | 100.00 |
| | **Total cases** | 24 | 100.00 |

F: Frequency; P(%): Percentage (%).

In this study, the diffuse distribution evidence an expansion of lung damage; red coloration caused by congestion of pulmonary blood vessels and alveolar capillaries, suggesting an acute inflammatory process; while the mottled red color could be attributed to chronic cases; the elastic texture and failure of collapse; both features occur as a consequence of thickening of the alveolar walls. These features described are generic and a definitive diagnosis requires histopathological examination for confirmation.

In suppurative bronchopneumonia they had relevance, such as cranioventral distribution, this term is used to describe the location of the lesions not only of the cranial lobes but also other portions involved, the consolidated texture was evidenced in 100% of the cases, the term consolidation indicates the firm texture as a result of loss of air spaces due to exudation and atelectasis. Among other macroscopic characteristics, the following were observed: red and red-gray color, which are characteristic and refer to the time of evolution of the pneumonia, that is, if it is in acute or chronic stage, being the red color referring to acute cases and the tendency to gray refers to those that are progressing to chronic or are chronic.

Different types of pneumonia, type of exudate and stage were found in the microscopic lesion (Table 2).

Likewise, the type of pneumonia, acute or chronic presentation is detailed. On the other hand, 54.17% of interstitial bronchopneumonia and 37.50% interstitial pneumonia; and 8.33% of them correspond to bronchopneumonia (Table 3).

**Table 2.** Microscopic diagnosis of pneumonic lesions in 24 Streptococcus pneumoniae-positive guinea pig lungs.

| Pattern of pneumonias | F | P(%) |
|---|---|---|
| Moderate acute nonsuppurative interstitial pneumonia | 9 | 37.50 |
| Moderate acute nonsuppurative interstitial bronchopneumonia | 7 | 29.17 |
| Moderate chronic nonsuppurative interstitial bronchopneumonia | 2 | 8.33 |
| Moderate acute suppurative interstitial bronchopneumonia | 2 | 8.33 |
| Severe chronic suppurative interstitial bronchopneumonia | 1 | 4.17 |
| Severe acute fibrinosuppurative interstitial bronchopneumonia | 1 | 4.17 |
| Severe acute fibrinosuppurative bronchopneumonia | 1 | 4.17 |
| Severe acute suppurative bronchopneumonia | 1 | 4.17 |
| **Total** | 24 | 100.00 |

The lesional diagnoses present different patterns, which are described based on cellular findings (Table 1,2,3).

**Table 3.** General classification of pneumonias in 24 Streptococcus pneumoniae-positive guinea pig lungs.

| Diagnosis of pneumonia | Acute | Percentage (%) | Chronic | Percentage (%) | Total (%) |
|---|---|---|---|---|---|
| Interstitial bronchopneumonia | 10 | 41.67% | 3 | 12.50% | 54.17% |
| Interstitial pneumonia | 9 | 37.50% | 0 | 0.00% | 37.50% |
| Bronchopneumonia | 2 | 8.33% | 0 | 0.00% | 8.33% |
| Subtotal | 21 | 87.50% | 3 | 12.50% | 100.00% |

Interstitial pneumonia; due to its observed characteristics, it presented heterophilic and mononuclear infiltration in the alveolar interstitium, congestion, edema and type II pneumocyte hyperplasia (Figure 1).

