

Second Edition

# Farm Animal Anesthesia

Cattle, Small Ruminants,  
Camelids, and Pigs

Edited by  
HuiChu Lin  
Thomas Passler  
Stuart Clark-Price



WILEY Blackwell

# Table of Contents

[Cover](#)

[Title Page](#)

[Copyright Page](#)

[Dedication Page](#)

[Contributing Authors](#)

[Preface](#)

[About the Companion Website](#)

[1 Preanesthetic Considerations](#)

[1.1 Positioning](#)

[1.2 Ruminal Tympany](#)

[1.3 Regurgitation](#)

[1.4 Salivation](#)

[1.5 Malignant Hyperthermia](#)

[1.6 Differences in Sensitivity to Anesthetics](#)

[1.7 Preanesthetic Preparation](#)

[References](#)

[2 Commonly Used Preanesthetics](#)

[2.1 Acepromazine \(Phenothiazine Derivatives\)](#)

[2.2 Droperidol and Azaperone \(Butyrophenone Derivatives\)](#)

[2.3 Detomidine, Dexmedetomidine, Medetomidine, Romifidine, and Xylazine \( \$\alpha\_2\$  Agonists\)](#)

[2.4 Atipamezole, Tolazoline, Yohimbine, and Vatinoxan \( \$\alpha\_2\$  Antagonists\)](#)

[2.5 Diazepam and Midazolam \(Benzodiazepine Derivatives\)](#)

## [2.6 Chloral Hydrate](#)

### [References](#)

## [3 Standing Sedation and Chemical Restraint](#)

### [3.1 Cattle](#)

### [3.2 Small Ruminants and Camelids](#)

### [3.3 Swine](#)

### [References](#)

## [4 Injectable Anesthetics and Field Anesthesia](#)

### [4.1 Injectable Anesthetics](#)

### [4.2 Field Anesthesia](#)

### [References](#)

## [5 Neuromuscular Blocking Agents](#)

### [5.1 Physiology of the Neuromuscular Junction](#)

### [5.2 Mechanism of Action of NMBAs](#)

### [5.3 Clinically Useful NMBAs](#)

### [5.4 Monitoring of NMBA Action](#)

### [5.5 Reversal of NMBAs](#)

### [References](#)

## [6 Inhalation Anesthesia and Use of Ventilators](#)

### [6.1 Cattle](#)

### [6.2 Small Ruminants and Camelids](#)

### [6.3 Swine](#)

### [6.4 Use of Ventilators](#)

### [References](#)

## [7 Perioperative Monitoring and Management of Complications](#)

### [7.1 Perioperative Monitoring](#)

### [7.2 Supportive Fluid Therapy](#)

[7.3 Positioning](#)

[7.4 Recovery](#)

[7.5 Perioperative Complications](#)

[References](#)

## [8 Local and Regional Anesthesia in Food Animals](#)

[8.1 Local Anesthetic Agents](#)

[8.2 Anesthesia for Dehorning](#)

[8.3 Anesthesia for the Eye and Eyelids](#)

[8.4 Nasal Anesthesia](#)

[8.5 Anesthesia for Reproductive Procedures and for Cessation of Straining](#)

[8.6 Anesthesia for Laparotomy](#)

[8.7 Anesthesia for Udder and Teats](#)

[8.8 Anesthesia of the Limbs](#)

[8.9 Castration](#)

[References](#)

## [9 Anesthetic Management of Specific Procedures](#)

[9.1 Urogenital Surgery in the Male](#)

[9.2 Urogenital Surgery in the Female](#)

[9.3 Surgical Disorders of the Abdomen](#)

[9.4 Musculoskeletal Indications](#)

[9.5 Wounds, Lumps, Bumps, and Abscesses](#)

[References](#)

## [10 Pain Management for Farm Animals](#)

[10.1 Local Anesthetics](#)

[10.2 Systemic Pain Management](#)

[10.3 Drug Combinations for Pain Management](#)

[10.4 Local or Regional Analgesia](#)

