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RESEARCH PAPER

The use of lingual venous blood to determine the acid-base and blood-gas status of dogs under anesthesia

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Abstract

Objective To assess the suitability of lingual venous blood (LBG) as an alternative to arterial blood (ABG) samples in determining acid-base balance and blood-gas status in dogs anesthetized for elective procedures and with medetomidine and isoflurane administration under experimental conditions.

Study design Prospective, randomized clinical and experimental study.

Animals Clinical population of 18 ASA I/II dogs for elective surgery and five healthy Beagles (3 females and 2 males) for the experimental study.

Methods Blood sampling was simultaneously performed at dorsal pedal arterial and lingual venous sites, generating paired data. Two paired samples were collected from each dog in the clinical part and four from each dog in the experimental part (two during isoflurane anesthesia and two during isoflurane plus medetomidine). A modified Bland and Altman method was used to examine data from the clinical part and the experimental data were subjected to a paired sign's test following transformation where appropriate.

Results The pH of LBG overestimated ABG, with limits of agreement of (−0.01, 0.02). The partial pressure of carbon dioxide (PCO_2) of LBG overestimated ABG by 0.6 mmHg [0.1 kPa], with limits of agreement of (−3.5, 4.6) mmHg [−0.5, 0.6 kPa]. The partial pressure of oxygen (PO_2) of LBG underestimated ABG by 86.3 mmHg [−11.5 kPa], with limits of agreement of (−199.8, 27.3) mmHg [−26.6, 3.6 kPa]. During medetomidine administration values for PO_2 ($p = 0.03$) and lactate ($p = 0.03$) were lower for LBG when compared with ABG. The LBG value of PO_2 was lower ($p = 0.03$) during medetomidine and isoflurane administration *versus* isoflurane alone.

Conclusions and clinical relevance The pH and PCO_2 of LBG samples provide clinically acceptable substitutes of ABG samples in the dog population studied. The wider limits of agreement for PO_2 render it less reliable as a substitute for ABG. The difference in PO_2 identified between LBG and ABG during medetomidine administration may not preclude the use of LBG as substitutes for ABG samples.

Keywords anesthesia, arterial, blood-gas, dog, lingual, medetomidine.

Introduction

Arterial blood (ABG) sample analysis provides critical information in the monitoring of blood-gas and acid-base homeostasis (Wagner et al. 1991).

However, sampling of arterial blood is not without complications. These include bleeding, transient or permanent vessel obstruction, infection and patient discomfort in humans (Mortensen 1967; Shapiro et al. 1994). Furthermore, the small size of many animals makes arterial puncture or the placement of catheters difficult and sites may be rendered inaccessible during surgery (van Sluijs et al. 1983; Wagner et al. 1991).

Alternative techniques to arterial sampling have been investigated in both humans (Lundsgaard & Moller 1922; Singer et al. 1955; Maas & van Heijst 1961; Langlands & Wallace 1965; Harrison et al. 1997; Yildizdas et al. 2004) and animals (Sharpe et al. 1968; Rodkey et al. 1978; van Sluijs et al. 1983; Abou-Madi & Robertson 1989; Wagner et al. 1991).

Sites investigated have included capillary blood samples (CBG) in humans from the finger or heel (Harrison et al. 1997; Escalante-Kanashiro & Tantalean-Da-Fieno 2000; Yildizdas et al. 2004) and earlobe (Dar et al. 1995; Sauty et al. 1996; Eaton et al. 2001). In dogs, the margin of the ear (Rodkey et al. 1978; van Sluijs et al. 1983) and lingual venous samples (Abou-Madi & Robertson 1989; Wagner et al. 1991) have been used for sample collection. The theory underlying CBG and lingual venous blood (LBG) samples is that a small arterio-venous difference in parameters of interest (partial pressure of oxygen, PO_2; partial pressure of carbon dioxide, PCO_2; standard base excess, SBE; pH and lactate) allows substitution of these sample sites for ABG. Compared with ABG, these sites are less challenging to sample and associated with fewer complications (Abou-Madi & Robertson 1989; Wagner et al. 1991; Dar et al. 1995). It may be a misnomer to refer to CBG sites as 'capillary' as typical sampling sites probably reflect a mixture of capillary, arteriolar and venular blood. The precise composition of the blood varies with the degree of local perfusion and vasoconstriction (Pandit 1995).

This study comprised two parts. The aim of the clinical part was to quantify the relationship between arterial and LBG samples in anesthetized dogs and their use in the assessment of respiratory function and acid-base status. The aim of the experimental part was a pilot study to provide initial information on the potential effect of a constant rate infusion (CRI) of medetomidine during isoflurane anesthesia on the same parameters using the same sampling sites.

Materials and methods

This study was approved by the Animal Use and Ethics Committee of the Faculty of Veterinary Medicine of the Université de Montréal (CÉUA), which operates under the auspices of the Canadian Council on Animal Care.

For the clinical part, dogs scheduled for orthopedic or soft tissue surgery at the Faculty of Veterinary Medicine small animal hospital were recruited. Inclusion criteria included ASA class I/II patients at the small animal clinic, scheduled to have an arterial catheter placed for direct systemic blood pressure monitoring, and arterial blood sampling, as part of anesthetic management. Exclusion criteria included known coagulopathies, dental disease and skin disease at the site of arterial catheter placement. Samples were only taken when the following criteria were met: direct mean systemic arterial blood pressure (MAP) of 60–100 mmHg, esophageal temperature of 37.0 ± 1 °C, and normocapnea (partial pressure of end-tidal carbon dioxide [$P_E'CO_2$] between 35 and 45 mmHg [4.7–6.0 kPa]).

No exclusion was made on the basis of breed, weight (median [range] 27.5 [4.6–60] kg) or age (median [range] 50 [3–149] months). Breeds included were Australian Shepherd (2), mixed breed (4), Bouvier de Flandres (1), Chesapeake Bay Retriever (1), Leonberger (1), Bull Mastiff (1), Pyrenean Mountain Dog (1), Labrador Retriever (2), Airedale (1), Shih Tzu (1), Rottweiler (1), Golden Retriever (1), Shetland Sheepdog (1). Two paired samples, each pair comprising an LBG and ABG were taken from each animal and with a minimum period of 20 minutes between samples. Immediately prior to sample collection, the following physiological parameters were recorded: pulse rate (as calculated from the arterial pressure trace; PR), MAP, esophageal temperature (Temperature Probe, Esophageal/Rectal, 700 Series, Adult Reusable; Datascope Corporation, Montvale, NJ, USA) and $P_E'CO_2$ (NPB-75; Nellcor Puritan Bennett, Plesanton, CA, USA). Body temperature was monitored using an esophageal probe inserted to the level of the fifth intercostal space. Sampling was not performed when physiologic parameters were outside the predetermined ranges. A catheter (20-SWG, 1.16 inch or 22-SWG, 1.00 inch, BD Insyte-W; Becton Dickinson Infusion Therapy Systems Inc, Sandy, UT, USA) to allow monitoring of systemic arterial blood pressure and repeated sampling, was introduced into either the left or right dorsal pedal