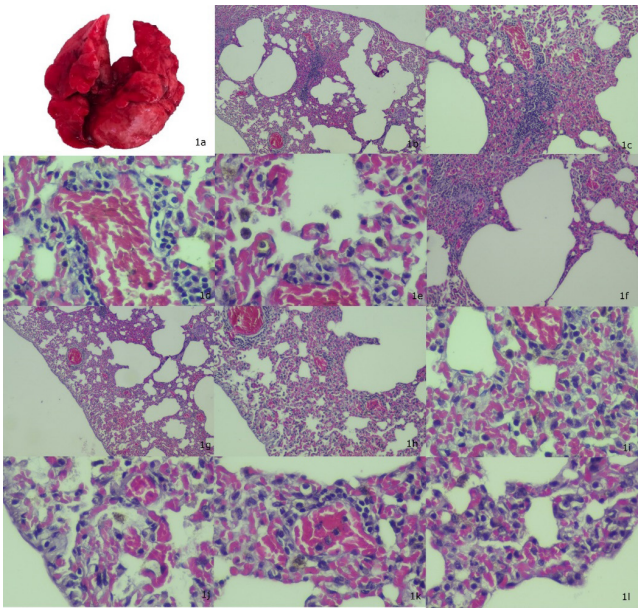

**Figure 1.** Guinea pig lung. Moderate acute non-suppurative interstitial pneumonia (1a) Red color diffusely distributed throughout the lung lobes. (1b) 4x, (1c) 10x, perivascular mononuclear infiltrate, (1d) 40x, (1e) 40x extravasated erythrocytes, free hemosiderin granules, (1f) 10x, (1g) 4x, (1h) 10x, thickened alveolar septa and marked congestion of alveolar capillaries, thickened alveolar septa cause a smaller alveolar lumen. (1i), (1j), (1k), (1l) 40x Alveolar septa are thickened with dilled and congested capillaries. There is mononuclear inflammatory infiltrate (lymphocytes and macrophages), scarce neutrophils in the HE interstitium.

Bronchopneumonia, the acute stage is evidenced by accumulation of exudate, either suppurative or fibrinous, and in some cases both types of exudate, hyperemic or congestive blood vessels. Proliferative changes of fibroblasts, angiogenesis, goblet cell hyperplasia and most importantly, fibrosis is a determinant of the chronic stage (Figure 2).

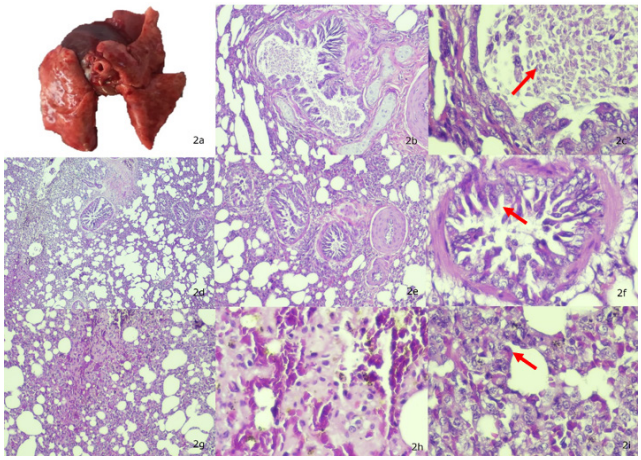

**Figure 2.** Guinea pig lung. Moderate acute diffuse non-suppurative interstitial bronchopneumonia (2a) Diffuse red coloration is evident in the lobes, elastic texture. (2b) 10x and (2c) 40x, (➔) Evidence of catarrhal exudate, cellular detritus, necrosis of bronchial epithelium, exfoliated epithelium in bronchial lumen, areas of hyperplasia of bronchial epithelium. (2d) 4x and (2e) 10x Thickened alveolar septa and congestion of alveolar capillaries, thickened alveolar septa cause smaller alveolar lumen, (2f) 40x (➔) hyperplasia of bronchiolar epithelium, cellular detritus, exfoliating epithelial cells, epithelialization process and catarrhal exudate in bronchiole lumen. (2g) 10x, (2h) and (2i) 40x Congestion, edema, erythrocyte extravasation, macrophage cytoplasm with hemoglobin-derived pigments and mononuclear inflammatory infiltrate in interstitial space, (➔) hyperplasia of type II pneumocytes. HE.

In water suppurative bronchopneumonia, exudate was evidenced in the alveolar, bronchiolar and bronchial lumen, differences were found in the type of exudate, in the case of acute suppurative bronchopneumonia showed abundant suppurative exudate in the bronchial, bronchiolar, alveolar lumen, and congestion; which is compatible with the diagnosis. In the case of fibrinosuppurative bronchopneumonia, it showed the same characteristic of acute suppurative bronchopneumonia with fibrinous exudate (Figure 3).

