Chronic Bronchopneumonia in Cattle

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Summary

Twenty-five calves affected had the following clinical signs of chronic bronchopneumonia: depression, gaunt appearance, subnormal appetite, bilateral mucopurulent nasal discharge, increased respiratory and heart rate, inspiratory or expiratory dyspnea, infrequent cough and an average rectal temperature of 103.5°F. On auscultation normal vesicular or harsh vesicular sounds were heard most commonly in the dorsal tripartition, moist or dry rales in the middle tripartition, and dry rales in the ventral tripartition.

Changes associated with chronic bronchopneumonia were significantly decreased arterial blood pH, PO_2, HCO_3, total CO_2, and base excess. The significantly decreased venous blood values were pH, HCO_3, total CO_2, and base excess.

Contrast bronchograms revealed extensive consolidation and atelectasis of the apical lobes and cardiac and diaphragmatic lobes ventral to the traches.

Angiograms revealed decreased blood supply to areas of the lung affected with chronic bronchopneumonia.

Gross pathological changes were atelectasis and consolidation of the anterior ventral aspect of the lungs and emphysema dorsally. Histopathological changes consisted of atelectasis, emphysema, fibrous thickening of alveolar septa, abscess formation, peribronchial lymphocytic hyperplasia, and obstructive bronchiolitis.

Bovine respiratory disease represents one of the more important economic problems to the cattle industry because of death losses, reduced weight gains, and less than optimum therapeutic and preventative measures (20). Numerous reports indicate the complexity of bovine respiratory disease with the involvement of a multitude of microbiological agents and stress factors (3,9,11,-14,15,16,19,20,25,26,27). Sequelae to these infections frequently is bronchopneumonia. Lack of early recognition of bronchopneumonia (4), inadequate or resistance to antibacterial chemotherapy by the microbiological agent (10) may prevent complete resolution of the pathological process. The result is that bronchopneumonia may become chronic (17). Calves affected with chronic bronchopneumonia were studied to provide data that may be helpful in recognition of these cases clinically and to explore the reasons why these calves were chronic cases of bronchopneumonia.

Materials and Methods

Chronic Bronchopneumonia: Twenty-five calves (14 Hereford, 5 Holstein-Friesian, 2 Charolais, 3 Holstein-Angus crossbred, and 1 Angus) ranging from 1 to 12 months of age and found nonresponsive to at least 5 days of antibacterial chemotherapy for bronchopneumonia were clinically studied. All calves were given a general physical examination and the respiratory system was evaluated as follows: character and rate of respirations, type of dyspnea (inspiratory or expiratory), frequency and type of cough, and the character of nasal discharge. The trachea and both lungs were ausculted with special emphasis placed on comparative auscultation of the lung field divided into dorsal, middle, and ventral tripartitions.

When the calves were clinically examined, 4 cc of heparinized arterial blood was obtained anaerobically from the ventral coccygeal artery and 10 cc of heparinized anaerobic venous bleed, from the external jugular vein, both placed immediately into ice water and analyzed with a Corning pH blood gas analyzer (Corning pH/Blood Gas Model 165, Scientific Instruments, Corning Glass, Medford, Mass.) within 60 minutes for blood gas parameters of pH, PCO_2, PO_2, total CO_2, HCO_3 and base excess parameters. EDTA blood samples were collected from the external jugular vein for determination of hematocrit hemoglobin content, total and differential white blood cell counts, and serum protein electrophoresis.

Normal Calves: Heparinized arterial blood samples were obtained anaerobically from the ventral coccygeal artery of 52 normal calves ranging in age from

1 to 12 months (35 Holstein-Freisian, 10 Hereford and 7 Angus). Heparinized venous blood samples were obtained anaerobically from the external jugular vein of 62 normal calves ranging in age from 1 to 12 months (35 Holstein-Friesian, 20 Herefords, and 7 Angus). The blood samples were handled as described above.

Statistical Determination: Statistical evaluation was obtained by comparing values of arterial and venous blood gases of normal animals to values from calves affected with chronic bronchopneumonia. Values for hematocrit hemoglobin content, total and differential white blood cell counts, and serum protein electrophoresis were statistically analyzed for the calves affected with chronic bronchopneumonia.

