

Thoracic ultrasound to monitor lung health and assist decision making in preweaned dairy calves

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Abstract

In young dairy cattle, respiratory disease is economically challenging, subclinical disease exists, and producer-based diagnosis lacks in sensitivity. Therefore, monitoring lung health in young cattle should be considered a priority for maintaining proper drug use, animal wellbeing, and profitability. Incorporating lung ultrasound at regular intervals provides an understanding of the epidemiology of respiratory disease in client herds, and can help identify problems before they become catastrophic. The growing pains from learning how to perform lung ultrasound are worthwhile, and will help you become indispensable to your clients. This article will review the available technologies, the benefits of a systematic examination, and how to implement thoracic ultrasound to monitor lung health and assist in management decisions.

Key words: dairy, calves, lung, ultrasound

Résumé

Chez le jeune bovin laitier, la maladie respiratoire est un défi économique. De plus, la maladie sous-clinique est souvent présente et le diagnostic par le producteur est peu sensible. Par conséquent, la surveillance de la santé pulmonaire chez les jeunes bovins devrait être une priorité afin d'assurer une utilisation judicieuse des médicaments, le bien-être de l'animal et la rentabilité. L'utilisation de l'échographie pulmonaire à intervalle régulier permet de mieux comprendre l'épidémiologie de la maladie respiratoire dans les troupeaux du client et peut aider à identifier les problèmes avant qu'ils ne deviennent trop sérieux. Les difficultés d'apprentissage liées à l'utilisation de l'échographie pulmonaire en valent la peine et vont vous aider à devenir indispensable auprès de vos clients. Cette présentation examine les technologies disponibles, les bénéfices d'un examen systématique et comment mettre en place l'échographie thoracique pour surveiller la santé pulmonaire et aider à la prise de décision en matière de régie.

Introduction

Whether or not portable ultrasound is considered a new technology for a practice, most veterinarians fail to capture the full economic potential of their investment because they rarely move beyond the basic reproductive

exam. The transrectal probes that are widely used by bovine veterinarians permit the best access to the axillary region and cranial thorax, making them the most suitable tool for practical field-based thoracic ultrasound (TUS) in young cattle. These machines typically range in frequency from 3.5 to 8 MHz, which are all acceptable frequencies and can reach appropriate depths of 8 to 10 cm for evaluating lungs. You can choose between using a machine with an attached screen, a wireless screen, or goggles, based on personal preferences. At the end of the day, if you can diagnose a pregnancy in an adult cow, you should be able to diagnose pneumonia in a calf with the same machine.

Operator positioning, restraint, and transducing agents are all necessary considerations when scanning. During the examination, it is up to the operator to decide whether to stand or squat down next to the calf. Short individuals and those with low back pain typically prefer squatting; whereas those with knee pain or the gift of height often choose to stand. When standing, it is easiest to scan each side of the calf by reaching over the dorsum to the opposite side.

In most situations, restraint should be minimal, rarely requiring a halter, headlock, or chute, particularly in young dairy animals. Increasing the level of restraint often only manages to increase handling time, therefore reducing the practicality of the procedure. Most often, the young dairy calf can be restrained by placing the hindquarters in the corner and hand under the chin or in front of the chest. In headlocks, calves often lean backwards reducing access to the first few ICS beneath the forelimb. On the farm, 70% isopropyl alcohol is the transducing agent of choice, and the hair is not clipped or shaved from the chest. Ninety percent (or greater) isopropyl alcohol functions well but is excessively drying to the US probe as well as the skin of both the operator and the calf, and should be avoided. Coupling gel and even vegetable oil will work; however, both products create a substantial mess compared to alcohol. Significantly less alcohol is required if a household spritzer/spray bottle is used.

Within reason, the TUS technique can be modified based on the goals of the exam. Individual sick or "poor-doing" animals are more likely than the average calf to harbor lesions, specifically lung abscesses, in the caudal lung lobe. In these cases, the caudal lung lobe should always be assessed as well as the more cranial lung lobes. This requires scanning the right lung from the 10th intercostal space (ICS) cranial to the 1st ICS and the left lung from the 10th ICS cranial to the 2nd ICS.

