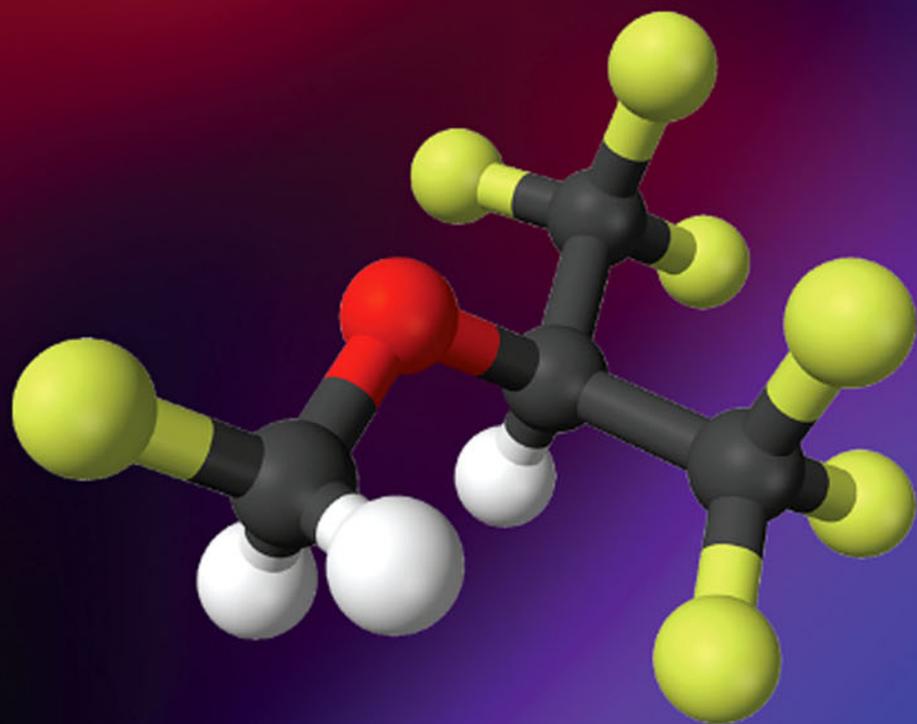


THIRD EDITION

LABORATORY ANIMAL ANAESTHESIA



PAUL FLECKNELL



Laboratory Animal Anaesthesia

Third Edition

This page intentionally left blank

Laboratory Animal Anaesthesia

Third Edition

Paul Flecknell

Comparative Biology Centre
Medical School
Newcastle University
Newcastle-upon-Tyne, UK



ELSEVIER

AMSTERDAM • BOSTON • HEIDELBERG • LONDON
NEW YORK • OXFORD • PARIS • SAN DIEGO
SAN FRANCISCO • SINGAPORE • SYDNEY • TOKYO

Academic Press is an imprint of Elsevier



Academic Press is an imprint of Elsevier
32 Jamestown Road, London NW1 7BY, UK
30 Corporate Drive, Suite 400, Burlington, MA 01803, USA
525 B Street, Suite 1900, San Diego, CA 92101-4495, USA

Copyright © 2009, Elsevier Inc. All rights reserved

No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means electronic, mechanical, photocopying, recording or otherwise without the prior written permission of the publisher

Permissions may be sought directly from Elsevier's Science & Technology Rights Department in Oxford, UK: phone (+44) (0) 1865 843830; fax (+44) (0) 1865 853333; email: permissions@elsevier.com. Alternatively visit the Science and Technology Books website at www.elsevierdirect.com/rights for further information

Notice

No responsibility is assumed by the publisher for any injury and/or damage to persons or property as a matter of products liability, negligence or otherwise, or from any use or operation of any methods, products, instructions or ideas contained in the material herein. Because of rapid advances in the medical sciences, in particular, independent verification of diagnoses and drug dosages should be made

Library of Congress Cataloging-in-Publication Data

A catalog record for this book is available from the Library of Congress

British Library Cataloguing in Publication Data

A catalogue record for this book is available from the British Library

ISBN: 978-0-12-369376-1

For information on all Academic Press publications
visit our website at www.elsevierdirect.com

Typeset by Macmillan Publishing Solutions
www.macmillansolutions.com

Printed and bound in the United States of America
09 10 11 12 13 10 9 8 7 6 5 4 3 2 1