## References

### 11 Fluid Therapy

#### 11.1 General Considerations

#### 11.2 Physiology of Body Fluids

#### 11.3 Patient Assessment

#### 11.4 Fluid and Electrolyte Therapy in the Perioperative Period

#### 11.5 Monitoring Fluid Administration

## References

### 12 Regulatory and Legal Considerations of Anesthetics and Analgesics Used in Food-producing Animals

#### 12.1 Alpha-2 Agonists and Antagonists

#### 12.2 Barbiturates

#### 12.3 Benzodiazepines

#### 12.4 Dissociative Anesthetics

#### 12.5 Local Anesthetics

#### 12.6 Opioids

#### 12.7 Nonsteroidal Anti-inflammatory Drugs

#### 12.8 Phenothiazine Derivatives

#### 12.9 Propofol

## References

### 13 Euthanasia of Farm Animals

#### 13.1 Considerations Prior to Euthanasia

#### 13.2 The Process of Euthanasia

#### 13.3 Methods of Euthanasia

#### 13.4 Considerations Subsequent to Euthanasia

## References

## Index

## End User License Agreement

# List of Tables

## Chapter 3

[Table 3.1 Doses of drugs and drug combinations used for sedation and chemica...](#)

[Table 3.2 Doses of drugs and drug combinations used for sedation and chemica...](#)

[Table 3.3 Doses of drugs and drug combinations used for sedation and chemica...](#)

## Chapter 4

[Table 4.1 Doses of injectable anesthetic and anesthetic combinations used in...](#)

[Table 4.2 Doses of injectable anesthetic and anesthetic combinations for she...](#)

[Table 4.3 Doses of injectable anesthetic and anesthetic combinations used in...](#)

## Chapter 6

[Table 6.1 Blood-gas solubility, metabolism, and MAC of isoflurane, sevoflura...](#)

[Table 6.2 Normal respiratory parameters when using control ventilation in ca...](#)

## Chapter 7

[Table 7.1 The body temperature, heart rate, respiratory rate, and arterial b...](#)

[Table 7.2 Normal values for hematology and blood chemistry of cattle.](#)

[Table 7.3 Normal values for hematology and blood chemistry of goats.](#)

[Table 7.4 Normal values of hematology and blood chemistry of sheep.](#)

[Table 7.5 Normal values for hematology and blood chemistry of camelids.](#)

[Table 7.6 Normal values for hematology and blood chemistry of pet pigs.](#)

## Chapter 10

[Table 10.1 Doses of drugs used for systemic pain management in cattle, shee...](#)

[Table 10.2 Doses of drugs used for systemic pain management in camelids and...](#)

[Table 10.3 Doses of drugs used to produce local and regional analgesia for ...](#)

[Table 10.4 Doses of drugs used to produce local and regional analgesia for ...](#)

## Chapter 11

[Table 11.1 Estimating level of dehydration based on physical examination fi...](#)

[Table 11.2 Components and formulas for perioperative fluid therapy.](#)

[Table 11.3 Formulas for preparing local electrolyte solutions.](#)

## Chapter 12

[Table 12.1 Examples of anesthetics and anesthetic adjuncts approved for use...](#)

[Table 12.2 Recommended withdrawal times for anesthetics and anesthetic adju...](#)

# List of Illustrations

## Chapter 1

[Figure 1.1 The effect of lateral recumbency on the position of the diaphragm...](#)

[Figure 1.2 Lateral recumbency of an adult bovid; note the elevation of the t...](#)

[Figure 1.3 Lateral recumbency of a small ruminant; note the elevation of the...](#)

[Figure 1.4 \(a\) Intubation in an adult bovid using digital palpation techniqu...](#)

[Figure 1.5 Guide tube/stylet and laryngoscope used for endotracheal intubati...](#)

[Figure 1.6 Anatomic structures for endotracheal intubation in camelids.](#)

[Figure 1.7 Endotracheal intubation in anesthetized goats.](#)

[Figure 1.8 "Stick intubation" \(blind intubation\) in anesthetized goats.](#)

[Figure 1.9 Technique for endotracheal intubation in swine.](#)

## Chapter 3

[Figure 3.1 Acepromazine-induced calming effect in a rodeo bull prior to indu...](#)

[Figure 3.2 \(a\) Chemical restraint in a calf with xylazine \(0.1 mg/kg IV\) and...](#)