When screening a group of calves for pneumonia, a different approach can be taken compared to that used for an individual sick animal. Since bronchopneumonia usually localizes to 3 specific lung lobes during the early phase of disease, the cranial aspect of the right cranial lung lobe, the right middle lung lobe, and the caudal aspect of the left cranial lung lobe should be the focus of the exam. The caudal aspect of the right cranial lung lobe, the cranial aspect of the left cranial lobes, and caudal lung lobe are rarely consolidated without consolidation of the previously mentioned lobes. It is important to scan both sides of the thorax, since consolidation may occur unilaterally in up 1 of 3 dairy calves.¹ When a systematic clinical score, such as the Wisconsin Respiratory Score² is also incorporated, calves can be categorized by BRD subtypes including upper respiratory tract infections, clinical pneumonia, and subclinical pneumonia. In this context, upper respiratory infection is defined as a positive respiratory score and a normal TUS; clinical pneumonia is defined by a positive respiratory score and abnormal TUS; and subclinical pneumonia is defined by a normal respiratory score and an abnormal TUS. The distributions of BRD subtypes will vary from farm to farm.

A systematic approach to TUS depends on an understanding of the external thoracic anatomy of the calf, the internal anatomy of the lung, and appropriate ultrasonographic landmarks. The external anatomy of the calf refers to the specific ICS where the probe is placed. The internal anatomy refers to the specific lung lobes that are being evaluated. Lastly, the ventral image landmarks provide unique identifiers for each lung to ensure that the high-risk locations for pneumonia are examined. Once comfortable with the technique and scoring system, an accurate ultrasonographic diagnosis can be made within 20 to 30 seconds. An algorithm for scoring is provided below.

In general, the recommended TUS examination extends from the caudal thorax to the cranial thorax by moving the probe along the grain of the hair in a dorsal to ventral fashion within each ICS. The probe should move parallel to the rib within the ICS. It is a common mistake to move the probe perpendicular to the ground. Instead, the probe should be moved slightly caudally, staying within 1 ICS to avoid imaging the rib. Very slight adjustments can move the ultrasound beam onto or off the rib surface and/or enhance visualization of a lung lesion. These small movements include moving the tip (or the end) of the probe side to side or rotating the footprint (the portion of the probe in contact with the body wall) so that it is facing more cranial or caudal within the ICS. If the rib obscures the image of the lung, simply stop moving, readjust the angle of the probe until the lung is present, and then continue ventrally within the ICS.

The 6-point scoring system and scoring algorithm is suggested for scoring lung lesions and has served as a practical means to document and monitor lung lesions on commercial dairy farms. In order to properly score, the operator must be able to recognize the difference between aerated

lung, aerated lung with diffuse pleural roughening (also called comet-tail artifacts), lobular lung lesions (also called lobular consolidations or lobular pneumonia), and lobar lung lesions (also called lobar consolidations or lobar pneumonia). In the context of this US scoring system, lobular and lobar lesions simply reflect the extent of which the lung lobe is consolidated on the ultrasound image. Lobular lesions are relatively small discreet areas of consolidation within an otherwise aerated lung lobe. In other words, the hyperechoic pleural interface with reverberation artifact of normal lung can be seen both dorsal and ventral to the lobular lesion when the probe is placed vertically within the rib space. Lobar lesions indicate full thickness consolidation of the lung lobe that extends proximally from the tip of the lobe. In the US image, the hypoechoic parenchyma of the entire distal lung lobe is visible, and aerated lung cannot be seen ventral to the lesion.

In general, US scores 0-1 are considered normal and ultrasound scores ≥ 3 are consistent with bacterial bronchopneumonia whereas ultrasound score 2 can represent either bacterial or viral infection.³ Abnormalities such as pneumothorax, pleural fluid, abscesses, and necrosis are not inherently included in the scoring system. Instead, a comment is included within the record regarding the abnormality (e.g. US score 4 plus 4 cm abscess in right caudal lung lobe at the level of the 8th intercostal space).

