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Pulse oximetry as a handy tool for determining oxygen saturation in goats with respiratory illness: A brief study

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Abstract
Pulse oximetry is an important non-invasive means of determining oxygen saturation in both animals and humans. However, it has not been standardized in small ruminants. Hence, the present study envisages standardization of pulse oximetry in goats. Briefly, 36 respiratory affected goats were evaluated against 36 healthy goats for pulse oximetry at different sites (Pinnae, lower lip and tip of the tail). The animals were resistant to allow the probes to be placed at lower lip. No reading was obtained at pinnae. However, satisfactory results were obtained at the tail. SpO_2 was found to be significantly ($p<0.05$) lower in affected group (Group 2) compared to the healthy control group (Group 1). Clinical parameters *viz*. rectal temperature, heart rate and respiratory rate were significantly increased ($p<0.05$) in affected group compared to the control group. TNF-α levels were significantly ($p<0.05$) higher in affected group compared to the control group whereas IL-10 levels were significantly ($p<0.05$) lower in affected group compared to the control group. Hence, this study concludes that pulse oximetry can be an efficient non-invasive tool to measure blood oxygen saturation in goats.

Keywords: Blood oxygen saturation, goats, oximeter, respiratory illness, SpO_2

1. Introduction
Pulse oximetry is a non-invasive technique that finds its importance in veterinary science to measure blood oxygen saturation. They are portable, doesn't require blood collection thus eliminate the potential pain and stress in patients (Grubb and Anderson, 2017) [2]. Pulse oximeters use two wavelengths of light, a red (R) wavelength (generally 660 nm) and an infrared (IR) wavelength (generally 920-930 nm). Poorly oxygenated hemoglobin (HbO2) absorbs more red light and less infrared light than that of oxygen-saturated haemoglobin (Hb) (Clark *et al*., 1992; Mendelson, 1992) [1, 7]. The data is reported as percent (%) saturation, and the R/IR wavelength ratio is compared to calibration curves programmed into the pulse oximeter. A crude method of observing the mucous membranes to diagnose the blood oxygen saturation has been tried but significant changes in the mucous membrane are evident only when a minimum of 5 g/dL of deoxygenated haemoglobin is present. In humans, pulse oximetry has been used to diagnose acute respiratory distress, assess the severity of respiratory diseases and to manage other respiratory illnesses (Wick *et al*., 2022) [10]. Pulse oximetry has been documented in many veterinary species including dogs, cats, calves, horses and llamas or alpacas and its validation in these species has also been attempted (Huss *et al*., 1995; Jacobson *et al*., 1992; Martinez *et al*., 1996; Vender *et al*., 1995; Whitehair *et al*., 1990) [3, 4, 6, 8, 9]. However, very scanty information is available on use of pulse oximeter in small ruminants including goats. Sites like nasal septum, the lip, vulva, prepuce, ear and scrotum have been evaluated for placement of pulse oximeter probes but the results were less reliable (Grubb and Anderson, 2017) [2]. However, nasal septum and tongue have given satisfactory results in llamas and alpacas which can be more or less considered to be reliable (Grubb and Anderson, 2017) [2]. We hypothesized that pulse oximetry can be an accurate and reliable tool to assess blood oxygen saturation and can aid in management of patients during crisis thus can save life. This study is aimed to attempt the standardization of pulse oximetry in both healthy goats and the goats with respiratory illness and to look for the suitable site for placement of probe.

2. Materials and Methods

2.1 Grouping of animals

Adult Bakarwal cross goats (N=72) of 1-2 years age reared under common environment were divided in two groups *viz*. Group 1 and Group 2. Group 1 consisted of 36 healthy goats with no signs of clinical illness whereas 36 clinically affected goats with the respiratory signs including cough, nasal discharges, dyspnea, history of fever and anorexia were considered as Group 2 which was supported by diagnostic imaging showing lung lesions (Data on microbiological diagnosis and diagnostic imaging not presented). SpO_2 was measured with portable pulse oximeter.

2.2 Site preparation and placement of pulse oximeter probe

For this study, animals were restrained properly, clinical examination was conducted, and the sites *viz*. pinnae, lower lip and tip of the tail were cleaned and shaved for placement of pulse Oximeter probe (Tushti International Pvt. Ltd.). Approximately 5-7 cm of tail area was shaved. Probe was tested at the three sites as shown in Figure 1 a, b and c.