[Figure 3.3 Chemical restraint in a potbellied pig with xylazine \(4 mg/kg IM\)...](#)

## Chapter 4

[Figure 4.1 Endotracheal intubation using the digital palpation technique in ...](#)

[Figure 4.2 Endotracheal intubation in an alpaca anesthetized with xylazine \(...\)](#)

[Figure 4.3 A potbellied pig anesthetized with Telazol, ketamine, and xylazin...](#)

## Chapter 5

[Figure 5.1 Examples of peripheral nerve stimulators used to assess the funct...](#)

[Figure 5.2 Placement of a peripheral nerve stimulator on the pelvic limb of ...](#)

[Figure 5.3 A peripheral nerve stimulator that utilizes acceleromyography. Th...](#)

[Figure 5.4 A peripheral nerve stimulator that utilizes acceleromyography. Th...](#)

[Figure 5.5 A peripheral nerve stimulator that utilizes acceleromyography. Th...](#)

[Figure 5.6 A peripheral nerve stimulator that utilizes acceleromyography. Th...](#)

## Chapter 6

[Figure 6.1 Anesthesia machine with isoflurane vaporizer.](#)

[Figure 6.2 Anesthesia machine with sevoflurane vaporizer.](#)

[Figure 6.3 Preset respiratory parameters, respiratory rate, tidal volume, pe...](#)

[Figure 6.4 Preset respiratory parameters, respiratory rate, tidal volume, pe...](#)

[Figure 6.5 Ventilator with standing bellows for small pediatric animals \(Hal...](#)

[Figure 6.6 Ventilator with hanging bellows for large animals \(SurgiVet\).](#)

[Figure 6.7 Piston-driven ventilator \(Tafonius\).](#)

[Figure 6.8 Pneumatically powered with electrical control ventilator with rub...](#)

[Figure 6.9 Piston-driven ventilator with polyvinyl chloride breathing system...](#)

[Figure 6.10 A goat anesthetized with isoflurane using a small-animal anesথে...](#)

[Figure 6.11 A bull anesthetized with isoflurane using a large-animal anesথে...](#)

## Chapter 7

[Figure 7.1 Changes in eyeball positions during anesthesia in cattle: A, awak...](#)

[Figure 7.2 Placement of the ETCO<sub>2</sub> sample collection line and SpO<sub>2</sub> probe on a...](#)

[Figure 7.3 V/Q mismatch during dorsal recumbency in adult cattle: \(a\) V/Q > ...](#)

[Figure 7.4 Placement of a jugular catheter for collection of blood samples a...](#)

[Figure 7.5 \(a\) Placement of an inner tube under the shoulder during lateral ...](#)

[Figure 7.6 Anesthetized adult cattle in the lateral recumbency position.](#)

## Chapter 8

[Figure 8.1 Lateral view of cow head. Cornual nerve \(white arrow\) for dehorni...](#)

[Figure 8.2 Facial nerve blocks in cattle: \(A\) cornual nerve block for dehorn...](#)

[Figure 8.3 Lateral view of goat head. Cornual branch of the infratrochlear n...](#)

[Figure 8.4 Cornual block for dehorning in a small ruminant \(dorsal view\). Co...](#)

[Figure 8.5 Cornual block for dehorning in a small ruminant \(lateral view\). C...](#)

[Figure 8.6 Four point retrobulbar eye block. Needles are placed at the four ...](#)

[Figure 8.7 Peterson's eye block. Landmarks are supraorbital process \(black r...](#)

[Figure 8.8 Curved needle used for Peterson's eye block.](#)

[Figure 8.9 Bovine skull. Infraorbital foramen \(blue arrow\) and facial tubero...](#)

[Figure 8.10 Locations for needle placement for caudal epidural anesthesia at...](#)

[Figure 8.11 Tuohy needle. Left, the difference in length of a Tuohy needle a...](#)

[Figure 8.12 Lumbosacral epidural catheterization in laterally recumbent catt...](#)

[Figure 8.13 Pudendal nerve block. Caudal view of a bull. Needles 1 and 2 sho...](#)

[Figure 8.14 Dorsal penile nerve block. The arrow indicates the location for ...](#)

