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J.T. Fox

M.F. Spire

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Near infrared spectroscopy as a potential method to detect bovine respiratory disease

Abstract

Bovine respiratory disease continues to be the leading cause of illness and death loss from weaning through finishing. There is no objective method to evaluate a live animal's severity of sickness or their response to treatment. A pilot study was conducted at a commercial feedyard to evaluate the ability of near infrared spectroscopy to differentiate between cattle identified as healthy and those identified as having undifferentiated Bovine Respiratory Disease (BRD). At processing, 215 randomly selected 900 lb heifers were evaluated to determine tissue oxygen saturation (StO₂) levels. Mean ranks of the StO₂ values were 176.86 ± 5.50 . One hundred cattle pulled for clinical signs of bovine respiratory disease were evaluated in the hospital. Animals were classified as: 1st pull, 2nd pull, and 3rd pull on the basis of clinical observations. First-pull animals were those having no previous history of being treated for respiratory disease and having signs of BRD, with rectal temperature at or above 104°F. Second pulls and 3rd pulls were those animals failing to respond to either a first treatment or a second treatment for BRD as evidenced by no improvement in clinical appearance or by rectal temperature remaining above 104°F. Mean StO₂ ranks were 110.42 ± 11.29 , 120.08 ± 14.48 , and 132.83 ± 19.00 for 1st, 2nd, and 3rd pulls, respectively. A significant difference was found between the rank of the StO₂ values in cattle at processing and those classified as 1st, 2nd, or 3rd pulls ($P < 0.05$). No difference was found between the three pull classifications. Results provide the basis for further research in the evaluation of BRD with near infrared spectroscopy.

Keywords

Cattlemen's Day, 2004; Kansas Agricultural Experiment Station contribution; no. 04-242-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 923; Beef; Near infrared spectroscopy; Bovine respiratory disease

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NEAR INFRARED SPECTROSCOPY AS A POTENTIAL METHOD TO DETECT BOVINE RESPIRATORY DISEASE

J. T. Fox¹ and M. F. Spire¹

Summary

Bovine respiratory disease continues to be the leading cause of illness and death loss from weaning through finishing. There is no objective method to evaluate a live animal's severity of sickness or their response to treatment. A pilot study was conducted at a commercial feedyard to evaluate the ability of near infrared spectroscopy to differentiate between cattle identified as healthy and those identified as having undifferentiated Bovine Respiratory Disease (BRD). At processing, 215 randomly selected 900 lb heifers were evaluated to determine tissue oxygen saturation (StO₂) levels. Mean ranks of the StO₂ values were 176.86 ± 5.50 . One hundred cattle pulled for clinical signs of bovine respiratory disease were evaluated in the hospital. Animals were classified as: 1st pull, 2nd pull, and 3rd pull on the basis of clinical observations. First-pull animals were those having no previous history of being treated for respiratory disease and having signs of BRD, with rectal temperature at or above 104°F. Second pulls and 3rd pulls were those animals failing to respond to either a first treatment or a second treatment for BRD as evidenced by no improvement in clinical appearance or by rectal temperature remaining above 104°F. Mean StO₂ ranks were 110.42 ± 11.29 , 120.08 ± 14.48 , and 132.83 ± 19.00 for 1st, 2nd, and 3rd pulls, respectively. A significant difference was found between the rank of the StO₂ values in cattle at

processing and those classified as 1st, 2nd, or 3rd pulls ($P < 0.05$). No difference was found between the three pull classifications. Results provide the basis for further research in the evaluation of BRD with near infrared spectroscopy.

Introduction

Pulse oximetry is a technique used in human medicine as an objective measure of arterial oxygen saturation. When used in cattle, pulse oximetry has shown less arterial oxygen tension in animals with respiratory disease. Pulse oximetry has limitations because readings can be influenced by the color of the hide and placement of the probe. A similar technology, near infrared spectroscopy, uses reflected energy waves to measure tissue saturation of oxygen (StO₂). It is not limited by color of the hide or other factors that limit pulse oximetry. This paper describes results of using near infrared spectroscopy in cattle with and without clinical bovine respiratory disease.

Near infrared spectroscopy is a non-invasive technique that has many different applications in human medicine. It is commonly used to evaluate compartmental syndrome, exercise tolerance, and peripheral vascular disease. Near infrared spectroscopy uses specific, calibrated wavelengths of near infrared light to noninvasively illuminate the

¹Department of Diagnostic Medicine/Pathobiology.

tissue underlying the skin. These wavelengths, between 650 nm and 810 nm, scatter in the tissue and are absorbed differently, depending on the amount of oxygen attached to hemoglobin in the arterioles, venules, and capillaries. Light that is not absorbed is returned as an optical signal and analyzed to produce a ratio of oxygenated hemoglobin to total hemoglobin, expressed as % StO₂. The selected wavelengths and accompanying unit algorithms quantify tissue hemoglobin dynamics. StO₂ values determined with a near infrared spectroscopy system are comparable to arterial-blood-gas values obtained concurrently in the same animal when the measurement is taken directly over an artery.

