FIFTH EDITION

THE Feline PATIENT

EDITED BY **GARY D. NORSWORTHY**

with website

WILEY Blackwell

The Feline Patient
Fifth Edition

The Feline Patient
Fifth Edition

Edited by
Gary D. Norsworthy, DVM, DABVP (Feline)

Associate Editor
Lisa M. Restine, DVM

WILEY Blackwell

This edition first published 2018

Edition History
Blackwell Publishing (4e, 2010);

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.

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.

Library of Congress Cataloging-in-Publication Data
Names: Norsworthy, Gary D., editor. | Restine, Lisa M., editor.
Title: The feline patient / edited by Gary D. Norsworthy ; associate editor, Lisa M. Restine ; founding authors, Gary D. Norsworthy, Sharon Fooshee Grace, Larry P. Tilley.
Description: Fifth edition. | Hoboken, NJ : Wiley, 2018. | Includes bibliographical references and index. |
Identifiers: LCCN 2017042908 (print) | LCCN 2017044592 (ebook) | ISBN 9781119269045 (pdf) | ISBN 9781119269052 (epub) | ISBN 9781119269038 (cloth)
Subjects: LCSH: Cats–Diseases. | MESH: Cat Diseases–diagnosis | Cat Diseases–therapy
Classification: LCC SF985 (ebook) | LCC SF985 .F46 2018 (print) | NLM SF 985 | DDC 636.8/089–dc23
LC record available at https://lccn.loc.gov/2017042908

Cover Design: Wiley
Cover Images: Courtesy of Gary D. Norsworthy

Set in 8/10pt Palatino LTStd by Aptara Inc., New Delhi, India

10 9 8 7 6 5 4 3 2 1

The Feline Patient, *First Edition*, circa 1998, was conceived by four individuals who wanted to produce a practical book to guide veterinarians who treat cats, whether in feline-only practice or in mixed-animal practice. Their goal was to produce a book that emphasized diagnosis, treatment, and prognosis, and did so in a rapid retrieval approach. The Founding Authors, as we designated ourselves, identified the important diseases of the cat and authored every chapter. With each subsequent edition, more authors with specialized expertise were added as the list of diseases expanded. This is to recognize the Founding Authors for their foresight and determination to achieve the original goals of producing a quick-reference book for the busy practitioner.

Founding Authors

Gary D. Norsworthy, DVM, DABVP (Feline)
Chief of Staff
Alamo Feline Health Center
San Antonio, TX
Adjunct Professor
College of Veterinary Medicine
Mississippi State University

Sharon Fooshee Grace, DVM, DABVP (Canine/Feline), DACVIM (SAIM)
DACVIM (Internal Medicine)
Mississippi State University
College of Veterinary Medicine
Mississippi State, MS

Larry P. Tilley, DVM, DACVIM (SAIM)
President, VetMed Consultants
Consultant, New Mexico Veterinary Referral Center
Santa Fe, NM

Mitchell A. Crystal, DVM, DACVIM (SAIM)
North Florida Veterinary Specialists
Jacksonville, FL

Dedications

Gary D. Norsworthy, DVM, DABVP (Feline)

After 45 years in practice, even in my constant state of denial, I must admit that I am getting somewhat close to the end of my career. Looking back on those 45 years gives me great pleasure in many ways. Linda, my wife of 49 years, and I started with almost no material wealth and a student loan, and now we have achieved financial security, so we can afford a few luxuries even after raising two children and paying for their college educations. However, those financial rewards pale in comparison to the relationships I have made over the last four decades. I have clients I have known for decades and who have become friends, I have former externs who greet me affectionately when I see them at conferences, I have former associates who still call me for personal and professional advice, and I have employees who have me convinced that they love having me as their boss. I make this dedication to every one of you. Without each of you my career would have not been nearly as personally satisfying.

I would also like to recognize companies that have allowed all of us to better diagnose and treat feline diseases. The following have made significant contributions to my patient care; Abaxis: Hematology and Blood Chemistry Machines, Epica Medical: The Vimago CT scanner, Nutramax: Denamarin, Cobalaquin, Purina: Low Carb/High Protein Diet (DM), Weight Management Diet (OM), Urinary Diet (UR), Texas Veterinary Pathology: Pathology services, Universal Medical Systems: Digital Radiograph Machine, Ultrasound Machine and Zoetis: Convenia, Cerenia

Lisa M. Restine

To my wonderful husband – you have followed me and supported me on my veterinary journey through all of the twists and turns. I love you.

