NTU Journal of Agricultural and Veterinary Science - (NTU-JAVS)
(P-ISSN: 2788-9890 e-ISSN: 2788-9904)

Using of Oximeter and Sound Analysis for Detection of Lung Lesions in Buffalo Calves

1st Mohammed Tawgeeg Al-noaemy [1] 2nd Osamah Muwaffaq Al-iraqi [2]
Email: 1. Mohammad.20vmp43@student.uomosul.edu.iq
2. osamamuwafag@uomosul.edu.iq
1, 2. Department of Interal and Preventive Medicine / College of Veterinary Medicine / University of Mosul / Iraq.
Received: 17-10-2022, **Accepted:** 28-10-2022, **Published online:** 10-11-2022

Abstract. Auscultation of the lung is the first line for the diagnosis of lung lesions. Analysis of the auscultated sounds is promising in the diagnosis confirmation. The aim of this study is to evaluate the use of sound analysis and oximeter for detection of the lung lesions in buffalo calves. The study included 100 calves showing respiratory symptoms and 30 clinically healthy calves serving as a control group which aged between (2-6) months from different areas in Mosul City. A pulse oximeter was used to measure the percentage of oxygen blood saturation, then measuring sound frequencies based on multi-resolution sound wave analysis by using digital program (WavePad). Affected calves showed coughing (100%), lacrimation (88%), nasal discharge (86%) and fever (58%). The sound analysis indicated that the natural sound frequency was (221) Hz, gradually increasing to (390.5) Hz in case of pneumonia. It then became (428) Hz in calves with wheezing sound. Diminished breathing sound had a frequency of 426) Hz synchronous with pauses that lasted (0.4) seconds after each complete inhalation and exhalation cycle. An oximeter reading had a positive correlation with each nasal discharge and eye lacrimation, while it had a negative correlation with both coughing and body temperature. The study concluded that sound wave analysis and oximeter were highly accurate in diagnosing the severity of the lung lesion compared to the detection of the clinical signs.

Keywords: Buffalo, Calves, lung, Sound Analysis, Oximeter.

Introduction

Respiratory diseases are characterized by appearance of clinical signs that vary according to the infection stage and calf ages. These signs include coughing, lacrimation, nasal discharge and fever. Coughing is one of the most clinical signs associated with the disease (1)(2). One of the causes of lacrimation in respiratory diseases begins in the form of serous secretions and turns over the time into purulent secretions as a result of chronic inflammation and bacterial infection (3)(4). The cause of a nasal discharge results from upper respiratory tract infection where purulent mucus is produced in the trachea and then transported into the pharynx by the movement of mucous cilia or by coughing(5)(6). Fever in calves suffering from pneumonia can often be attributed to infection with various bacterial. Viral and inflammatory diseases are due to introduction of this exogenous pyrogens into the body and inducing the hosts cell (macrophages) to produce and release endogenous pyrogens such as interleukin-1 and transmitted to the hypothalamic thermoregulatory centre where they induce synthesis of prostaglandins (PGE2) and raise the thermostatic set point to initiate the febrile response(7)(8)(9).

The natural lung sounds are produced as a result of the movement of air through the tracheobronchial tree; thus, the sound becomes louder during inhalation compared to exhalation (10)(11). Auscultation of the lungs and airways is an important clinical examination of the respiratory system,. It is preferable to perform the examination in a quiet environment as much as possible although the animal sufficiently restrained so that the examiner can focus on the lung sounds. The auscultation is preferable starting with the larynx, trachea, and tracheal bifurcation area to assess the rate of air flow and the volume of air sound that can be heard on the lungs (5)(12).

The pulse oximeter device is of a high value in assessing the respiratory infection, and it has a proven effectiveness as an accurate, inexpensive and easy to carry a method. It is possible to start the immediate examination on the animal to detect the oxygen saturation percentage of the peripheral blood (13). It is noteworthy that the nature of the pulsatile blood flow is detected by sensors when putting it on the areas resulting from a gradient variation of the absorbed light and

then translating into the ratio of oxygenated to deoxygenated hemoglobin (14)(15). When the pulse oximeter reading is ≥ 95%, the animal is considered normal; but, when the reading is within 90-94%, the animal is considered to have a mild to moderate hypoxia. Then, the infection is considered severe and threatens the life of an infected animal at the reading ≤ 90% (14). This study aims at evaluating the use of sound analysis and oximeter for the detection of the lung lesions in buffalo calves.

