

Anaesthesia of small rodents during magnetic resonance imaging

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Abstract

The use of experimental animals for magnetic resonance studies requires anaesthesia to provide immobility and acquire signals with minimal stress and maximal reproducibility. However, the conduct of anaesthesia within a magnetic resonance imaging (MRI) suite implicates many problems, because most of the anaesthetic and monitoring equipment contains ferromagnetic substances. To decrease disturbances during anaesthesia and make data interpretation more accurate, it is mandatory that investigators become familiar with methods and physiologic effects of anaesthesia under these special conditions.

This article is intended to give an overview of anaesthetic medication, administration routes and practical instructions for anaesthesia in small rodents during MRI.

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1. Introduction

Magnetic resonance imaging (MRI)¹ has become a growing impact to analyze physiological and pathophysiological alterations and their mechanisms in small experimental animals. To investigate these animals, they need to be anaesthetized in order to obtain signals with minimal motion, minimal stress and maximal reproducibility. However, the hazards and artifacts caused by ferromagnetic substances have entailed numerous limitations on anaesthetic management in the MRI suite [1–5]. The problems related to anaesthesia in MRI include the constant presence of a strong magnetic field and radio frequency (RF)

pulses with their effects on anaesthesia machine, monitoring devices, magnetically coded material and loose ferromagnetic objects [6].

This article describes a selection of anaesthetic regimes and technical equipments for MRI investigations. It further introduces in anaesthetics, including possible administration ways, for a short recovery time after the anaesthesia. During these processes, animals should be protected from pain, suffering and distress.

2. Anaesthetic machines

Equipment for anaesthesia can be as simple as a syringe or as complex as a ventilator with supported equipment. In either case, careful selection based on an understanding of its use and limitations is necessary. The quality of anaesthesia care has an immediate and long-term effect on the welfare of the animal and is important in both ethical and pragmatic terms. However, in order to assure successful imaging and the safety of the animal, it remains important that no common equipment be used in the MRI vicinity [7]. Anaesthetic machines used for animal research are spe-

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¹ *Abbreviations used:* CNS, central nervous system; Fig., figure; g, gram; G, gauche; GABA, gamma-aminobutyric acid; i.h., inhalative; i.m., intramuscular; i.p., intraperitoneal; i.v., intravenous; kg, kilogram; mg, milligram; ml, milliliter; mm, millimeter; MRI, magnetic resonance imaging; O₂, oxygen; RF, radio frequency; s.c., subcutaneous; WAG, wasted anaesthetic gas.

cially designed or may be machines originally intended for human use. Respirator units for small rodent research are often very simple and may lack even an absorber system. Any machine should be provided for the safe delivery of breathing gas containing a controlled amount of anaesthetic agent.

MRI and other high magnetic field environments require special respirators and vaporizers without metallic elements [8]. Therefore, if a common commercial ventilator has to be used in the MRI, it is necessary to place it at a safe distance from the magnet. This implicates that ventilators are located at some distance from the animal. This is possible with long hoses (several meters) between breathing gas source and the animal. However, long hoses can create troublesome dead space problems

and significant transit times delays for inspiration and expiration.

2.1. Principles of the anaesthetic machine

The basic anaesthetic delivery system consists of a source of oxygen (O_2) and O_2 -flowmeter, a precision vaporizer, which produces vapor from a volatile liquid anaesthetic, an animal breathing circuit (tubes, connectors and valves) (Fig. 1a) and a scavenging device that removes any excess anaesthetic gases [9]. This is critical, since room pollution with anaesthetic gases may lead to health problems in animals as well as in humans, and is strongly overseen by the occupational safety staff.

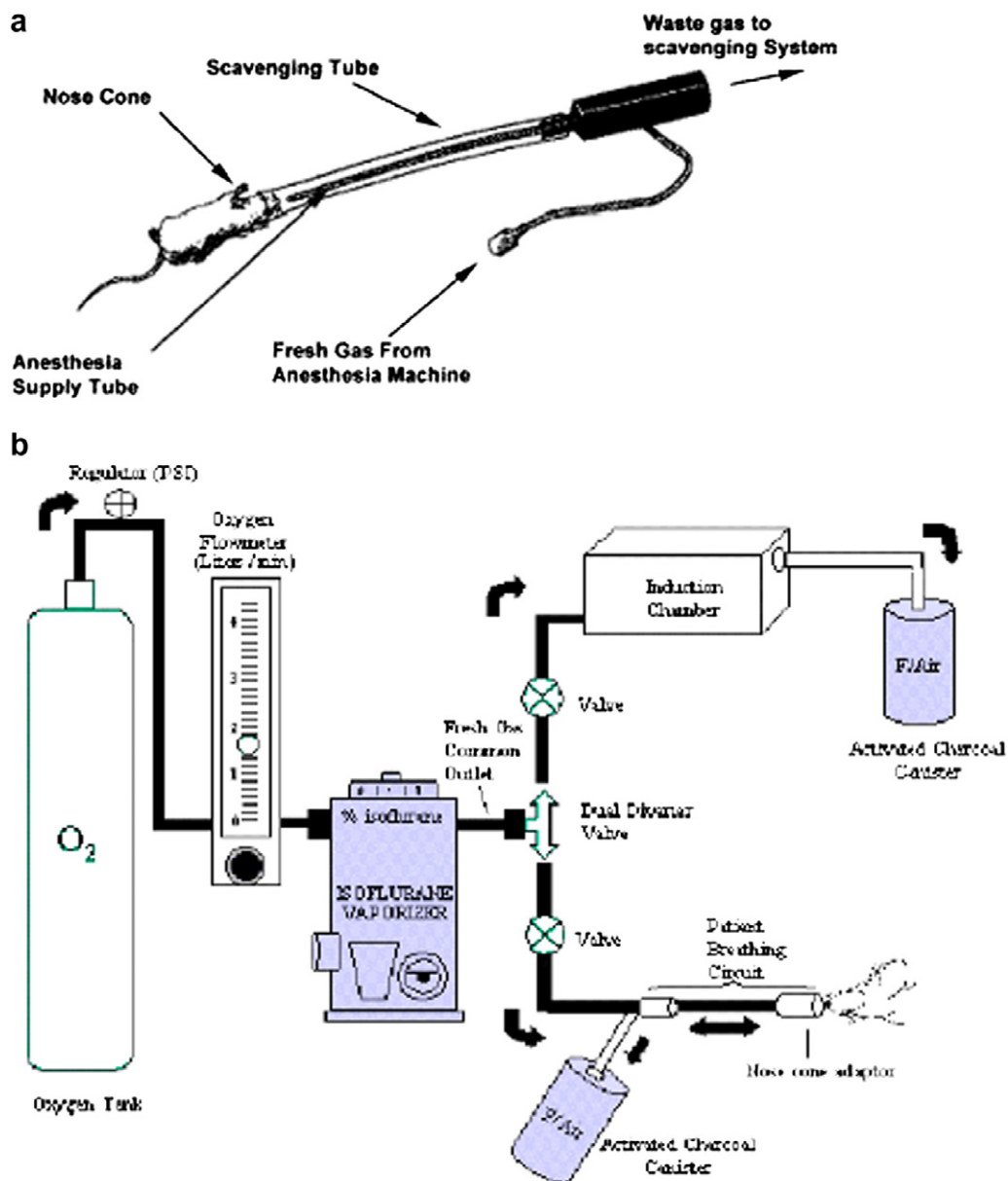


Fig. 1. Principles of anaesthetic machines. (a) Animal breathing circuit (Bain style) used for rodent anaesthesia. (b) Components of the rodent anaesthetic machine.

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