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2003

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Epperson, William B., "A Preliminary Assessment of Lung lesion Distribution in Fed Cattle" (2003). *South Dakota Beef Report, 2003.* Paper 4.
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A Preliminary Assessment of Lung Lesion Distribution in Fed Cattle

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BEEF 2003 – 03

Introduction

Lung lesions are a group of lung abnormalities observable in cattle at slaughter. One type frequently seen is pleural adhesions, which are fibrous tissue tags stretching between 2 lung lobes or from 1 lobe to other thoracic viscera. Other types of lung lesions include non-ventilated areas (i.e. consolidated) or areas of active infection. Lung lesions result from inflammation, most likely due to microbial infection.

Previous reports indicate lung lesions are present in 33-76% of slaughtered fed cattle (Bryant, 1997; Wittum et al, 1996). While cattle treated for respiratory disease in the feedlot are more likely to have lung lesions, the vast majority of lesions appear in cattle never detected ill (Griffin et al, 1995). This suggests that lung lesions are a result of a subclinical respiratory illness, occurring sometime prior to slaughter. Lung lesions have been associated with decreased rate of feedlot gain, decreased quality grade, and decreased meat tenderness (Wittum et al, 1996; Gardner et al, 1999).

Lung lesions can be assessed at slaughter by visualization and palpation. The bovine lung is compartmentalized into 8 lobes. Lobes are named according to the relative cranial (forward or toward the head) to caudal (backward or toward the tail) and side (right or left) they occupy. As depicted in Figures 1 and 2 and starting with the most forward lobe, there are 4 right side lobes, named right cranial cranial, right cranial caudal, right middle, and right caudal. On the left side there are 3 lobes, named left cranial cranial, left cranial caudal, and left caudal. The 8th lobe, named the accessory lobe, is located behind the heart under the caudal lobes, and is not easily observed without inverting the lungs.

Depending on the line speed and layout of the packing plant, it may be possible to observe all, some, or no lung lobes of slaughtered cattle. The objectives of this research were to describe the lobar location of lung lesions and determine diagnostic sensitivity of lung lesion detection when only a portion of lobes are evaluated.

Materials & Methods

Lungs from 391 cattle were examined for evidence of lung lesions. Observations were from cattle involved in applied genetic or management studies at SDSU (n = 198), enrolled in the SDSU Calf Value Discovery program (n = 71), or cattle from sources other than SDSU (n = 125). Various breeds were represented, and cattle were 12-15 months of age at slaughter. Cattle were slaughtered between 6/13/2001 – 7/18/2001 at a commercial packer (Caldwell Packing Co., Windom, MN). Line speed at this plant was approximately 80 animals/hour.

Seven lung lobes were visually examined and palpated to determine the presence of lung lesions. The accessory lobe was not observed in this system. Lesions were categorized into lesion type, severity, and lobar location. Lesion types consisted of pleural lesions (fibrous connective tissue adhering lobes to lobes or lobes to other structures), consolidated lesions (non-aerated areas of lung) and active lesions (enlarged bronchial lymph nodes with exudate indicative of acute inflammation, or lung abscesses). Lesion severity was categorized as 1 if lesions were mild and affected <5% of lung, 2 if moderate and affected 5-14% of lung, and 3 if affecting ≥15% of lung (Bryant et al, 1996). Lobar location was the lobe(s) affected by any lesion. If a pleural lesion extended from the right middle lobe to the right caudal lobe, both lobes were considered affected. A total lung score, indicative of lung lesion severity, was calculated by summing lesion severity scores over all 3 lesion types.

Examinations were made immediately after USDA personnel inspected the heart and lungs.

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Results were recorded on paper and transferred to a computer spreadsheet for analysis (Microsoft ® Excel 97, Redmond, WA). Descriptive analysis was performed using spreadsheet software. Correlation coefficients were calculated and forward stepwise regression analysis was performed using JMP version 4.0 (SAS Institute, Cary, NC).

Results

Complete lung examinations were available on 391 cattle. An additional 21 were not fully evaluated and were excluded from analysis. Of the 391 lungs, 173 (44.2%) were affected with lung lesions. Of lungs with lesions, 46% were very mild, with the remaining 54% displaying moderate to severe lesions.

