# Inter-rater agreement of different thoracic ultrasonography techniques performed by novice operators on preweaned dairy calves

## Application:

In preweaned dairy calves, thoracic ultrasound scanning method, image interpretation and scoring technique are important determinants of the level of agreement, which may be improved in novice operators by using a consistent method and a simplified scoring technique.

## Introduction

Thoracic ultrasonography (TUS) is a validated method for the identification of lung pathology associated with bovine respiratory disease (Ollivett and Buczinski, 2016). Multiple techniques for TUS are described, each seeking to optimise precision, accuracy and examination duration. However, TUS is an imperfect method for the diagnosis of pneumonia, and differences in examination technique and image interpretation will affect the diagnosis prescribed to individual calves. In this study, we sought to evaluate the agreement between novice raters following basic training when performing different scanning and scoring methods.

## Materials and Methods

A convenience sample of 8 qualified veterinarians within the Farm Animal Health and Production Group at the Royal Veterinary College were enrolled in the study. 24hrs prior to the start of the study, TUS was performed on 40 calves by an experienced rater, with the probe passed in a dorsal-to-ventral direction within each intercostal space bilaterally and the results recorded. Thereafter, participants were provided with a one-hour classroom teaching session regarding TUS image interpretation, scoring and scanning techniques. Three published TUS scanning techniques were demonstrated; LUS (Masset et al., 2022), FLUS (Pravettoni et al., 2021) and qTUS (Jourquin et al., 2022), based upon their description within the literature. Briefly, to perform LUS the probe was passed systematically throughout the 5th to the 1st and the 5th to the 2nd intercostal spaces on the right and left hand side, respectively. For FLUS, the entire middle and ventral third of the 4th and 5th intercostal spaces were scanned bilaterally, whereas qTUS involved a single movement of the probe from the 9th intercostal space cranioventrally. Upon reaching the heart the probe was advanced dorsally and cranially around it. For each method, participants were asked to score up to 10 different preweaned dairy calves aged between 6-8 weeks within a 45-minute timeframe, with calves in each group selected to ensure a range of healthy and unhealthy individuals. Responses collected included a 6-point TUS score (TUS6) as described by Ollivett and Buczinski (2016), as well as a binary response regarding if the lesion was <1cm2 or ≥1cm2 (CE1). Agreement and reliability was assessed for all raters using equally weighted percentage agreement (PA) and Krippendorff’s Alpha (KA). Pairwise agreement between raters and the experienced rater was assessed using Cohens Kappa. Interpretation of agreement was based upon Landis and Koch (1977), whereby values of <0.00, 0.00-0.20, 0.21-0.40, 0.41-0.60, 0.61-0.80 and 0.81-1.0 were interpreted as poor, slight, fair, moderate, substantial and almost perfect agreement, respectively. All analysis was performed using R (R Core Team, 2022).

## Results

Overall PA and KA for TUS6 was 0.31 (95%CI 0.21-0.42, P<0.05) and 0.17 (95%CI 0.05-0.21, P<0.05). PA for TUS6 between raters varied by ultrasonographic technique performed. Values of 0.40 (95%CI 0.13-0.68), 0.35 (95%CI 0.13-0.57, P<0.05) and 0.13 (95%CI 0.02-0.25, P<0.05) for LUS, FLUS and qTUS were found, respectively. Agreement improved when raters provided a binary response regarding lesion size. For CE1, overall PA and KA were 0.72 (95%CI 0.59-0.86, P<0.05) and 0.36 (95%CI 0.21-0.52, P<0.05). A contingency table of Cohen’s Kappa agreement for TUS6 between pairs of raters is shown in Table 1., where observer 1 represents the experienced rater, performing a more thorough TUS technique.

*Table 1. Contingency table of Cohen’s Kappa agreement for TUS score between pairs of raters.*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 1 |   | 0.52 | 0.38 | (-0.02) | 0.39 | 0.47 | 0.37 | (0.10) |
| 2 |   |   | 0.74 | (0.01) | 0.69 | 0.67 | 0.63 | (0.20) |
| 3 |   |   |   | (-0.03) | 0.56 | (0.23) | 0.59 | (-0.04) |
| 4 |   |   |   |   | (0.08) | (-0.07) | (-0.03) | (-0.04) |
| 5 |   |   |   |   |   | 0.49 | 0.51 | (0.13) |
| 6 |   |   |   |   |   |   | 0.61 | (0.14) |
| 7 |   |   |   |   |   |   |   | (0.07) |
| 8 |   |   |   |   |   |   |   |   |

In all cases equal weighted kappa was performed. P < 0.05 in all cases except those displayed in brackets. Values are shaded based upon the extent of agreement, with darker shades corresponding with higher values (greater agreement).

## Conclusions

Inter-rater agreement between participants for TUS6 was fair overall, with marked variation between raters and between technique performed. Agreement was improved when observers provided a binary score based upon lesion size, in comparison to TUS6. We hypothesise that scoring consistency may be improved by the provision of practical training and use of simplified lesion scoring methods. In circumstances where multiple operators are performing TUS, measurement of inter-rater agreement is an essential consideration, in order to ensure the validity of any described outcomes.

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## References

Jourquin, S., Bokma, J., De Cremer, L., van Leenen, K., Vereecke, N. & Pardon, B. (2022). *Journal of Veterinary Internal Medicine,* 36**,** 820-828.

Landis, J. R. & Koch, G. G. (1977). *Biometrics***,** 159-174.

Masset, N., Assié, S., Herman, N., Jozan, T. & Herry, V. (2022). *Veterinary Medicine and Science,* 8**,** 1229-1239.

Ollivett, T. L. & Buczinski, S. (2016). *Veterinary Clinics: Food Animal Practice,* 32**,** 19-35.

Pravettoni, D., Buczinski, S., Sala, G., Ferrulli, V., Bianchi, F. & Boccardo, A. 2021. *Journal of Dairy Science,* 104**,** 4929-4935.