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Research Article

Pathologic Lesions in Condemned Lungs of Cattle at Two Selected Abattoirs Around Harare, Zimbabwe

Vhori Farai*, Wandayi Simbarashe and Sakara Grace M

Department of Veterinary Pathobiology, University of Zimbabwe, Zimbabwe

***Corresponding Author:** Vhori Farai, Department of Veterinary Pathobiology, University of Zimbabwe, Zimbabwe.

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Abstract

In this paper, the author used gross and histologic methods to characterize lesions from condemned (deemed unfit for human consumption by public health officials) cattle lungs, determine their prevalence and estimate the associated financial losses for evaluation. This cross-sectional study was done at two selected abattoirs within 50km radius of Harare during the period May 2019 to August 2019. Gross and histologic methods were used for evaluation. Gross lesions were characterized and grouped based on the texture, distribution, appearance, and/or type of exudate. Samples of approximately 2cm3 were collected from the affected lobes, preserved in 10% formal saline and processed routinely for further histopathologic evaluation. McNemar's test and the Cohen's kappa statistic were used to test the interrater reliability of the two methods (k = 0.39). Gross diagnosis is often misleading since various lesions can have a similar presentation. Of the 1275 lungs inspected, 21.8% were condemned. The frequency of lung condemnations varied significantly ($P < 0.05$) between the two abattoirs; abattoir 1 (25%) and abattoir 2 (18%). Lesions were grouped into pre-existing conditions and those that could have developed during the slaughter processes. Pre-existing conditions accounted for a greater portion of lung condemnations (74.8%) with pneumonia contributing 81.3% of them. The other pre-existing lesions seen were pulmonary edema (12.9%) and fibrosis (1.1%). Conditions related to the slaughtering process occupied 25.1% of lung condemnation with blood splash (12.9%) as the main reason. In conclusion, these results indicated that pneumonia at large and specifically interstitial pneumonia (41.4%) had the highest prevalence and is a challenge that needs appropriate strategy for prevention and control. In addition to this, the slaughtering technique is also contributing to a sizeable financial loss (approximately 25% of lung condemnations).

Keywords: Pathologic; Condemned Lungs; Cattle; Abattoirs

Introduction

Livestock play an important part in improving livelihoods and the financial prudence of developing countries [1]. In Zimbabwe cattle account for 35-38 percent of the Gross Domestic Product (GDP) contributed by the agricultural sector and they are a crucial asset providing income, employment and nourishment for the population as a whole [2].

Diseases are the major drawbacks to animal production especially in developing countries [3]. According to an unpublished source from data collected by meat inspectors in Harare, organ condemnations can be up to 60% of the slaughtered animals amongst which lung condemnation contributes 18%. It therefore implies that the proportion of cattle with lung condemnation could be a useful indicator for animal health surveillance purposes as well as for detecting emerging diseases. In addition, the extent to which the public is exposed to zoonotic conditions is also estimated. Developing countries including Zimbabwe are confronted with both economic and technological challenges in putting to use most of the modern methods of disease surveillance and as such abattoirs provide an excellent opportunity for detection of these diseases [5].

The need for food safety and disease control obliges meat inspection at the abattoirs [7]. An abattoir or slaughterhouse is a facility or premise approved and registered by the controlling authority for hygienic slaughtering and inspection of animals, processing and effective preservation and storage of meat products for human consumption [8]. Diseases affecting cattle are characterized

by gross lesions best seen during postmortem examination at abattoirs (meat inspection) and microscopic lesions seen on histology. Rapid presumptive diagnosis and further laboratory investigations can be made based on the pathological findings observed at necropsy. On top of the list are respiratory diseases which present a serious problem to farmers because of the economic losses they cause as well as the production losses and expenses of the care or preventions that they generate. These diseases affect the ability of an animal to survive, grow and reproduce [11,12]. The current beef cattle herd in Zimbabwe is estimated to be around 5.5 million (figures are uncertain). Beef consumption has since declined from 13kg to 4 to 6kg per capita reflecting rising cost of beef, income changes and the availability of cheap chicken meat [13].