To my parents – you never stopped believing in me and have been nothing but encouraging and understanding since their 12 year old decided she wanted to be a veterinarian.

To Dr. Norsworthy – you have given me this amazing opportunity in feline medicine. This is better than anything I ever imagined for myself.

To the staff at Alamo Feline Health Center – you have helped me learn and grow as both a doctor and as a person. You guys rock!

To the doctors I worked with at East Brunswick Animal Hospital – I would not have started out on this path if it wasn't for your care of my kitties. Thank you for inspiring me to pursue a career in this field.

To my furry feline companions, Ruby, Albus, Macklin, Roxie and Domiano – thank you for keeping me grounded and for just being cats.

Sharon Fooshee Grace

Dedicated to Jesus Christ – my Lord and Savior;
My family – Pete, Branion, and Mary;
The memory of my parents – Joel and Janie Fooshee;
And Cleopatra – the kitten who continues to inspire me.

Larry Patrick Tilley

To my late mother, Dorothy, who instilled values in my brother Steve and me that have helped us throughout life.

To my grandson, Tucker, who is keeping me young.

To family and animals who represent the purity of life.

Contents

Section 2: Behavior

Section 3: Surgery

Section 4: Cytology

Section 5: Clinical Procedures

Section 6: Topics of Special Interest

Contributors

Fernanda Vieira Amorim da Costa, DVM, MS, PhD
Associate Professor
Head of Feline Medicine Service
Department of Animal Medicine
College of Veterinary Medicine
Rio Grande do Sul Federal University
Founder and Vice President, Brazilian Academy of Feline Practice
Porto Alegre, RS, Brazil

James W. Barr, DVM, DACVECC
Assistant Professor
Department of Small Animal Clinical Sciences
College of Veterinary Medicine & Biomedical Sciences
Texas A&M University, TX

Jerold S. Bell, DVM
Adjunct Professor of Genetics
Department of Clinical Sciences
Cummings School of Veterinary Medicine
Tufts University, CT

Jan Bellows, DVM, Dipl. AVDC, DABVP (Canine/Feline)
All Pets Dental
Weston, FL

Charles H. Bonney, DVM, PhD
Director, Animal Eye Hospital
San Antonio, TX
Research to Prevent Blindness Professorship
Medical School
University of Texas Health Sciences Center
San Antonio, TX
Guest Scientist. National Eye Institute
National Institutes of Health, Bethesda, MD

Karen R. Brantman
Blue Pearl Veterinary Partners
Grand Rapids, MI

Jane E. Brunt, DVM
Cat Hospital at Towson
Baltimore, MD

Ryan Butler, DVM, MS, Diplomate ACVS-SA
Assistant Professor, Small Animal Surgery
College of Veterinary Medicine
Mississippi State University, MS

Anthony P. Carr, Dr. med. vet., DACVIM (SAIM)
Professor, Small Animal Clinical Sciences
Western College of Veterinary Medicine
Saskatoon, Canada

Dennis J. Chew, DVM, Dip ACVIM (Internal Medicine)
Professor Emeritus, The Ohio State University
Columbus, OH

Elizabeth J. Colleran, DVM, MS, DABVP (Feline)
Owner and Hospital Director
Chico Hospital for Cats
Chico, CA
Cat Hospital of Portland
Portland, OR

Audrey K. Cook, BVM&S, MRCVS, Dip ACVIM-SAIM, ECVIM-CA & ABVP (Feline Practice), PG Cert Vet Ed
Associate Professor, Small Animal Internal Medicine
Department of Small Animal Clinical Sciences
College of Veterinary Medicine and Biomedical Sciences
Texas A&M University, TX

Katia Barão Corgozinho, MV, MSc, DSc
Praça Aquiles 50
Rio de Janeiro, Brazil

Rick L. Cowell, DVM, MS, Diplomate ACVP (Clinical Pathology), MRCVS
Clinical Pathologist
IDEXX Labs Inc.
Stillwater, OK

Melanie J. Dobromylskyj, BSc Vet Path (Hons), BVSc, PhD, FRCPath, MRCVS
Finn Pathologists Histopathology Department
One Eyed Lane
Weybread, Diss
Norfolk, UK