While it is not realistic to expect that every calf is ultrasounded, periodically ultrasounding a subset of calves at a predetermined frequency for a predetermined reason can give you very useful information and help you make management decisions. The key to success is to know what question(s) you would really like to answer. Ten questions that you can answer using lung ultrasound include:

1. How many calves have pneumonia and is this higher or lower than last month?
2. When are calves most likely to get pneumonia?
3. Which barn is more likely to have sick calves?
4. Are sick calves detected early enough?
5. Are treatment protocols (or vaccine protocols) working?
6. Why are calves not growing well?
7. Did lung health improve after installing new positive pressure tubes?
8. Is metaphylaxis worth the cost of treating every calf?
9. Calf facilities are overcrowded, which calves should be kept?
10. Should this show animal or replacement heifer be purchased?

Often, an easy place to begin when first starting to ultrasound lungs for your clients and while becoming comfortable with the technique is by looking at the calves that were recently treated. Obtain a list of calves that were treated within the last 24 to 36 hours. By scanning these calves, the competency of animal care personnel can be assessed by calculating the proportion of calves scoring >3 at their first

treatment. A high proportion of animals with lobar pneumonia affecting more than 1 lobe at first treatment (ultrasound score 4 or 5) suggests delayed detection and warrants additional training and protocol review with the employees. Efficacy of detection and treatment protocols can be assessed by re-evaluating those same calves 7 to 10 days later. Lung scores should be significantly improved if calves are detected early and the treatment protocol is effective.

Another step in monitoring BRD at the herd level with TUS is to acquire a baseline of the calves at risk (on a small farm) or a random subset of calves at risk (8 to 12 calves could be a minimum number. Based on this information, along with clinical scoring, the distribution of the BRD subtypes, age of onset, duration of disease can be determined.⁴

Calf lung ultrasound data will help measure the impact of management changes that are not reflected by changes in clinical signs or treatment records.

Algorithm for scoring ultrasonographic lung lesions in dairy calves

1. Determine the orientation of your probe
2. Identify ventral image landmarks
3. Determine if lung is aerated or non-aerated
4. If lung is non-aerated, determine if the lesion represents lobular or lobar pneumonia
5. If lobar pneumonia is identified, count the number of lobes affected to create the US Score

1. Determine the orientation of your probe

- a. Touch your finger to the tip of probe, which will be dorsal when placed in the intercostal space, and see where it appears on the screen
- b. Ollivett images are always in the same orientation
 - Left side of image = Dorsal
 - Right side of image = Ventral

2. With probe in the intercostal space, identify the ventral image landmark in your image

- a. What landmark(s) do you see?
 - Diaphragm
 - Costochondral junction and pleural deviation
 - Heart
 - Internal thoracic artery and vein
 - Liver
 - Kidney

3. Determine if lung is aerated or non-aerated

- a. Is reverberation artifact present?
 - i. Continuous = aerated lung
 - ii. Interrupted = non-aerated lung
- b. Aerated lung
 - i. Few to no comet tails: **US Score 0**
 - ii. Severe, diffuse comet-tailing: **US Score 1**
- c. Non-aerated lung: **US Score 2 – 5**

4. If lung is non-aerated, determine if the lesion represents lobular or lobar pneumonia

- a. Is there a gap present in the reverberation artifact?
 - i. Yes - lobular pneumonia: **US Score 2**
- b. Does the reverberation artifact and pleural line terminate prematurely resulting in the hypoechoic architecture of the lung lobe being visible?
 - i. Yes – lobar pneumonia

5. If lobar pneumonia is identified, count the number of lobes affected to determine the US Score.

- a. **US Score 3:** 1 lobe
- b. **US Score 4:** 2 lobes
- c. **US Score 5:** 3 or more lobes

Conclusion

The portable rectal ultrasound machines already in use by bovine veterinarians for reproductive examinations are a fast, accurate, and practical means of diagnosing the lung lesions associated with BRD in young cattle. When combined with respiratory scoring, systematic TUS allows for the differentiation of BRD into specific practical subtypes including upper respiratory tract disease, clinical pneumonia, and subclinical pneumonia, all of which can be performance limiting. In individuals, TUS can be used to identify poor prognostic indicators such as caudal lung lobe consolidation, lung abscessation, and lung necrosis, and can aid culling and purchasing decisions. At the herd level, TUS can be used to identify specific populations at risk for developing the subtypes of BRD, monitor the prevalence and severity of BRD over time, and evaluate the impacts of management changes, such as ventilation, vaccination, changes in treatment protocols or personnel. In conclusion, TUS can add to the services provided by bovine veterinarians, increasing their value and impact on animal health.

References

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