In Zimbabwe, statistical data on the frequency of pulmonary diseases are unavailable and no comprehensive research has been done on their epidemiology. In this study focus is on the gross and histologic examination of the condemned lungs because it is usually sufficient to classify a condition even if the etiology cannot be identified. In addition, knowledge of the pattern of pneumonia provides important clues as to the probable etiology, route of exposure to the causative agent, pathogenesis of the lesions, effect on pulmonary function, and the sequalae and complications [14].

Diagnostic work in the beef industry is currently based on gross inspection and condemnation of organs with obvious lesions at abattoirs. Examination with the unaided eye has a low sensitivity when compared to other diagnostic techniques. Further analysis to confirm accuracy and importance of gross postmortem findings from condemned organs at slaughterhouses is lacking. This leaves a gap for passage of diseased and potentially harmful meat into the food chain or incineration of condemned but otherwise harmless offals which could be rendered for pet food. Various zoonotic diseases such as tuberculosis, hydatidosis, cysticercosis and toxoplasmosis are transmissible to humans through the consumption of infected meat [15]. Information about the degree to which the public is exposed to certain zoonotic conditions of cattle origin is missing. Veterinarians are regularly called to diagnose, treat, and implement health management practices to decrease the impact of these diseases. To do so they need specific information including the pattern of the lesions under consideration and most likely etiologic agents affecting the specified area. This information is currently unavailable and it slows down the implementation of control programs.

Livestock processed at abattoirs represent, to some extent, a valid cross-section of the livestock population. On top of the list are respiratory system diseases in cattle production which have a huge economic impact evidenced by the high morbidity and mortality on most farms [19]. Lungs are good sentinels for surveillance of diseases affecting both animals and man [20]. This information can be used to estimate financial losses due to condemnations and understanding patterns of diseases affecting the lung will also form the basis for disease prevention and control measures.

Materials and Methods

Description of the study site

A purposive selection method was used to select two government inspected abattoirs within a 50km radius of Harare CBD, Zimbabwe (17^0 49' 4" South, 31^o 2' 41" East.). These abattoirs slaughter adult cattle from agro-ecological region II. The areas where the cattle come from receive an average of 805.2 mm of rainfall per year and a temperature range of 13 ^{o}C-31^{o}C.

Study design

A cross- sectional study was conducted. The selected abattoirs were visited from May 2019 to August 2019 to obtain information and samples from the condemned cattle lungs.

Sample size determination

The average number of cattle slaughtered was 50 per day for each abattoir. Approximately 12 196 cattle were slaughtered during the study period. The average weight of lungs from a single animal was 3kg and the average wholesale price of lungs was USD 1.5/kg during the period of study. We randomly selected about 10% of the cattle slaughtered during the study period. The 10% of the cattle were considered adequate after calculating the minimum sample size using the formula given by Thrusfield (2005) with a 95% confidence level and a required 5% precision as shown below:

$$n = \frac{Z^2 p(1-p)}{d^2}$$

Where n is the required sample size, Z = 1.96, p is the expected prevalence, and d is the required precision.

Currently there is no information on the prevalence of lung condemnations. Prevalence on condemnations were based on the study by Chambers (1986), in which 12.9% of all bovine offal items examined were condemned. However, in this study they did not in-

dicate the frequency of condemned lungs but indicated that 50% were livers. We therefore assumed that lungs and intestines made up the remaining 50% of the offals making the prevalence of lung condemnations approximately 7%. The minimum sample size was thus determined to be 101 cattle. Lungs from one cow were considered to be a single observation.