Working together to grow
libraries in developing countries

www.elsevier.com | www.bookaid.org | www.sabre.org

ELSEVIER

BOOK AID
International

Sabre Foundation

Contents

Preface	vii
Preface to the Second Edition	ix
Preface to the First Edition	xi
Glossary	xiii
List of Tables	xv
List of Figures	xix
Acknowledgements	xxi
Introduction	xxiii
1 Preparing for Anaesthesia	1
Anaesthetic equipment and anaesthetic drugs	1
Other equipment	8
Personnel	14
The animal	15
2 Anaesthesia	19
General anaesthesia	20
3 Anaesthetic Management	79
Pre-operative preparations	79
Monitoring anaesthesia	81
Anaesthetic problems and emergencies	95
4 Special Techniques	109
Use of neuromuscular blocking agents	109
Controlled ventilation	113
Long-term anaesthesia	119
Anaesthesia of pregnant animals	131
Anaesthesia of neonates	134
Anaesthesia for imaging	135
5 Analgesia and Post-operative Care	139
The recovery room environment	140
Problems during the recovery period	142
Management of post-operative pain	147
Pain assessment	153

Pain relief	160
Conclusions	179
6 Anaesthesia of Common Laboratory Species: Special Considerations	181
Small rodents	183
Rabbits	204
Cats	212
Dogs	217
Ferrets	221
Pigs	222
Sheep and goats	227
Primates	231
Other species	234
Bibliography	243
Appendix 1 Recommended Techniques and Physiological Data	275
Appendix 2 Estimation of Required Quantities of Volatile Anaesthetics and Anaesthetic Gases	281
Appendix 3 Examples of Dilutions of Anaesthetic Mixtures for Small Rodents	283
Appendix 4 Manufacturers of Equipment and Other Items Illustrated or Cited in the Text	287
Index	291

Preface

The additions and amendments to this new edition reflect developments in anaesthetic practice and changes in our attitudes towards laboratory animal welfare. Standards of anaesthesia for laboratory animals have increased greatly since the publication of the second edition, and the use of technically demanding procedures have become much more widespread. This new edition attempts to balance the need for additional information in these areas with the main goal of the first edition: the provision of an introductory text for new investigators.

With the continued move towards evidence-based medicine, the number of references has been increased. It has never been my intention to provide a comprehensive anaesthesia textbook, so references have been used primarily to support contentious statements, to indicate conflicting opinions and to provide a starting point for searching the more specialist scientific literature. Whenever possible, recent papers that contain a good discussion of the literature have been selected for citation at appropriate points in the text where older references represent original useful material they have been retained.

Paul Flecknell

This page intentionally left blank

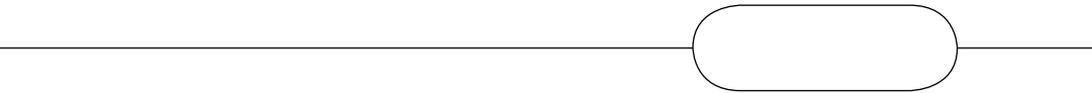


Preface to the Second Edition

Since writing the first edition of this book, there has been a welcome increase in concern for the welfare of laboratory animals. One result of this has been the introduction by a number of countries of formal training requirements for new research workers. This increased interest in animal welfare has also led to the improved dissemination of information regarding ‘best practice’ in many aspects of laboratory animal science. The second edition of *Laboratory Animal Anaesthesia* has benefited from this exchange of information, and the additions and revisions which have been included owe much to comments from my colleagues from around the world. A major addition to this new edition is the inclusion of illustrations of techniques and equipment. The format of the book remains relatively unchanged, except for Chapter 7, which now incorporates some of the information previously included in the appendices. This enables more of the information relating to a particular species to be accessed quickly and easily. Brief descriptions of anaesthetic techniques for fish, amphibia, reptiles and birds have also been included, to provide some basic guidance for dealing with these species.

Paul Flecknell

This page intentionally left blank



Preface to the First Edition

The majority of laboratory animals are anaesthetized by staff who have not received specialist training in this field. Unfortunately, most currently available textbooks of human or veterinary anaesthesia assume that the reader has a basic knowledge of the subject. Because of this, a good deal of published information has remained relatively inaccessible, and this has limited the introduction of new techniques into the field of laboratory animal anaesthesia.

This handbook attempts to provide a basic guide to anaesthesia for research workers and animal technicians. It is not intended to be a comprehensive text on animal anaesthesia, but concentrates on those areas that are of greatest practical importance when anaesthetizing laboratory animals.

The first sections of the book deal with the general principles of pre-operative care, anaesthetic techniques and anaesthetic management. The most important properties of the anaesthetic and other agents used are outlined, but a detailed description of their pharmacology has been deliberately excluded. These sections also provide details of some of the equipment which the author has found useful when anaesthetizing laboratory animals.

These general sections of the book should be read before using any of the anaesthetic regimes described in the final sections. In particular, it is hoped that the reader will study the sections on post-operative care and the provision of effective pain relief before carrying out any operative procedures on animals.

