Epidemiology and disease modeling of bovine respiratory disease

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Introduction

Bovine respiratory disease (BRD) and other pulmonary syndromes are the most frequent causes of morbidity and mortality in post-weaned beef calves.[1] Multiple etiologic factors have been associated with BRD including viral and bacterial pathogens. Risk factors known to contribute to the likelihood of BRD occurrence include transportation,[2,3] stress, commingling,[4] weather,[5] and population demographics.[6,7] Multiple risk factors have been identified for BRD, yet most research has focused on occurrence early in the feeding phase with an emphasis on bronchopneumonia.

Previous research indicates most (> 70%) BRD cases occur early in the feeding phase;[8,9] however, recent research has identified respiratory cases later in the feeding period.[10] Potential reasons for this shift in disease timing are unknown and research has identified several distinct cohort-level disease timing patterns.[11] Most cohorts have the majority of cases early in the feeding phase although some cohorts incur BRD cases that do not occur until later in the period. The reasons for potential differences in disease timing from the early to mid- or late-feeding phase could be related to specific pathogens, cattle demographics or other factors. Knowledge gaps exist on timing of BRD in cohorts and individuals.

Typically, BRD is referred to as a clinical syndrome and while etiologies vary, the expected pulmonary pathology is consistent with bronchopneumonia (BP). Another pulmonary disease occurring in feedyard cattle is acute interstitial pneumonia (AIP). Distinguishing BP from AIP can be important as BP typically has a bacterial component which may respond to antimicrobial therapy, but in AIP cases a bacterial component is not expected. Epidemiologic patterns also differ between the two syndromes with BRD expected earlier in the feeding phase while AIP has been reported as more common later in the feeding phase and in heifers.[12] Research has also identified a third syndrome incorporating pathological processes associated with BP and AIP resulting in a categorization of bronchopneumonia with an interstitial pattern (BIP).[13] The BIP syndrome may have differing risk factors than either BP or AIP[14] and warrants research evaluating the frequency of occurrence and risk factors.

While BRD is one of the most studied disease syndromes on feedyard cattle, most work is focused on bronchopneumonia early in the feeding phase. The objective of this manuscript is to describe recent literature evaluating risk factors for BRD in the mid- to late-feeding phases, determining the frequency of pulmonary pathologies, and elucidating the risk factors for specific pulmonary syndromes.

Risk factors for late day BRD

Anecdotal evidence and recent reports[10] have described BRD occurring later in the feeding phase than previously expected. The specific causes of this potential shift in disease timing are

unknown, but research was conducted using retrospective observational studies to determine potential risk factors for mid- and late-day BRD at both the cohort and individual animal level.[15,16] In both projects, retrospective individual animal and cohort-level data were utilized to evaluate the timing of BRD occurrence with potential demographic factors including cattle sex, time of arrival, and weight at arrival. In each study data were aggregated from multiple feeding operations and the case definition for BRD diagnosis was based on protocols within each operation.

Defining mid- and late-day BRD is challenging due to the varied length of feeding periods for individual cohorts. In the cohort level analysis the disease timing patterns (morbidity curve) were evaluated by consulting veterinarians and this was reconciled with evaluating the portion of the feeding period with the majority of the BRD treatments. Each feeding period was divided into 33% sections with the first 33% considered early BRD, the next 33% mid-day BRD, and the last 33% considered late-day BRD. The same methodology for dividing the feeding period into thirds was used in the individual animal evaluation.

At the cohort-level most (94%) cohorts were considered early BRD with 50% of morbidity occurring by day 18 of the feeding phase.[15] Fewer cohorts were considered mid- (4%, 50% morbidity by day 53) or late-day (2%; 50% morbidity at day 75). In this population morbidity and mortality were higher in cohorts classified as early BRD compared to those classified as late (16% vs. 12% morbidity and 2.7% vs. 2.3% mortality, respectively). Multiple risk factors were assessed for association with cohort-level disease timing and only the quarter of arrival was associated with a shift from early to mid- or late- day. Cattle arriving in the 2nd quarter of the year had a lower likelihood to be early cohort level BRD (84%) compared to cattle arriving in quarters 1,3, or 4 (93%, 94%, or 96%, respectively). This research identified that early BRD at the cohort level is overall most common and cattle arriving in the second quarter were less likely to have early BRD.