[Figure 8.15 Sacral paravertebral nerve block. Lateral sacrum. Needles in sac...](#)

[Figure 8.16 \(a\) Needle placement for lumbosacral epidural anesthesia in catt...](#)

[Figure 8.17 Line block for laparotomy \(blue line\) or cesarean section \(yello...](#)

[Figure 8.18 Inverted L block \(blue lines\) with incision site \(yellow line\) i...](#)

[Figure 8.19 Proximal and distal paravertebral blocks.](#)

[Figure 8.20 Proximal paravertebral block in cattle. Left lateral view of a c...](#)

[Figure 8.21 Distal paravertebral block. Left lateral view of a cow with the ...](#)

[Figure 8.22 Teat blocks for cattle: \(A\) inverted-V block, \(B\) teat ring bloc...](#)

[Figure 8.23 Bovine thoracic limb. Radial vein \(orange arrow\) and abaxial pal...](#)

[Figure 8.24 Bovine pelvic limb. Lateral saphenous vein \(black arrow\) and dor...](#)

[Figure 8.25 Bier block performed at the medial approach of the front limb wi...](#)

[Figure 8.26 Bier block performed at the lateral approach of the front limb w...](#)

[Figure 8.27 Intratesticular anesthesia. The bull is in left lateral recumben...](#)

[Figure 8.28 Spermatic cord block. The bull is in left lateral recumbency wit...](#)

## Chapter 13

[Figure 13.1 Example of a decision algorithm that can be implemented as part ...](#)

[Figure 13.2 \(a\) Frontal and \(b\) lateral views of the accurate site and angle...](#)

[Figure 13.3 Dorsal view of the proper placement of a gunshot or captive bolt...](#)

Figure 13.4 (a) Frontal and (b) lateral views of the proper placement of a g...

# Farm Animal Anesthesia

## Cattle, Small Ruminants, Camelids, and Pigs

Second Edition

Edited by

**HuiChu Lin, DVM, MS, DACVAA**

*College of Veterinary Medicine, Auburn University  
Auburn, AL, USA*

**Thomas Passler, DVM, PhD, DACVIM-LA**

*College of Veterinary Medicine, Auburn University  
Auburn, AL, USA*

**Stuart Clark-Price, DVM, MS, DACVIM-LA, DACVAA,  
CVA**

*College of Veterinary Medicine, Auburn University  
Auburn, AL, USA*

**WILEY** Blackwell

This edition first published 2022  
© 2022 John Wiley & Sons, Inc.

*Edition History*

John Wiley & Sons Inc. (1e, 2014)

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, except as permitted by law. Advice on how to obtain permission to reuse material from this title is available at <http://www.wiley.com/go/permissions>.

The right of HuiChu Lin, Thomas Passler, and Stuart Clark-Price to be identified as the authors of the editorial material in this work has been asserted in accordance with law.

*Registered Office*

John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, USA

*Editorial Office*

111 River Street, Hoboken, NJ 07030, USA

For details of our global editorial offices, customer services, and more information about Wiley products visit us at [www.wiley.com](http://www.wiley.com).

Wiley also publishes its books in a variety of electronic formats and by print-on-demand. Some content that appears in standard print versions of this book may not be available in other formats.

*Limit of Liability/Disclaimer of Warranty*

The contents of this work are intended to further general scientific research, understanding, and discussion only and are not intended and should not be relied upon as recommending or promoting scientific method, diagnosis, or treatment by physicians for any particular patient. In view of ongoing research, equipment modifications, changes in governmental regulations, and the constant flow of information relating to the use of medicines, equipment, and devices, the reader is urged to review and evaluate the information provided in the package insert or instructions for each medicine, equipment, or device for, among other things, any changes in the instructions or indication of usage and for added warnings and precautions. While the publisher and authors have used their best efforts in preparing this work, they make no representations or warranties with respect to the accuracy or completeness of the contents of this work and specifically disclaim all warranties, including without limitation any implied warranties of merchantability or fitness for a particular purpose. No warranty may be created or extended by sales representatives, written sales materials or promotional statements for this work. The fact that an organization, website, or product is referred to in this work as a citation and/or potential source of further information does not mean that the publisher and authors endorse the information or services the organization, website, or product may provide or recommendations it may make. This work is sold with the understanding that the publisher is not engaged in rendering professional services. The advice and strategies contained herein may not be suitable for

your situation. You should consult with a specialist where appropriate. Further, readers should be aware that websites listed in this work may have changed or disappeared between when this work was written and when it is read. Neither the publisher nor authors shall be liable for any loss of profit or any other commercial damages, including but not limited to special, incidental, consequential, or other damages.

