

The use of pulse oximetry in clinical veterinary anaesthesia

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SUMMARY

A commercial human pulse oximeter was used in several species to measure heart rate and arterial oxygen saturation (SaO_2), and the results compared with those from an ECG and bench oximeter. The heart rates were always the same, but differences in the SaO_2 ranged between 4.2 per cent to 10.3 per cent. Correlation coefficients between the two SaO_2 measurement techniques ranged from 0.81 to 0.94, depending on the species investigated.

INTRODUCTION

Pulse oximetry has been used for many years in human anaesthesia to provide a continuous and non-invasive measurement of oxygen saturation (Altemeyer, Mayer, Berg-Seiter and Fosel 1986; Barrington, Finer and Ryan 1988; Severinghaus and Naifen 1987; Yelderman and New 1983). Published studies of pulse oximetry in animals are, however, confined to dogs and are orientated towards the use of animals as experimental models of human disease (Sendak, Harris and Donham 1988; Tremper *et al* 1984) rather than the use of pulse oximetry in veterinary clinical practice.

Pulse oximeters are potentially well suited to veterinary anaesthesia as they are easy to set up and give a useful amount of information. They detect desaturation long before cyanosis is apparent, giving warning of an impending problem. A variety of problems, both respiratory and circulatory, will lead to arterial desaturation or poor peripheral pulse quality and will be indicated by the unit.

This study reports on the use of a pulse oximeter in several species and compares the results with those obtained from a bench oximeter.

MATERIALS AND METHODS

A Physio Control (Redmond, Washington, USA) pulse oximeter was used in these studies. The unit gave a continuous display of arterial haemoglobin oxygen saturation (SaO_2) and pulse rate, with variable alarm limits for both these parameters. The SaO_2 trend was displayed along with a vertical bar graph which indicated the amplitude of the peripheral pulse signal. The unit could be operated from the mains or internal batteries. The studies were mostly performed in sedated or anaesthetised animals as the probe is susceptible to movement artefacts. The heart rate was recorded using a standard ECG monitor. SaO_2 readings from the pulse oximeter were compared with the results obtained from analysis of arterial blood samples taken from the femoral or central ear artery via a

catheter. The samples were analysed with a bench co-oximeter (Model 482, Instrumentation Laboratories, Lexington, Massachusetts, USA). Comparative studies were performed in rabbits, dogs, sheep, goats and pigs. For this study sheep and goats were considered together. The means \pm sd of the differences between the two saturation measurements were calculated. The correlation between the two techniques was calculated by regression analysis.

RESULTS

The pulse rate indicated by the pulse oximeter was the same as that determined from the ECG.

SaO_2 measurements by co-oximetry were nearly always lower than those shown by the pulse oximeter. The mean differences range from 4.2 per cent to 10.3 per cent (Table 1). The lower the SaO_2 , the greater were the differences.

Differences in SaO_2 of up to 10 per cent were found when two identical pulse oximeters were applied to the tongue and lip in the same animal. SaO_2 in the tongue was higher than the lip when the animal was well oxygenated and lower when the animal was poorly oxygenated.

Regression analysis showed reasonable correlations between the two techniques (Figs 1a to 1d). The worst correlation ($r = 0.81$) was in rabbits and the best ($r = 0.94$) was in sheep and goats.

DISCUSSION

The pulse oximeter unit was able to produce a value for heart rate and SaO_2 in all animals except the rat, in which it was unable to cope with the high heart rate (300 to 350 beats per min). The higher values of SaO_2 produced by the pulse oximeter compared with the co-oximeter may be because the pulse oximeter also responds to methaemoglobin and carboxyhaemoglobin, although the levels of these forms of haemoglobin were not measured in this study. The bench co-oximeter can distinguish between the different types of haemoglobin (Altemeyer *et al* 1986).

The shape of the haemoglobin dissociation curve will also affect the accuracy of the pulse oximeter reading. The haemoglobin absorption spectrum of the dog is very similar to that in man (Sendak *et al* 1988); there are no

Table 1: Differences between SaO_2 measured by pulse oximeter and bench oximeter

Species	number	Difference in SaO_2 (%)	
		mean	SD
dogs	52	10.3	6.5
rabbits	21	5.4	10.8
sheep/goats	51	7.3	3.5
pigs	36	4.2	7.1