Erin O'Docharty Dresner, DVM, DABVP (Feline)
Just Cats Veterinary Services
The Woodlands, TX

Beate Egner
VBS GmbH
Neuer Weg 4
64832 Babenhausen
Germany

Leandro Fadel, MV, MSc
Vice-President Brazilian Veterinary Emergency and Critical Care Society
Professor of Anesthesiology
Lutheran University of Brazil
Canoas, Brazil

William Ray Folger, DVM, DABVP (Feline)
Memorial Cat Hospital
Houston, TX

Michèle Fradin-Fermé, DVM, PhD
Clinique Veterinaire Reservee aux Chats
21bis, Rue de l'église 94300
Vincennes, France

Joao Felipe de Brito Galvao, MV, MS
Diplomate, American College of Veterinary Internal Medicine (SAIM)
Medical Director
Internal Medicine, Interventional Radiology, Nuclear Medicine
VIN consultant – Urology-Nephrology
VCA Arboretum View Animal Hospital
Downers Grove, IL

Stephanie Gandy Murphy, DVM
Catisfaction Cat Clinic
Madison, AL

John C. Godbold, Jr., DVM
Stonehaven Veterinary Consulting
Jackson, TN

Sharon Fooshee Grace, DVM, DABVP (Canine/Feline), DACVIM (SAIM)
College of Veterinary Medicine
Department of Clinical Sciences
Mississippi State University, MS

Marcus Gunew, BVSc (Hons), BSc (Vet), FANZCVS
Fellow, Australia and New Zealand College of Veterinary Scientists in Feline Medicine
Director and Feline Specialist at The Cat Clinic Brisbane
The Cat Clinic
Mt. Gravatt
QLD, Australia

Justin Harper, DVM, MS, DACVS-LA
CEO & Head Surgeon
Texas Specialty Veterinary Services, TX
San Antonio, TX

Debra F. Horwitz DVM, DACVB
Veterinary Behavior Consultations
St. Louis, MO

Kathryn Jacocks, DVM, DACVP (Clinical Pathology)
IDEXX Reference Laboratories
Plano, TX

Heloisa Justen Moreira de Souza
Professor of Feline Medicine and Surgery
Department of Medicine and Surgery
University Federal Rural of Rio de Janeiro
Rio de Janeiro, Brazil

Otto I. Lanz, DVM
Diplomate ACVS
Professor, Small Animal Clinical Sciences
Chief of Small Animal Surgery
VA-MD College of Veterinary Medicine
Blacksburg, VA

Jennifer Lavallee, DVM
Cat Specialist, Inc.
Castle Rock, CO

Jonathan A. Lidbury, BVMS, MRCVS, PhD, DACVIM, DECVIM-CA
Assistant Professor of Small Animal Internal Medicine
Associate Director for Clinical Services of the Gastrointestinal Laboratory
Department of Small Animal Clinical Sciences, College of Veterinary Medicine & Biomedical Sciences, Texas A&M University, TX

Richard Malik DVSc DipVetAn MVetClinStud PhD FACVSc FASM
Valentine Charlton Specialist
Centre for Veterinary Education
The University of Sydney
Sydney, NSW, Australia

Rhett Marshall, BVSc, PhD, MANZCVS (Small Animal Surgery)
Member, Australian and New Zealand College of Veterinary Scientists in Small Animal Surgery
Director and Senior Feline Practitioner at The Cat Clinic Brisbane
The Cat Clinic
Mt. Gravatt, QLD, Australia

Mac Maxwell, DVM, MS, DACVS-SA
Memphis Veterinary Specialists
Cordova, TN

Michael S. Miller, MS, VMD, DABVP (Canine and Feline)
Cardiology-Ultrasound Referral Service
Veterinary Specialty Center of Delaware
Metropolitan Veterinary Associates
Veterinary Referral Center
Malvern, PA

Eduardo Raposo Monteiro, MV, MSc, PhD
Associate Professor
Department of Animal Medicine
Faculty of Veterinary Medicine
Universidade Federal do Rio Grande do Sul (UFRGS)
Porto Alegre, Brazil

Gary D. Norsworthy, DVM, DABVP (Feline)
Chief of Staff Alamo Feline Health Center
San Antonio, TX