Previous research showed that all cattle having a pulse oximetry reading of less than 80% at the time of presentation for bovine respiratory disease (BRD) died. This study looked at the nasal septum, vulva, scrotum, ear, tongue, and tail as sites from which to take pulse oximetry readings. The tail was the only placement on the animals that did not bring about objectionable behavior and had no adverse implications for the animals. Pulse oximetry is limited in that it is not able to take measurements through hair or measure cattle with dark skin pigmentation. Because of the many uses of near infrared spectroscopy in human medicine and because of the limitations of pulse oximetry, the hypothesis has been made that near infrared spectroscopy can be used to assess lung function in cattle.

Experimental Procedures

A total of 315 cattle were evaluated to determine percentage StO₂. Two hundred fifteen 900-pound heifers were randomly assessed at processing by using near infrared spectroscopy on the ventral aspect of the tail. Hutchinson Technology Near-Infrared Spectrometer (InSpectra™) was used with the 20 mm probe. The probe was oriented such that the tip of the probe was cranial, with light reflected dorsally into the ventral aspect of the

tail and the coccygeal artery being the target of interest. One hundred cattle, which were not part of the original 215, were evaluated in the hospital by using the same technique. These animals ranged in weight from 450 pounds to approximately 750 pounds. The cattle from the hospital were assigned to three groups on the basis of feedlot records. The three groups were: 1st pull, 2nd pull, and 3rd pull. Cattle never having been identified previously with bovine respiratory disease were placed in the 1st pull group. Cattle that required treatment for BRD a second time were placed in the 2nd pull group, and cattle that had to receive a third treatment for BRD were placed in the 3rd pull group. All cattle enrolled in the study from the hospital had to meet the requirements of having a rectal temperature greater than or equal to 104°F and/or seem clinically ill according to standard treatment protocol for this particular feedyard.

Initial statistical analysis revealed that the data was not normally distributed, so ranks were assigned to the StO₂ values and these ranks were then analyzed with the mixed procedure in SAS.

Results and Discussion

Cattle at processing had a mean StO₂ rank of 176.86 ± 5.50 (Table 1), with a StO₂ range of 78 to 98. Of the 100 cattle sampled at the hospital, 51 were in the 1st pull category, 31 in the 2nd pull group, and 18 in the 3rd pull group. The mean ranks were 110.42 ± 11.29 , 120.08 ± 14.48 , and 132.83 ± 19.00 , with StO₂ values ranging from 42 to 98, 70 to 98, and 84 to 98, respectively. A significant difference was found between the rank of the StO₂ values in cattle at processing and those classified as 1st, 2nd, or 3rd pulls ($P < 0.05$). No differences were found between the three pull classifications.

BRD is the primary cause of feedlot mortality and has an enormous economic impact on the industry. According to the 1999

NAHMS study, 56.8% of all feedlot mortalities are due to respiratory disease. This study also states that 14.4% of 11.75 million cattle were treated for BRD, at a cost of \$12.59 per animal, for a total of \$21.3 million, for the year in which the study was conducted. There is currently no technique available that will allow producers and practitioners to objectively evaluate an animal for BRD and attempt to control these costs. Near infrared spectroscopy may give the industry the ability to make objective decisions about the management and treatment of BRD. Because of the significant difference between the ranks of cattle at processing and the cattle identified as being ill, near infrared spectroscopy may prove to be a good technique to aid in the management of BRD.

Near infrared spectroscopy can potentially be used in purchasing, sorting, and treating cattle with BRD. Cattle could be assessed at purchase to determine if there is any pre-existing lung pathology. StO₂ may also be able to detect cattle that will perform better than others in both the feedyard and the packinghouse. Near infrared spectroscopy may be able to reveal if cattle have too much existing pathology to be treated effectively or if cattle that we think are “treated out” can still benefit from antibiotic therapy. Near infrared spectroscopy has the potential to drastically affect the way BRD is managed. Using near infrared spectroscopy, producers and veterinarians may be able to make informed, objective decisions about the management of their cattle.

Table 1. Blood Oxygen Content in Different Categories of Feedlot Cattle

| Item | Healthy at Receiving | Unhealthy | | |
|--|----------------------------|-----------------------------|-----------------------------|-----------------------------|
| | | 1st Pull | 2nd Pull | 3rd Pull |
| Number of cattle | 215 | 51 | 31 | 18 |
| StO ₂ rank (± Std. Dev.) | 176.86 ± 5.50 ^a | 110.42 ± 11.29 ^b | 120.08 ± 14.48 ^b | 132.83 ± 19.00 ^b |
| Median (StO ₂ %) | 98 | 94 | 96 | 96 |
| Range (StO ₂ %) | 78 to 98 | 42 to 98 | 70 to 98 | 84 to 98 |

^{ab}Means that have different superscripts differ (P<0.05).