*Library of Congress Cataloging-in-Publication Data*

Names: Lin, HuiChu, 1958- editor. | Passler, Thomas, editor. | Clark-Price, Stuart, 1972- editor.

Title: Farm animal anesthesia : cattle, small ruminants, camelids, and pigs / edited by HuiChu Lin, Thomas Passler, Stuart Charles Clark-Price.

Description: Second edition. | Hoboken : Wiley, 2022. | Includes bibliographical references and index.

Identifiers: LCCN 2021053030 (print) | LCCN 2021053031 (ebook) | ISBN 9781119672548 (cloth) | ISBN 9781119672623 (adobe pdf) | ISBN 9781119672531 (epub)

Subjects: MESH: Anesthesia-veterinary | Pain Management-veterinary | Animals, Domestic | Artiodactyla

Classification: LCC SF914 (print) | LCC SF914 (ebook) | NLM SF 914 | DDC 636.089/796-dc23/eng/20211206

LC record available at <https://lcn.loc.gov/2021053030>

LC ebook record available at <https://lcn.loc.gov/2021053031>

Cover Design: Wiley

Cover Image: © HuiChu Lin

I dedicate this book to my colleagues in the Food Animal Section of Auburn University for your team spirit and for making my job as an anesthesiologist easy and fun. I appreciate all the more your unreserved friendship and support. This book would not be a reality without you all.

HuiChu Lin, DVM, MS, DACVAA

To the most important people in my life: my parents Barbara Fechner and the late Hans Passler, my wife Nicole, my son William, and my American family, the Borgmeyers. Thank you for your unwavering love and support! And to my colleagues - the Auburn family - for their collegiality, friendship, and words of wisdom.

Thomas Passler, DVM, PhD, ACVIM

I would first like to start by thanking Dr. Hui-Chu Lin for inviting me to participate in the second edition of this textbook. It is exciting to see anesthesia and pain management for farm animals advance and to know that practitioners are utilizing this information to improve the lives of the animals and clients they serve. I therefore dedicate this book to those practitioners, some of whom have been students of mine, who tirelessly endeavor to provide care to the best of their abilities.

Stuart Clark-Price, DVM, MS, DACVIM, DACVAA

## Contributing Authors

***Manuel F. Chamorro, DVM, PhD***

Diplomate of American College of Veterinary Internal  
Medicine-LA

Associate Professor

Departments of Clinical Sciences, College of Veterinary  
Medicine, Auburn University, AL, USA

***Stuart Clark-Price, DVM, MS***

Diplomate of American College of Veterinary Internal  
Medicine-LA

Diplomate of American College of Veterinary Anesthesia  
and Analgesia

Associate Professor

Department of Clinical Sciences, College of Veterinary  
Medicine, Auburn University, AL, USA

***HuiChu Lin, DVM, MS***

Diplomate of American College of Veterinary Anesthesia  
and Analgesia

Professor

Departments of Clinical Sciences, College of Veterinary  
Medicine, Auburn University, AL, USA

***Benjamin Newcomer, DVM, PhD***

Diplomate of American College of Veterinary Internal  
Medicine-LA

Diplomate of American College of Veterinary Preventive  
Medicine

Associate Professor

Veterinary Education, Research, & Outreach Program,  
Texas A&M/West Texas A&M Universities, Canyon, TX, USA

***Thomas Passler, DVM, PhD***

Diplomate of American College of Veterinary Internal

Medicine-LA

Professor

Departments of Clinical Sciences, College of Veterinary  
Medicine, Auburn University, AL, USA

***Jessica Rush, DVM, MS***

Diplomate of American College of Theriogenologists

Assistant Clinical Professor

Departments of Clinical Sciences, College of Veterinary  
Medicine, Auburn University, AL, USA