Materials and Methods

Animals of the Study:

The study examined 130 domestic buffalo calves including (100) infected calves that showed respiratory signs (viz. coughing, eye lacrimation, nasal discharge and fever), and (30) clinically healthy calves considered as a control group during the period from November 2021 until April 2022, aged between (2-6) months and from different areas in Mosul City.

Auscultation, Sound Recording and Analysis:

Auscultation was performed using an electronic stethoscope (CloudSteth Company - China) at different places on both sides of the chest. The auscultated sounds were recorded and saved on a hard disk for analyzing normal and abnormal respiratory sounds and measuring sound frequencies based on multi-resolution sound wave analysis by inserting a sound file into the digital program (WavePad) that analyzed the sound frequencies and came out in the form of numbers and digital images (wavelengths) (18)(19).

Pulse Oximeter Reading:

A pulse oximeter (CMS60D-Vet, CONTEC TM / China) company was used to measure the percentage of blood oxygen saturation. The digital oximeter was placed at the base of the ear after shaving the hair and cleaning with alcohol to remove fat and other debris that obstructed the sensor reading. The examination took one minute for each calf and the reading was recorded. It was kept on the device's hard disk. The device reading was divided into (≥95) normal, (85-94) abnormal and (75-84) very abnormal. According to (20) readings, the normal reading was more than(95%), mild to moderate case was (90%-94%) and abnormal as well as needing oxygen therapy cases were less than (90%).

Statistical Analysis:

The study data were statistically analyzed using SigmaPlot for windows version 12.5.0, (Germany) and the Pearson correlation coefficient (21). A linear regression plot was used to find the value of the correlation coefficient and the relationship between two variables.

Results

Affected calves showed coughing (100%), lacrimation (88%), nasal discharge (86%), and fever (58%) (See Table 1 below).

Table 1. cClinical symptoms in infected animals.

Clinical signs	Frequency N=100	Percentage %
Coughing	100	100%
Lacrimation	88	88%
Nasal discharge	86	86%
Fever	58	58%

The normal sound frequency ranged from (71-371) hertz and at an average (221)Hz (See Figure 1 below) where infected calves had a crackling sound of (35%), a wheezing sound of (25%) and a diminished sound of (12%). The crackling sound had a frequency ranging (129-652) hertz at an average (390.5)Hz (See Figure 2), the wheezing sounds had a frequency ranging (322-535)Hz at an average (428) Hz (See Figure 3) while the diminished breathing sound had a frequency ranging (146-706)Hz at an average (426)Hz and with pauses of respiratory cycles that lasted (0.4) seconds after each complete inhalation and exhalation cycle (See Figure 4).

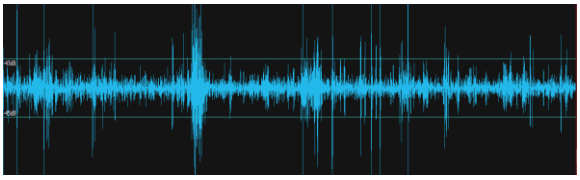

Fig 1. Frequencies analysis of the natural breathing sound wave from the lung of a healthy calf.

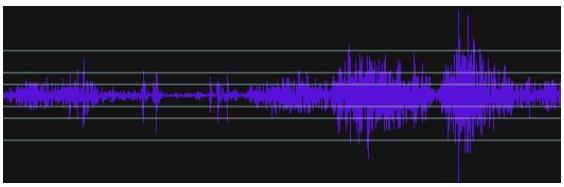

Fig 2. Frequencies analysis of the crackling sound wave frequencies analysis from the lung of an infected calf, the blue arrow indicates the clearest hearing of the crackling sound.

Fig 4. Frequencies Analysis of a diminished breathing sound wave,the blue arrows indicates the periods of pauses in breathing cycles.

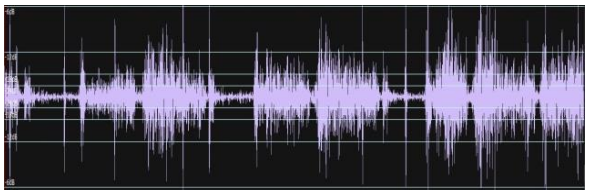

Fig 3. Frequency analysis of the wheezing sound wave from the lung of an infected calf.

