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RESEARCH PAPER

Comparison of two different methods for physiologic dead space measurements in ventilated dogs in a clinical setting

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Abstract

Objective To compare physiologic dead space (V_D) and physiologic dead space to tidal volume (V_T) ratio (V_D/V_T) obtained by an automated single breath test for carbon dioxide (CO_2) (method SBT) and a manual calculation (method MC) in ventilated healthy dogs.

Study design Prospective clinical study.

Animals Twenty client-owned dogs, ASA I and II undergoing anaesthesia for clinical purposes.

Methods Following pre-medication, induction of anaesthesia, and intubation of the trachea, intermittent positive pressure ventilation was commenced. Mixed expired CO_2 partial pressure ($P\bar{E}CO_2$) was measured by two methods: method MC by analysis, using an infrared capnograph, of the expired gas collected in a mixing box and method SBT which calculated it automatically by a device consisting of a mainstream capnograph and a pneumotachograph. At four time points arterial partial pressure of CO_2 ($PaCO_2$) was measured. Physiologic dead space variables (V_D and V_D/V_T) were calculated manually (method MC) or automatically (method SBT) using the Bohr–Enghoff equation.

Method MC and SBT were compared using Bland–Altman plots and linear regression. Intra-class correlation coefficient (ICC) was used to measure consistency of each method.

Results Four measurement pairs were obtained in all 20 dogs for method SBT and MC. The bias was −1.15 mmHg, 7.97 mL and 0.02 for $P\bar{E}CO_2$, V_D and V_D/V_T, respectively. Linear regression analysis revealed a correlation coefficient (r^2) of 0.79, 0.94, and 0.83 for $P\bar{E}CO_2$, V_D and V_D/V_T, respectively. The ICC revealed an excellent consistency for both methods.

Conclusions The single breath test (SBT) can be used for clinical evaluation of V_D and V_D/V_T in anaesthetized ventilated dogs.

Clinical relevance Through measuring V_D and V_D/V_T important information about lung ventilation can be obtained and the SBT is an easy method to use for this purpose.

Keywords dead space, dog, single breath test, ventilation.

Introduction

Physiologic dead space (V_D) or 'wasted ventilation' is crucial to understand the relationship between minute volume, tidal volume (V_T) and the arterial partial pressure of CO_2 ($PaCO_2$) of a patient during

anaesthesia. Physiologic dead space represents the sum of the alveolar (V_{Dalv}) and the airway dead space (V_{Daw}). Airway dead space is a more accurate description for what was previously termed 'anatomical dead space' as its size is dynamic and changes with respiratory variables such as respiratory rate (f_R), V_T, airway flow rates and positive pressure ventilation (Tusman et al. 2009). Calculation of V_D during anaesthesia using the Bohr–Enghoff equation requires the simultaneous measurement of mixed expired carbon dioxide tension ($P\bar{E}CO_2$) and $PaCO_2$ (Enghoff 1938). Mixed expired CO_2 can be sampled from a Douglas bag or a mixing box incorporated in the expiratory limb of the anaesthetic circuit (Fig. 1). More recently an alternative method based on volumetric capnography became available for clinical use. Volumetric capnography represents the plot of expired CO_2 concentration *versus* expired volume (Fig. 2) and is also called single-breath test for expired CO_2 (SBT) (Aitken & Clark-Kennedy 1928). Figure 2 shows a typical volumetric capnography curve and illustrates the fact that the expired CO_2 is plotted against the expired volume and demonstrates the difference between volumetric capnography and a capnogram where the expired CO_2 is plotted against time. The SBT technique uses information obtained by a mainstream capnograph and a pneumotachograph. The sensors of both devices are inserted between the endotracheal tube and the Y-piece of the breathing system. To calculate V_D, the obtained $PaCO_2$ values are entered and an algorithm is used, making separate measurement of $P\bar{E}CO_2$ unnecessary. In humans SBT is used to determine physiologic dead space variables after pulmonary embolism, bronchoconstriction and to adapt ventilator settings in intensive care units (Fletcher 1990; Arnold et al. 1995; Olsson et al. 1999; Verschuren et al. 2004).

The objective of this study was to compare values for V_D and for its ratio to V_T (V_D/V_T) obtained by manual calculation (method MC) and volumetric capnography (method SBT) in anaesthetized dogs undergoing elective surgery in a clinical setting.

Materials and methods

The protocol was discussed and approved by the head of the department.

Animals

Twenty dogs of different breeds, scheduled for routine elective surgery, with a median bodyweight of 33.2 kg (range: 19–55.7 kg) and age of 1.6 years (range: 0.5–10 years) were included initially in this study. Ten dogs were females and 10 males. Inclusion criteria were a bodyweight above 15 kg, American Society of Anesthesiologists classification 1 or 2, unremarkable lung auscultation at pre-anaesthetic evaluation, and an arterial line in the dorsal pedal artery. Eighteen dogs underwent orthopaedic procedures and two soft tissue mass excisions. Seventeen dogs were positioned in dorsal and three dogs in lateral recumbency during the measurement period.

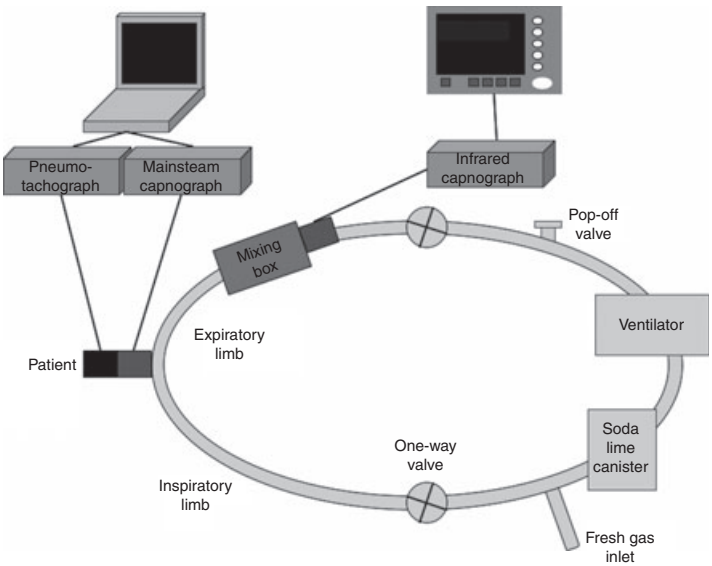

Figure 1 Graphical illustration of the arrangement of the circle system, mixing box, and measurement devices.