In order to provide rapid, easily accessible guidelines, a list of recommended anaesthetic regimes for each of the common laboratory species is given in Appendix 1. For those research workers who require alternative techniques, a wider range of anaesthetic regimes is discussed together with an extensive list of dose rates for each species in Chapter 7.

In addition to providing guidance on basic anaesthetic techniques, an introduction to more specialist procedures such as long-term anaesthesia and the use of neuromuscular blocking agents has been included. These sections provide only initial guidance, and it is recommended that, whenever possible, an experienced veterinary anaesthetist should be consulted before attempting these techniques.

Paul Flecknell

This page intentionally left blank

Glossary

Inevitably, a number of specialist terms are used throughout this book and these are defined below.

Anaesthesia a state of controllable, reversible insensibility in which sensory perception and motor responses are both markedly depressed

Analgesia the temporary abolition or diminution of pain perception

Analeptic drug which stimulates respiration

Anoxia complete deprivation of oxygen for tissue respiration

Apnoea temporary cessation of breathing

Arrhythmia (cardiac) alteration in the normal rhythm of the heart

Asystole lack of cardiac muscle contractions

Ataxia lack of co-ordination, 'wobbliness'

BMR basal metabolic rate

Bradycardia slowing of the heart rate

CNS central nervous system

CNS depressant any agent which modifies function by depressing sensory or motor responses in the CNS

Cyanosis blue or purple colouring of the skin or visible membranes due to the presence of an increased concentration of reduced haemoglobin in capillary blood, symptomatic of hypoxia

Dosages mg of drug per kg body weight (mg/kg) except for the neuroleptanalgesic combinations which are more conveniently expressed as ml of commercial or diluted premixed solution per kg body weight (ml/kg)

Dosage schedules u.i.d. – once daily

b.i.d. – twice daily

t.i.d. – three times daily

q.i.d. – four times daily

Dyspnoea laboured breathing

ECG electrocardiogram

Hypercapnia elevated blood carbon dioxide content

Hyperpnoea fast or deep breathing

Hypertension elevated (arterial) blood pressure

Hypnotic a drug which induces a state resembling deep sleep, but usually with little analgesic effect

Hypocapnia reduced blood carbon dioxide content

Hypopnoea slow or shallow breathing

Hypotension a fall in (arterial) blood pressure

Hypothermia a fall in body temperature

Hypovolaemia a fall in circulating blood volume

Hypoxia depressed levels of oxygen

Induction (of anaesthesia) the initial establishment of a state of anaesthesia

Injection routes iv – intravenous

im – intramuscular

ip – intraperitoneal

sc – subcutaneous

Laryngospasm spasm of the vocal cords, producing complete or partial obstruction of the airway

Minute volume the volume of gas breathed in 1 minute, that is, the product of tidal volume and respiratory rate

Narcosis a state of insensibility or stupor from which it is difficult to arouse the animal

Normovolaemic having a normal circulating blood volume

PCO₂ partial pressure of carbon dioxide

Per os by mouth

PO₂ partial pressure of oxygen

Polypnoea rapid, panting breathing

Pulmonary ventilation the mechanical expansion and contraction of the lungs in order to renew alveolar air with fresh atmospheric air

Tachycardia an increase in heart rate

Tachypnoea rapid respiration

Tidal volume the volume of gas expired with each breath



List of Tables

CHAPTER 1

- Table 1.1 Pre-anaesthetic checks of anaesthetic equipment
- Table 1.2 Endotracheal intubation, equipment required

CHAPTER 2

- Table 2.1 Physical characteristics and relative potency (MAC_{50}) of different volatile anaesthetics
- Table 2.2 Recommended fresh gas flow rates for different anaesthetic circuits
- Table 2.3 Induction and maintenance concentrations of inhalation anaesthetic agents
- Table 2.4 Minimum alveolar concentration (MAC_{50}) values (%) for inhalation anaesthetics in different species
- Table 2.5 Checklist of criteria for selection of an anaesthetic regimen for laboratory animals

CHAPTER 3

- Table 3.1 Blood gas values for animals breathing air
- Table 3.2 Basic guide for coping with cardiovascular emergencies, and infusion rates of some drugs commonly used for cardiovascular support

CHAPTER 4

- Table 4.1 Dose rates for neuromuscular blocking agents
- Table 4.2 Suggested ventilation rates for laboratory animals
- Table 4.3 Suggested regimens for total intravenous anaesthesia for long-term anaesthesia

