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Venous Blood Gas and Acid-base Values in Captive Asian Elephants (*Elephas maximus*)

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ABSTRACT

Background: Blood gas and acid base values are essential for health assessment and disease diagnosis of captive elephants when clinical signs were non-specific and other diagnostic techniques were not available for immediate applications. Regional specific normal healthy animal profile is valuable in health care planning for captive elephants. The aim of this study was to assess and evolve the baseline reference values for blood gas and acid base parameters for captive Asian elephants raised in Tamil Nadu, India.

Methods: A total of 46 venous blood samples were analyzed for blood gas and acid base values such as partial pressure of oxygen (PvO_2), partial pressure of carbon-di-oxide ($PvCO_2$), oxygen saturation (SvO_2), total carbon dioxide content ($TvCO_2$), bicarbonate and base excess (BEecf), bicarbonate (HCO_3^-) and by using i-STAT®1 hand held analyzer (i-STAT System, ©2013 Abbot Point of Care inc., USA).

Result: The mean±SEM, lower and upper values, 95% and 99% of confidence interval of the pH, $PvCo_2$, PvO_2, $TvCo_2$, BEecf, HCO_3^-, SvO_2, lactate were assessed. As the elephants in this study were apparently healthy, these ranges of values could well serve as a reference range for captive Asian elephants.

Key word: Acid-base values, Asian elephant, Lactate, Venous blood gas values.

INTRODUCTION

India has a long fascinating history of domesticating wild elephants. Captive Asian elephants are closely associated and deeply entwined with the religion, myths and cultural heritage of India for centuries (Kumar *et al*., 2019a). Elephants have adapted to a wide variety of environments in captive conditions. The health status of captive elephants depends on various factors such as body mass index, husbandry management, nutrition and infectious and non-infectious diseases, *etc*. (Mikota *et al*., 1994; Schmitt, 1998; Sadler, 2001). Studies on health and disease of captive elephant are far less; therefore, evolving measures to promote health and welfare remain challenging one. Understanding the health-related parameters and evidence of diseases in the captive-reared elephants will be significantly helpful towards enriching the management as well as their healthcare.

The health and disease related information on captive Asian elephants is very limited. Elephants are prone to a variety of infectious and non-infectious diseases; but recognizing that they are even sick may be difficult and challenging (Miller and Fowler, 2015). Elephants often do not manifest clinical signs of illness until the disease status is well advanced. Such masking of clinical signs makes identifying and treating the diseases in the elephants is challenging for veterinarians and zoo managers. Clinical and clinico-pathological examinations including blood values, serum biochemistry and blood gas and acid base values and electrolytes are often the valuable diagnostic tools for elephants, especially when the clinical signs were non-specific and other diagnostic techniques were not be available for immediate applications (Fowler and Mikota, 2006). Hence, establishing a base-line data of biological values for the captive Asian elephants will be significantly useful not only for monitoring/diagnostic purpose but also for treatment purpose. Establishment and use of regional-specific reference values for blood parameters will help to plan health care activities and clinical management programmes. Therefore, the present study was undertaken to establish the base-line blood gas and acid base values for the captive elephants of Tamil Nadu, India.

Though blood gas and acid base values were extensively evaluated for different species of wild animals (Kilgallon *et al*., 2008; Jeong *et al*., 2017; McNally *et al*., 2020). however, little information is available for the elephants (Honeyman *et al.,* 1992). Moreover, blood gas

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and acid base values were varied with different geographical locations for the Asian elephants due to feeding management, geographic, climate and management conditions, *etc*. (Janyamethakul *et al*., 2017). Therefore, this present study was attempted to establish the baseline reference values for venous blood gas and acid base values for captive Asian elephants maintained in Tamil Nadu, India.

MATERIALS AND METHODS

As a part of the health care programme for captive elephants maintained in Tamil Nadu, clinical and clinico-pathological assessments were undertaken. During this process, a total of 46 venous blood samples were collected as per the standard protocol (Fowler and Mikota, 2006) and the samples were analyzed for blood gas and acid base values such as PvO_2, $PvCO_2$, SvO_2, $TvCO_2$, BEecf, HCO_3^-, pH and lactate by using i-STAT®1 hand held analyzer (i-STAT System, ©2013 Abbot Point of Care inc. USA) with manufacturer's instruction (Yogeshpriya *et al*., 2017). The parameters were analyzed in the venous blood samples which were collected from elephants in lateral recumbent position in Lithium heparin coated vials (BD vacutainer® lithium heparin 2 ml) Whole blood (20 µL) was placed in a chosen CG4+ dry cartridge for the estimation (Isaza *et al*., 2003) and the analysis was undertaken.

RESULTS AND DISCUSSION

Health management of captive elephants is always a challenging task. Many a time sickness is not even deducted, as elephant does not manifest clinical symptoms unless advanced disease status; however, assessment of health parameters is helpful to diagnose the disease prevalence. Regular monitoring helps to diagnose the diseases and strategic therapeutic intervention. Besides, evaluation of routine blood parameters, blood gas and acid base values will help to monitor the severity of the disease and its emergency interventions. A normal baseline reference range is required for wildlife veterinarians to assess the health or disease status of the animals and formulate the mitigation protocols for the disorders.

The level of PvO_2, $PvCO_2$, SvO_2, $TvCO_2$, BEecf, HCO_3^- and pH were assessed in venous blood samples of elephants by i-STAT ® 1 hand held analyzer. The mean±SEM, lower and upper value, 95% and 99% of confidence interval of the blood gas and acid base values were shown in Table 1. The lactate level was found to be 10.69±0.21 nmol/L in the study.