Gross Examination

The postmortem procedure for lung evaluation was carried out according to guidelines on meat inspection for developing countries [21]. In summary, lung evaluation was through visualization, palpation, and incisions of affected portions. Lungs with pathology or contamination were condemned to prevent their entrance into the human food chain. The conditions were categorized into preexisting conditions and conditions that could have developed during slaughter processes [22]. The preexisting conditions were pneumonia, fibrosis, edema, cysts and parasites while blood splash, emphysema and atelectasis were slaughter related.

Pneumonia was used to refer to any inflammatory lesion in the lungs. Diffusely edematous and heavy lungs that at times fail to collapse when the thorax is opened were categorized as having interstitial pneumonia. Rib imprints were a common finding and the affected lungs had an elastic texture [23,24]. Lungs with a cranioventral consolidation were categorized as having bronchopneumonia. The type of exudate on cut surface was used to further classify bronchopneumonia as either suppurative or fibrinous [25].

Lungs that were wet and heavy with notably distended interlobular septa, most of which with tracheal frothing, were considered to have pulmonary edema. These lungs had a gelatinous appearance on cut surface [26,27].

Conditions related to slaughter were also grouped together. Lungs with multifocal to diffuse petechial hemorrhages were categorized as blood splash [28]. Atelectasis without any other pathology was classified as a slaughter related pathology and classified with the major lesion if the two existed together. This was the same criteria used for pulmonary emphysema and congestion.

Sample preparation for histopathology

Samples averaging 2-4cm in thickness from the condemned lungs were taken for further confirmatory histopathological evaluation. Samples were then immediately preserved in 10% formal saline [29]. After 5 days of formalin fixation, the preserved samples were processed routinely for histopathology. Sample processing was done as described by Bancroft., *et al*. (1996). The paraffin wax - embedded tissue blocks were sectioned into 5 µm thickness by a rotary microtome. Formalin fixed paraffin embedded tissue was stained by hematoxylin and eosin [30]. Viewing of the slides was done using a light microscope (Leica DM500) and pictures were also captured with the aid of Leica Software.

Histopathologic classification of pulmonary lesions

In general sections with thickened interstitial septa were classified as interstitial pneumonia which was further classified into three forms, acute subacute and chronic. The acute form was characterized by the presence of plasma proteins into the alveolar space and hyaline membranes which appear as linear masses of discrete, densely eosinophilic material lining the junction between the alveolus and the alveolar septa [31]. Lungs with the proliferative phase where type II pneumonocytes proliferate to replace the injured type I pneumonocytes were categorized as the subacute interstitial pneumonia [23]. The chronic form was characterized by alveolar fibrosis and in some cases accumulation of mononuclear inflammatory cells in the interstitium and persistence of hyperplastic type II pneumonocytes [32].

Sections with leukocytes, mucus and desquamated cells filling the bronchioles and alveoli the bronchiolar lumen were classified as suppurative bronchopneumonia [10,33]. These were also further categorized as suppurative and fibrinous bronchopneumonia depending on the predominant exudate. A combination of features consistent with bronchopneumonia and interstitial pneumonia was classified as broncho interstitial pneumonia.

Sections with intact erythrocytes in alveoli with no other obvious lesion were categorized as having blood splash [34]. As with the gross classification, atelectasis, emphysema and congestion without any other pathology were classified as slaughter related pathology and classified with the major lesion if the two existed together.

Data analysis

Appropriately grouped and coded postmortem findings and histologic observations were entered into Microsoft excel spread

sheet. The specific pulmonary lesions were grouped and classified accordingly before transferring the data to SPSS version 21 which was used for data analysis. Data analysis was performed using descriptive statistics by computing the combined prevalence (95% CI) of lung condemnations and also the frequencies of each specific lesion. Proportions were compared to check for significant differences using EpiCalc 2000®. McNemar's test and Cohen's kappa were used to evaluate the IRR between the two evaluation methods (gross and histologic).