***Jenna Stockler, DVM, MS***

Diplomate of American College of Veterinary Internal

Medicine-LA Assistant Clinical Professor Departments of  
Clinical Sciences, College of Veterinary Medicine,  
Auburn University, AL, USA

***Paul H. Walz, DVM, PhD***

Diplomate of American College of Veterinary Internal  
Medicine-LA

Professor

Departments of Pathobiology, College of Veterinary  
Medicine, Auburn University, AL, USA

## Preface

The first edition of *Farm Animal Anesthesia: Cattle, Small Ruminants, Camelids, and Pigs* was published in 2014. Since then we have received encouraging comments from veterinarians on the usefulness and practicality of the information provided in the book. Many veterinarians complimented the ease of searching for the information needed for their daily practice: anesthetic patient care, drug dosages, and drug combinations for different circumstances and surgical procedures ([Chapters 1–6](#) and [Chapters 8](#) and [10](#)). Information on the local and regional anesthetic techniques and pain management chapters provided many options to minimize perioperative and postoperative pain, and reduce patient suffering ([Chapters 7](#) and [10](#)). The chapter on regulatory and legal considerations of anesthetics and analgesics ensured avoidance of human consumption of drug residues in meat and milk from food-producing animals ([Chapter 11](#)). The euthanasia chapter offered clear information on different methods that a veterinarian can use to effectively and humanely end an animal's suffering when there are no available treatments that can improve an animal's deteriorating condition ([Chapter 12](#)). The contributing authors and editors are extremely proud and honored that the first edition of the book was well received by our professional colleagues, who continue to provide best patient care.

Great advances have been made in farm animal medicine and surgery in the recent years. Many farm animal species are now also kept as companion animals, particularly small ruminants and potbellied pigs. Advanced treatment options and complex surgeries have become available. The second

edition of the book includes new information published since the first edition, including newer anesthetics and analgesics, surgical procedures, fluid therapy, and updates on regulations pertaining to anesthetic drugs used in farm animals. We believe farm animal veterinarians will continue to find the second edition to be a useful and practical guide for anesthetics and pain management in their daily practice. Included in this edition are videos of different local and regional anesthetic techniques to guide veterinarians to perform nerve blocks for intended surgeries safely and effectively. Also included is information on the application of neuromuscular blocking agents and the clinical use of ventilators when complicated and long duration surgery is necessary. As surgical techniques progress, the increased complexity will require that some patients are administered neuromuscular blocking agents and the knowledge of the use of these drugs and mechanical ventilators will become an essential part of anesthetic management.

The editors greatly appreciate the contributing authors, Drs. Benjamin Newcomer, Manuel Chamorro, Jessica Rush, and Jenna Workman Stockler, for their work and efforts in making this book a complete book on farm animal anesthesia. We thank the illustrators, Kim Crosslin and Katlyn King, for their picture-perfect artwork and Dr. Ray Wilhite for excellent anatomical images. We also want to thank Merryl Le Roux, Managing Editor, and her staff at John Wiley & Sons for their patience and much needed assistance throughout this process.

*HuiChu Lin*  
*Thomas Passler*  
*Stuart Clark-Price*

## About the Companion Website

This book is accompanied by a companion website:



[www.wiley.com/go/lin/farm](http://www.wiley.com/go/lin/farm)

The website includes:

- Video clips

# 1

## Preanesthetic Considerations

*HuiChu Lin*

*Department of Clinical Sciences, College of Veterinary Medicine, Auburn University, Auburn, AL, USA*

