



Contents lists available at ScienceDirect

Asian Pacific Journal of Tropical Disease

journal homepage: www.elsevier.com/locate/apjtd



Infectious disease research

doi:10.1016/S2222-1808(15)61009-X

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Pattern and associated risk factors of caprine pneumonia complex in Nigeria

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ARTICLE INFO

Article history:

Received 29 Jan 2016

Received in revised form 17 Feb 2016

Accepted 8 Mar 2016

Available online 16 Mar 2016

Keywords:

Caprine pneumonia

Risk factors

Goats

Nigeria

ABSTRACT

Objective: To investigate the pattern of lung consolidation in natural infections and identify the risk factors associated with caprine pneumonia in Nigeria so as to elucidate and aid the understanding of caprine respiratory disease complex in Nigeria.

Methods: A total of 700 goats were examined before slaughtering between March 2014 and July 2015. Ante mortem evaluation for physical characteristics, body condition, breed and sex, gross morphometry for estimation of the percentage of lung consolidation and histopathology was performed according to standard techniques. Data were presented in percentages, mean \pm SEM and subjected to non-parametric analysis.

Results: The results showed that 30.3% of goats belonged to the breed of West African Dwarf, 55.4% Red Sokoto (RS) and 14.3% Sahelan. As for the age distribution, 3.7% of them were one year old, 30.7% were two years old and 65.6% were above two years old. The overall prevalence of pneumonia was 59.7%. The mean lung consolidation score was 8.1 ± 0.5 , consolidation for male was 7.8 ± 0.5 and 21.4 ± 7.7 for female ($P < 0.05$). There was more consolidation on the right lung and caudal lobes, and RS showed the highest prevalence of consolidation. There was a positive correlation of contralateral lobar consolidation in the pneumonic animals, while significant effect of sex and body scores on the lung consolidation was observed ($P < 0.05$). The types of pneumonia observed were bronchopneumonia (41.6%), bronchiointerstitial pneumonia (8.7%), interstitial pneumonia (7.9%), verminous pneumonia (0.3%), granulomatous pneumonia (0.9%) and normal lungs (40.7%).

Conclusions: Sex, breed and body scores were observed to be risk factors associated with caprine pneumonia in Nigerian goats. In this study, transport stress may be responsible for the high consolidation in RS. This information will help to increase the knowledge on the pathogenesis and the risk factors that often aggravate the prevalence of pneumonia in goats.

1. Introduction

Goats are important commodities to a large segment of the world's population as a source of meat, milk and skin. Goats (*Capra hircus*) are descendants from the species *Capra aegragus*, and the first ruminant to be domesticated[1]. The economic importance of goats cannot be overemphasized because they serve as a source of income for the poor, because they are comparably

cheap to manage and serve as essential livestock in rural households[2]. However, goats are on the receiving end of adverse environmental influences, stressful management practices and conditions which predispose to respiratory diseases.

Pneumonia is no doubt a major constraint to small ruminant production worldwide[3], causing severe morbidity manifested physically as unthriftiness or weight loss[4] and large scale mortality in domestic and wild goats[2,5]. Pattern of pulmonary consolidation or pneumonia serves as a reliable clinical parameter in auscultation[6]. The pattern of pulmonary consolidation has been reported in experimental conditions. Emikpe and Akpavie[7] reported a mean pulmonary consolidation score of 6.83 in West African Dwarf (WAD) goats, 3%–80% pulmonary consolidation score in aerosol-vaccinated calves[8] and 32% pulmonary consolidation score in Markor goats[5], but little is known regarding the influence of age, sex, body score and breed on the

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All experiment procedures involving animals were conducted in accordance to international guides for use and care of experimental animals and approved by University of Ibadan animal care use in research and experiment committee.

Foundation Project: Supported by the University of Ibadan (Grant No. SRG/FVM/2010/6A).

The journal implements double-blind peer review practiced by specially invited international editorial board members.

pattern of caprine pneumonia in Nigerian goats.

The knowledge of the lobar and morphologic pattern of pulmonary consolidation, especially with respect to age, sex, breed and body score in goats, will provide insight as to the probable etiology, route of exposure to the causative agent, pathogenesis of the lesions, effect on pulmonary function, possible complications and sequelae of the pulmonary lesion.

This study investigated the pattern of lung consolidation in natural infections and attempted to identify the risk factors associated with caprine pneumonia in Nigeria so as to elucidate and aid the understanding of caprine respiratory disease complex in Nigeria.

2. Materials and methods

2.1. Study area

This study was conducted at the slaughterhouse posted by the University of Ibadan Zoological Garden, Ibadan, southwest of Nigeria for over 60 weeks. During the study period, an average of 25 goats were slaughtered weekly. The study was conducted between March 2014 and July 2015.

