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# Lung Ultrasound Scoring: A Way to Visually Detect Lung Damage

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Respiratory disease is one of the leading causes of illness in young dairy calves. In 2014, more than 11% of pre-weaned and 5.1% of weaned dairy heifers were treated for some form of respiratory disease (USDA, 2018). Respiratory damage can have detrimental effects on future performance. Lung damage caused by respiratory disease is claimed to impact growth, development, reproduction, and lactation. Dr. Michael Overton of Elanco found that a calf diagnosed with bovine respiratory disease within the first 120 days of age costs the producer at least $245 (Overton, 2019). Farms need a definitive way, other than observation of clinical signs, to diagnose respiratory infections on individual animals.

Researchers at the University of Wisconsin-Madison have developed a Calf Health Scoring System to quantify the physical symptoms of respiratory disease. This system assigns numbers from 0 (normal) to 3 (severe health observation) to five respiratory symptoms: rectal temperature, cough, nasal discharge, eye scores, and ear scores (McGuirk, 2008). The full University of Wisconsin-Madison Calf Health Scoring Chart can be found at this url: https://www.vetmed.wisc.edu/dms/fapm/fapmtools/8calf/calf_health_scoring_chart.pdf

This scoring system is based on individual observation of respiratory symptoms. However, determination of respiratory disease clinical signs can be inconsistent, and early diagnosis can be highly variable from person to person, especially with changes in personnel. Additionally, variation between animals in how they display clinical signs can add to the inconsistency in respiratory disease diagnosis. Therefore, a more objective on-farm tool to diagnose respiratory disease is needed.

Veterinarians are starting to utilize thoracic ultrasonography, more commonly known as lung scanning, to create a more objective form of diagnosing lung damage. This tool is non-invasive, relatively easy to use, and has been validated for its accuracy in identifying damaged lungs (Buczinski et al., 2015). Thoracic ultrasonography is highly correlated with post-mortem examinations, meaning a trained operator can positively identify lung damage with this technique. Lung scanning can also be used to assess on-farm personnel's ability to diagnose respiratory disease. This tool can be used anytime throughout the pre- or post-weaning phases, but common time points are at weaning and before calves' transition to the next growing phase. One application of lung ultrasounds is to assess lung damage in early life and make better informed replacement heifer culling decisions.

## Lung Scoring Technique and Scoring System

Thoracic ultrasonography is relatively easy to implement at some point during early calf development. The ultrasound equipment needed is also used for pregnancy diagnosis in cattle. The variable frequency ultrasound machine (i.e., IBEX Medical Imaging Ultrasound) is portable and equipped with a linear rectal probe (i.e., 8.5 MHz). The machine can be used for both purposes, allowing the investment cost to be prorated over more animals. There are several steps to follow when lung scanning calves:

### Lung Scoring Steps

1. Select a group of calves to lung scan. Weaning is a good opportunity to scan before moving to group housing because farmers can also monitor heifer growth during the pre-weaning period.
2. Prepare all necessary equipment: ultrasound machine, 70% isopropyl alcohol, clippers, recording device (pen/paper or electronic recording), and method of restraint (halter or headlocks).
3. Properly restrain animal so they are secure and you have access to both sides of the calf.
4. Clip hair from both sides of the calf between the 1st and 8th rib spaces on the bottom half of the calf. (**Figure 1a**)
5. Spray the clipped area with isopropyl alcohol.
6. Begin scanning with the linear probe directly behind the shoulder between the space of the first and second ribs. (**Figure 1b**)
7. Place the linear probe on top of the clipped area, and follow the rib space down until you reach the bottom of the clipped area.
8. Repeat step 7 for each rib space up and including the 8th rib space.
9. Assign a cumulative lung score (**Figure 2**) for that side.
10. Repeat steps 5-9 for the opposite side.