From the results of the study, there was a positive correlation between oximeter reading and each of the nasal discharge and eye lacrimation. The value of the correlation coefficient was (0.280),(0.239) at the level of significance (P<0.01),(P<0.05) respectively. However, there was a negative correlation between the blood oximeter reading and both cough and body temperature. Thus, the correlation coefficient value was (-0.103), (-0.058) respectively and without a significant difference between them as shown inTable (2), chart(1)

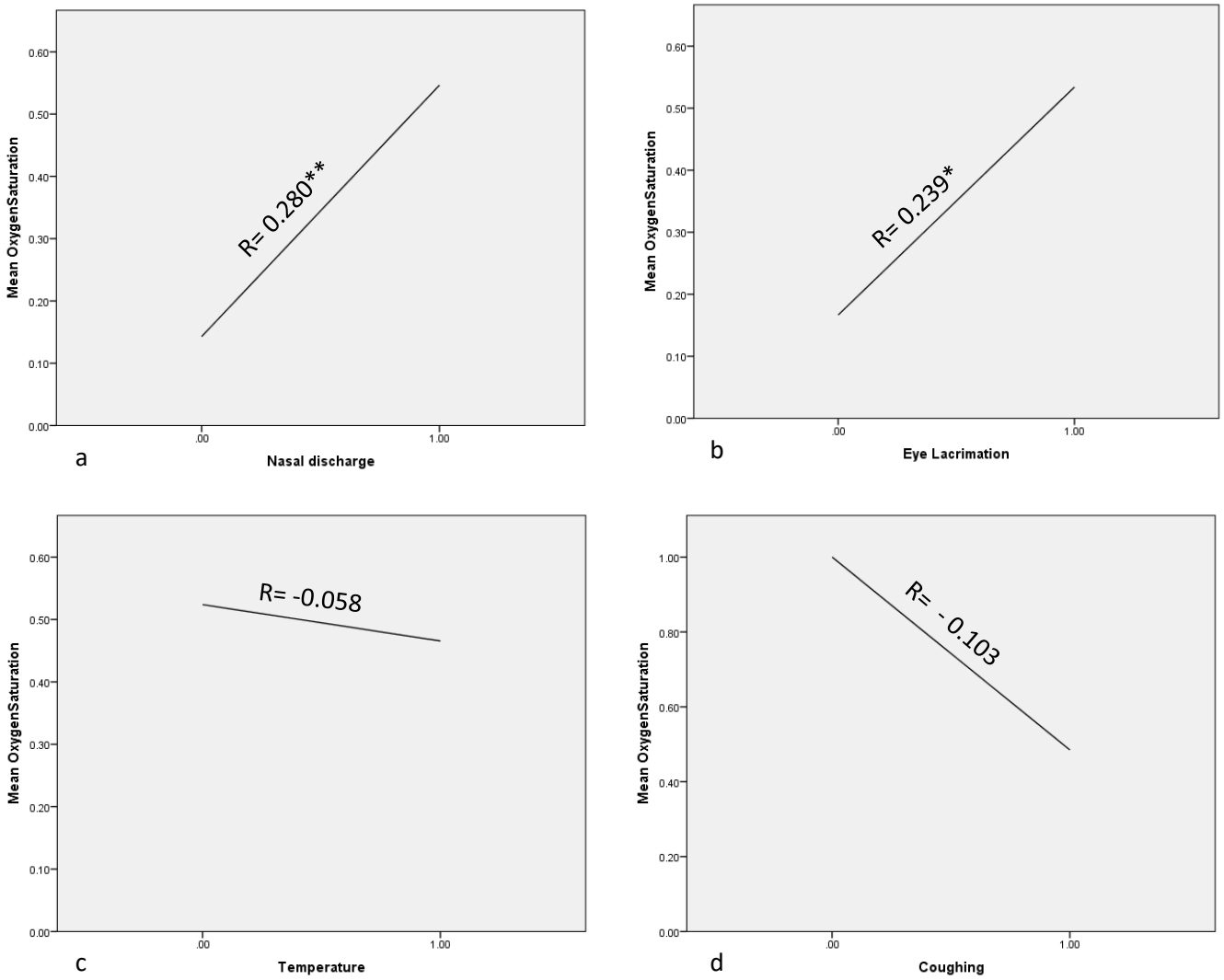

Fig 5. The correlation between Oximeter reading and Clinical signs.

100% of the calves suffereding from respiratory diseases agreed with the researchers (2) and (22). Coughing is significantly associated with respiratory diseases and with lung consolidation in calves. The coughing occuring was due to irritation of the pharynx, trachea by caustic substances or bacteria, as the respiratory system worked to remove excess mucus and inflammatory secretions (5)(23).