Radiology of Chronic Bronchopneumonia: Lateral radiographs of the thorax were taken on 8 calves, bronchograms were done on 18 calves and angiographic studies were done on 10 calves affected with chronic bronchopneumonia.

Radiographs were obtained using a conventional, three phase X-ray machine delivering 6.6 mas and 80-120 kvp. A 12:1 reciprocating bucky grid, 14 x 17 cassettes with high speed plus intensifying screens loaded with R-P 14 X-ray files were used. The focal film distance was 40". The central X-ray beam was centered over the 5th intercostal space and halfway between the sternum and vertebrae with the calf in right lateral recumbency. For the angiocardiographic studies 11 x 14 films were used.

Bronchograms: Each calf was tranquilized with Xylazine (Rompun, Chemargo Co., Kansas City, Mo. 64120), 0.1 mg/lb. body weight I.V. The ventral mid-cervical tracheal region was surgically prepared and draped with the calf in right lateral recumbency. A 1 cm skin incision was made in the skin over the mid third of the trachea and then a 2" 14-gauge needle was passed into the trachea. An 80 cm 8 French catheter guide wire was passed into the trachea and the needle removed. A 40 cm 8 French single hold angiographic catheter was then passed into the trachea and guide wire was removed. The catheter was passed to the estimated bifurcation of the trachea and 30-40 cc of micronized Ba CO_4 (Burns Biotec Lab. Inc., Oakland, Ca.) suspension was slowly injected as the calf was rolled from lateral to sternal to dorsal recumbency. The filling of the bronchial tree on some calves was monitored with fluoroscopy. Lateral radiographs were taken of the thorax after the contrast media was delivered. Little or no contrast media went into the left bronchial tree as the calves were always kept with the right side dependent.

Angiocardiograms: All calves were tranquilized with Xylazine (Rompun, Chemargo Co., Kansas City, Mo. 64120) and the left side of the jugular furrow was surgically prepared. General anesthesia was induced with Halothane (Fluothane, Ayerst Laboratories, N.Y., N.Y.). The left external jugular vein was surgically isolated and a #9 French angiographic catheter was passed into the pulmonary artery. Renographin 60 (E.R. Squibb & Sons, Inc., Princeton, N.J.) was injected at 100 lbs. pressure using an Amplatz injector. Six lateral radiographs were taken at half-second intervals starting at the time of injection. A Sanchez-Perez seriograph was used to change the cassettes. After removal of the catheter the incision in the jugular vein was closed with 00 Dexon (American Cyanamid Co., Pearl River, N.Y.) suture material using a simple continuous pattern. The skin was closed in routine fashion utilizing size 0 Vetafil (S. Jackson, Inc., Washington, D.C.) suture material.

Pathology: Twenty calves clinically affected with chronic bronchopneumonia were euthanatized and subjected to necropsy examination. Gross changes were recorded. Samples for bacteriologic examination were taken from the dorsal, middle, and ventral tripartitions of the right and left apical, cardiac and diaphragmatic lobes of each animal. Antibiotic sensitivity tests were performed on bacterial isolates obtained. The surface of each lung was seared with a hot spatula and an incision was made into the underlying tissue with scissors sterilized by flaming in 70% alcohol. A sterile swab was used to transfer material from the lung to each of four agar plates (blood agar base with 5% sheep blood, MacConkey agar, phenylethyl alcohol agar with 5% sheep blood and *Salmonella-Shigella* agar). Each agar plate was streaked for isolation after the initial inoculation with the swab. All cultures were examined after 24 and 48 hours incubation at 37°C. Colonies that grossly appeared to by typical of *Pasteurella* were inoculated into triple sugar iron agar, SIM media and urea agar base slants.

Colonies suspected to be *Corynebacteria* were transferred to casein agar. Gram stains for morphology and catalase tests were performed.

Lung samples were taken from all lung lobes in the dorsal, middle, and ventral areas, and fixed in 10% neutral buffered formalin, embedded in paraffin, sectioned at 6 microns and stained with hematoxylin and eosin (H&E).