Courtney North, VMD, DACVIM
Auckland, New Zealand

James K. Olson, DVM, DABVP (Feline)
Cat Specialist, Inc.
Castle Rock, CO

Sarah O'Neill, VMD, DACVD
Nashville Veterinary Dermatology
Nashville, TN

Medora B. Pashmakova, DVM, DACVECC
Assistant Professor
Department of Small Animal Clinical Sciences
College of Veterinary Medicine and Biomedical Sciences
Texas A&M University, TX

Lindsey N. Pelych, DVM
Bluepearl Veterinary Partners
Southfield, MI

Jason B. Pieper, DVM, MS, DACVD
Clinical Assistant Professor, Dermatology and Otology Clinic
Diplomate, American College of Veterinary Dermatology
Service Head, Dermatology and Otology Clinic
University of Illinois, IL

Amy L. Pike, DVM, DACVB
Chief, Behavior Medicine Division
Veterinary Referral Center of Northern Virginia
Manassas, VA

Arnold Plotnick MS, DVM, DACVIM (Internal Medicine)
Manhattan Cat Specialists
New York, NY

Lisa M. Restine, DVM
Alamo Feline Health Center
San Antonio, TX

Casey C. Robinson, DVM
VCA Farmington Hills Animal Hospital
Farmington Hills, MI

Anne Romeo, MS, DVM
Pfennig Lane Animal Hospital
Pflugerville, TX

Linda Schmeltzer, RVT
Head Technician
Alamo Feline Health Center
San Antonio, TX

Bradley R. Schmidt, DVM, DACVIM (Oncology)
Medical Director
North Florida Veterinary Specialists, P.A.
Jacksonville, FL

Paula A. Schuerer, DVM, MBA, DABVP (Canine-Feline)
Animal Ark Animal Hospital, LLC
Franklin, TN

Gwen H. Sila, DVM, DACVO
Board Certified in Veterinary Ophthalmology
BluePearl Veterinary Partners
Southfield, MI

Christopher J. H. Simpson, BVSc, MANZCVS
Victoria Veterinary Clinics
Yuen Long
Hong Kong

Francis W.K. Smith, Jr., DVM, DACVIM (Cardiology & Small Animal Internal Medicine)
Vice-President, VetMed Consultants, Lexington, MA
Clinical Assistant Professor
Cummings School of Veterinary Medicine
Tufts University, North Grafton, MA

Andrew Sparkes, BVetMed, PhD, DECVIM, MANZCVS, MRCVS
Veterinary Director
International Cat Care and International Society of Feline Medicine
Tilsbury, Wiltshire, UK

Jörg M. Steiner, med.vet., Dr.med.vet., PhD, DACVIM, DECVIM-CA, AGAF
The Dr. Mark Morris Chair of Small Animal Gastroenterology and Nutrition
Professor of Small Animal Internal Medicine
Director of the Gastrointestinal Laboratory
Texas A&M University, TX

Sabine Tacke
Certified Specialist of Veterinary Anesthesia, Intensive Care and Pain Therapy
Certified Specialist of Veterinary Surgery
Department of Veterinary Clinical Sciences
Clinic for Small Animals, Surgery
Anesthesia, Pain Therapy, Perioperative Intensive Care
Justus-Liebig-University Giessen
35392 Giessen, Germany

John Metcalfe Thomason, DVM, MS, DACVIM (Small Animal Internal Medicine)
Assistant Professor
Small Animal Internal Medicine
Department of Clinical Sciences
College of Veterinary Medicine
Mississippi State University, MS

Larry P. Tilley, DVM, DACVIM (SAIM)
President, VetMed Consultants
Santa Fe, NM

Karen Lovelace Tofte, DVM
City Kitty
Providence, RI

Amy C. Valenciano, DVM, MS, DACVP
Veterinary Clinical Pathologist
IDEXX Reference Laboratories, Inc.
Dallas, TX

Stella de Faria Valle
Diretora Hospital de Clínicas Veterinárias-HCV
Coordenadora Laboratório de Análises Clínicas Veterinárias - LACVet
Universidade Federal do Rio Grande do Sul - UFRGS
Porto Alegre, Brazil

Teija Kaarina Viita-aho, DVM, MANZCVS (Medicine of Cats)
Evidensia Cat Clinic Felina
Työmiehenkatu 4 C
Helsinki, Finland

Alice E. Villalobos, DVM, FNAP
Director, Pawspice & Animal Oncology Consultation Service
VCA Coast Animal Hospital,
Hermosa Beach, CA