Clinical examination of all the animals was carried out and the parameters including temperature, heart rate, and respiratory rate were recorded. Inflammatory cytokine TNF-α and anti-inflammatory cytokine IL-10 was estimated by ELISA kit (Shanghai Coon Koon Biotech Co., Ltd.) from serum samples.

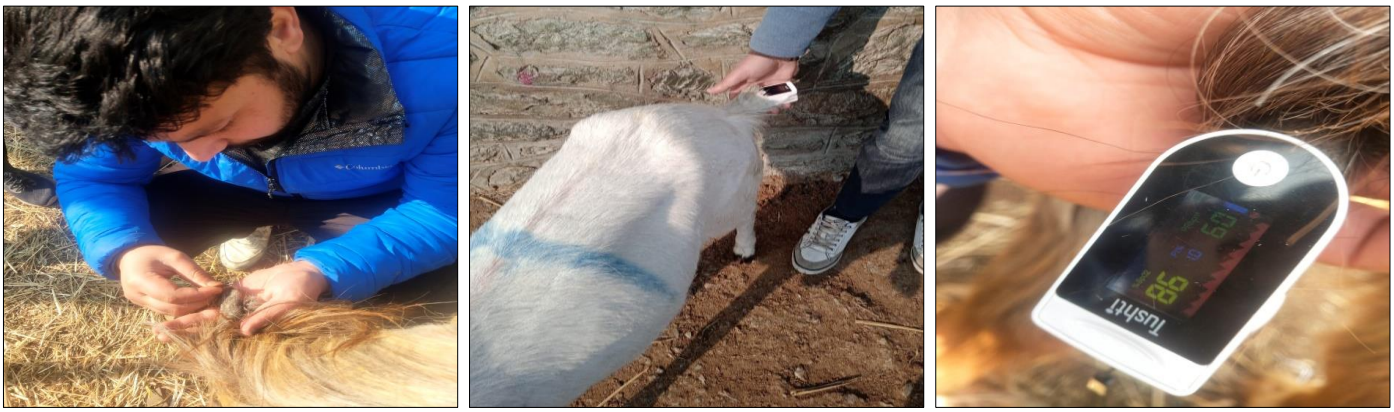

Fig 1a: Preparation of the site **Fig 1b:** Placement of probe **Fig 1c:** Recording of SpO_2

Fig 1: Pulse oximetry in goats

2.3 Statistical evaluation

Data was subjected to t - test to determine mean and standard error. Significance of $p<0.05$ was set for different parameters and the scope of data was determined.

3. Results

Placement of probe was tried at three different sites including pinnae, lower lips and the tip of tail. We found that the animals were resistant to allow the probes to be placed at lower lip. No reading was obtained at pinnae. However, satisfactory results were obtained at the tail. We faced difficulty in animals with coloured tail skin and less tail diameter, and it took a relatively longer time get pulse oximeter reading. SpO_2 was found to be significantly ($p<0.05$) lower (76.16 ± 6.37) in affected group (Group 2) compared to the healthy control group (Group 1) (92.33 ± 0.99) as shown in Figure 2.

Clinical parameters *viz*. rectal temperature, heart rate and respiratory rate were significantly increased ($p<0.05$) in affected group (103.12 ± 0.13, 92.83 ± 4.90 and 42.33 ± 2.28) compared to the control group (101.97 ± 0.20, 62.50 ± 0.89 and 25.33 ± 0.80) respectively (Table 1). TNF-α (1642.77±101.72) levels were significantly higher ($p<0.05$) in affected group compared to control group (1043.10±66.76) and IL-10 levels were significantly decreased ($p<0.05$) in affected group (0.40±0.01) compared to control group (0.77±0.04) as shown in Figure 3 and 4 respectively.