CHAPTER 5

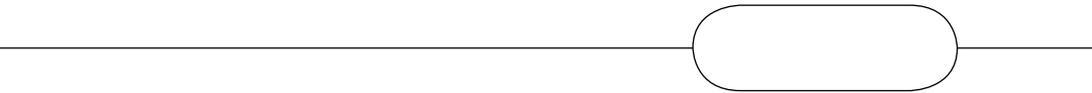
- Table 5.1 Approximate volumes for fluid replacement therapy by intraperitoneal or subcutaneous administration
- Table 5.2 Antibiotic and antibacterial dose rates for laboratory animals (small mammals)
- Table 5.3 Antibiotic and antibacterial dose rates for laboratory animals (larger species)
- Table 5.4 Pain-related behaviour in rats, mice and rabbits
- Table 5.5 Suggested dose rates for non-steroidal anti-inflammatory drugs in laboratory animals
- Table 5.6 Suggested dose rates for non-steroidal anti-inflammatory drugs in laboratory animals
- Table 5.7 Suggested dose rates for opioid analgesics in laboratory animals
- Table 5.8 Suggested dose rates for opioid analgesics in laboratory animals

CHAPTER 6

- Table 6.1 Sedatives, tranquillizers and other pre-anaesthetic medication for use in the rat
- Table 6.2 Anaesthetic dose rates in the rat
- Table 6.3 Antagonists to anaesthetic regimens for use in rodents and rabbits
- Table 6.4 Sedatives, tranquillizers and other pre-anaesthetic medication for use in the mouse
- Table 6.5 Anaesthetic dose rates in the mouse
- Table 6.6 Sedatives, tranquillizers and other pre-anaesthetic medication for use in the hamster
- Table 6.7 Anaesthetic dose rates in the hamster
- Table 6.8 Sedatives, tranquillizers and other pre-anaesthetic medication for use in the gerbil
- Table 6.9 Anaesthetic dose rates in the gerbil
- Table 6.10 Sedatives, tranquillizers and other pre-anaesthetic medication for use in the guinea pig
- Table 6.11 Injectable anaesthetic dose rates in the guinea pig
- Table 6.12 Sedatives, tranquillizers and other pre-anaesthetic medication for use in the rabbit
- Table 6.13 Anaesthetic dose rates in the rabbit
- Table 6.14 Sedatives, tranquillizers and other pre-anaesthetic medication for the cat
- Table 6.15 Anaesthetic dose rates in the cat
- Table 6.16 Sedatives, tranquillizers and other pre-anaesthetic medication for use in the dog
- Table 6.17 Anaesthetic dose rates in the dog
- Table 6.18 Sedatives, tranquillizers and other pre-anaesthetic medication for use in the ferret

- Table 6.19 Anaesthetic dose rates in the ferret
- Table 6.20 Sedatives, tranquillizers and other pre-anaesthetic medication for use in the pig
- Table 6.21 Anaesthetic dose rates in the pig
- Table 6.22 Sedatives, tranquillizers and other pre-anaesthetic medication for use in the sheep and goat
- Table 6.23 Anaesthetic dose rates in the sheep and goat
- Table 6.24 Sedatives, tranquillizers and pre-anaesthetic medication for use in the non-human primate
- Table 6.25 Anaesthetic dose rates in the non-human primate
- Table 6.26 Anaesthetic, sedative and analgesic drugs for use in birds

This page intentionally left blank



List of Figures

CHAPTER 1

- Figure 1.1 Pin index system for anaesthetic gas
- Figure 1.2 Pressure gauges for nitrous oxide and oxygen cylinders
- Figure 1.3 Methods for opening and closing anaesthetic gas cylinders
- Figure 1.4 Flow meters for measuring anaesthetic gas flow rates
- Figure 1.5 Turret-type flow meter
- Figure 1.6 Vaporizer key-filling system
- Figure 1.7 Vaporizer mounting system
- Figure 1.8 Anaesthetic chamber for use with small mammals
- Figure 1.9 Double anaesthetic chamber system
- Figure 1.10 Face masks for use with a range of laboratory species
- Figure 1.11 Concentric mask system for rodents and rabbits
- Figure 1.12 Endotracheal tubes of different sizes and designs
- Figure 1.13 Laryngoscope blades of various designs

CHAPTER 2

- Figure 2.1 Open-mask breathing circuit
- Figure 2.2 Down-draft operating table
- Figure 2.3 Ayre's T-piece
- Figure 2.4 T-pieces with low-dead space connectors
- Figure 2.5 Standard and low-dead space endotracheal tube connectors and T-pieces
- Figure 2.6 Photograph of Bain's circuit and modified Bain circuit
- Figure 2.7 Schematic representation of Bain's circuit and modified Bain circuit
- Figure 2.8 Photograph of Magill circuit
- Figure 2.9 Schematic representation of Magill circuit
- Figure 2.10 Photograph of circle system
- Figure 2.11 Schematic representation of circle system