2.2. Study animals

The goats were sourced mostly from the northern regions of Nigeria and transported to the University of Ibadan where the animals were meant to feed the captive wild carnivores housed in the prestigious zoo. A total of 700 indigenous goats comprising WAD, Red Sokoto (RS) and Sahelian (SH) breeds were examined.

2.3. Ante mortem examination

The sex of the goats was determined physically, and their age was determined by the dentition method described by Ethiopia Sheep and Goat Productivity Improvement Program[9], and the general body condition was evaluated systemically with a nominal scale of 0 to 2 (good, fair and poor).

2.4. Postmortem evaluation of pneumonia

Gross examination of the lungs for changes in consistency, texture, color and degree of consolidation was performed. The extent of pneumonia was determined by visual observation, palpation and measurement of the lesion which was then manually plotted onto a lung diagram for estimation as a percentage of each lung lobe and for morphometric evaluation. The degree of pulmonary consolidation expressed as a percentage of the total lung volume was thereby estimated[7,8].

2.5. Morphometric evaluation

Each of the lobes was consecutively numbered on the ventral and

dorsal side, and the surface proportion in relation to the total lung surface was calculated[7].

2.6. Statistics

The distributions of the animals were presented in frequency and percentages. The pulmonary consolidation scores were expressed as mean \pm SEM. Odd ratio was estimated and data inferentially analysed by *Chi*-square test, *t*-test and ANOVA at 5% significance by using SPSS version 16.

3. Results

3.1. Distribution of the animals

Among those 700 goats, 685 (97.9%) were male and 15 (2.1%) female. A total of 212 (30.3%) of them were WAD, 388 (55.4%) RS and 100 (14.3%) SH (mixed) breeds. As for the age distribution, 26 (3.7%) were one year old, 215 (30.7%) were two years old and 459 (65.6%) were above 2 years old (Table 1).

Table 1

Distribution of the goats based on the identification of pneumonia.

Physical characteristics		Non-Pneumonic	Pneumonic	Total	Odd ratio	<i>P</i> value
Breed	WAD	70 (10.0%)	142 (20.3%)	212 (30.3%)	0.029	
	RS	166 (23.7%)	222 (31.7%)	388 (55.4%)		
	SH	46 (6.6%)	54 (7.7%)	100 (14.3%)		
	Total	282 (40.3%)	418 (59.7%)	700 (100.0%)		
Sex	M	274 (39.1%)	411 (58.7%)	685 (97.9%)	0.583	0.045
	F	8 (1.1%)	7 (1.0%)	15 (2.1%)		
	Total	282 (40.3%)	418 (59.7%)	700 (100%)		
Age (year)	< 1	14 (2.0%)	12 (1.7%)	26 (3.7%)	0.326	
	2	83 (11.9%)	132 (18.9%)	215 (30.7%)		
	> 2	185 (26.4%)	274 (39.1%)	459 (65.6%)		
	Total	282 (40.3%)	418 (59.7%)	700 (100.0%)		
Body score	Good	81 (11.6%)	81 (11.6%)	162 (23.1%)	0.016	
	Fair	127 (18.1%)	213 (30.4%)	340 (48.6%)		
	Poor	74 (10.6%)	124 (17.7%)	198 (28.3%)		
	Total	282 (40.3%)	418 (59.7%)	700 (100.0%)		

M: Male; F: Female.

3.2. Clinical examination

Clinically, 162 (23.1%) of the animals were in good body condition, 340 (48.6%) apparently in fair body condition, and 198 (28.3%) in poor body condition. The prevalence of pneumonia in the goats studied was 59.7% (418) while 282 (40.3%) were normal.

3.3. Consolidation pattern

From the 418 (59.2%) pneumonic goats, different patterns of pulmonary consolidation were observed grossly, including 294 were cranioventral with marked consolidation of the apical to the middle lobes (Figure 1), 56 caudodorsal consolidation affecting the diaphragmatic lobes, 51 accentuated and markedly distended interlobular pattern and 8 multifocal, 4 emphysematous and 5 haemorrhagic.