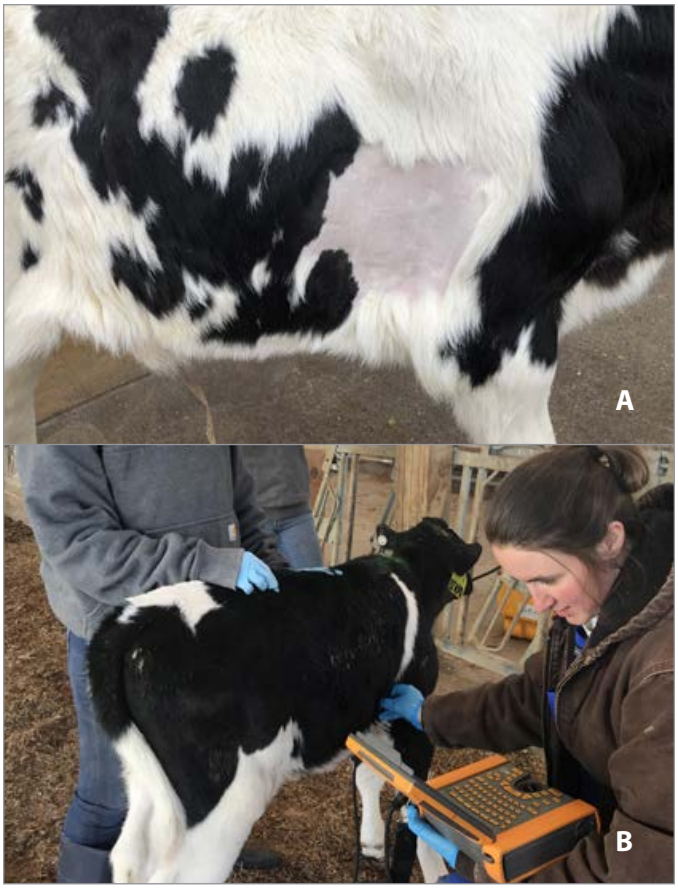


**Figure 1.** (**A**) Lung scoring location. (**B**) Lung scoring technique: a calf in an automated calf feeding system gets scanned for lung damage.

Our Purdue research lab uses a lung scoring system of 1-4 to quantify the severity of damage to the lungs. The scoring system is based on the validated technique reported by Buczinski et al. (2015).

## Lung Consolidation Score (LCS)

**1** = no consolidation
**2** = comet tails on the pleural surface
**3** = one location of consolidation ≥1 cm but <6 cm
**4** = consolidation ≥6 cm or more than one location of consolidation

**Figure 2.** Lung consolidation scoring chart

Lung consolidation is the term used to describe damage to the lung tissue, and once the lung has been damaged, consolidation cannot typically be reversed. Consolidation can be thought of as scar tissue within the lung, reducing both lung capacity and the ability to properly oxygenate blood. **Figure 3** shows visual images of LCS 1 to 4; these images show consolidation in one location (between one of the 1-8 rib spaces) of different calves. When viewing LCS 1 of Figure 3, the white horizontal line across the scan shows the lung tissue lining (pleural surface). The smooth undisrupted line displays a normal, healthy lung. Animals with an LCS of 2 show a slight disruption in the pleural surface of the lung tissue. On the ultrasound scan, this disruption appears as small white lines lying vertically to the pleural surface (LCS 2 in Figure 3). These white lines are called comet tails. Comet tails are the beginning of damage to the tissue but are commonly found when scanning calves. According to Buczinski et al. (2014), 104 out of 106 calves lung scanned expressed at least one comet tail; therefore, it is not considered consolidation when scoring. Lung consolidation scores of 3 and 4 (Figure 3 LCS 3 and 4) show varying degrees of disruption and should raise concern for dairy producers. **Figure 4** shows what damaged lung lobes (LCS 3 and 4) look like. There are differing severities of lung damage. For example, calves may have one location of damage in their lungs on one side (right/left), multiple locations on one side, one location on both right and left sides, or multiple locations on both right and left sides. Therefore, it is important to document the lung score on both sides because animals with lung damage on both sides are at a higher risk of reduced growth than calves with lung damage on only one side. With experience, this technique can be performed in approximately two minutes per calf.

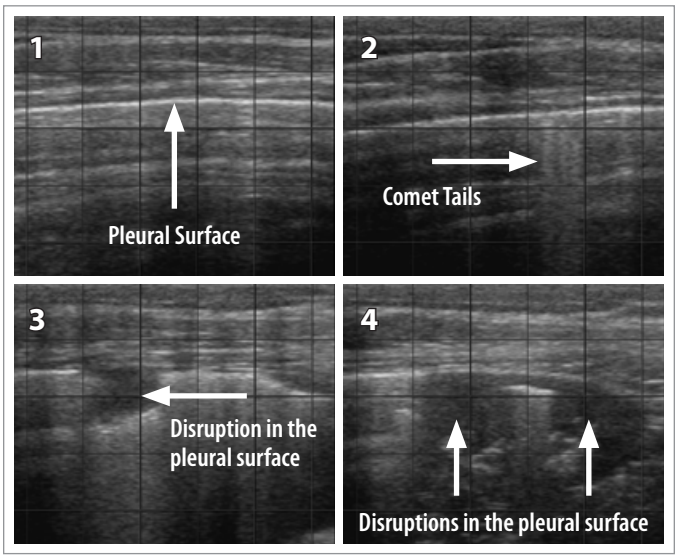


**Figure 3.** Pictured above are ultrasound images of 60 day old calf lungs between the 1st and 8th rib spaces. Each picture represents a numerical lung score (1-4).

