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# *Short communication:* Ultrasonographic assessment of lung consolidation postweaning and survival to the first lactation in dairy heifers

**E. A. Adams*[1] and S. Buczinski†**
*Dairy Technical Services Team, Merck Animal Health, 35500 W 91st Street, De Soto, KS 66018
†Département des sciences cliniques, Faculté de Médecine Vétérinaire, Université de Montréal, CP5000, Saint-Hyacinthe, J2S 7C6, Québec, Canada

## ABSTRACT

The aim of this prospective cohort study was to assess the association of systematic thoracic ultrasonography findings postweaning on calves' survivability to the first lactation. Three-month-old Jersey heifers (n = 250) returning from a custom heifer grower were scanned by thoracic ultrasonography and lungs assessed using a scoring system with a scale from 1 to 4. A score of 1 was attributed to calves with no abnormality. A score of 2 was assigned if multiple comet tails or B-lines (coalescence of multiple comet tails) were observed. A score of 3 was assigned to calves with ≥1 location of lung consolidation ≥1 cm but <6 cm. Calves with extensive consolidation (≥6 cm in one or more locations) or evidence of abscessation or pleural effusion (>1 cm) were assigned a score of 4. Calves with a score of 4 had greater risk of dying or being culled [26% (95% credibility interval: 13–47%)] than calves with a score of 1 [1% (0–6%)], 2 [3% (1–9%)], or 3 [5% (1–17%)]. We found no association between age of first calving in the remaining calves and lung score. Thus, lung lesion severity assessed by thoracic ultrasound is associated with a long-term production outcome.
**Key words:** dairy calf, lung consolidation, ultrasonography, pneumonia

### Short Communication

Bovine respiratory disease complex (**BRD**) continues to be a challenge for dairy producers and custom calf raisers (USDA-APHIS, 2011). During a pneumonic event, damage to the lung from the pathogen itself or due to the calf's own immune response can causes consolidation, fibrosis, effusion, and abscessation (Panciera and Confer, 2010). Evidence indicates that these lesions have negative effects on performance in cattle as seen by the decreased ADG of beef cattle with lungs lesions found at slaughter compared with cattle without lung lesions (Wittum et al., 1996). A study of South African feedlot cattle found that the overall effect of BRD, defined by lung lesions measured at slaughter, was a 24-g reduction in ADG and a 5.1-d increase in days on feed (Thompson et al., 2006). Calves with a history of being treated for pneumonia during calfhood have an increased age at first calving and are likely to make less milk in the first lactation and be culled within the first lactation (Bach, 2011; Stanton et al., 2012). On many calf-raising operations, treatment records are not permanent and the pneumonia diagnosis is highly subjective (Van Donkersgoed et al., 1993; Sivula et al., 1996; McGuirk, 2008). Therefore, the true effect of pneumonia is still not well defined because most of the previous studies have relied on the farm's treatment recording of disease incidence, which is based on different subjective clinical impressions and imperfect case definitions. Among more specific tools for BRD detection, thoracic ultrasound allows the operator to image the lung surface. Ultrasound can serve as an objective tool for the diagnosis of BRD-induced lung damage compared with necropsy (Braun et al., 1997; Rabeling et al., 1998; Flöck, 2004). Thoracic ultrasound can also be used calf-side on the farm (Ollivett et al., 2011) and is easily and consistently performed, even for novice operators with proper training (Buczinski et al., 2013). The accuracy of thoracic ultrasound for BRD detection in calves has recently been determined with a sensitivity of 79.4% [95% Bayesian credibility interval (BCI) of 66.4–90.9%] and a specificity of 93.9% (95% BCI: 88.0–97.6%; Buczinski et al., 2015). The objective of this study was to determine if fixed-time lung ultrasound findings could be applied on farm to predict whether calves have increased odds of not entering the productive state (first lactation). Our hypothesis was that pathologic ultrasonographic lung anomalies are associated with a negative outcome of not entering the first lactation and eventually delayed age at first calving (**AFC**).

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[1]Corresponding author: elizabeth.adams@merck.com

Three-month-old Jersey heifers returning from a custom heifer grower were selected as candidates for this study. The calves were from 3 different source farm locations in California that were under the same ownership and management strategies. They left their home dairies on d 2 of life and were raised by a custom grower who raised calves for multiple other dairies in addition to the calves enrolled in this study. Treatment records and specifics of the feeding program while the calves were at the custom calf-growing operation were unavailable. Upon reaching 3 mo of age, the calves left the custom calf grower and returned to a single heifer-growing operation operated by the owner of the calves. At 6 mo of age, the calves were grouped and transported to Texas to continue their heifer development and breeding. Pregnant heifers returned to California as springers when they were 7 mo pregnant with their first calf. For the purposes of this study, record keeping began when the calves were 3 mo old and returned under the management of ownership until freshening.