Results

Clinical Findings: Most calves exhibited depression, rough hair coat and gaunt appearance. Some exhibited inappetance and most had subnormal appetites. All calves had above 30 respiratory rates with an average of 60/min. All except one had heart rates above normal 30 with an average of 96/min. Rectal temperatures ranged from normal to 106.4°F, averaging 103.5°F.

Most calves had an increased depth of respiration while a few exhibited shallower breathing, primarily abdominal. Fifty percent of the calves had inspiratory dyspnea with the inspiratory phase of the respiratory cycle emphasized; while 25% had expiratory dyspnea with more noticeable expiratory phase of the respiratory cycle.

One calf grunted on expiration and a few calves had open-mouth breathing and salivation. No other breathing abnormalities were detected.

Most of the calves had a slight bilateral mucopurulent nasal discharge, a few had slight mucous or serious nasal discharge; some had no nasal discharge.

The mucous membranes of the nasal cavity were pink in most calves, but the conjunctival mucous membranes in most calves were congested.

Muzzle color was normal, supervicial lymph nodes were not enlarged. A few calves had diarrhea.

Table 1:
Frequency of Lung Ausculative Observation in 21 Calves With Chronic Bronchopneumonia

	Left Lung	Right Lung
Normal Vesicular Sounds:		
Dorsal	8	6
Middle	1	1
Ventral	0	0
Harsh Vesicular Sounds:		
Dorsal	13	15
Middle	3	5
Ventral	0	0
Moist Rales:		
Dorsal	2	2
Middle	9	5
Ventral	1	4
Dry Rales:		
Dorsal	1	1
Middle	11	14
Ventral	19	15
No Lung Sounds:		
Dorsal	0	0
Middle	0	0
Ventral	9	7
Pleural Friction Sounds:		
Dorsal	0	0
Middle	2	3
Ventral	2	2
Emphysema:		
Dorsal	1	1
Middle	3	2
Ventral	3	2
Bronchial Tones:		
Dorsal	0	0
Middle	2	0
Ventral	2	2

Ausculatation of the trachea revealed mostly dry rales. Most calves had an infrequent cough that ranged from a harsh dry non-productive cough to a low productive cough.

Comparative Ausculation: Data from the lungs of 25 calves with chronic bronchopneumonia are shown (Table 1). The most frequent observations were either normal or harsh vesicular sounds in the dorsal tripartition, moist or dry rales in the middle tripartition, and dry rales in the ventral tripartition.

Statistical Determination: Statistical findings of arterial blood gases in 28 calves with chronic bronchopneumonia are compared to normal calves (Table 2). The arterial blood pH, PO_2, HCO_3, total CO_2 and base excess were significantly decreased in pneumonic calves, while the PCO_2 was not significantly decreased.

Statistical findings of venous blood gases in 30 calves with chronic bronchopneumonia are compared to normal calves (Table 3). The venous blood pH, HCO_3, total CO_2, and base excess were significantly decreased in pneumonic calves while PO_2 and PCO_2 were not significantly decreased.

Statistical values for hematocrit hemoglobin content, total and differential white blood cell counts and serum protein electrophoresis are shown in Table 4.

Radiological Changes: All calves with chronic bronchopneumonia showed extensive consolidation of the apical lobes and of the lung tissue ventral to the trachea in the cardiac and diaphragmatic lobes (Figures 1-3). Air bronchograms of the mainstem bronchi were often seen within the consolidated lung tissue. Enlargement of the bronchial lymph nodes was a common finding. Areas of bullous emphysema were common within the lung tissue dorsal to the bifurcation of the trachea. In the bronchograms only the primary bronchi could be outlined in the affected regions; however, there was good outlining of the bronchial tree in the normal lung tissue. The angiograms revealed a decrease in the blood supply to the affected lung tissue (Figures 4 and 5).

