Article

A simplified scoring system for the diagnosis of diarrhea and respiratory diseases in dairy calves

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Abstract

Objective

To compare the capacity of a simplified calf health scoring chart (SIM score) with the University of Wisconsin's calf health scoring chart (WIN score) for the diagnosis of calf diarrhea and calf respiratory disease (RD).

Animals and procedures

Holstein calves (N = 222) were clinically evaluated for diarrhea and RD diagnosis using the WIN and SIM scores. The WIN score was based on fecal consistency for diagnosis of diarrhea (0 = feces of normal consistency to 3 = watery feces; score ≥ 2 = positive diagnosis); and on nasal discharge, ocular discharge, coughing, ear position, and rectal temperature for diagnosis of RD (each clinical sign receives a score of 0 to 3; aggregate score ≥ 5 = positive diagnosis). The SIM score was based on a hide cleanliness score for diagnosis of diarrhea [0 = negative (calf was clean) and 1 = positive (tail head region, thighs, and/or legs were soiled)]; and on nasal discharge, ocular discharge, coughing, and ear position for diagnosis of RD (rectal temperature measurement was not required and each clinical sign had 2 levels of severity; aggregate score ≥ 5 = positive diagnosis).

Results

In the RD diagnosis, the SIM score had a sensitivity of 88.24%, a specificity of 95.01%, a positive predictive value (PPV) of 55.56%, and a negative predictive value (NPV) of 99.13%. In the diarrhea diagnosis, the SIM score had a sensitivity of 94.62%, a specificity of 49.64%, a PPV of 18.22%, and an NPV of 98.73%.

Conclusion

Compared with the WIN score, the SIM score is a reliable test for diagnosing RD but not for diagnosing diarrhea.

Résumé

Un système de notation simplifié pour le diagnostic de la diarrhée et des maladies respiratoires chez les veaux laitiers

Objectif

Comparer la capacité d'un tableau de notation simplifié de la santé du veau (score SIM) avec le tableau de notation de la santé du veau (score WIN) de l'*University of Wisconsin* pour le diagnostic de la diarrhée du veau et de la maladie respiratoire du veau (RD).

Animaux et procédures

Des veaux Holstein (N = 222) ont été évalués cliniquement pour le diagnostic de diarrhée et de RD à l'aide des scores WIN et SIM. Le score WIN était basé sur la consistance fécale pour le diagnostic de diarrhée (0 = fèces de consistance normale à 3 = fèces aqueuses; score ≥ 2 = diagnostic positif); et sur l'écoulement nasal, l'écoulement

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This work was supported by UNLP Incentive Program V11/278 grant to RLS, and by UNLP Young Researcher grant no. 1145/17 to MJ.

oculaire, la toux, la position des oreilles et la température rectale pour le diagnostic de RD (chaque signe clinique reçoit un score de 0 à 3; score global ≥ 5 = diagnostic positif). Le score SIM était basé sur un score de propreté de la peau pour le diagnostic de diarrhée [0 = négatif (le mollet était propre) et 1 = positif (la région de la tête de la queue, les cuisses et/ou les pattes étaient souillées); et sur l'écoulement nasal, l'écoulement oculaire, la toux et la position des oreilles pour le diagnostic de RD (la mesure de la température rectale n'était pas requise et chaque signe clinique avait 2 niveaux de gravité; score global ≥ 5 = diagnostic positif).

Résultats

Dans le diagnostic de RD, le score SIM avait une sensibilité de 88,24 %, une spécificité de 95,01 %, une valeur prédictive positive (VPP) de 55,56 % et une valeur prédictive négative (VPN) de 99,13 %. Dans le diagnostic de diarrhée, le score SIM avait une sensibilité de 94,62 %, une spécificité de 49,64 %, une VPP de 18,22 % et une VPN de 98,73 %.

Conclusion

Comparé au score WIN, le score SIM est un test fiable pour diagnostiquer le RD mais pas pour diagnostiquer la diarrhée.