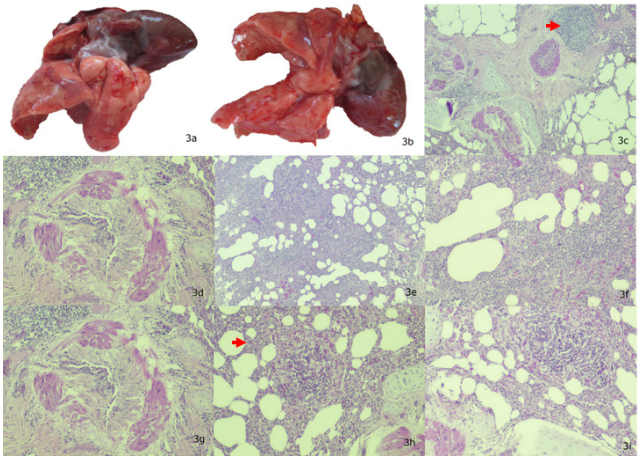

**Figure 3.** Guinea pig lung. Moderate chronic diffuse non-suppurative interstitial bronchopneumonia. (3a), (3b) Diffusely mottled red lung lobules, elastic texture and areas of petechial hemorrhages. (3c) 4x (➔) BALT hyperplasia, proliferated connective tissue in bronchial lumen, (3d) 10x bronchial epithelium depressing undergoing degeneration, loss of attachment, necrosis and lumen exfoliation. (3e) 4x, (3f) 10x, (3g) 40x, (➔) Mononuclear inflammatory infiltrate in interstitial space and proliferation of connective tissue in interstitium, hyperplasia of type II pneumocytes, (3h) 4x, (3i) 10x at bronchiolar level, exfoliated necrotic epithelial cells, detritus, desquamated cells still preserve architecture, detritus, mononuclear infiltrate. HE.

Water fibrinosuppurative interstitial bronchopneumonia showed the features described for fibrinosuppurative bronchopneumonia, with evidence of hyperplasia of type II, mononuclear and heterophilic pneumocytes in the alveolar interstitium. Chronic suppurative interstitial bronchopneumonia showed features of suppurative bronchopneumonia with addition of fibroblast proliferation, angiogenesis, BALT hyperplasia, and vessel-associated lymphoid aggregates (proliferative changes associated with a chronic phase); in addition, the described features of interstitial pneumonia showed proliferative changes which are associated with a chronic stage of the picture (Figure 4).

Interstitial bronchopneumonia; necrosis of the bronchial and bronchiolar epithelium, pneumocyte hyperplasia, inflammatory infiltrates formed by mononuclear and heterophilic infiltrates in the interstitium and alveolar, bronchiolar and bronchial lumen, edema, congestion, hyperemia in acute cases and proliferation of fibrocytes, fibroblasts, angiogenesis, hyperplasia of BALT (bronchial associated lymphoid tissue) and lymphoid aggregates associated with the vessel in chronic cases (Figure 5).

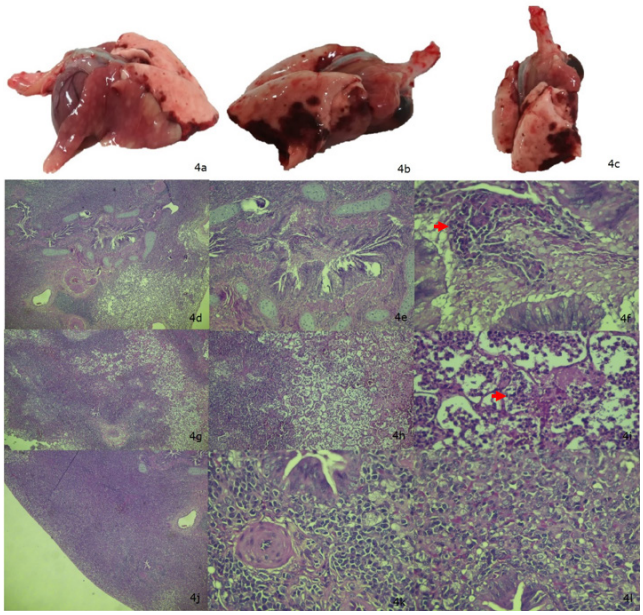

**Figure 4.** Severe acute interstitial fibrinosuppurative bronchopneumonia (4a), (4b) and (4c); cranioventral consolidation, red color of cranial and middle lobes, ecchymotic hemorrhages in caudal lobes, diffuse hemorrhage. (4d) 4x, (4e) 10x, (4f) 40x (➔) Infiltrate of heterophilic PMNs and cells with degenerative processes associated with necrosis, together with catarrhal exudate in the bronchial lumen. (4g) 4x, (4h) 10x, and (4i) 40x (➔) Infiltrate of abundant heterophils, fibrin, and erythrocytes in the alveolar lumen, cells with degenerative processes associated with necrosis. (4j) 4x, (4k) and (4l) 40x the alveolar walls are thickened by hyperplasia of type II pneumocytes, infiltration of heterophils, fibrin threads invading the alveolar lumen. HE.