Table 2:
Comparison of Arterial Blood Gases of Chronic Bronchopneumonic Calves with Normal Calves

Criterion	Item	Blood pH	Blood PO_2 mmHg	Blood PCO_2 mmHg	Blood HCO_3 mM/L	Blood Total CO_2 mM/L	Blood Base Excess mEq/L
Pneumonic Arterial Blood	Total No. of Calves	28	28	28	28	28	28
	Mean	7.41	52.33	36.07	23.06	24.50	0.22
	SD	0.06	11.58	8.23	4.75	4.99	5.10
	SEM	0.01	2.18	1.55	0.89	0.94	0.96
Normal Arterial Blood	Total No. of Calves	52	52	52	36	36	36
	Mean	7.450	77.02	37.69	26.35	27.67	3.82
	SD	0.050	6.94	7.94	5.98	6.18	5.52
	SEM	0.008	0.96	1.10	0.99	1.03	0.92
Significance		2.7385	11.9272*	0.8561	2.2057*	2.2057*	2.6736

SD = standard deviation
SEM = standard error of the mean
Significant* at 95% level

Table 3:
Comparison of Venous Blood Gases of Chronic Bronchopneumonia Calves to Normal Calves

Criterion	Item	Blood pH	Blood PO_2 mmHg	Blood PCO_2 mmHg	Blood HCO_3 mM/L	Blood Total CO_2 mM/L	Blood Base Excess mEq/L
Pneumonic Venous Blood	Total No. of Calves	30	30	30	30	30	30
	Mean	7.36	28.08	41.38	23.56	25.61	0.83
	SD	0.06	4.57	10.49	5.50	6.11	6.48
	SEM	0.01	0.83	1.91	1.00	1.11	1.18
Normal Venous Blood	Total No. of Calves	62	62	62	45	45	45
	Mean	7.41	29.15	45.39	30.68	32.38	7.18
	SD	0.06	4.05	8.44	8.75	9.20	7.95
	SEM	0.008	0.51	1.07	1.30	1.37	1.18
Significance		3.5861*	1.1401	1.9680	3.9605*	3.5386*	4.5971*

SD = standard deviation
SEM = standard error of the mean
Significant* at 95% level

Table 4

Hemograms and Serum Proteins in Chronic Bronchopneumonia Calves

	Hematocrit (Vol %)	Hemoglobin (gm %)	White blood cell count (cells/cmm)	Metamyelocytes (cells/cmm)	Bonds (cmm)	Neutrophils (cmm)	Lymphocytes (cmm)	Monocytes (cmm)
N:	24	24	24	2	17	23	23	23
Mean:	31.8	10.3	8292	118	423	2182	4971	862
SD*:	5.1	1.5	2930	40	510	1636	2259	697
SEM**:	1.1	0.3	612	140	127	348	481	148

	Eosinophils (cmm)	Basophils (cmm)	Total Protein (gm %)	Albumin (gm %)	Globulin (gm %)	Alpha globulin (gm %)	Beta globulin (gm %)	Gamma globulin (gm %)
N:	10	7	22	19	19	10	10	10
Mean:	336	136	6.3	2.99	3.53	1.823	.078	1.498
SD*:	284	86	0.59	0.420	0.89	0.293	0.158	0.648
SEM**:	94	35	0.13	0.096	0.204	0.093	0.05	0.205

SD* = standard deviation
SEM** = standard error

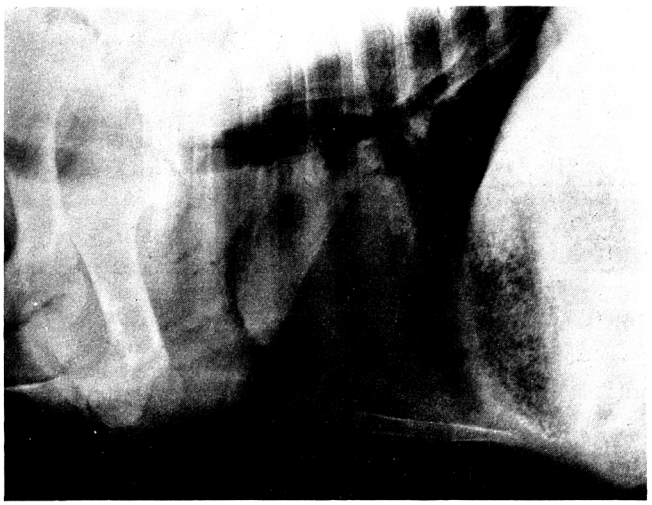


Figure 1. Lateral radiograph of thorax of a calf with bronchopneumonia. Note prominent "air bronchograms" in the consolidated apical lobes. "Air bronchograms" can also be seen in the cardiac and diaphragmatic lobes, indicating involvement of these lobes as well.