(Traduit par Dr Serge Messier)

Can Vet J 2023;64:553–557

Introduction

Diarrhea and calf respiratory disease (RD) are the 2 most common diseases during the calfhood period, and both result in economic losses and impaired calf welfare (1–3). Losses include the costs of treatments, an increased mortality rate and premature culling, reduced growth, impaired fertility, and reduced milk production (4,5). Diagnosing diarrhea and RD is challenging due to inaccurate detection methods, inappropriate timing of screening, and lack of staff time (4). Therefore, researchers from different universities have developed clinical scoring systems for diarrhea and RD diagnoses (4,6,7). However, most of these systems require calf handling (*i.e.,* to stimulate calves to defecate in the case of diarrhea, or to induce a cough or carry out temperature measurement in the case of RD), which increases the time of clinical evaluation, the stress on the calves, and the risk of disease transmission by humans. Therefore, the present study aimed to compare a simplified calf health scoring chart (SIM score) with the University of Wisconsin's calf health scoring chart (WIN score) for diagnosing calf diarrhea and calf RD.

Materials and methods

This study was approved by the Institutional Animal Care and Use Committee of the Facultad de Ciencias Veterinarias, Universidad Nacional de La Plata, Argentina (code no. 70-1-17B). Holstein calves (N = 222) between 1 and 3 d of age from 1 commercial dairy farm located in Castelli, province of Buenos Aires (36°09′S, 57°81′W), Argentina, were enrolled in this study between September 2017 and December 2018. The farm was visited once per wk, and although all calves were eligible, a maximum of 5 were included in each visit.

A 5-milliliter blood sample was taken from each calf by jugular venepuncture using a 21-gauge hypodermic needle (0.8 × 25 mm). The sample was drawn into sterile tubes (COD: 11055005MOS/G; Tecnon Laboratorios, Berisso, Argentina) in a cooling container until it was tested in the laboratory within 6 h of sampling (Veterinary Research and Diagnostic Centre, Faculty of Veterinary Science, National University of La Plata, Chascomús, Argentina). At the laboratory, the samples were centrifuged, and the serum was used to determine the total protein concentration by manual refractometry (REF_CLI_8107; Alla France, Chemillé-en-Anjou, France). The cut-point used as indicative of the failure of passive transfer (FPT) was < 5.2 g/dL (8).

The calves were evaluated once per wk for 9 wk. The occurrence of diarrhea and RD was determined using the SIM and WIN scores. In the case of RD diagnosis, calves were evaluated from August 2018 (n = 62); in the case of diarrhea, calves were evaluated from September 2017 (n = 222). The WIN score was based on fecal consistency and used a 4-level scoring scale for the diagnosis of diarrhea, where 0 = normal consistency, 1 = semi-formed or pasty, 2 = loose feces, and 3 = watery feces. Calves were considered positive for diarrhea when the fecal score was ≥ 2. For the diagnosis of RD, the WIN score was based on the following signs that also used 4-level scoring scales: nasal discharge (0 = normal serous discharge, 1 = small amount of unilateral cloudy discharge, 2 = bilateral cloudy or excessive mucus discharge, and 3 = copious bilateral mucopurulent discharge); ocular discharge (0 = normal, 1 = small amount of ocular discharge, 2 = moderate amount of bilateral ocular discharge, and 3 = heavy ocular discharge); coughing (0 = none, 1 = induced single cough, 2 = induced repeated coughs or occasional spontaneous coughs, and 3 = repeated spontaneous coughs); ear position (0 = normal, 1 = ear flick or head shake, 2 = slight unilateral droop, and 3 = head tilt or bilateral droop); and rectal temperature (0 = 37.8 to 38.2°C, 1 = 38.3 to 38.8°C, 2 = 38.9 to 39.4°C, and 3 = > 39.4°C). Calves were considered positive for RD when the aggregate score was ≥ 5.