General anesthesia in farm animals, like cattle, sheep, goats, llamas, alpacas, and pigs, requires special attention due to the uniqueness of the anatomical and physiological characteristics as compared to dogs, cats, and horses. Camelids (llamas and alpacas) only have two forestomachs but are otherwise similar in many ways to cattle and small ruminants. Although some farm animals may cost as much as purebred companion animals, farm animal veterinarians are often faced with economic constraints and a limited number of approved drugs for use in surgical procedures requiring anesthesia. Physical restraint and local anesthetic techniques are most commonly employed to produce immobility and analgesia for these species. Ruminants generally tolerate physical restraint and recumbency well. This, along with local and/or regional anesthetic techniques, allows many minor surgical procedures to be performed in the standing position and under field conditions. General anesthesia is more frequently performed in camelids and swine for even minor surgical procedures due to their intolerance of physical restraint. It is important to remember that farm animals perceive pain no differently than other species, therefore analgesia for prevention and easing of pain is just as important as it is for companion animals. With surgical procedures requiring general anesthesia, balanced anesthetic technique should be employed to provide narcosis, analgesia, and muscle relaxation, thereby

minimizing the stress response induced by surgery and anesthesia. Most of the anesthetics and anesthetic adjuncts commonly used in farm animal practice do not have Food and Drug Administration (FDA) approval for use in ruminants, camelids, and swine [1, 2]. However, per the Animal Medicinal Drug Use Clarification Act (AMDUCA) of 1994, extralabel use of drugs is permitted when animal health is threatened or death may result if not treated [3]. While prevention of violative residues should always be considered, anesthetics are usually used for a short duration, and anesthetized animals are unlikely to be marketed immediately after surgery. Furthermore, anesthetics used today tend to have very short half-lives ( $t^{1/2}$ ), and they are potent enough that only low doses are required to produce general anesthesia. The possibility of an animal carrying anesthetic residues within its edible tissues after the surgical incision has healed, which normally occurs within an average of 14 days, is extremely low. Thus, problems with anesthetic drug residues appear to be rare [4]. Nevertheless, veterinarians should consult the Food Animal Residue Avoidance Databank (FARAD) for meat and milk withdrawal intervals for extralabel use of analgesics, sedatives, and injectable anesthetics as well as for updates of drugs prohibited from extralabel use [1, 2].

Prior to anesthesia, an appropriate patient history, including breed, age, sex, condition, and temperament of the patient, and a complete physical examination are indicated. Due to economic reasons, blood work including complete blood count and chemistry profile is performed only in farm animals with significant systemic diseases and those considered to have a higher anesthetic risk. For example, animals with severe gastrointestinal (GI) abnormalities often suffer extreme dehydration with or without electrolyte alteration, which may require intervention to optimize the patient's condition with fluid

therapy prior to the induction of anesthesia [5]. In healthy animals, total plasma protein and packed cell volume are sufficient indicators of a patient's hydration status.

Most sedatives and general anesthetics cause some degree of cardiovascular depression, which may not be a great concern for healthy patients. However, normal cardiovascular protective mechanisms or reflexes in response to the depressing effects of anesthetics may be obtunded in animals with compromised cardiac function or severe electrolyte imbalances as a consequence of disease conditions. Maintaining a balance of concentrations of electrolytes like calcium, sodium, and potassium across the cell membranes is essential in establishing normal cell membrane potential and contractility. Disturbance of these electrolyte balances across cell membranes changes cellular resting membrane potentials and subsequent initiation and propagation of cellular depolarization and repolarization. Acidosis has been shown to cause electrolyte imbalances resulting in decreased myocardial contractility and increased response of the myocardial cells to circulating catecholamines. Therefore, anesthetic-induced cardiovascular depression combined with severe preexisting acidosis and electrolyte imbalances can lead to detrimental side effects like severe cardiac arrhythmias, bradycardia, decreased myocardial and vascular cellular contractility, reduced cardiac output, and hypotension. As a result, anesthetized animals may not be able to maintain adequate cardiac output or arterial blood pressure leading to significantly decreased peripheral tissue and muscle perfusion with subsequent development of severe adverse effects such as irreversible postanesthetic neuromyopathy [6].

## **1.1 Positioning**

Ruminants, camelids, and swine are susceptible to complications associated with anesthesia and recumbency. Positioning of these animals, particularly adult cattle, in dorsal or lateral recumbency for surgery allows for the weight of abdominal viscera to shift ventrally and cranially, causing the diaphragm to be pushed further into the thoracic cavity, thereby reducing the functional residual capacity of the lungs ([Figure 1.1](#)). As a result, an increased ventilation/perfusion mismatch may lead to significant hypoventilation and hypoxemia during anesthesia. Furthermore, the weight of the abdominal viscera may compress great vessels such as the vena cava leading to decreased venous return, cardiac output, and arterial blood pressures [7]. Therefore, close monitoring of cardiovascular and pulmonary functions and institution of appropriate treatments to ensure normal arterial blood pressure and adequate ventilation are important parts of perioperative anesthetic management.