At the individual animal level further risk factors were identified which modified the likelihood of an animal being treated for BRD in the early, mid- or late-feeding phase.[16] The effect of quarter of arrival on the likelihood of early BRD cases was modified by both gender and arrival weight. In general, cattle arriving in Q3 and Q4 were more likely to be early, but cattle arriving in Q1 and Q2 showed more likelihood of early disease in lighter weight animals. Gender also played a role with heifers less likely to be treated early in the feeding phase and this impact was more evident in animals arriving in Q1 and Q2.

In aggregate these evaluations identified most BRD cases occur early in the feeding phase but time of year may also play a role in the probability of BRD in the mid- or late feeding phase. In the individual animal analysis heifers were more likely to have mid- or late- BRD relative to steers in Q1 and Q2 arrivals.

Frequency of pulmonary pathology

Two major pulmonary pathologies reported in feedyard cattle are bronchopneumonia (BP) and acute interstitial pneumonia (AIP). Recent research illustrated that a third syndrome (bronchopneumonia with an interstitial pattern; BIP) occurs frequently in Canadian cattle,[14] but little research has been completed in the U.S. population. A cross-sectional observational study

was completed evaluating gross and histopathological pulmonary findings from 402 animals in six central high plains feedyards.[17] The first study objective was to determine the frequency of BP, AIP, BIP as determined by histopathology and gross necropsy. The second study objective was to compare histopathologic and gross necropsy diagnosis. All animals were necropsied by technicians with diagnosis confirmed by a veterinarian and 4 histopathological sections were evaluated (right cranioventral, left cranioventral, right caudodorsal, and left caudodorsal) on a subset (n=172) of cases.

The two most common disease syndromes identified were BIP (36% based on gross, 36% based on histopathology) and BP (37% based on gross, 32% based on histopathology). Gross necropsy identified AIP in 10% of the cases while this syndrome was identified in 12% of cases by histopathology. While the overall frequencies of each pulmonary pathologic syndrome were similar among the diagnostic modalities a comparison of individual cases revealed differences in the classification of individual animals. This work illustrated that BP and BIP were the most frequent pulmonary pathology in this population of deceased feedyard cattle.

Risk factors for pulmonary pathology

While risk factors for BP in feedyard cattle early in the feeding phase are well documented, relatively little recent work has evaluated the risk factors for BIP and AIP in feedyard cattle. An observational study was conducted evaluating epidemiologic factors associated with AIP, BP, and BIP in feedyard cattle with diagnosis occurring through gross necropsy.[18] In this study 357 animals from six feedyards in the central high plains were evaluated by gross necropsy and the likelihood of specific pulmonary lesions were evaluated in comparison to cattle demographics (sex, days on feed, previous treatment history). The population consisted primarily of heifers (71%).

Comparing gross necropsy findings to clinical diagnosis identified several differences illustrating the importance of gross necropsy for final diagnostic information. Of note, the timing of some pulmonary pathology disease patterns differed between clinical and gross pathological diagnosis. Using clinical diagnosis, the distribution of timing of AIP cases was much tighter and later in the feeding phase compared to when gross pathological designation of AIP cases was evaluated. This discrepancy could be due to previous training of the cattle health observers of the increased likelihood of AIP occurring later in the feeding phase.

Risk factor evaluation for AIP revealed heifers were more likely than steers to suffer from this syndrome and cattle that died at 100-150 days on feed were more likely to have AIP relative to cattle in the 0-50 days on feed category at death. These findings are like previous work describing risk factors for AIP. Evaluating BIP risk factors revealed the early feeding phase (d 0-50) was less likely than days 150-200. Additionally, cattle with 0 previous treatments were less likely to be diagnosed with BIP compared to cattle with 1 or >3 treatments.

Conclusions

Bovine respiratory disease is an important syndrome in the feedyard industry. Understanding factors associated with disease timing may lead to improved prevention and intervention techniques. Pulmonary pathologic syndromes differ among individual mortalities with BIP and BP being the most common. Epidemiologic factors associated with disease risk differ among

each pulmonary pathologic syndrome. Clear, repeatable case definitions for pulmonary pathology are critical for recording and determining future epidemiological shifts.

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