The distribution of lung lesions is described in Tables 1 and 2. The majority (54.3%) of lesions affected only a single lobe. Of the 173 cattle with lung lesions, 67.1% had lung lesions present in the right cranial cranial lobe. The right middle lobe was affected in 31.2% of cattle with lung lesions. Lung lesions affected the right lobes in 75.7% of cases, and lesions were less frequent in caudal lobes.

Table 3 is a correlation table among affected lung lobes, with significant correlations ($P < 0.05$) highlighted. Significant negative correlations are noted between lesions on the right cranial cranial lobe and right middle, right caudal, and left cranial caudal lobes. Significant positive correlations are noted between lesions of the right middle and right caudal lobes, left cranial cranial and left cranial caudal lobes, and left cranial caudal and left caudal lobes.

In an attempt to identify lung lobes strongly associated with lung lesions, stepwise regression was performed, with presence of any lung lesion the outcome, modeled as a continuous variable. The 7 observed lung lobes were taken as explanatory variables, with presence of lesion on a given lobe coded 1, and absence of lesion coded 0. No interaction effects were modeled. The model contained the right cranial cranial, right middle, left cranial caudal, and left cranial cranial lobes as significant explanatory variables. Regression analysis was used to "screen" for significant relationships, and correlation analysis was performed to confirm and visualize these relationships.

Table 4 displays the detection sensitivity of lung lesions, by observation of specific lobe(s). Examination of the right cranial cranial lobe alone detected 67.1% of lungs with lesions. Adding examination of the right middle lobe allowed detection of 86.1% of cattle with lung lesions. Examination of right cranial cranial, right middle, and left cranial caudal together detected 92% of all lung lesions, and adding the left cranial cranial to the previous 3 lobes increased detection to 96.5%.

To examine the effect of lesion severity on diagnostic sensitivity, lungs were stratified into categories of mild, moderate, and severe lesions, according to total lung score, and sensitivity of lesion detection was re-examined (Table 5). Within each row, the diagnostic sensitivity generally increased as lesions progressed from mild to severe (left to right).

Discussion

Results of this study suggest that examination of the right cranial cranial and right middle lobes would diagnose 86.1% of bovine lungs with lesions. Though evaluation of all lobes is required for 100% sensitivity, active examination of all lobes in high-throughput commercial (340 animals/hr) packing houses is not always feasible. In addition to speed, arrangement of the viscera table, location of plant workers, and nuances of viscera table inspectors may impede access to lungs. In the event of limited access to lungs, diagnostic sensitivity in detecting lung lesions is not seriously impaired if access to the right cranial cranial and right middle lobes is possible.

In cattle with lung lesions, 54.3% had lesions affecting only 1 lobe. This suggests that one can miss lung lesions at slaughter with a limited examination. Severe, multiple lobe lesions can be easily visualized from a distance, but these constitute a minority of lung lesions. If an accurate lung health assessment is desired, examination techniques employed must result in good diagnostic sensitivity.

Lung lesions were present in greatest proportion in the right cranial cranial, followed by right middle, then right cranial caudal, right caudal, and left cranial cranial, left cranial caudal, and left caudal lobes (Figure 2). If maximum diagnostic sensitivity with a minimum number of lobar observations is desired, the probability a given lobe will be affected and the correlation of lobar observations must be considered. In the case of 2 positively correlated observations, similar information is obtained by examination of 1 of the 2 lobes. In the case of 2 negatively correlated observations, different information is gained from each lobe, so observation of both lobes may be necessary.

Figure 3 is a graphical description of the frequency of lesions in a given lobe and the correlation of observations between lobes. It is imperative to examine the right cranial cranial lobe at slaughter because lesions are frequently found there. Since there is a positive correlation between right middle and right caudal, many lesions that affect the right caudal also affect the right middle lobe. Therefore, examination of the right middle lobe alone detects all right middle, and many right caudal lesions. Positive correlation exists among the left cranial caudal and other left lung lobes. Therefore, observation of only the left cranial caudal lobe will detect many lesions affecting the left side.

In this data set, the right cranial caudal lobe does not appear to be significantly correlated with any other lobe, yet is affected in 23% of cattle with lung lesions. However, when the right cranial caudal lobe is affected, a lesion is also observed in 78% of right cranial cranial lobes. Therefore, observation of the right cranial cranial lobe detects the majority of lesions present in the right cranial caudal lobe, making observation of the right cranial caudal lobe unnecessary. The large difference in probability of lung lesions between these lobes is responsible for the insignificant and weak correlation reported in Table 3. The stepwise regression results more accurately reflected this association.