Results

Gross evaluation

A total of 1275 cattle were examined from the two abattoirs. Of these, 21.8% (CI 19.5-23.8) had their lungs condemned. Approximately 12 196 cattle were slaughtered within the 4 months of study. The estimated value of lungs during the study period was USD 1.5/kg (wholesale price that was obtained from the two abattoirs) and average weight of the lungs from the two abattoirs was 3.06kgs. We estimated the loss due to condemnation to be USD 12 203.56 for the study period for the two abattoirs. The distribution of lung condemnations from the two abattoirs were as shown in table 1 below. Abattoir 1 had significantly higher prevalence of condemned lungs.

	Number of cattle inspected	Number of cattle with lesions	Prevalence of pulmonary lesions and (95% CI)
Abattoir 1	685	171	25% [a] (21.8 -28.3)
Abattoir 2	590	107	18.1% [b] (14.9- 21.0)
Total	1275	278	21.8% (19.5- 23.8)

Table 1: Prevalence's of gross pulmonary lesions in cattle at the two selected abattoirs around Harare.

Different superscripts indicate significant difference (P = 0.05).

Characterization of the condemned lungs

The condemned lungs were categorized into preexisting conditions and conditions associated with slaughtering processes. Table 2 shows the categories of these condemned lungs. The gross and histopathological ratings were evaluated using the McNemar test followed by comparing for the inter-rater reliability (IRR) through computation of Cohen's kappa values (using histology as the golden test). A Cohen's *kappa* value of 0.39 was obtained. The gross method had a diagnostic sensitivity of 59.1% (95% CI 52.1- 65.8) and a specificity of 94.3% (95% CI 85.3- 98.2). Using histology 208 out of 278 lungs were condemned because of pre-existing conditions.

	Pathology	Number		Prevalence and (95% CI)	
		Gross	Histopathology	Gross	Histopathology
Pre-existing conditions	Fibrosis	10	3	3.6 (1.4-6.1)	1.1 (0.0- 2.5)
	Pneumonia	42	169	15.1 (10.8-19.4)	60.8 (55.0-66.5)
	Edema	75	36	27 (21.9-32.0)	12.9 (9.0-17.3)
	Total	127	208	45.6 (39.7-51.7)	74.8 (69.2-79.7)
Abattoir conditions	Blood splash	40	36	14.4 (10.1- 18.7)	12.9 (9.0-17.3)
	Atelectasis	15	2	5.4 (2.9-7.9)	0.7 (0.0-1.8)
	Emphysema	53	23	19.1 (14.4-23.4)	8.3 (5.0-11.5)
	Congestion	43	9	15.5 (11.2-19.8)	3.2 (1.4-5.4)
	Total	151	70		

Table 2: Causes of lung condemnations in cattle slaughtered at two selected abattoirs.

Characterization of pre-existing conditions

Using histological evaluation the predominant cause of lung condemnations was pneumonia (60.8%) followed by pulmonary edema (12.9%) and lastly fibrosis (1.1%) as shown in table 2. Pneumonia was further characterized as shown in table 3. The major type of pneumonia was interstitial pneumonia which presented in three forms: acute, subacute and chronic. The subacute type was the most prevalent. Figure 4 shows interstitial pneumonia on gross and histologic evaluation.

Bronchopneumonia was seen in 49 lung tissues of which 46 had the suppurative type and 3 had the fibrinous type. Four of the suppurative bronchopneumonia had abscessation. Broncho interstitial pneumonia was seen in five lung tissues as presented in table 3.

Pulmonary edema without any other pathology was seen in 36 lung tissues. The trachea of these cattle had froth and their lungs extensive frothing also on cut surface. On histology the alveoli were

filled with amorphous eosinophilic material as shown in figure 1. Fibrotic lesions were seen in 3 lung tissues and presented as shown in figure 3.