Few studies were conducted on analysis of the blood gas and acid base profiles in elephants. In this study, blood gas analysis was carried out with use of venous blood samples collected for periodical health monitoring. The estimated mean pH value was 7.23±0.02 with the range of 7.0 to 7.4. This was in agreement with Fowler and Mikota (2006), who reported that the mean pH value in elephants was 7.36±0.01. Bouda *et al*. (2000) reported a narrow range of pH (7.35-7.45) in a healthy red deer (*Cervus elaphus*). As the elephants in this study were apparently healthy; therefore, pH range could serve as a reference range for healthy captive Asian elephants.

Venous partial pressure of carbon dioxide

The mean value for $PvCO_2$ in the present study was 54.35±0.72 mmHg. The $PvCO_2$ value reported herein was slightly lower than the value reported by Honeyman *et al*. (1992) in mixed population of captive elephants and Isaza*et al*. (2003) in Asian elephants. Lee *et al.* (2015) reported a value of 45.7 ± 4.50 mmHg in domestic calves, which was also lower than the mean value observed in this study. Possibly stress during the restraining of elephants during sampling could be a reason for the differences observed in $PvCO_2$ in the venous blood. Montesinos and Ardiaca (2013) opined that higher or lower carbon dioxide concentrations were due to neurologic, respiratory, musculoskeletal or extra respiratory system dysfunctions. Recumbency position could alter the respiratory dynamics; therefore, the value was varied (Isaza *et al*., 2003). Further studies on the positional influence on blood gas and acid base parameters in elephants may help in a better understanding.

Venous partial pressure of oxygen

The partial pressure of oxygen in venous blood level measured in this study (42.50±1.33 mmHg) was found to be comparatively lower than the values reported previously in elephants (50±7 mmHg) by Isaza *et al*. (2003). These variations could be possibly due to undetermined environmental factors including location, ambient temperature, stress factors etc. Ortiz-Prado *et al*. (2019) stated that the amount of dissolved oxygen within the tissues and the cells depends on various factors including

Table 1: The Mean±SE, lower and upper value and confidence intervals (95% and 99%) for blood gas and acid base values.

Parameters	Mean±SEM	Max	Min	95% confidence interval	99% confidence interval
$PvCO_2$ (mmHg)	54.35±0.72	60.2	48.7	52.938-55.762	52.494-56.206
PvO_2 (mmHg)	42.50±1.33	57	33	39.892-45.108	39.072 ±45.928
SvO_2 (%)	98.79±0.08	99	98	98.626-98.954	98.574-99.006
HCO_3^- (mEq/L)	23.39±0.44	27.6	20.2	22.534-24.246	22.265-24.515
$TvCO_2$ (mmol/L)	24.63±0.59	30	19	23.470-25.790	23.105-26.155
BEecf (mmol/L)	-5.42±0.37	-2	-9	-6.136 - -4.704	-6.361- -4.479
Lactate (mmol/L)	10.69±0.21	12.55	8.42	10.254-11.126	10.117-11.263
pH	7.23±0.02	7.4	7	7.182-7.278	7.167-7.293

climatological conditions such as temperature, relative humidity, latitude, altitude as well as physiological, pathological and physical-chemical processes within the animals itself. In this study, all the 46 elephants were apparently healthy.

Bicarbonate

The mean level of serum HCO3- in this study was 23.39±0.44 mmHg (range: 20.2 to 27.6 mmHg) and it was similar to the values reported by Isaza *et al*. (2003) in Asian elephants. Respiratory distress is a common presenting problem in the emergency medicine due to derangements of HCO_3^- concentration (Dillane *et al.*, 2018). Generally, metabolic acidosis was observed during direct loss of bicarbonate through the gastrointestinal tract (enteritis) or kidneys (renal tubular acidosis) whereas metabolic alkalosis was observed when there was loss of hydrochloric acid (vomiting of stomach contents) or from gaining up of HCO_3 by sodium bicarbonate administration (Montesinos and Ardiaca, 2013). In this study elephants were apparently healthy.

Venous oxygen saturation

The percent of SvO_2 levels measured in this study (98.79±0.08%) was similar to the values reported by Honeyman *et al*. (1992) and Isaza *et al*. (2003) in Asian elephants. These values were higher compared to those reported in other species (Kilgallon *et al*. 2008; Lee *et al*., 2015; Dillane *et al.,* 2018). Haemoglobin (Hb) saturated with oxygen (SO_2) was higher in elephants compared to other species because elephant blood has highest affinity for oxygen (Fowler and Mikota, 2006).

Lactate

Lactate is essential not only to assess the metabolic health, but also to evaluate the muscle health. The present study revealed that the mean value of lactate was 10.69±0.21 mmol/L in captive elephants, which was close to the values (9.01 mmol/L) reported by Fowler and Mikota (2006). Plasma lactate concentrations in apparently healthy animals were less than 1.5 to 2.0 mmol/L. However, reasons for the variations require further studies like especially serial monitoring studies to gain a better understanding on the lactate concentration in elephants.

CONCLUSION

Normal range of parameters for blood gas and acid base values were estimated for captive Asian elephants. The observed values in this study indicated that these captive elephants had good health and wellbeing. These parameters were evaluated from 46 elephants and serve as the regional reference values to assess the health and welfare of captive elephants for Tamil Nadu, India. These parameters can be made as part of the panel of health and welfare indicators for captive elephants, as these assessment helped in identifying the overall body health status of elephants.

Conflict of interest: None.

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