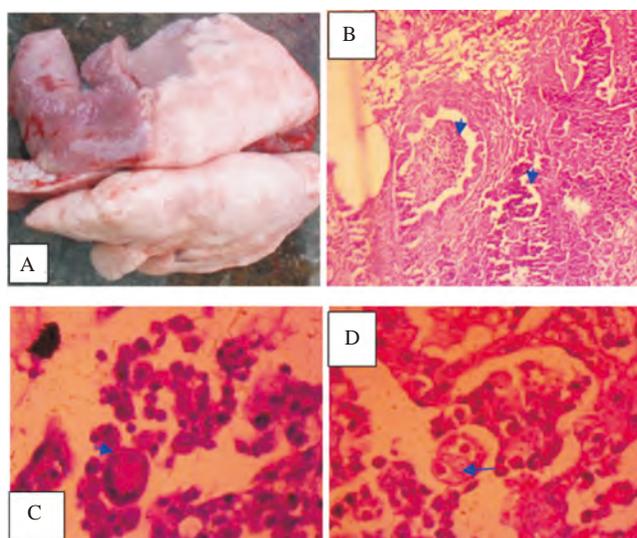


Figure 1. Gross-right unilateral cranio-ventral consolidation affecting 22% of the lungs (A); Diffuse fibrino-purulent bronchopneumonia with exudates (arrow) in air ways and spaces (100×) (B); Giant cell (arrow) in broncho-interstitial pneumonia (1 000×) (hematoxylin-eosin) (C); Verminous pneumonia showing section of larva (arrow) (400×) (D).

The right lung had higher consolidation followed by the caudal lobes in the goats. The right cranial (apical) lobe had the highest occurrence of consolidation followed by the right middle lobe, right cranial posterior lobe, left cranial lobe and caudal lobes. The accessory lobe was the least consolidated in the examined goats.

The RS breed had the highest occurrence of pulmonary consolidation and the least was observed in the SH/mixed breeds. Furthermore, animals in fair and poor body conditions had the highest occurrence of pulmonary consolidation as compared to those in good ($P < 0.05$). And more female animals were observed with high occurrence of pulmonary consolidation (Figure 2).

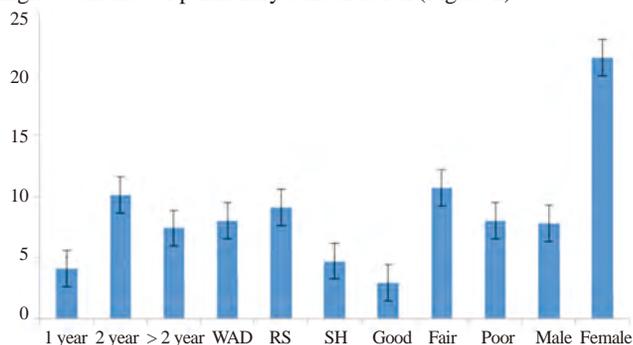


Figure 2. Distribution of the consolidation scores in examined Nigerian goats.

It was also observed that the occurrence of pneumonia increased with ages of the goats across breeds. However, more pneumonic cases were from above 2 years old in RS breed. Similar pattern was observed from the fair and poor body scores (Table 1).

The mean pulmonary consolidation score was 8.1 ± 0.5 , 7.8 ± 0.5 in male goats and 21.4 ± 8.7 in the female goats. The influence of age was also remarkable in the susceptibility of pneumonia as higher consolidation score was observed in goats within one year. The RS breed had higher consolidation score than that of the WAD and less in the SH breed. The goats with poor body conditions and in clinically debilitated states had higher consolidation scores. The specific mean consolidation score on the different pulmonary lobes

are shown in Figure 3. There was significant correlation between lobar consolidation on each side of the lung ($P < 0.05$).

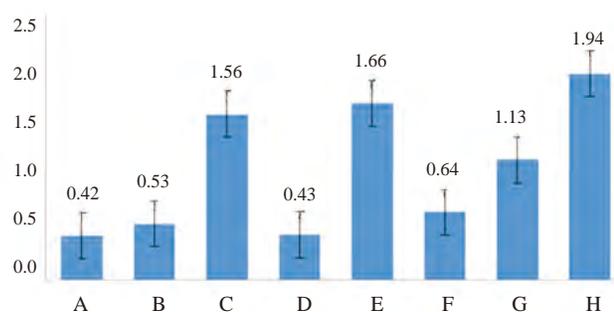


Figure 3. Lobal distribution of pulmonary consolidation scores from the examined goats.

A: Left cranial lobe; B: Left cranial P lobe; C: Left caudal lobe; D: Accessory lobe; E: Right cranial anterior lobe; F: Right cranial posterior lobe; G: Right middle; H: Right caudal lobe.

3.4. Histologic pattern

The histological morphologies of the pneumonic goats include bronchopneumonia (41.6%) - fibrinous and suppurative (Figure 1B), broncho-interstitial pneumonia (8.7%) with giant cell formation (Figure 1C), interstitial pneumonia (7.9%), verminous pneumonia (0.3%) (Figure 1D) and granulomatous pneumonia (0.9%). There were also a few with congestion, edema, and atelectasis, and normal lung (40.7%). The distribution across breeds, sex, ages and body scores of the animals is shown in Table 2.