	Type	Number	Prevalence (%)	95% CI
Interstitial Pneumonia	Chronic	11	4.0	2.1-7.2
	Acute	18	6.5	4.0-10.2
	Subacute	86	30.9	25.6-36.8
	Total	115	41.4	55.6-47.2
Broncho pneumonia	Suppurative	46	16.5	12.2-21.2
	Fibrinous	3	1.1	0.3-3.4
	Total	49	17.6	13.4-22.7
Broncho interstitial		5	1.8	0.7-4.4
Total		169	60.8	55.0-66.5

Table 3: Classification of pneumonia from the condemned lungs.

Characterization of conditions that could have developed at the abattoir

The total number of condemned cattle lungs because of conditions that could have developed at the abattoir was 70. The most predominant was blood splashing (12.9%) followed by emphysema (8.3%), congestion and edema (3.2) and atelectasis (0.7%).

Discussion

There is limited information on occurrence of lung condemnation in Zimbabwe. The frequency of lung condemnation (21.8%) in our study is higher than frequencies found in other African countries, for example, South Africa had 6.0% [9] and Tanzania had 13.2% [35]. This can possibly indicate poor disease control and slaughtering technique [36]. The economic meltdown and anthropologic factors affecting disease epidemiology have been described in Zimbabwe [37]. In the developed countries like USA and Canada condemnation of lungs varied from 2.2 to 14% [38,39].

The prevalence of pulmonary lesions in the sampled population could even be higher than that observed at the abattoirs because of the above-mentioned reasons. We found a poor inter rater reliability and lower sensitivity of the gross method compared to histologic evaluation. In this study we did not further evaluate grossly normal lungs using histology and therefore we could have underestimated lungs with lesions.

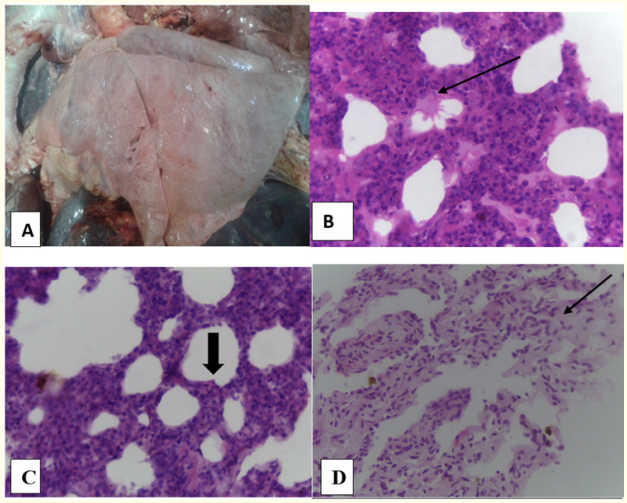

Figure 1: A: Diffusely distended, pale and elastic lung lobes as seen on gross evaluation; B: Is a micrograph of lungs (x 40 objective magnification). Note the thickened alveolar interstitium with evidence of hyaline membrane formation (indicated by arrow); C: Is a micrograph of lungs (x40 magnification) showing thickened interstitial septa (arrow) with increased cellularity representing subacute interstitial pneumonia; D: Is a micrograph (x40 objective magnification). This micrograph show the thickened alveolar interstitium with abundant fibrous tissue (arrow) which represented chronic interstitial pneumonia.

In the period of the survey the financial loss due to lung condemnations was estimated at USD 12 203.56 for the two abattoirs. This can contribute to the inhibition of growth of the beef industry and availability of the animal-based protein in Zimbabwe.

Several studies done just indicate pneumonia as the leading cause of lung condemnation without classifying it [9]. Pneumonia is also the leading cause of condemnations in this study, but the frequency is relatively higher than most recorded studies in surrounding regions except for Ethiopia which had 33.33% [40]. We further classified pneumonia into its types in our study and the major type was interstitial pneumonia. Interstitial pneumonia is the most difficult to diagnose at necropsy and requires microscopic confirmation as it is easily mistaken in the lung showing congestion, edema, hyperinflation or, emphysema [25]. This may explain the low sensitivity of the gross evaluation obtained in our study. Major causes of interstitial pneumonia are viral infections, hypersensitivity and al-

lergic reaction [23]. The limitation of this study was that we did not find the etiology for the pneumonia which was beyond the scope of this study. However, it is known that viral conditions caused by IBR and parainfluenza occur at high frequencies in Zimbabwe Hypersensitivity reactions have not yet been reported in Zimbabwe [41]. Thus, we think the findings could be of viral origin. Most of these cattle were free range and therefore poor ventilation which is one of the major causes of pneumonia is less likely.