In addition, the study results showed that lacrimation and nasal discharge were 88% and 86% respectively. This result is consistent with(24)(25). The cause was attributed to inflammatory diseases of the upper respiratory tract in addition to the filling of the sinuses by mucus leading to blockage of the tear duct with inflammatory substances (6)(26).

The results showed an increase of temperature (58%) representing the lowest percentage among the clinical symptoms. This result agrees with (2)(7). The fever indicating the inflammatory processes within the lung tissue was due to the infection with pathogens including bacteria and virus (5)(27). Other calves not having fever may be the chronic stage of infection. These results agree with (28),(29), as acute pneumonia caused a rise in temperature, while the temperature was within the normal level in cases of chronic infection (5).

During auscultation of the infected calves, there were a crackling sound (35%), a wheezing sound (25%) and a diminished breathing sound (12%). This result is consistent with (30),(31). The crackling sound occuring was due to presence of inflammatory secretions and exudation in the respiratory tract and edematous bronchial mucosa. The researchers (32),(33) showed that the pneumonia associated with crackle sounds has a frequency rate of 300 Hertz, furthermore, the wheezing sound is attributed to the vibrations of the respiratory tracts or through the passage of air from a narrow respiratory tract (5) where the wheezes sound frequency associated with pneumonia ranges from (300-600) Hertz and frequency ranges from (100-1000) hertz (31),(34), while the diminishing breathing sound is associated with non-respiratory factors, including infection and lesions that both affect the central nervous system, the low temperature and the metabolic activities such as low blood sugar level or epileptic seizures(35).

AS for the results of the statistical analysis, they showed a strong positive correlation between oximeter read level and each of the nasal discharge as well as eye lacrimation. The correlation coefficient value was (0.280), (0.239) at a significant level ($P<0.01$) and ($P<0.05$) respectively. This result is consistent with (36), which says that a partial obstruction of the airways due to inflammatory reaction leads to a lack of lung oxygen filling, and thus the process of gas exchange decreases between outside air and lungs (37)(38)(39). Other researchers (40) found that partial obstruction of the nose leads to hypoxia and disturbances in lung function. On the other hand, the correlation was negative and the correlation coefficient value was (-0.103), (-0.058) respectively with no significant difference between the values. This result agrees with (41); viz. coughing eliminates nasal secretions and sputum from the lungs; however in turn, it allows oxygen to enter the lungs thus increasing the oxygen saturation of blood (26). This result agrees with (42); viz the increase in temperature has a slight effect on increasing oxygen consumption (43).

Conclusion

The study concluded that a clinical examination by a simultaneous oximeter with a sound wave analysis improves the respiratory disease diagnosis in buffalo calves.

References

[1] Pardon B, De Bleecker K, Dewulf J, et al. Prevalence of respiratory pathogens in diseased, non-vaccinated, routinely medicated veal calves. Vet Rec. 2011;169(11):278. doi.org/10.1136/vr.d4406.

[2] Lowie T, Van Leenen K, Jourquin S, Pas ML, Bokma J, Pardon B. Differences in the association of cough and other clinical signs with ultrasonographic lung consolidation in dairy, veal, and beef calves. J Dairy Sci. 2022;105(7):6111-6124. https://doi.org/10.3168/jds.2021-21570.

[3] Jubb T and Perkins NR,. Veterinary Handbook for Cattle, Sheep and Goats. Australia. 2015; Available online: https://www.veterinaryhandbook.com.au/

[4] McGuirk SM, Peek SF. Timely diagnosis of dairy calf respiratory disease using a standardized scoring system. Anim Health Res Rev. 2014;15(2):145-147. doi:10.1017/S1466252314000267.

[5] Constable P. Veterinary Medicine: A Textbook of the Diseases of Cattle, Horses, Sheep, Pigs, and Goats, 11th edition, Volumes 1 and 2. Can Vet J. 2017;58(10):1116.

[6] Al-Mallah KH, Zar AA, Mohammad A. Cellular assessment of nasal swabs from sheep showing rhinitis in Mosul city. Iraqi J Vet Sci. 2019;32(2):23-28. doi:10.33899/ijvs.2019.153873.

[7] Hussein HA, Binici C, Staufenbiel R. Comparative evaluation of ultrasonography with clinical respiratory score in diagnosis and prognosis of respiratory diseases in weaned dairy buffalo and cattle calves. J Anim Sci Technol. 2018;60:29. Published 2018 Dec 3. doi.org/10.1186/s40781-018-0187-3.