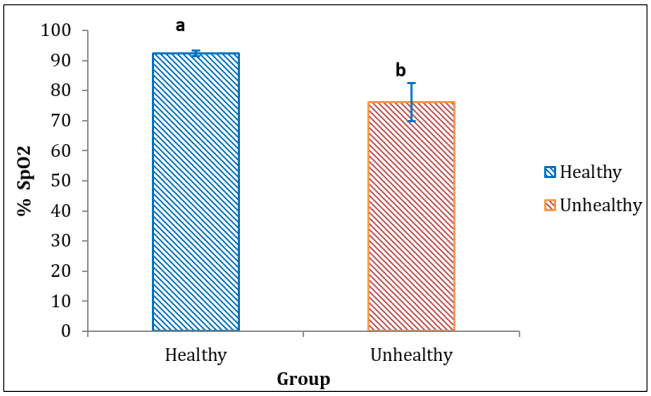

Fig 2: Comparison of % SpO_2 in healthy and affected goats

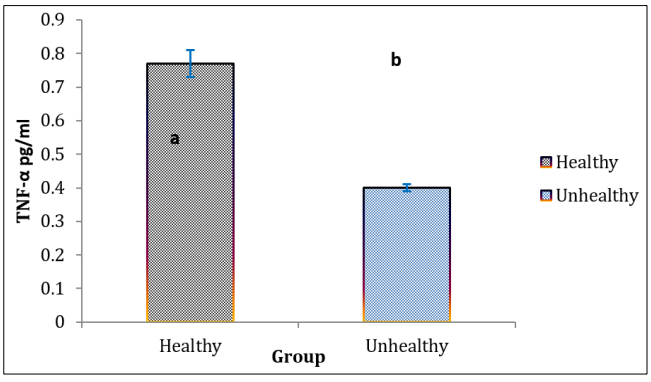

Fig 3: Status of TNF-α in healthy and affected goats

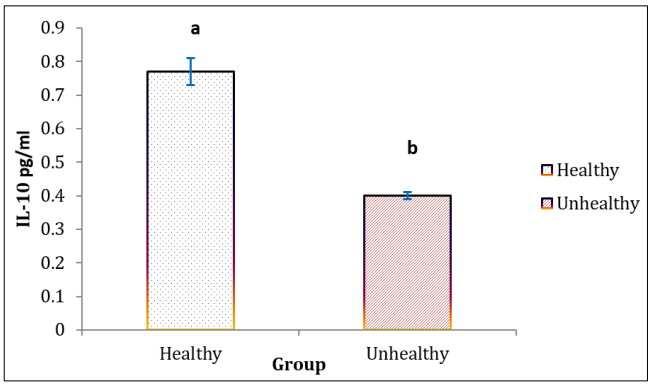

Fig 4: Status of IL-10 in healthy and affected goats

4. Discussion

Oxygen saturation which is measured in terms of SpO_2 by pulse oximetery is affected in respiratory diseases however there is lack of reports on use of pulse oximetery in case of small ruminants. Hence through this study we evaluated SpO_2 by noninvasive pulse oximetery at different sites in healthy and affected goats.

Affected goats showed significantly ($p<0.05$) lower % SpO_2 levels compared to the healthy control. This can be attributed to the severe lung insult caused by pathogen and alteration of gaseous exchange in lungs due to accumulation if inflammatory fluid in the lungs of affected goats. Similar findings have been reported by Kattimani *et al*. (2020) [5] in goats with respiratory illness and have also suggested the role of blood oxygen saturation in detecting the severity of respiratory diseases.

Significantly ($p<0.05$) higher temperature, heart rate and respiratory rate in affected group (Group 2) compared to the healthy control group (Group 1) can be due to the infection that elicits immune response of body against the pathogen. Increase in temperature in goats affected with respiratory illness has been reported (Yatoo *et al*., 2019) [11]. Significantly ($p<0.05$) higher TNF-α levels in affected group indicate cellular immune response against the pathogen. Lower IL-10 levels in affected goats indicates response of body to promote inflammation in early stages of infection.

5. Conclusions

Pulse oximetry is a non-invasive technique that avoids unnecessary pain and suffering to animals associated with the blood collection for venous blood oxygen saturation. In goats tail can be a good site for pulse oximetry. This technique can be a handy tool for management of goats with respiratory illnesses. In future standardization of pulse oximetry in goats and assessment of other feasible devices or possible sites in goats is indicated.

6. Ethical clearance

This study is approved under Institute Animal Ethics Committee (IAEC) *vide* Order No. AU/FVSc/PS-57/4298-99 and AU/FVS/20/4804.

7. Conflict of interest

Authors declare that there is no conflict of interest

8. Acknowledgement

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