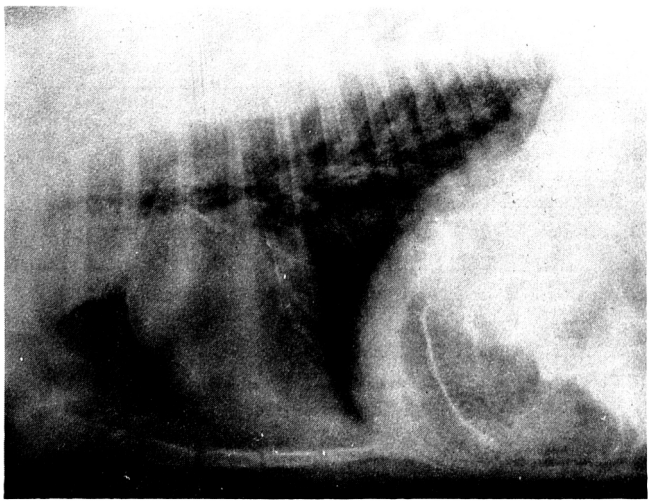


Figure 2. Normal bronchographic study in a calf.

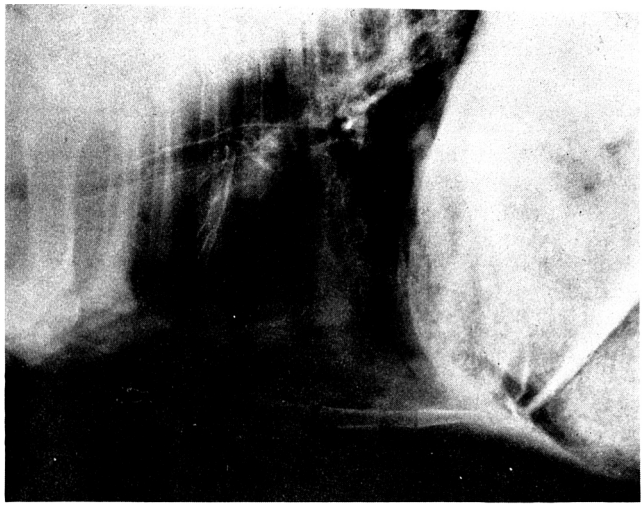


Figure 3. Bronchographic photo of a calf with bronchopneumonia. Only the major bronchi to the apical lobes were outlined. The dorsal diaphragmatic lobes were highly congested.

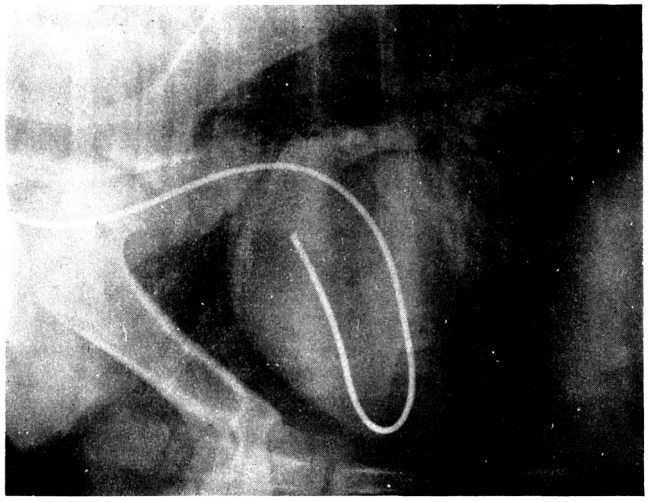


Figure 4. Angiocardiograms of a normal calf.