[8] Buczinski S, Buathier C, Bélanger AM, Michaux H, Tison N, Timsit E. Inter-rater agreement and reliability of thoracic ultrasonographic findings in feedlot calves, with or without naturally occurring bronchopneumonia. J Vet Intern Med. 2018;32(5):1787-1792. doi:10.1111/jvim.15257.

[9] Grissett GP, White BJ, Larson RL. Structured literature review of responses of cattle to viral and bacterial pathogens causing bovine respiratory disease complex. J Vet Intern Med. 2015;29(3):770-780. doi:10.1111/jvim.12597.

[10] Jackson, P., & Cockcroft, P. Clinical examination of farm animals.1st edition ,John Wiley & Sons.

[11] Tessema BA, Nemomssa HD, Simegn GL. Acquisition and Classification of Lung Sounds for Improving the Efficacy of Auscultation Diagnosis of Pulmonary Diseases. Med Devices (Auckl). 2022;(15):89-102. Published 2022 Apr 7. doi:10.2147/MDER.S362407.

[12] Demirci BA, KocyiGiT Y, Kizilirmak D, Havlucu Y. Adventitious and Normal Respiratory Sound Analysis with Machine Learning Methods. Celal Bayar University Fen Bilim Derg.2022; 18(2), 169-180. Published online May 27, 2022. doi:10.18466/cbayarfbe.1002917.

[13] Bleul U, Kahn W. Monitoring the bovine fetus during stage II of parturition using pulse oximetry. Theriogenology. 2008;69(3):302-311. doi.org/10.1016/j.theriogenology.2007.09.033.

[14] Proulx J. Respiratory monitoring: arterial blood gas analysis, pulse oximetry, and end-tidal carbon dioxide analysis. Clin Tech Small Anim Pract. 1999;14(4):227-230. doi.org/10.1016/S1096-2867(99)80015-2.

[15] Schnapp LM, Cohen NH. Pulse oximetry. Uses and abuses. Chest. 1990;98(5):1244-1250. doi.org/10.1378/chest.98.5.1244.

[16] Khudhair YI, Aeyyz HN, Hussain MH. Phylogenetic analysis of ovine herpes virus-2 (OHV-2) in malignant catarrhal fever infected cattle in Al-Qadisiyah governorate of Iraq. Iraqi J Vet Sci. 2019;33(1): 51-58. doi:10.33899/ijvs.2019.125522.1044.

[17] Aziz TA, Lafta IJ. Isolation and antimicrobial resistance of Staphylococcus spp., enteric bacteria and Pseudomonas spp. associated with respiratory tract infections of sheep. Iraqi J Vet Sci. 2021; 35 (Supplement I-III): 53-58. doi:10.33899/ijvs.2021.131098.1917.

[18] Ferrari S, Piccinini R, Silva M, Exadaktylos V, Berckmans D, Guarino M. Cough sound description in relation to respiratory diseases in dairy calves. Prev Vet Med. 2010;96(3-4):276-280. doi:10.1016/j.prevetmed.2010.06.013.

[19] Booker CW, Jim GK, Grimson TM, Hill KT, Wildman BK, Nickell JN. Association between computer-aided lung auscultation and treatment failure risk in calves treated for respiratory disease. Can Vet J. 2021;62(5):511-514. PMCID: PMC8048236.

[20] Balakrishnan A, King LG. Updates on pulmonary function testing in small animals. Vet Clin North Am Small Anim Pract. 2014;44(1):1-18. doi:10.1016/j.cvsm.2013.08.007.

[21] Al-Mallah KH. Pathological study of the relation between the incidences of claws lesions and carpo-digital joint capsule lesions in front limbs of sheep slaughtered in Mosul. Iraqi J Vet Sci. 2021;35(4):693-697. doi:10.33899/ijvs.2021.127788.1530.

[22] Callan RJ, Garry FB. Biosecurity and bovine respiratory disease.Vet Clin North Am Food Anim Pract. 2002;18(1):57-77. doi.org/10.1016/s0749-0720(02)00004-x.

[23] Leruste H, Brscic M, Heutinck LF, et al. The relationship between clinical signs of respiratory system disorders and lung lesions at slaughter in veal calves. Prev Vet Med. 2012;105(1-2):93-100. doi:10.1016/j.prevetmed.2012.01.015.

[24] McGuirk SM. Disease management of dairy calves and heifers. Vet Clin North Am Food Anim Pract. 2008;24(1):139-153. doi.org/10.1016/j.cvfa.2007.10.003.