As lesions become more severe, diagnostic sensitivity tended to increase, regardless of the lobar combinations observed (Table 5). However, diagnosis of either very mild or moderate lesions required observation of at least the right cranial cranial and right middle to achieve 80% sensitivity in lung lesion detection.

This is a preliminary study because the population is entirely spring born, “calf fed” animals. Lung lesion distribution and diagnostic sensitivity calculated here may not apply to other populations. However, in this population, lung lesions were reliably diagnosed by observation of the right cranial cranial and right middle lung lobes. Observation of these 2 lobes alone resulted in diagnostic sensitivity of ≥90% for moderate to severe lesions, and 80% for mild lesions. Sensitivity can be enhanced slightly by additional observation of the left cranial caudal lobe, but requires access to lobes on the left side.

Acknowledgements

The cooperation of Dr. Don Marshall, Dr. Emilie Campbell, Dr. Dick Pruitt, and Caldwell Packing Company were essential for generation of this report. Thanks go to Ms. Nancy Grathwohl for data collection assistance.

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Tables

Table 1. Number of lobes affected in lungs with lesions

Lobe(s) Affected[a]	Number	%
1 lobe only	94	54.3
2 lobes	48	27.7
3 lobes	22	12.7
4 or more lobes	9	5.2
Total	173[b]	99.9

[a] 7 lobes examined for lung lesions, accessory lobe not examined.
[b] Total cattle examined = 391; 173 affected with lung lesions (44.2%).

Table 2. Distribution of lung lesions by lung lobe affected

Lobe affected[a]	Number affected[b]	%[c]
Right cranial cranial (RCC)	116	67.1
Right cranial caudal (RCD)	40	23.1
Right middle (RM)	54	31.2
Right caudal (RD)	34	19.7
Left cranial cranial (LCC)	28	16.2
Left cranial caudal (LCD)	21	12.1
Left caudal (LD)	7	4.0
Right lobes only	131	75.7
Left lobes only	17	9.8
Both left and right lobes	25	14.5

[a] Accessory lobe not examined.
[b] Total affected = 173.
[c] Calculated as $\frac{\text{N Affected}}{173}$, % total does not add up to 100 because multiple lobes affected.

Table 3. Univariate correlation of lung lesions by location[a]

	Correlation coefficient[b]						
	RCC	RCD	RM	RD	LCC	LCD	LD
RCC	–	0.12	-0.40[b]	-0.30[b]	-0.06	-0.19[b]	-0.11
RCD	.012	–	0.01	-0.03	0.06	-0.04	0.03
RM	-0.40[b]	0.01	–	0.67[b]	-0.03	-0.02	-0.01
RD	-0.30 [b]	-0.03	0.67[b]	–	0.02	0.04	0.05
LCC	-0.06	0.06	-0.03	0.03	–	0.17[b]	-0.01
LCD	-0.19 [b]	-0.04	-0.02	0.04	0.17[b]	–	0.55[b]
LD	-0.11	0.03	-0.01	0.05	-0.01	0.55[b]	–

[a] See Table 2 for explanation of abbreviations.
[b] Coefficients differ from 0 *($P < 0.05$).*

Table 4. Sensitivity of lung lesion detection by observation of specific lobe(s) [a]

Observed lobes	Lesions detected	Sensitivity[b] (% of total)
[c] RCC only	116	67.1
[c] RCC and RM	149	86.1
[c] RCC, RM, and LCD	159	92.0
[c] RCC, RM, LCD, and LCC	167	96.5
RCC and RCD	125	72.3
RCC, RCD, and RM	155	89.6

[a] See Table 2 for explanation of abbreviations.
[b] Total lungs with lesions = 173.
[c] Significant in stepwise regression.

Table 5. Sensitivity of lung lesion detection stratified by lesion severity

	Lung lesion severity (% detected)[b]		
Lobe(s) examined [a]	Mild[c]	Moderate[c]	Severe[c]
RCC	53.8	57.9	92.7
RCC and RM	80	89.5	92.7
RCC, RM, and LCD	87.5	97.4	94.5
RCC, RM, LCD and LCC	92.5	100	100
Number of observations (column)	80	38	55

[a] See Table 2 for explanation of abbreviations.