Bacterial conditions which are normally typified by bronchopneumonia were not as common as the interstitial pneumonia [42]. Usually, they tend to be acute diseases and are associated with movement of animals to the abattoir [43]. In this study we had 1.0% cases of bronchopneumonia predominated by suppurative bronchopneumonia which could indicate that the involved pathogens had a low virulence [44]. Fibrinous bronchopneumonia suggestive of conditions like shipping fever was only seen in three cattle [45]. Normally bronchopneumonia is secondary to stress and immune suppression often linked to animal movement [46]. Thus bronchopneumonia is an animal welfare issue which is stress related where the bacteria is given an opportunity to evade the animal's defense mechanisms [47]. We could not trace back the shipping conditions of the animals that presented with bronchopneumonia to assess stress levels. Bacterial culture or PCR to identify the bacteria involved [48] was going to be ideal but however this was beyond the scope of this study.

Pulmonary edema is not a specific finding on its own. However, we have recorded a relatively higher value that what is recorded in most literature around the region [9,12,40]. The major causes of pulmonary edema in cattle in Zimbabwe include tick borne diseases such as theileriosis and ehrlichiosis which could have contributed to the observed findings. Recently there have been major outbreaks of these conditions due to the economic meltdown and poor disease control. Although we did not do serology or PCR it is most likely that they are the causes.

Preventable conditions recorded were emphysema, atelectasis, blood splash and congestion. Pulmonary emphysema had a prevalence of 8.3% which is higher than most studies and is therefore a cause of concern. Pulmonary emphysema occurs secondary to obstruction of outflow of air or agonal at slaughter. Suffocation of animals due to overcrowding in the lairages, lack of enough rest before slaughter, and exposure to bacterial and/or viral infections may lead to development of emphysema and pneumonia [49]. These abattoir related lesions (45%) could be due to inefficient slaughtering techniques. This is an unnecessary loss and a cause of concern in terms of animal welfare.

Conclusions and Recommendations

The study indicates that we have a high percentage of condemned lungs resulting in substantial financial losses. There is therefore need to evaluate these lesions at a larger scale since some of the lung lesions can be zoonotic. We also found that the common method used for evaluating lungs had a low agreement with histological evaluation suggesting that a lot of diseased lungs could have been passed as healthy and fit for human consumption.

Interstitial pneumonia is predominantly the cause of lung condemnation. Causes of interstitial pneumonia are quite varied ranging from parasitic, viral and bacterial to toxic. Regular deworming of animals and vaccination against the bovine respiratory disease complex should be advised. In addition to this, serology for screening viral conditions that affect the respiratory system is recommended.

Considering that in other countries toxic agents constitute the most economically important cause of this condition in cattle, farmers should be advised on denying animals exposure to known pneumotoxic agents such as lush pasture and supply ample good forage so that cattle will not as likely consume toxic plants. It is therefore crucial to conduct studies which would pinpoint the major contributing factor to development of interstitial pneumonia in Zimbabwe. Studies should be carried out to compare similarity between these lung lesions in cattle to lung lesions in other species from same areas. Further studies should also be done to compare cost benefit analysis and animal welfare of controlling these conditions.

Conditions associated with inappropriate slaughtering techniques also contribute to lung condemnation. Further evaluation of the effectiveness of the slaughtering techniques used by the abattoirs should be done and improve them where necessary to minimize condemnation.

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