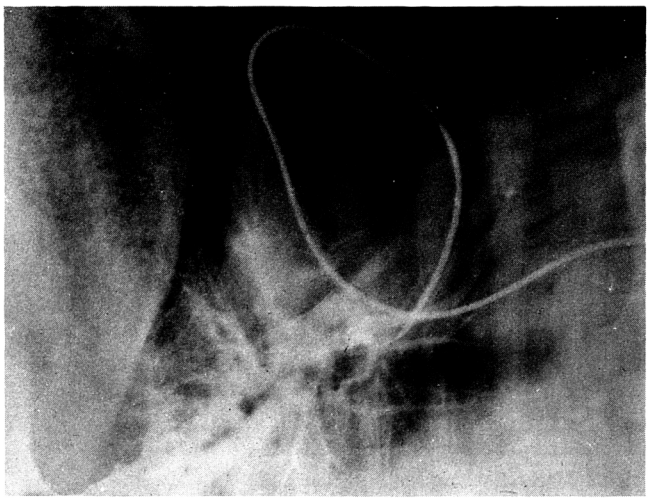


Figure 5. Angiocardiogram of calf with bronchopneumonia. Blood supply to the consolidated apical lobes is decreased. Note prominent air bronchograms in the consolidated lung tissue.

Table 5:
Antibiotic Sensitivity of *Pasteurella multocida* Isolated From Lung Tissue of Twenty Calves With Chronic Bronchopneumonia

Antibiotic	# of Isolates Sensitive	# of Isolates Resistant
Chlortetracycline	10	10
Bacitracin	10	10
Chloramphenicol	18	2
Nitrofurazine	16	4
Genatmicin	9	11
Lincomicin	4	16
Neomycin	5	15
Penicillin	4	16
Streptomycin	5	15
Sulfathiazole	10	10
Oxytetracycline	5	15
Tetracycline	11	9

Pathological Changes: *Pasteurella multocida* was isolated from all lung samples and the results of antibiotic sensitivity tests are recorded in Table 5. *Corynebacterium pyogenes* was isolated from one animal with many abscesses in the lung. No isolation was attempted for viral, mycoplasma or chlamydia agents.

The upper respiratory tracts such as nasal passages, nasopharynx and trachea were normal with the exception of some mucous material in the trachea in most calves. Two animals had a mucopurulent rhinitis (Figure 6).

Gross pathologic appearance of the lungs was as follows: The right apical lobe usually was affected most severely. The anteroventral portion of the lung was dark, heavy, and depressed below the surface. The lung was variegated in color and consistency on cross section, and had an exaggerated lobular pattern with widened interlobular septa. A few animals had fibrinous pleuritis. A common gross change of the dorsal aspects of the lungs, in particular the diaphragmatic lobes, was bullous emphysema (Figure 7). Cross sections of the lung lobes revealed bronchi filled with purulent exudate and emphysematous areas dorsally.

Histological examination revealed acute bronchopneumonia in areas of the middle and dorsal aspects of the lung. The most frequent change in the dorsal aspects of the lungs was lobular and interlobular emphysema. The lung parenchyma in the ventral parts revealed various chronic changes such as atelectasis, fibrosis, abscess formation and necrosis. The air passages revealed purulent bronchiolitis, and polypous fibrous proliferative changes. Another frequent change was peribronchiolar organization (Figures 8-10). Bronchiolitis extended in all cases beyond grossly visible consolidation and atelectasis. Obliterative bronchiolitis was common to all cases.

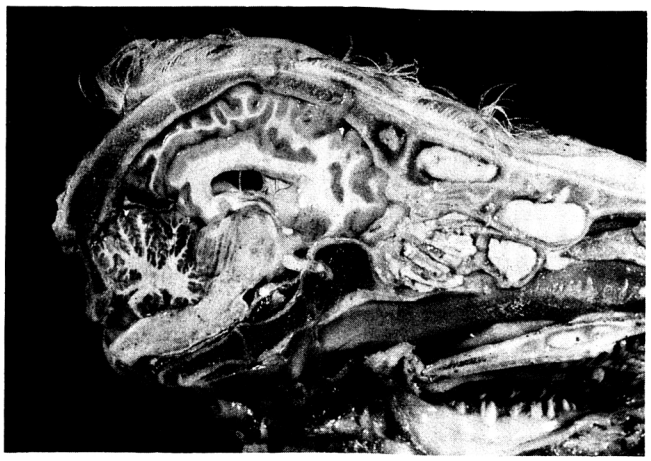


Figure 6. Chronic rhinitis. Note thick tenaceous exudate.

