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RESEARCH PAPER

The effect of experimentally induced hypothyroidism on the isoflurane minimum alveolar concentration in dogs

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Abstract

Objective To determine the effect of experimentally induced hypothyroidism on isoflurane (ISO) minimum alveolar concentration (MAC) in dogs.

Study design Prospective experimental study.

Animals Eighteen adult female mongrel dogs, age 2–4 years and weighing 8.2–13.1 kg.

Methods Hypothyroidism was induced in nine dogs by the intravenous administration of 1 mCi kg^{-1} of ^{131}Iodine. The remaining nine dogs served as controls. Dogs were studied 9–12 months after the induction of hypothyroidism. Anesthesia was induced with ISO in oxygen via a mask. The trachea was intubated, and anesthesia was maintained using ISO in oxygen using a semi-closed rebreathing circle system. The dogs were mechanically ventilated to maintain an end-tidal carbon dioxide concentration between 35 and 45 mmHg. End-tidal ISO concentrations were measured with an infrared gas analyzer. The MAC was determined in duplicate using a tail clamp technique. The mean values for the groups were compared using a two sample *t*-test.

Results The mean ± SD MAC of isoflurane in the hypothyroid and euthyroid dogs was 0.98 ± 0.31% and 1.11 ± 0.26%, respectively. The mean MAC of isoflurane in hypothyroid dogs was not significantly different from the mean MAC of isoflurane in the control dogs ($p = 0.3553$).

Conclusion and clinical relevance The MAC of ISO in dogs was not significantly affected by experimentally induced hypothyroidism. The dose of ISO in dogs with hypothyroidism does not need to be altered.

Keywords dogs, hypothyroidism, isoflurane, minimum alveolar concentration.

Introduction

Hypothyroidism is one of the most common endocrine disorders diagnosed in dogs. Because thyroid hormones are essential for normal function of all body systems, hypothyroidism is associated with a wide array of clinical abnormalities. The effects of this disorder on the neurologic and cardiovascular systems and on drug metabolism are of particular importance for appropriate anesthetic management of affected dogs. Not surprisingly, empirical observations in anesthetized hypothyroid dogs have led to opinions that they require less anesthetic agent for a given effect and are often difficult to manage during anesthesia.

The standard measurement used to determine the potency of an inhaled anesthetic agent is the minimum alveolar concentration (MAC). The MAC of anesthetic agents is defined as the concentration at which 50% of patients will not move in response to a noxious stimulus (Quasha et al. 1980). The term was first used in 1963 by Merkel and Eger (Merkel & Eger 1963) and has been used as the

major index of anesthetic potency in anesthetic literature ever since.

The concept of MAC not only provides a method to compare the potencies of different inhalation anesthetic agents, but it also serves as a sensitive tool to determine the interaction of altered physiologic states with the inhaled anesthetics (Stanski 2000). Several factors have been identified that may alter an animal's anesthetic requirements, or MAC. Of these variables, hypothyroidism has been commonly considered to decrease anesthetic requirements in both humans and dogs (Babad & Eger 1968; Stanski 2000). However, only one study evaluating the MAC value in hypothyroid dogs has been performed. In this study, the effect of hypothyroidism on halothane requirements was examined in six dogs (Babad & Eger 1968). The authors demonstrated that the MAC of halothane in hypothyroid dogs was reduced by approximately 4–6% (Babad & Eger 1968). No studies have been performed in dogs to evaluate the effect of hypothyroidism on the MAC value of a more modern inhaled anesthetic agent, such as isoflurane (ISO).

The objective of this study was to evaluate the effects of experimentally induced hypothyroidism on the MAC of ISO in the dog.

Materials and methods

Eighteen healthy female adult mongrel dogs weighing between 8.2 and 13.1 kg were used. All dogs were determined to be healthy based on lack of significant abnormalities on physical examination, complete blood count, serum chemistries, urinalysis, Dirofilaria antigen test, and zinc sulfate fecal floatation. Serum concentrations of total thyroxine (T_4), free T_4 by equilibrium dialysis, and endogenous canine thyroid stimulating hormone (TSH) were within their respective reference ranges.

Food was withheld for 12 hours before anesthesia. Water was available *ad libitum*. This study was approved by the University Animal Care and Use Committee.

Induction and confirmation of hypothyroidism

Hypothyroidism was induced in nine randomly selected dogs by the intravenous (IV) administration of 1 mCi kg^{-1} of ^{131}Iodine (Panciera & Johnson 1996). Hypothyroidism was confirmed by measuring a serum T_4 concentration <5 nmol L^{-1} prior to and 4 hours post IV administration of 50 μg human recombinant TSH (Panciera & Johnson 1996). Confirmation testing was performed nine and 38–45 weeks after ^{131}I administration. All control dogs had a serum T_4 concentration ≥37 nmol L^{-1} after TSH administration. The ISO MAC was determined 9–12 months after the induction of hypothyroidism. All studies were performed during anestrous.

Determination of ISO MAC

Anesthesia was induced with ISO in oxygen delivered via mask. The trachea was intubated and anesthesia was maintained with ISO in oxygen delivered via a circle system with an oxygen flow rate of 30–40 mL kg^{-1} $minute^{-1}$. The dogs were placed in lateral recumbency and a 20-gauge catheter was placed in a cephalic vein. Lactated Ringer's solution was administered at 5 mL kg^{-1} $hour^{-1}$. Dogs were mechanically ventilated to maintain an end-tidal carbon dioxide tension ($P_E'CO_2$) of 35–45 mmHg (4.7–6.0 kPa). $P_E'CO_2$ and end-tidal ISO concentrations (F_E'Iso) were continually monitored using an infrared gas analyzer (AS/3; Datex-Ohmeda, Finland). The gas analyzer was calibrated at the start of each day using the calibration gases supplied by the manufacturer (DOT-39 NRC 300/375; Datex-Ohmeda). Esophageal temperature was monitored electronically. Warm water and forced air blankets were used to maintain the dogs' temperatures between 37 and 39 °C. The electrocardiogram, heart rate, and percent saturation of hemoglobin (SpO_2) were monitored throughout the experiment (AS/3; Datex-Ohmeda).

F_E'Iso was held constant at 1.7% for at least 30 minutes prior to the determination of ISO MAC. At the end of this equilibration period, F_E'Iso was decreased to 1.2% and maintained for at least 20 minutes. A noxious stimulus, which consisted of clamping the tail, was then applied using a 24 cm sponge forceps with plastic tubing on each jaw (Valverde et al. 2003). The forceps was applied 10 cm from the base of the tail and closed to the first notch. The forceps remained in place for 60 seconds or until gross purposeful movement, defined as a twisting or lifting of the head or a paddling or running motion of the limbs, was observed. Movements that were not considered purposeful included swallowing, chewing, or coughing. If gross purposeful movement was observed, the F_E'Iso was increased by 0.1%. If no movement was recorded, the F_E'Iso