The SIM score was based on a hide cleanliness score and used a 2-level scoring scale for the diagnosis of diarrhea, where 0 = calf was clean, only manure at lower ends of legs; and 1 = tail head region, thighs, and/or legs were soiled with manure. Calves were considered positive for diarrhea when the hide cleanliness score was 1 (2). For the diagnosis of RD, the SIM score was based on the following signs that also used 2-level scoring

Table 1. The sensitivity, specificity, positive predictive value, negative predictive value, positive likelihood ratio, and negative likelihood ratio of a simplified calf health scoring chart for calf respiratory disease and diarrhea diagnosis, using the University of Wisconsin's calf health scoring chart as the reference method.

Endpoint	Respiratory disease (n = 515 diagnostic procedures)	Diarrhea (n = 1226 diagnostic procedures)
True positive, *n*	30	123
True negative, *n*	457	544
False positive, *n*	24	7
False negative, *n*	4	552
Sensitivity, % *(n)*	88.24 (30/34)	94.62 (123/130)
Specificity, % *(n)*	95.01 (457/481)	49.64 (544/1096)
Positive predictive value, % *(n)*	55.56 (30/54)	18.22 (123/675)
Negative predictive value, % *(n)*	99.13 (457/461)	98.73 (544/551)
Positive likelihood ratio	17.6	1.86
Negative likelihood ratio	0.12	0.10

scales (6): nasal discharge (0 = normal, 4 = any discharge); ocular discharge (0 = normal, 2 = any discharge); coughing (0 = normal, 2 = spontaneous only); and ear position (0 = typical, ear flick or head shake; 4 = ear droop or head tilt). Unlike the WIN score, the SIM score did not include inducing cough and measuring temperature. Calves were considered positive for RD when the aggregate score was ≥ 5. Also, growth was estimated using a heart-girth measuring tape around the thorax, just caudal to the forelimb, with the calf standing in a neutral position. In addition, data about sex, type of parturition, birth weight, and deaths were recorded during the visits.

To assess the predictive capacity of the SIM score for diarrhea and RD, with the WIN score as the reference method, the sensitivity (SE), specificity (ES), positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio (PLR), and negative likelihood ratio (NLR) were calculated. Also, the *Kappa* coefficient was calculated to evaluate the agreement between methods (WIN score and SIM score) in the diagnosis of diarrhea and RD (Proc Freq function of SAS version 9.4). This analysis included 1226 diagnostic procedures from 171 dairy calves with diarrhea and 515 diagnostic procedures from 62 dairy calves with RD.

The odds for diarrhea and RD were evaluated by logistic regression models with repeated measures that included FPT, type of parturition (assisted *versus* unassisted), birth weight (as a continuous variable), and sex as fixed predictors with the Proc Glimmix function of SAS version 9.4. A 1st-order autoregressive correlation structure was used to handle repeated measures in time (wk). The least squared means for FPT, sliced by wk, were estimated. Linear regression models with repeated measures evaluated the association between growth and disease events with the Proc Mixed procedure of SAS version 9.4. The model for RD included, as categorical predictors, the occurrence of RD, the wk of observation, and their interaction. The model for diarrhea included, as categorical predictors, the occurrence of diarrhea with 3 levels (score of fecal consistency: 0 to 3; score 0 and 1 *versus* score 2 *versus* score 3), the wk of observation, and their interaction. Other covariables included in both models were FPT, the type of parturition, birth weight as a continuous predictor, sex, and the interaction of wk by FPT. Finally, a 1st-order autoregressive correlation structure was used to handle the effect of repeated measures (wk).

Results

The 2 scoring systems had a substantial agreement for the diagnosis of RD (*Kappa* coefficient of 0.65) and a slight agreement for the diagnosis of diarrhea (*Kappa* coefficient of 0.15). In the RD diagnosis, the SIM score had a sensitivity of 88.24% and a specificity of 95.01%, whereas the PPV was 55.56%, NPV was 99.13%, PLR was 16.8, and NLR was 0.17. In the diarrhea diagnosis, the SIM score had a sensitivity of 94.62% and a specificity of 49.64%, whereas the PPV was 18.22%, NPV was 98.73%, PLR was 1.86, and NLR was 0.10 (Table 1).