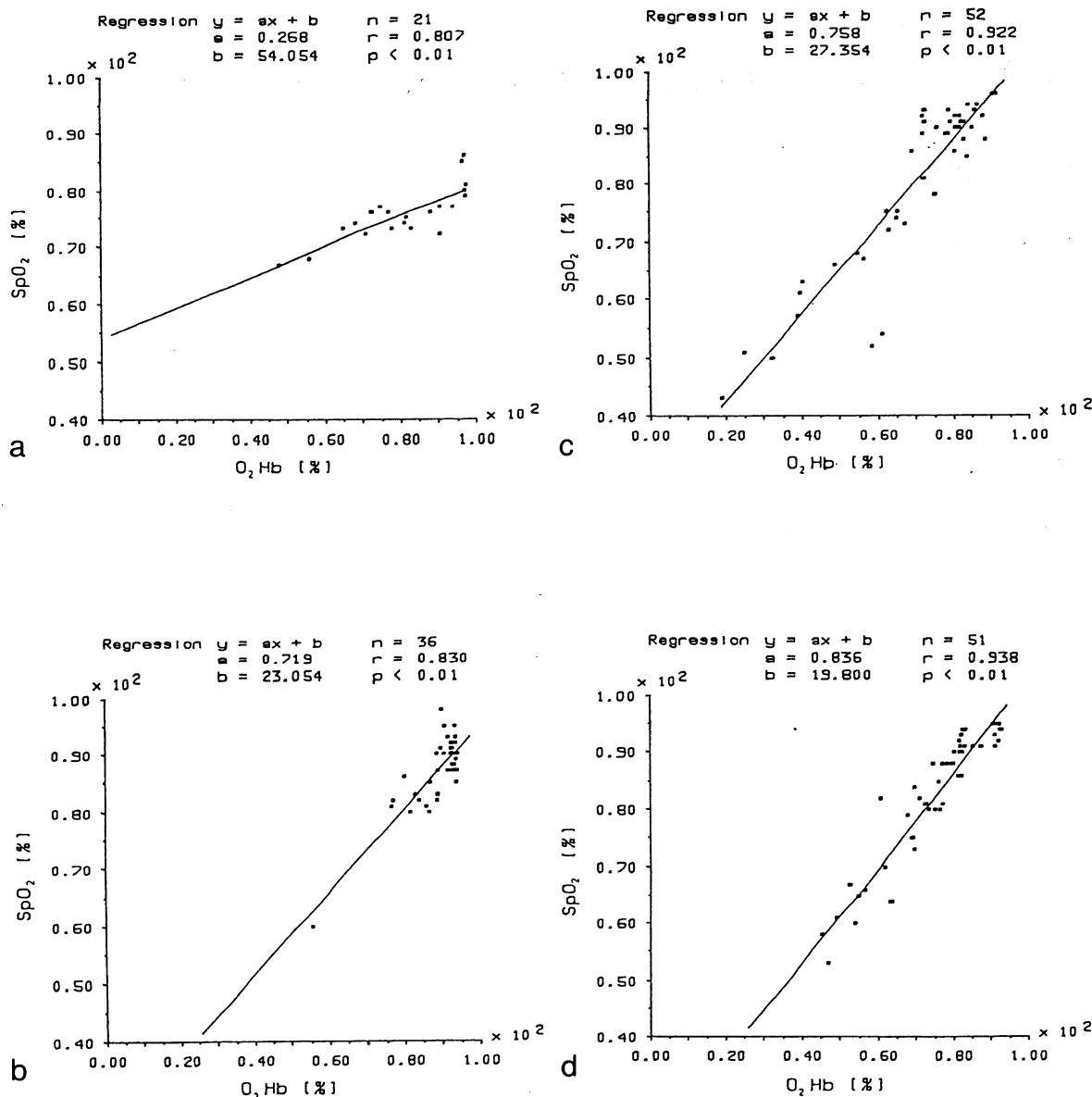


Fig 1: Regression lines for arterial oxygen saturation measured by pulse oximetry (y axis) against haemoglobin saturation measured by a bench co-oximeter (x axis). (a) rabbits; (b) pigs; (c) dogs; (d) sheep and goats

previous reports of haemoglobin absorption spectra in other species. The co-oximeter used in this study measured haemoglobin saturation directly and was not affected by species differences in haemoglobin structure.

The difference in values of SaO_2 recorded from the lip and tongue may be an artefact produced by movement of muscle cells near to the arterioles. The different oxygen affinities of haemoglobin and myoglobin (Lendl) may thus contribute to the apparent differences in SaO_2 .

The correlation between SaO_2 as measured by pulse oximetry and co-oximetry was reasonably good, and the pulse oximeter gave a reliable indication of any changes in SaO_2 . A comparison of pulse oximetry, blood gas analysis and measurement of HbO_2 via fibreoptic haemorelectometry showed that there was a high correlation between SaO_2 measurements by the three techniques but there was sometimes a constant difference between the values (Erhardt *et al* 1989). The pulse oximeter has the advantage that a continuous, on-line result is available. It is much more practical than transcutaneous arterial oxygen tension measurements (Tremper *et al* 1984). Disadvantages of pulse oximetry are that it can only be used in calm or anaesthetised patients and it does not work with poorly perfused tissues.

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