[25] Berman J, Francoz D, Abdallah A, Dufour S, Buczinski S. Evaluation of inter-rater agreement of the clinical signs used to diagnose bovine respiratory disease in individually housed veal calves. J Dairy Sci. 2021;104(11):12053-12065. doi:10.3168/jds.2021-20503.

[26] Peek SF, Ollivett TL, Divers TJ. Respiratory Diseases. Rebhun's Diseases of Dairy Cattle. 2018;94-167. doi.org/10.1016/B978-0-323-39055-2.00004-8.

[27] Moran J. Calf Rearing: A Practical Guide. Landlinks Press; 2002. https://books.google.ps/books?id=E9DAQ0IRoScC.

[28] Radaelli E, Luini M, Loria GR, Nicholas RA, Scanziani E. Bacteriological, serological, pathological and immunohistochemical studies of Mycoplasma bovis respiratory infection in veal calves and adult cattle at slaughter. Res Vet Sci. 2008;85(2):282-290. doi.org/10.1016/j.rvsc.2007.11.012.

[29] Buczinski S, Buathier C, Bélanger AM, Michaux H, Tison N, Timsit E. Inter-rater agreement and reliability of thoracic ultrasonographic findings in feedlot calves, with or without naturally occurring bronchopneumonia. J Vet Intern Med. 2018;32(5):1787-1792. doi.org/10.1111/jvim.15257.

[30] Burn JF, Franklin SH. Measurement of abnormal respiratory sounds during over-ground exercise. Equine Vet J. 2006;38(4):319-323. PMID: 16866198.

[31] Rao A, Huynh E, Royston TJ, Kornblith A, Roy S. Acoustic Methods for Pulmonary Diagnosis. IEEE Rev Biomed Eng. 2019;12:221-239. doi.org/10.1109/RBME.2018.2874353.

[32] Loudon R, Murphy RL Jr. Lung sounds. Am Rev Respir Dis. 1984;130(4):663-673. doi.org/10.1164/arrd.1984.130.4.663.

[33] Priftis KN, Hadjileontiadis LJ, Everard ML, Breath Sounds. From Basic Science to Clinical Practice. 1st Ed, Cham: Springer; 2018.

[34] Gross V, Dittmar A, Penzel T, Schüttler F, von Wichert P. The relationship between normal lung sounds, age, and gender. Am J Respir Crit Care

Med. 2000;162(3 Pt 1):905-909. doi.org/10.1164/ajrccm.162.3.9905104.

[35] Marchal F, Bairam A, Vert P. Neonatal apnea and apneic syndromes. Clin Perinatol. 1987;14(3):509-529. PMID: 3311537.

[36] Coghe J, Uystepruyst C, Bureau F, Lekeux P. Non-invasive assessment of arterial haemoglobin oxygen saturation in cattle by pulse oximetry. Vet Rec. 1999;145(23):666-669. PMID: 25705771.

[37] Poulsen KP, McGuirk SM. Respiratory disease of the bovine neonate. Vet Clin North Am Food Anim Pract. 2009;25(1):121-vii. doi.org/10.1016/j.cvfa.2008.10.007.

[38] Ellis J, Waldner C, Gow S, Jackson M. Relationship of the extent of pulmonary lesions to the partial pressure of oxygen and the lactate concentration in arterial blood in calves experimentally infected with bovine respiratory syncytial virus. Can J Vet Res. 2013;77(3):205-210. PMCID: PMC3700446.

[39] Chernitskiy, A, Shabunin, S, Kuchmenko, T, & Safonov V. On-farm diagnosis of latent respiratory failure in calves. Turkish Journal of Veterinary & Animal Sciences. 2019; 43(6), 707-715. doi.org/10.3906/vet-1810-37.

[40] Sobh E, Elhussieny F, Ismail T. Elimination of nasal obstruction improves pulmonary functions and oxygenation. Egypt J Bronchol. 2021;15(1):32. doi.org/10.1186/s43168-021-00079-6.

[41] Neary J, Garry F, Raabis S. Age-related changes in arterial blood-gas variables in Holstein calves at moderate altitude. Open Access Animal Physiology. 2014;6:13-20. doi.org/10.2147/OAAP.S60976.

[42] Lansing AM, Jamieson WG. Mechanisms of fever in pulmonary atelectasis. Arch Surg. 1963;87:168-174. doi:10.1001/archsurg.1963.01310130170021.

[43] Engoren M. Lack of association between atelectasis and fever. Chest. 1995;107(1):81-84. doi.org/10.1378/chest.107.1.81