Tail docking [202](#)

TCO<sub>2</sub>. *see* [Total carbon dioxide \(TCO<sub>2</sub>\)](#).

Teat blocks, for cattle [179](#)

Teeth floating [202](#)

Teflon indwelling catheter [144](#)

Telazol [7](#), [18](#), [39](#), [46](#), [47](#), [53](#), [63](#), [64](#), [76](#), [77](#), [82](#), [83](#)

Telazol, acepromazine and lumbosacral epidural lidocaine (TAL) [84](#)

Telazol, ketamine and acepromazine (TKA)

Telazol/ketamine/xylazine-pigs (TKX-P) [53](#), [83](#), [84](#), [204](#)

Telazol/ketamine/xylazine-ruminants (TKX-Ru) [47](#), [53](#), [65](#), [72](#)

Thrombophlebitis [69](#)

Tiletamine [63](#), [271](#)

Tiletamine-zolazepam (Telazol) [72](#)

Tissue oxygenation [138](#)

TIVA. *see* [Total intravenous anesthesia \(TIVA\)](#).

TKX-P. *see* [Telazol/ketamine/xylazine-pigs \(TKX-P\)](#).

TKX-Ru. *see* [Telazol/ketamine/xylazine-ruminants \(TKX-Ru\)](#).

Tolazoline [7](#), [26-27](#), [71](#)

Tolfenamic acid [219](#)

Total carbon dioxide (TCO<sub>2</sub>) [251](#)

Total intravenous anesthesia (TIVA) [77](#)

Toxicity studies [263](#)

Tracheal intubation [9](#), [10](#), [40](#), [68](#), [69](#), [119](#)

Train-of-four pattern [106](#)

Tramadol [213](#)-214, [231](#)  
Tranquilization/sedation [16](#)-17  
    of acepromazine [17](#)  
    higher doses of [37](#)  
Traumatic reticuloperitonitis [197](#)  
Triple Drip [69](#)  
Trochlear nerve [163](#)  
Tuohy needle [168](#)-169

## **u**

Udder, anesthesia for [179](#)-180  
Umbilical hernias [200](#)-201  
Unilateral ovariectomy [195](#)  
Urinary bladder surgery [199](#)-200  
Urinary tract obstruction/rupture, fluid therapy in [257](#)-  
258  
Urogenital surgery  
    in female [193](#)-196  
    in male [190](#)-193  
Urolithiasis [199](#)-200  
US Food and Drug Administration (FDA) [209](#), [263](#)  
Uterine motility [167](#)

## **v**

Vaginal prolapse [195](#)  
Vasectomy [193](#)

Vasoconstriction [151](#)-152

Vatinoxan [26](#)-27

Vecuronium [104](#)

Ventilation/perfusion ( $V/Q$ ) mismatch [138](#), [139](#)

Ventilators usage

ascending and descending bellows [123](#)-125, [127](#)

driving force of [124](#)

electrically powered [124](#)

mechanical control ventilation [122](#)

nonpiston-driven [127](#)-128

piston-driven [124](#)

pneumatically powered [124](#)-125

respiratory depression [121](#)

volume-limited and pressure-limited [122](#)-123

Volume-limited ventilators [122](#)-123

## **W**

Whole-blood transfusions [258](#)

Wound management [203](#)-204

## **X**

Xylazine [6-7](#), [46](#), [47](#), [52](#), [74-75](#), [77](#), [82](#), [150](#), [169](#), [194-197](#), [200](#), [203](#)

cattle [19-20](#)

field anesthesia [69-71](#)

in food animals [266-269](#)

small ruminants and camelids [22-23](#)

standing sedation and chemical restraint [37-41](#)

swine [25](#)

## **y**

Yohimbine [26-27](#), [85](#)

Young ruminants, castration in [191](#)

## **z**

Zolazepam [63](#), [64](#)

Zygomaticotemporal nerve [201](#)