Figure 7. Chronic bronchopneumonia; note areas of pneumonia and atelectasis in anterioventral parts of right lung and emphysema in dorsal aspect of diaphragmatic lobe.

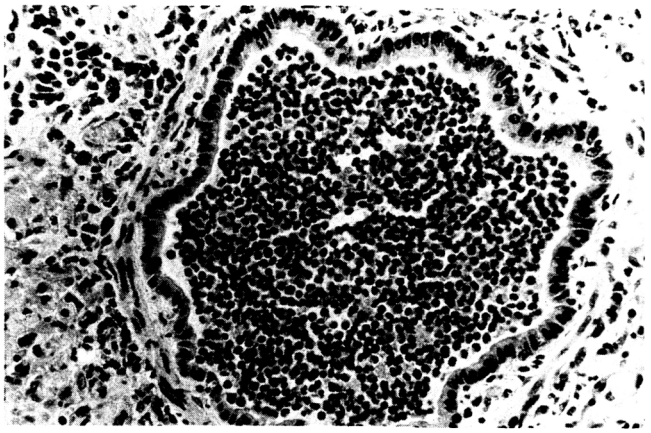


Figure 8. Purulent bronchiolitis. Note purulent material in bronchiolar lumen. H & E, 200X.

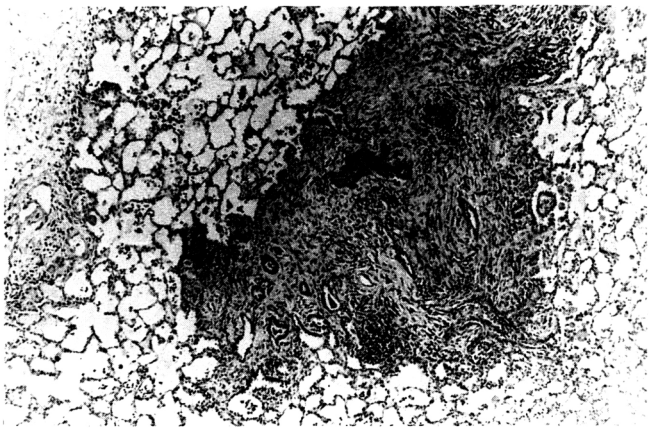


Figure 9. Photomicrograph of chronic peribronchiolac reaction. Note fibrous tissue surrounding bronchioles. H & E, 60X.

Figure 10. Photomicrograph of chronic lung changes. Note lymphoid hyperplasia surrounding bronchiole. H & E, 60X.

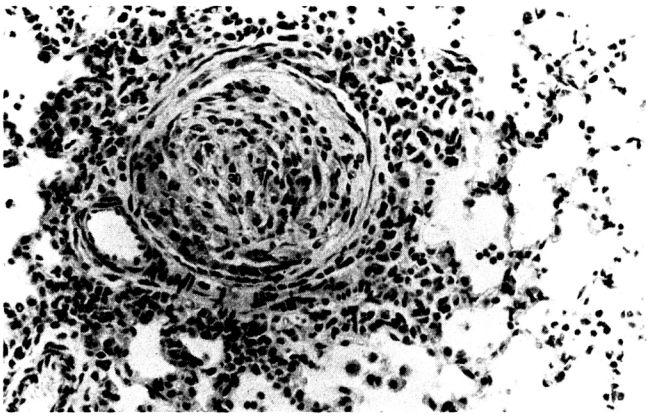
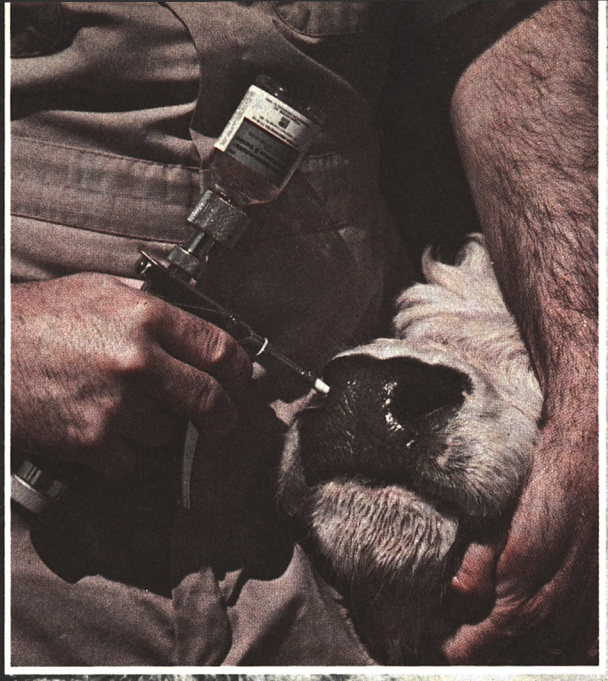


