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RESEARCH PAPER

The effects of different inspired oxygen fractions on gas exchange and Tei-index of myocardial performance in propofol-anesthetized dogs

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Abstract

Objective To evaluate the influence of different inspired oxygen fractions (FiO_2) on pulmonary oxygen exchange and Tei-index of myocardial performance in propofol-anesthetized dogs.

Study design Prospective crossover, randomized, experimental trial.

Animals Eight adult dogs weighing 8.6 ± 1.8 kg.

Methods The animals were anesthetized on five occasions, receiving either an FiO_2 = 1.0 (F100), 0.8 (F80), 0.6 (F60), 0.4 (F40) or 0.21 (F21). Propofol was used for induction (6.45 ± 0.69 $mgkg^{-1}$ IV) followed by a continuous rate infusion (CRI, 0.7 $mgkg^{-1}$ $minute^{-1}$). The dogs breathed spontaneously. The initial measurements of arterial partial pressures of oxygen (PaO_2) and carbon dioxide ($PaCO_2$), arterial hemoglobin saturation (SaO_2), heart rate (HR), mean arterial pressure (MAP), cardiac index (CI), stroke index (SI), pre-ejection period (PEP) and left ventricular ejection time (LVET) were performed 30 minutes after beginning the CRI (T0) and then, at 15-minute intervals (T15–T60). From these measurements the following were calculated; alveolar oxygen partial pressure (PAO_2), alveolar-arterial oxygen gradient ($AaDO_2$), arterial oxygen partial pressure/inspired oxygen fraction ratio (PaO_2/FiO_2), arterial-to-alveolar oxygen tension ratio (PaO_2/PAO_2), respiratory index (RI), oxygen delivery ($\dot{D}O_2$), PEP/LVET ratio, isovolumic relaxation time (IVRT) and Tei-index.

Results At T30, $PaCO_2$ in F100 was higher than in F21. The $AaDO_2$ mean in F100 was greater than in other treatments. PaO_2/FiO_2 in F21 was lower than F100 and F80 at T0 and than in F80 and F60 at T15. At T15, PaO_2/PAO_2 and RI in F100 were higher than in F80, F60 and F21. At T30, PaO_2/PAO_2 in F21 was lower than in F100 and F60. At T30, PEP/LVET in F100 was higher than F80, F40 and F21, which was lower than F80 and F40.

Conclusion The Tei-index and cardiovascular parameters are not affected by different FiO_2.

Clinical Relevance An FiO_2 of 1.0 and 0.21 impaired respiratory efficiency.

Keywords cardiac function, monitoring, total intravenous anesthesia, venous admixture.

Introduction

The high inspired oxygen fraction (FiO_2) used during anesthesia may be a concern, because high oxygen concentration has been correlated with atelectasis. A low oxygen concentration has been advocated to avoid this problem (Hedenstierna 2003). This collapse of part of the lung has been proven in dogs during anesthesia (Staffieri et al. 2007).

Atelectasis is a cause of venous admixture and, therefore, of hypoxemia (Aldrich et al. 2002). The quantification of venous admixture, which can be assessed by several different methods, provides an assessment of the oxygenating efficiency of the lung (Aldrich et al. 2002; Haskins 2004).

The changes in gas exchange can alter cardiac activity, because hypoxia improves and hyperoxia worsens systolic myocardial performance (Frøbert et al. 2004). Maruyama et al. (1992) documented a simultaneous reduction in both systolic and diastolic left ventricular function when hypercapnic acidosis was present in dogs ventilated with 6.3% oxygen.

Recently, by means of transthoracic echocardiography, a Doppler-derived index, that combines systolic and diastolic time intervals, has been developed to assess global cardiac function (Tei et al. 1995). This index, often referred to as the Tei-index of myocardial performance, is defined as the sum of isovolumic contraction time and isovolumic relaxation time divided by ventricular ejection time (Ärnlöv et al. 2005). This index is not affected by heart rate (Poulsen et al. 2000), blood pressure (Tei et al. 1995), and ventricular loading conditions (Moller et al. 1999). In dogs anesthetized with isoflurane, the Tei-index seems to be a sensitive and heart-rate-independent indicator of the depressant effects of the anesthetic on global left ventricular function (Sousa et al. 2007). However, Tei-index has not been studied during total intravenous anesthesia with propofol to assess systolic and diastolic function in dogs.

This study was designed to establish the influence of different FiO_2s on pulmonary oxygen exchange in dogs during continuous rate infusion (CRI) of propofol and breathing spontaneously. The effects of different FiO_2 on myocardial performance were also investigated by evaluation of Tei-index. Furthermore the correlations between Tei-index and heart rate, Tei-index and stroke index, and Tei-index and cardiac index were evaluated.

Material and methods

This study was approved by the Institutional Animal Care and Use Committee (protocol number 017678-06). After the experiment, the animals were offered for adoption.

Eight mature mongrel dogs, four males and four females, weighing 8.6 ± 1.8 kg, were enrolled in the study. All animals were determined to be healthy based on a complete physical examination, a cell blood count (CBC), standard serum biochemistry test, chest radiograph, electrocardiogram and echocardiogram.

The animals were provided with water and regular dog food (Pedigree adulto carne & marrowbone, Mars Brazil, Mogi Mirim, SP, Brazil) and were kept in individual cages at the Veterinary Hospital. Before the experiment started, the dogs were acclimatized to the procedure by daily contact with the researchers and visits to the laboratory twice a week. Every time animals were brought to the laboratory, they were restrained on the echocardiography table and underwent complete routine transthoracic echocardiography.

Dogs were anesthetized on five occasions, with a 10-day interval in between, receiving: FiO_2 = 1 (F100), 0.8 (F80), 0.6 (F60), 0.4 (F40) and 0.21 (F21) in a crossover randomized order. At the beginning of this study, the order of FiO_2 was randomized, with a resulting order of 60, 100, 80, 40 and 21%.

After performing a baseline transthoracic echocardiogram, anesthesia was induced with 6.45 ± 0.69 mg kg^{-1} of propofol IV (Fresofol 1%, Fresenius Kabi Brazil Ltda, SP, Brazil), administered over approximately 1 minute, the dose needed for the animals to lose their laryngeal and tracheal reflexes. After endotracheal intubation, the animals received the assigned FiO_2, at 30 mL kg^{-1} $minute^{-1}$ via a circle anesthetic circuit (Mod. Excel 210SE, Datex Ohmeda, WI, USA). Oxygen concentration was monitored using a gas analyzer (DX 2010LCD, Dixtal, AM, Brazil).

Immediately after induction, a continuous rate infusion (CRI) of propofol was administered at a rate of 0.7 mg kg^{-1} $minute^{-1}$, using an infusion pump (Infusion Pump 670T, Samtronic, SP, Brazil). The animals were positioned in left lateral recumbency, on an echocardiography table, that allowed the transducer to be placed in a left parasternal position (Boon 1998). A thermal mattress (Brasmed, SP,