[b] $\% \text{ detected} = \frac{\text{cell N}}{\text{column total}} \cdot 100.$

[c] Mild = total lesion score = 1; Moderate = total lesion score = 2; Severe = total lesion score ≥ 3.

Figures

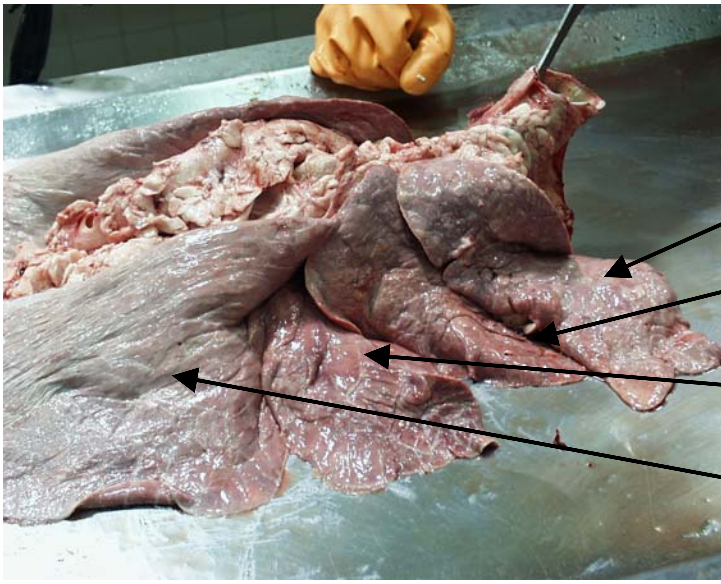


Figure 1. Right lung lobes

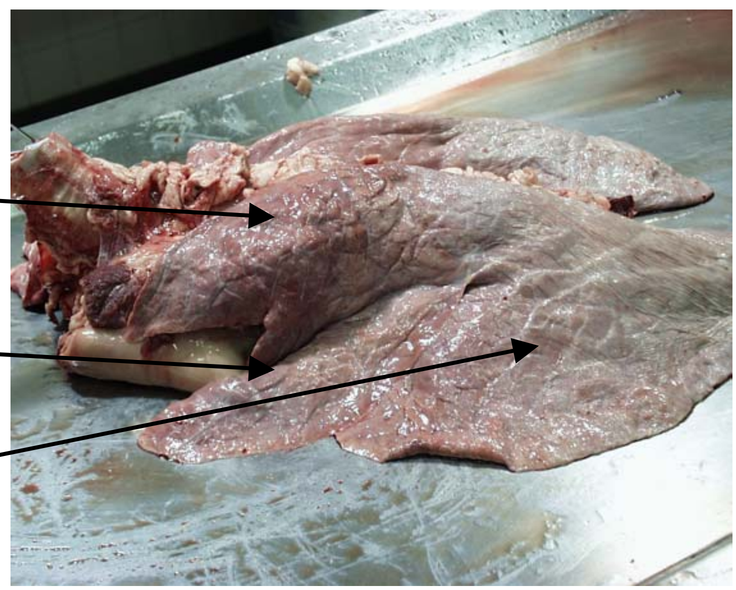
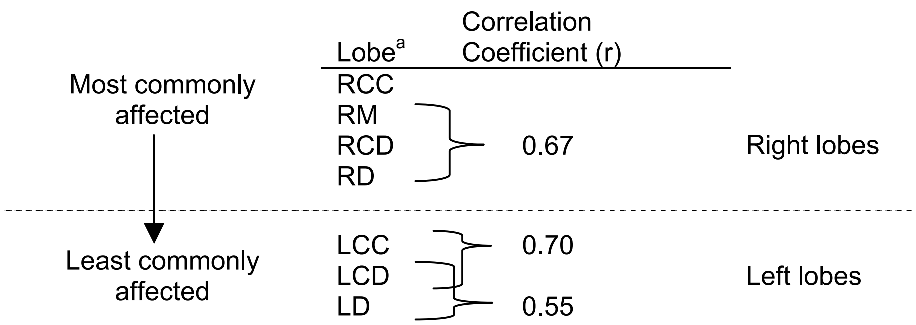


Figure 2. Left lung lobes



[a] See Table 2 for explanation of abbreviations.

Figure 3. Pictorial view of associations and hierarchy for lung lobe selection to maximize sensitivity