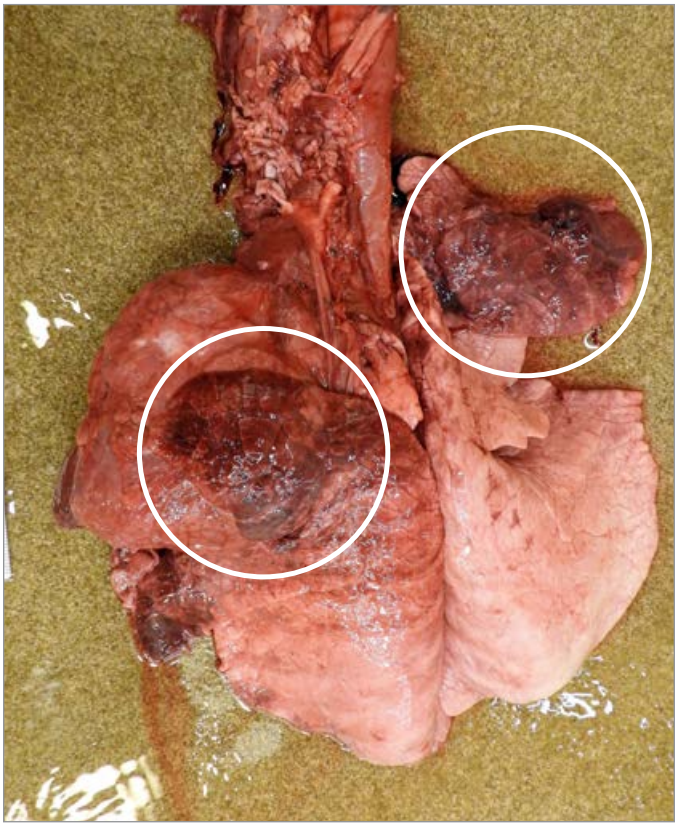

**Figure 4.** Pictured above is the bovine lungs consisting of 8 different lobes. The dark red sections circled in white are consolidated lung lobes. The bottom right of the picture shows the color of a normal calf lung lobe.

## Implications of Lung Damage on Future Performance of Dairy Heifers

To study how lung damage affects calf pre-weaning performance, our Purdue University research lab took the lung scanning technology to a commercial dairy farm with automated calf feeders. One technician lung scanned 420 calves near weaning (average 56 days of age) between January and March 2019. This project used the lung consolidation scoring technique described above, but simplified the system to try and understand if lung damage affects production parameters such as average daily gain (ADG). **Figure 5** shows how no consolidation (lung score 1 or 2 on both lungs), single side consolidation (lung score >2 on one lung), or double side consolidation (lung score >2 on both lungs) impacts ADG in this farm's automatic calf feeding system.

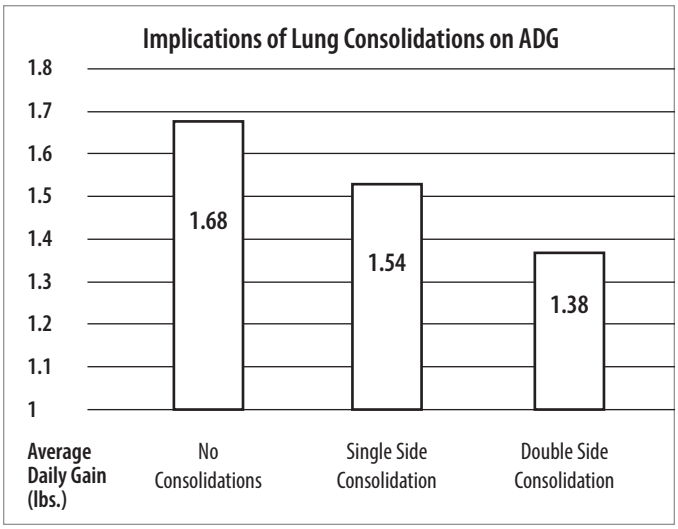


**Figure 5.** Implications of lung consolidation on ADG in pre-weaning calves.

These results confirm that calf lung consolidation during the pre-weaning phase lowers calf performance. In an automated feeding system, calves with no lung consolidation drank more milk than calves with lung consolidation on one side (15 L less) or on both sides (26 L less). This lower milk consumption resulted in lower average daily gain (ADG) and higher feed to gain (F:G) in calves with tissue damage in their lungs. If a calf has lung damage on both sides it gained 17.9% slower per day than a calf with no lung damage. Over a 60-day period, the calf with double side lung damage gained approximately 18 pounds less than a calf with no lung damage.

Other researchers have observed decreased growth and ADG as well. Cramer and Ollivett (2019) found that calves who had lung consolidation had reduced gain of 0.24 pounds per day, versus calves who did not have lung consolidation. When calves were treated for respiratory disease during the 60 days following weaning, they were 32 pounds lighter at 13 months of age (Stanton et al., 2012).

Lung consolidation also affects performance of heifers later in life. Replacement heifers with lung consolidation at 60 days of age conceive later during their first breeding season, calve later with their first calf, and have a higher probability of leaving the herd before they finish their first lactation. Lung damage may also affect the ability of the first-calf heifer to rebreed after freshening (Texiera, 2017) and lower total milk production (1160 pounds; Dunn et al., 2018) during her first lactation.

While lung scanning can be a useful tool in monitoring disease incidence, it should not be substituted for visual observation and proper personnel training to detect respiratory disease. When used together, the combination of careful visual observation for clinical symptoms and lung scoring will help farm managers determine which heifers will be most productive. Lung scanning, especially after the pre-weaning period, can be a valuable diagnostic tool that farm managers should consider adding to their herds.

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