Don R. Waldron, DVM, DACVS
Blacksburg, VA

Tatiana Weissova, DVM, PhD
Slovak Association of Veterinarians of Small Animals and Slovak Society of Feline Medicine
Head of Department of Internal Diseases of Small Animals
Small Animal Clinic
University of Veterinary Medicine and Pharmacy in Kosice
Komenskeho, Slovakia

Michael C. West, DVM
Ophthalmology Department
BluePearl Veterinary Partners
Auburn Hills, MI

Elaine Wexler-Mitchell, DVM, DABVP (Feline)
The Cat Care Clinic
Orange, CA

Debra L. Zoran, DVM, PhD, DACVIM-SAIM
Professor and Operations Supervisor Texas A&M VET
Department of SA Clinical Sciences
College of Veterinary Medicine and Biomedical Sciences
Texas A&M University, TX

Preface

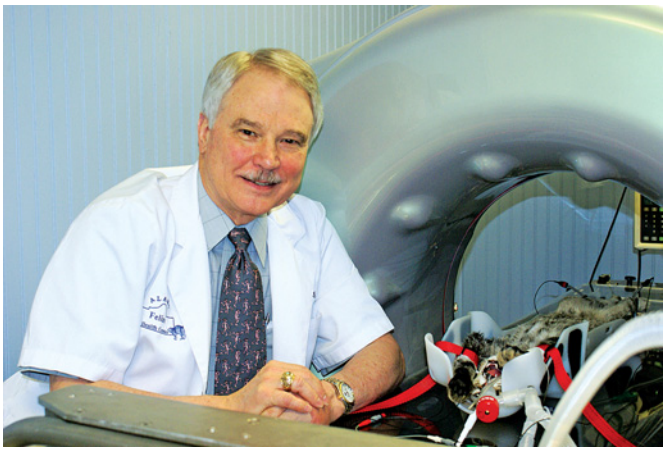
This is a "read it, see it, do it" book. The text is for reading, the images and videos are for seeing, and the practitioner is for doing.

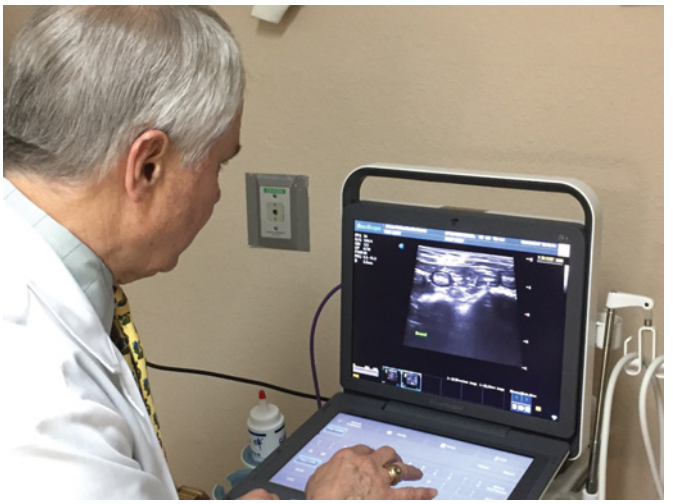
When I graduated in 1972 the expectation of the day was that primary care practitioners would diagnose and treat their patients. That sounds perfectly logical because that is the goal of veterinary education. However, there has been a shift within the profession away from that position.

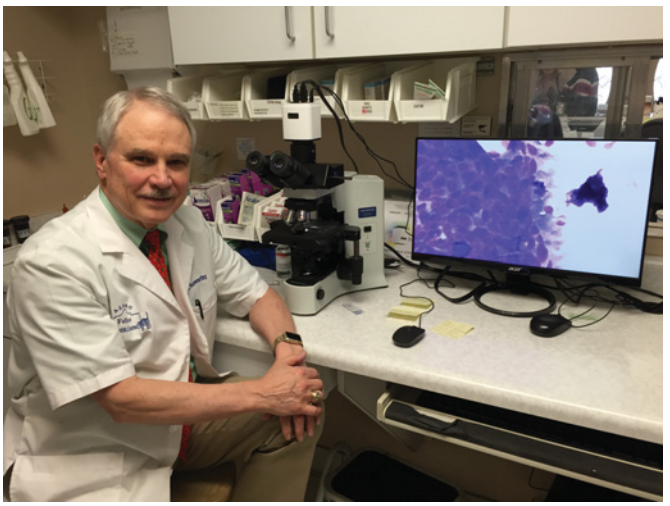
This book is written for the primary care practitioner with the intent of allowing you, within your capabilities, to manage your cases. I do not want to promote reckless experimentation in any form, but I want the primary care practitioner to wake up each morning looking forward to the challenges and opportunities of the new day.