The returning 3-mo-old calves were grouped (55–60 calves) in an open dirt corral with a roof, cement lane, and 60 appropriately sized locking head stanchions. The calves were vaccinated with a modified live viral with 5-way leptospira vaccine (Bovishield Gold 5L5, Zoetis Animal Health, New York, NY) upon returning to the dairy at 3 mo of age. A booster vaccine was administered 4 wk later. No metaphylaxis or group treatment with antibiotics was given to the animals when they returned at 3 mo of age. Upon returning from the custom calf raiser and for the duration of the study, the calves were evaluated for illness twice a day by a trained on-farm employee. On the day of enrollment, every other calf in a pen was unlocked and released from the head stanchion. The remaining calves were scanned with the ultrasound one time, a lung score assigned, and their performance followed to first lactation. A total of 250 calves were enrolled in this study over 2-mo period based on the availability of animals returning. Calves were delivered to the heifer growing operation every 2 wk in groups of 60 to 90 calves depending on the number of calves that met the minimum age requirement of 90 d. Calves were enrolled and their lungs scanned the day after they returned from the custom grower.

The thoracic lung ultrasound technique was performed as previously described (Babkine and Blond, 2009) with the substitution of acoustic gel for isopropyl alcohol. Briefly, hair on both sides of the thorax was clipped from the tenth rib space cranially to the third rib space and isopropyl alcohol applied to the skin. A 8.5-MHz linear transducer ultrasound (Ibex Pro, E.I. Medical Imaging, Loveland, CO) was used in the intercostal spaces where the hair was clipped to image the lung. The maximal depth of examination was set at 8 cm throughout the study period. The probe was moved from the caudal to the cranial lung fields, moving in each intercostal space from dorsal to ventral. Confirmation of viewing the entire lung field was made by imaging the liver on the right and spleen on the left in the caudal regions to the heart and lung cranial to the heart on the right and left sides in the cranial regions. The same operator (EA) scanned all of the calves that were enrolled in this study.

A simple scoring system that aimed to be compatible with a rapid calf-side use was developed to assess calf lung lesions. A calf was scored on a scale of 1 to 4 based on findings within the entire lung field as follows. A score of 1 was attributed to calves with no abnormalities, meaning only a healthy pleural surface or isolated comet tail within an image field could be seen (Figure 1A). A score of 2 was given if comet tails on the pleural surface that were multiple and B-lines (coalescence of multiple comet tails; Lichtenstein et al., 2004) without significant lung consolidation were observed (Figure 1B). A score of 3 was assigned to calves with one or more locations of lung consolidation $\geq$1 cm (Figure 1C). A score of 4 was assigned to calves with extensive consolidation ($\geq$6 cm in one or more locations), abscessation within the lung parenchyma seen as an encapsulated fluid filled space (Figure 1D), or significant pleural effusion (>1 cm; Figure 1E).

The calf lung ultrasound score was recorded as an item in the calf's individual Dairy Comp (Valley Agricultural Software, Tulare, CA) record. Future vaccinations, treatments, inseminations, pregnancy diagnosis, freshening, and dead events were also recorded in the calf's individual record. When an animal was sold for voluntary reasons, this was also recorded.

The analyses were performed using commercial software (SAS software, version 9.3; SAS Institute Inc., Cary, NC). Descriptive statistics were performed concerning the distribution of lesions scores and the mortality and culling proportions. The association between ultrasonographic findings and the risk of being removed from the herd, voluntarily or involuntarily, was investigated using a nonparametric Kaplan-Meier survival analysis (LIFETEST procedure in SAS) log-rank test and post-hoc Tukey-Kramer adjustments for multiple comparisons between lung scores. Because almost all the mortality or culling events occurred before 330 d of life, we focused on this specific period for survival analysis.

The AFC was compiled for all calves. The relation between AFC and lung score was assessed using a nonparametric Wilcoxon rank-sum test (NPAR1WAY procedure in SAS). The level of $\alpha$ (type I) error was set at $< 0.05$ and a tendency was reported $0.05 \leq \alpha < 0.10$.