The growth of calves was associated with the passive immune transfer, the occurrence of RD, and the occurrence of diarrhea score of 3. The odds of RD were greater in calves with FPT than in their mates (OR: 4.96, 95% CI: 1.03 to 23.83; $P = 0.046$). Calves with FPT weighed 2.73 kg less than their mates ($P = 0.002$), and calves with at least 1 episode of RD weighed 6.29 kg less than their mates without RD ($P < 0.001$; Figure 1). Also, calves that had at least 1 episode of diarrhea with a score of 3 (score of fecal consistency: 0 to 3) weighed 3.43 kg less than their healthy mates ($P = 0.003$; Figure 1), whereas calves with a score of 2 had no significant difference in weight ($P = 0.061$).

Discussion

The results from this study partially support our hypotheses, given that the SIM score is reliable for the diagnosis of RD but not for the diagnosis of diarrhea, compared with the WIN score.

The SIM score was proposed as a simple method for on-farm use in pre-weaned dairy calves and was compared with the WIN score, which is the most accepted clinical scoring system for on-farm use in dairy calves. As mentioned, diarrhea and RD are the most common diseases during pre-weaning (1,3,5). However, it is important to highlight that, although the WIN score is considered an accurate method for diarrhea diagnosis (2), its sensitivity and specificity for RD diagnosis are low (55% and 58%, respectively) (6). The main advantages of the SIM score are that it reduces the time of clinical evaluation, the stress on the animal, and the risk of transmission by humans because it does not require direct contact with the subject. Also, reducing the scoring scale from 4 levels to 2 makes learning and application easier. Therefore, the SIM score may facilitate the