3.4.1. Bronchopneumonia

There was hyperaemia, the bronchi, bronchioles and alveoli containing exudate and cellular debris. Exudate varies from oedema, fibrin, neutrophils, and abundant alveolar macrophages. Infilling of alveoli, bronchioles and small bronchi obliterated airspaces with attenuation of septa. There was also hyperplasia of bronchial associated lymphoid tissue and thickening of the pleura and formation of a few condensed fibrin thrombi in the parenchyma.

3.4.2. Broncho-interstitial pneumonia

There was also hyperaemia, degeneration, necrosis and sloughing of bronchial and bronchiolar mucosa epithelium. Peribronchial mononuclear cellular infiltrates to the broncho-alveolar bundle. Alveolar cells were also necrotic with the presence of macrophages, lymphocytes, a few neutrophils and syncytial giant cells in air spaces. Some of the degenerate epithelia cells contain eosinophil to basophilic intranuclear inclusion bodies.

3.4.3. Interstitial pneumonia

There was thickening or accentuation of the alveolar septa due to congestion of alveolar capillaries, haemorrhages and/or infiltration of mononuclear inflammatory cells including lymphocytes and macrophages. Disruption of alveolar lining and formation of hyaline membrane was also common.

3.4.4. Granulomatous pneumonia

There was diffuse expansion of the interstitium by infiltrating

Table 2Histological classification of the goats examined. *n* (%).

Classification		Normal	Bronchopneumonia	Broncho-interstitial	Interstitial pneumonia	Verminous pneumonia	Granulomatous pneumonia	Total	<i>P</i>
Breed	WAD	73 (10.4)	101 (14.4)	19 (2.7)	16 (2.3)	1 (0.1)	2 (0.3)	212 (30.3)	0.422
	RS	165 (23.6)	153 (21.9)	31 (4.4)	35 (5.0)	1 (0.1)	3 (0.4)	388 (55.4)	
	SH	47 (6.7)	37 (5.3)	11 (1.6)	4 (0.6)	0 (0.0)	1 (0.1)	100 (14.3)	
	Total	285 (40.7)	291 (41.6)	61 (8.7)	55 (7.9)	2 (0.3)	6 (0.9)	700 (100.0)	
Sex	Male	277 (39.6)	288 (41.1)	59 (8.4)	53 (7.6)	2 (0.3)	6 (0.9)	685 (97.9)	0.631
	Female	8 (1.1)	3 (0.4)	2 (0.3)	2 (0.3)	0 (0.0)	0 (0.0)	15 (2.1)	
	Total	285 (40.7)	291 (41.6)	61 (8.7)	55 (7.9)	2 (0.3)	6 (0.9)	700 (100.0)	
Age (year)	≤ 1	14 (2.0)	6 (0.9)	5 (0.7)	1 (0.1)	0 (0.0)	0 (0.0)	26 (3.7)	0.313
	2	83 (11.9)	94 (13.4)	21 (3.0)	14 (2.0)	0 (0.0)	3 (0.4)	215 (30.7)	
	> 2	188 (26.9)	191 (27.3)	35 (5.0)	40 (5.7)	2 (0.3)	3 (0.4)	459 (65.6)	
	Total	285 (40.7)	291 (41.6)	61 (8.7)	55 (7.9)	2 (0.3)	6 (0.9)	700 (100.0)	
Body score	Good	79 (11.3)	68 (9.7)	4 (0.6)	8 (1.1)	1 (0.1)	2 (0.3)	162 (23.1)	0.050
	Fair	130 (18.6)	137 (19.6)	35 (5.0)	36 (5.1)	0 (0.0)	2 (0.3)	340 (48.6)	
	Poor	76 (10.9)	86 (12.3)	22 (3.1)	11 (1.6)	1 (0.1)	2 (0.3)	198 (28.3)	
	Total	285 (40.7)	291 (41.6)	61 (8.7)	55 (7.9)	2 (0.3)	6 (0.9)	700 (100.0)	

mononuclear cells. Alveoli were obliterated. The presence of necrotic centre flanked by abundant macrophages, lymphocytes and plasma cells and an outer rim of connective tissue.

3.4.5. Verminous pneumonia

This was characterized by the presence of parasitic segments in airways (bronchi and bronchiole) with an associated peribronchial reaction and also identification of larva stages in the alveoli.