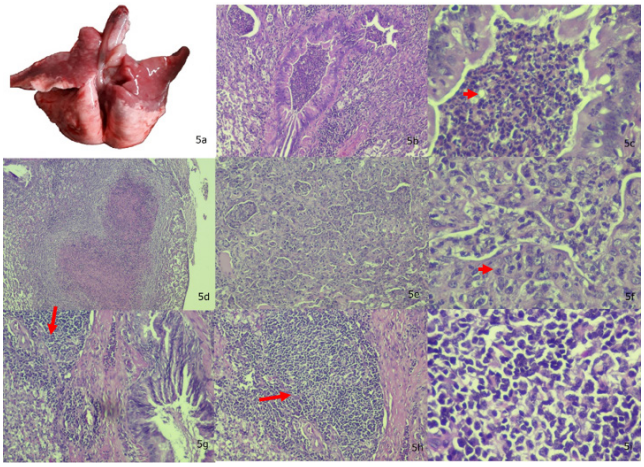

**Figure 5.** Severe chronic suppurative interstitial bronchopneumonia. (5a) Cranioventral consolidation, red-gray color. (5b) 10x and (5c) 40x (➔) suppurative exudate in the bronchial lumen consisting of heterophils, fibrin, necrotic cells and cellular detritus. (5d) 4x abscess, (5e) 10x y (5f) 40x (➔) proliferating connective tissue, mononuclear cells in the alveolar interstitium, hyperplasia of type II pneumocytes, mononuclear cells, PMNs together with necrotic cells and mononuclear cells in the alveolar lumen. (5g) 4x, (5h)10x, (5i)40x BALT hyperplasia (➔)HE.

## DISCUSSION

Of the lung samples evaluated, 17.4% (24/138) were positive for Streptococcus pneumoniae, this pathogen has also been reported in two studies from different organs of guinea pigs (20), and has also been associated with pneumonia in dogs (21). However, other concomitant bacterial forms have been identified in the pneumonic lungs evaluated, which have been reported in other studies, such as Bordetella bronchiseptica, Streptococcus zooepidemicus, Klebsiella pneumoniae and Pasteurella multocida, because they are associated as a common cause of bacterial pneumonia in guinea pigs (4,5,13,22). Likewise, Corynebacterium pseudotuberculosis was associated in alpacas (10), Pasteurella sp, E. coli, Staphylococcus sp in goats with pneumonia (23).

The macroscopic characteristics (Table 1) are related to the microscopic lesions (Table 2). In this study, interstitial pneumonia, was observed with diffuse distribution in 94.44% (17/24) of cases, red coloration (Figure 1a; 2a) in 83.33% (15/24) of cases, mottled red color (Figure 3a, b) 16.67% (3/24), suggesting a chronic process; elastic texture is 38. 89% (7/24) and collapse failure was involved in 38.89% (7/24); the macroscopic characteristics of interstitial pneumonia agree with descriptions in other species (24,25); in addition Cross et al (26) reports foci of hemorrhage in guinea pigs, this characteristic was found in 38.89% (7/24) of the evaluated cases (Table 1). In the case of interstitial bronchopneumonia the macroscopic findings present similarity in one characteristic; congestion (16), it is also associated with cranioventral consolidation (4), consolidation in intermediate lobe (27) but, it was not evidenced in this study. The definitive diagnosis of interstitial bronchopneumonia is microscopic.

At the microscopic level, moderate acute non-suppurative interstitial pneumonia was evidenced in 37.50% (9/24) (Table 2; Figure 1b-1l) this type of pneumonia was reported in some cases of guinea pigs (28,29,30,31).

In moderate non-suppurative interstitial bronchopneumonia (Table 2) in acute cases (Figure 2b-2i) and vessel-associated lymphoid aggregates in chronic cases (Figure 3c-3i) which showed in acute cases 29.17% (7/24) and chronic cases 8.33% (2/24) these microscopic features were also described in cattle, dogs (16,27,31,32).

In the case of suppurative bronchopneumonia, the macroscopic features (Table 1). The characteristic of as cranioventral consolidation, suppurative foci and among other described characteristics (Figure 4a-4c; 5a) orients the macroscopic diagnosis of suppurative bronchopneumonia. Likewise, fibrinous bronchopneumonia presents cranioventral consolidation and foci of hemorrhage, among other characteristics (Table 1) (7) (7).