Figure 11. Photomicrograph of endobronchiolar fibrous tissue. H & E, 200X.

Discussion

Clinical signs of calves affected with chronic bronchopneumonia are similar to cases previously described for enzootic pneumonia (2) and shipping fever complex (13), but many of the calves in this study exhibited subtle clinical signs related to the pathologic lesions in the lungs. All calves had increased respiratory rates, but many had rectal temperatures within normal range. The respiratory status of such a calf, if placed in a group of normal animals, could be difficult to identify without full assessment of the lungs by auscultation.

Most calves had dry rales, bronchial tones, or no lung sounds in the ventral or middle tripartition of the lung and this corresponded to consolidated areas or atelectasis on gross pathological examination. In



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the middle tripartition of the lung, most rales were commonly auscultated which corresponded to more acute exudative changes of pneumonia. Emphysematous sounds were not as common on auscultation, but were readily detected over bullous areas of emphysema of the lung. Emphysema is considered to be a complication of chronic bronchopneumonia (17). The severity of the emphysema is in part proportional to the number of bronchioles which become partially or completely obliterated, thus allowing collateral ventilation of alveoli, trapping of air, and consequent rupture of alveolar walls (21). The frankly audible pleural friction sounds were associated with organized fibrinous adhesions of the visceral pleura to the thoracic parietal pleura. Harsh vesicular sounds were commonly found in the dorsal tripartition of the lung associated with pathological changes of congestion and vesicular emphysema.

The arterial and venous blood gases were helpful diagnostic tools for assessing pulmonary function. The authors have since concentrated on repeated arterial PO_2 samples for use in the clinical assessment of both acute and chronic bronchopneumonia which are undergoing treatment. In this study no attempt was made to correlate the degree of pathological involvement of the lung with the arterial and venous blood gas values. At best, there is only limited data regarding normal values for arterial and venous blood gases for the bovine (5,8,24,28). Some of the values for arterial blood gases did not correspond to those reported elsewhere (8) possibly because our blood samples in these calves were obtained from the coccygeal artery instead of the carotid artery. It has been reported that comparative hematological values from the jugular vein and the coccygeal artery and vein may differ significantly (23).

Pasteurella multocida was isolated in most cases and *Corynebacterium pyogenes* from one calf. Previous observations show that *P. hemolytica* is more frequently associated with acute respiratory lesions (4). This may explain why it was not isolated from these cases, which were characterized by more chronic lung lesions.

Antibiotic therapy studies were not part of this study, but the laboratory antibiotic sensitivity tests for *Pasteurella multocida* are presented to draw attention to the resistance of the organism to many of the antibiotics which are often used in the routine treatment of bronchopneumonia.

The angiograms suggest that the arterial blood supply to pneumonic areas is reduced. Presumably the blood supply is diverted to better ventilated areas, as reported in man (6) and dogs (1).

The bronchograms correlated well with the gross pathological findings. This method provides an additional approach to the study of bovine respiratory disease (18,32).

The histopathological findings of atelectasis, emphysema, fibrous thickening of alveolar septa, abscess formation, peribronchial lymphocytic hyperplasia and obstructive bronchiolitis are irreversible (17). Some of these pathological changes associated with chronic bronchopneumonia have been described as enzootic (31) or proliferative (7,12,-22,29) types of pneumonia by others. These changes represent an unresolved pneumonic process.

References

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