Bronchopneumonia was common in all the three breeds as compared to interstitial in RS, verminous and granulomatous pneumonia in WAD ($P < 0.05$). Similar pattern of the body score as seen in the consolidation was observed with histological type of pneumonia ($P < 0.05$). However, these distribution was more in the male goats and those above 2 years ($P > 0.05$).

4. Discussion

This study elucidates the risk and predisposing factors of pneumonia complex in Nigerian goats. This is a part of the progressive study following our preliminary observations[2]. Pneumonia in goats is one of the most important infections which are frequently diagnosed in the field and abattoirs[10]. This study gives a detailed pathological scoring of the lung lesions in natural cases of caprine pneumonia in Nigeria.

Consolidation is the hallmark of pneumonia which is best detected by its firm texture on palpation. These lesions may be dark red, gray-pink, or gray depending on the age and nature of the process, but a color change without altered texture may simply represent patchy areas of congestion or hemorrhage (Akpavie, personal comment). In this study, the high consolidation observed on the lobes of the right lung suggests inhalation route involvement due to the abrupt and early branching of the bronchus[11]. Moreover, the caudal lobe involvement often suggests hematogenous route and atypical pneumonia.

The influence of age in this study was remarkable in the susceptibility to pneumonia as observed in the previous study where there was increased susceptibility of the young adult animals and has been attributed to increased immuno-susceptibility[2,12].

Our finding of 60.5% pulmonary consolidation is very much consistent with the findings of Bakke (1982) in a study of 209 sheep

lungs. However, the mean consolidation was slightly higher than 6.83% reported by Emikpe and Akpavie[7] in experimental induced caprine pneumonia but within a range of 3%–80% observed by Jericho and Langford[8] in calves, these variations could be added to the environmental influences.

The higher consolidation score observed in goats within two years of age corroborates the susceptibility of young adults to pneumonia which could be due to deficient pulmonary clearance. The RS breed had more consolidation score than that of the WAD breed and less than that in the mixed breed. This could be attributable to transport or other managemental stress associated with transport of RS from the northern region to the southern part of Nigeria where the study was conducted.

Animals with poor body conditions and clinically debilitated states had higher consolidation scores, which was similar to findings in WAD goats[13], in finished pigs[14], and in cattle[4]. Apparently, those with fair body scores were in advanced stages of pulmonary consolidation. The high consolidation scores in male animals may be due to the managemental factors allowing free ranging of the animal and increased activity of the male goat[15]. The pattern of bronchopneumonia further corroborates findings of Emikpe *et al.*[2] from archival lung samples of sheep and goats considering influence of season and stress. More so, Emikpe and Akpavie underscored the importance of manheimiosis in this environment[13].

In view of the present information, improvement of environmental conditions and management systems will lead to a reduction of respiratory diseases, particularly in face of bacterial complications. Additionally, disease surveillances are greatly required for effective control of infectious agents in this species which is experiencing ravaging mortality across Africa. Worthy of mention are mortalities from peste des petits ruminants virus[16], manheimiosis[7,17], and mycoplasmosis[18,19] which would also be elucidated. In this study, fibrinous bronchopneumonia was the commonest pattern of pneumonia. Sex and body scores were significant risk factors in caprine pneumonia. Transport stress may be responsible for the high consolidation in RS.

The consolidation associated with the viral infection has been established to be mild due to the fact that viruses do produce patchy consolidation affecting a small part of the lungs and the pattern of

the pneumonia is usually interstitial[20,21]. A peak consolidation was associated with the secondary bacterial complication of *Mannheimia hemolytica*, and other pathogenic bacteria[7,22,23]. The degree of consolidation has been associated with the virulence of the field strain of the bacteria encountered and the host immunosuppression from virus reduced efficiency of alveolar macrophages in pulmonary clearance[23].

Obviously, with these multifactorial influences on caprine pneumonia complex, multivalent vaccines had been proposed as a good solution to major upper and lower respiratory disease constraints in small ruminant production systems in lesser developed countries throughout the world[24]. And also the prospect of immunomodulation and the advantages of mucosal immunity raise hope in the face of these daunting respiratory challenges in small ruminant populations.

In conclusion, this study provides baseline information on the consolidation pattern of natural pneumonia in goats in the tropics and influence of host factors. It will also help to piece together the pathogenesis and prognosis, whether or not lesions have common features irrespective of the inciting causal factors. This information will also help increase the body of knowledge on risk factors and possible causal agents involved in caprine pneumonia complex especially in Nigeria.

Conflict of interest statement

We declare that we have no conflict of interest.

Acknowledgments

Sincere appreciation goes to the management of the zoological gardens of University of Ibadan for their support and unrestricted access during this study.

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