The described characteristics and lesion diagnoses (Table 2) at microscopic level are consistent with those reported in rabbits, dogs, cattle and guinea pigs (21,24,31,33). In addition, Zachary (7) mentions that the hemorrhage foci presented in fibrinous bronchopneumonias are produced by tissue damage generated by the noxa.

At the microscopic level (Table 2), acute suppurative bronchopneumonia was evidenced in 4.17%. For acute fibrinosuppurative bronchopneumonia another 4.17%; the characteristics and diagnosis have also been described in rabbits, dogs, cattle and guinea pigs (21,31,33).

On the other hand, severe acute fibrinosuppurative interstitial bronchopneumonia (Figure 4d-4l) with 4. 17% showed the characteristics described for fibrinosuppurative bronchopneumonia, with evidence of interstitial pneumonia characteristics, which makes us think of a possible coinfection and interaction between agents (31), which could generate this association of two patterns of pneumonias: Likewise, chronic suppurative interstitial bronchopneumonia (Figure 5b-5i) represented 4.17%, adding chronic interstitial pneumonia. Finally, acute suppurative interstitial bronchopneumonia accounted for 8.33% showed described features of acute bronchopneumonia, with additional features of acute interstitial pneumonia, suggesting a possible co-infection. The characteristics described are related to those described in cattle, sheep and rabbits (24,34, 35), they report that more than one agent can be involved in pneumonias.

Bronchopneumonia represented 8.33% (Table 3) of the lesional diagnosis of pneumonias with Streptococcus pneumoniae isolation, conformed by acute suppurative bronchopneumonia by 4.17%, acute fibrinosuppurative bronchopneumonia by 4.17% (Table 2). There are other reports of pneumonias caused by S. pneumoniae, in healthy white rabbits of the New Zealand breed, through experimental pneumonia in 75% of the most representative microscopic findings was bronchopneumonia (33); and in dogs with 6.10% (21).

54.17% represented interstitial bronchopneumonia (Table 3), conformed by 29.17% acute non-suppurative interstitial bronchopneumonia, 8.33% chronic non-suppurative interstitial bronchopneumonia, 8.33% acute suppurative interstitial bronchopneumonia, 4. 17% chronic suppurative interstitial bronchopneumonia, 4.17% acute fibrinosuppurative interstitial bronchopneumonia (Table 2), which has been reported in viral infections (7), inhaled toxic, Adenovirus in guinea pigs (4), influenza in an experimental study (16) or a complex as reported by Hick et al (37). This suggests coinfection and interaction between agents, which agrees with other authors (15) because they describe the possibility of a complex of viral and bacterial causes causing pneumonias. Likewise, the virus could be a preceding factor for the development of pneumococcal bacterial infection as described by Pittet et al (6), Ballinger and Standiford (36) in an experimental study in mice. However, interstitial pneumonia can be due to other factors Zachary (7); this could represent a limitation of the present study, since the participation of other pathogens such as virus, parasites, among others, was not diagnosed.

Interstitial pneumonia represented 37.50% (Table 3), conformed by acute non-suppurative interstitial pneumonia for 37.50% (Table 2); this lesional diagnosis has been reported in bovines (41.1%) (28), however, no bibliographic evidence of cause and effect with Streptococcus pneumoniae isolates was found.

Similar results were described by Jong-Hwan et al (38), where interstitial pneumonia was also shown by isolating bacterial agents. Interstitial pneumonias can be caused by virus inhalation of toxic gases, toxins absorbed in the alimentary tract (endotoxin), or toxic metabolites generated locally in the lungs (3-methylindole and paraquat) (7). In guinea pigs these lesions have been associated to Cytomegalovirus (CMV) and Parainfluenza 3(PI-3) (4), Sendai virus or mouse pneumonia virus (37), in an experimental study of Leptospira in guinea pigs (30), porcine circovirus-2 (PCV2) (39) and Lassa virus in an experimental study (40).

In conclusion, interstitial pneumonia, interstitial bronchopneumonia and bronchopneumonia with diagnosis of Streptococcus pneumoniae are lesional patterns found in intensive breeding systems in Lima.

## Conflict of interest

The authors have no conflicts of interest to declare.

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