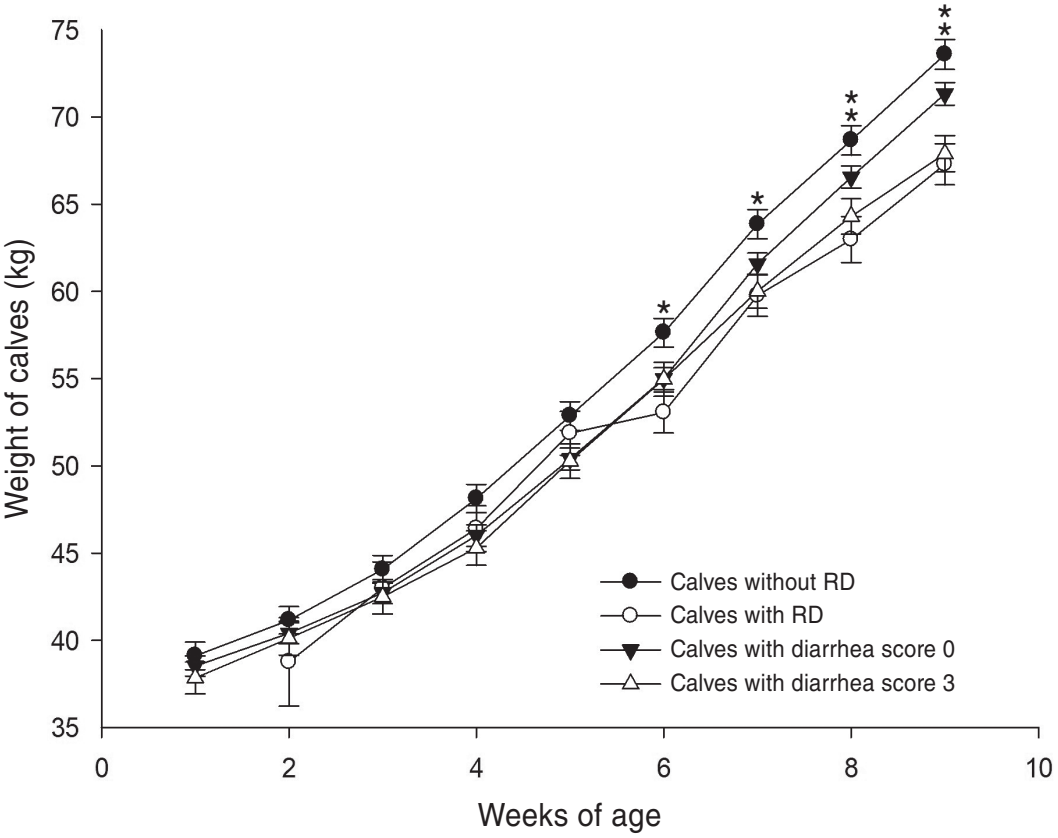

Figure 1. Association of fecal consistency and respiratory disease (RD) with weight during the first 9 wk in dairy calves ($n = 220$ and $n = 60$, respectively). The study was conducted on a commercial dairy farm located in Castelli, Argentina (36°09′S, 57°81′W), from September 2017 to December 2018. Diarrhea diagnosis was determined based on fecal consistency (0 to 3; calf health scoring chart of the University of Wisconsin) and was considered positive when the score was ≥ 2. Respiratory disease diagnosis was determined based on nasal discharge, ocular discharge, coughing, ear position, and fever (each sign was evaluated on a scale from 0 to 3; calf health scoring chart of the University of Wisconsin) and was considered positive when the total score was ≥ 5. The * symbol indicates a significant difference ($P < 0.05$).

detection of sick calves, especially in those systems where calves are housed in groups.

Our results showed that the SIM score agrees well with the WIN score for the diagnosis of RD and has high sensitivity, specificity, PLR, and NPV; low NLR; and acceptable PPV. It is known that the predictive values are associated with the prevalence of the disease: When the prevalence is low, false-positive diagnoses increase (9). Thus, rectal temperature measurement would be recommended on farms where the prevalence of RD is low, to confirm the disease and reduce false-positive cases. In the same way, in 1 of the 3 scoring systems presented by Love (6), rectal temperature measurement was proposed only when a calf's total score was ≥ 4. The scoring system also included a predictor of respiratory quality (normal/abnormal respiration). Unfortunately, this was not included in the SIM score. Another aspect not considered in the study was the severity of RD. It is important to determine the test's accuracy in the early stages of the disease. Conversely, the SIM score is not adequate to diagnose diarrhea. This result is in accordance with Graham *et al* (2), who hypothesized that cleanliness might be more related to bedding material than the fecal score. In agreement with that concept, Panivivat *et al* (10) compared different bedding materials (granite fines, sand, rice hulls, long wheat straw, and wood shavings) and found that calves were dirtiest when granite fines were used. Also, the cleaning frequency of the calves' environment affects its cleanliness and the time the calves are dirty. Graham *et al* (2) found calves more likely to have more days with abnormal cleanliness than with abnormal fecal consistency scores. The season is another factor that affects cleanliness score (11). It is possible that the inclusion of other parameters related to diarrhea and RD would improve diagnoses with the SIM score.

In agreement with the results presented by Windeyer *et al* (1), our results showed that calves with FPT had a higher risk for RD, but not for diarrhea. This may be because other factors play a role in its development, such as those related to the calf, infectious agents, and the environment (12). In this sense, a load of potential enteric pathogens to which calves are exposed may play an important role in developing this disease. Thus, the lack of an association between FPT and diarrhea may be related to other factors, such as high pathogen load, deficient hygiene practices or feeding programs, and high stocking density, that were not measured in the present study. It is important to highlight that the frequency of calf evaluation was once per

wk, which may have affected the detection of sick calves. The results indicate that the growth of calves was associated with the passive immune transfer. A possible explanation may be that colostrum intake induces anabolic processes in several tissues, improves intestinal maturation and absorption, and stimulates organ development and postnatal body growth (13,14). In addition, the results showed that RD and diarrhea are associated with calf growth rate.

In conclusion, the SIM score is a reliable test for diagnosing RD, but not for diagnosing diarrhea, compared with the WIN score. In diarrhea, assessing fecal consistency provides more helpful information than the cleanliness score. Nevertheless, rectal temperature measurement is recommended on farms where the prevalence of RD is low, to confirm the disease and reduce false-positive cases.

Acknowledgment

The authors acknowledge the owners and staff of the 2 dairy farms for their great cooperation and hospitality. CVJ

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