Primary care practice has been an extremely rewarding event for me on many levels. After 45 years, I am just as enthused about going to "plerk" as I was many decades ago. I wish this feeling to all primary care practitioners in our wonderful profession. Continue to climb new mountains. It will keep you challenged, looking upward, and wishing your career would never end.

Gary D. Norsworthy, DVM, DABVP (Feline)







Norsworthy's Notes

The publisher suggested that I comment on each chapter in the book from the perspective of a seasoned feline practitioner. I was hesitant at first, but the idea grew on me until I embraced it as a chance to share my experiences in treating feline patients for 45 years in a non-academic setting.

As an introduction to that concept, it would be well for the reader to know about my experiences in private practice. As stated in the chapter "The History of Feline-Only Practice," my interest in feline practice preceded my acceptance to veterinary school. Thus, I was one of the earliest to do this. After graduation from Texas A&M University in 1972 and two years at the Cat Clinic of Seattle, the nation's third feline-only hospital, I moved to San Antonio, Texas to practice with a colleague and friend. He and I were in small animal practice for 25 years.

Upon his retirement, I opened Alamo Feline Health Center and returned to feline-only practice in 2000. My practice consists of three full-time veterinarians, including me, and is highly equipped to treat primary care and referral patients. My equipment includes four endoscopes, diagnostic ultrasound (1990), a CO2 laser surgery unit (1995), a video-otoscope (2001), digital x-ray (2002), digital dental x-ray (2011), a CT scanner (2014), and a microscope camera for viewing and recording images (2016). I have used electronic medical records since 2002. Mine is one of six Texas practices licensed to use radioiodine. Although mine is a primary care practice, about 20% of my patient load consists of referral cases.

Norsworthy's Notes consists of comments from my perspective as a small animal practitioner (25 years), feline-only practitioner (20 years), and Board Certified feline specialist (23 years). Most of the time, my views will be identical to the chapter authors. However, in some cases my views will differ from the authors, occasionally even to the point of disagreement. But, l feel that two perspectives can be beneficial to the reader. If you are new to the profession, you will soon find that it is quite common for experts to disagree. If you have been in practice over 10 years, you have seen that happen frequently. Ultimately, it is up to you to decide how to treat your patients based on the best available data, realizing that the "facts" we rely on are constantly evolving and there is often more than one "right way" to do many things.

I hope this exercise is helpful to you in treating your feline patients.

Gary D. Norsworthy, DVM
Diplomate, ABVP (Feline)
Alamo Feline Health Center
San Antonio, Texas

About the Companion Website

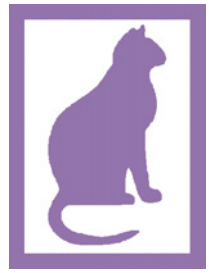
This book includes access to a companion website at

www.wiley.com/go/norsworthy/feline

The companion website features:

- Additional images not found in the book
- Video clips of clinical cases and procedures

SECTION



1

Diseases and Conditions

CHAPTER 1

Acetaminophen Toxicosis

Sharon Fooshee Grace

Overview

Acetaminophen toxicosis usually occurs when well-intentioned owners, unaware of the significant toxicity of this drug in cats, administer the drug for a variety of reasons. Most case reports indicate that owners give acetaminophen to individual cats as a pain reliever. Ingestion of as little as 10 mg/kg of acetaminophen may be fatal for some cats. This is less than one regular-strength tablet (325 mg) for a 4–5-kg (8.8–11-lb) cat. One case report described fatal toxicosis in a kitten that had played with an empty acetaminophen bottle. Methemoglobinemia and Heinz body hemolytic anemia are the classic hematologic findings in poisoned cats.

Acetaminophen preys upon several metabolic peculiarities of the feline species. Once the cat's limited ability to produce nontoxic drug metabolites via sulfate and glucuronide conjugation has been exceeded, toxic metabolites accumulate. The hepatic cytochrome P450 oxidase system converts acetaminophen to the reactive electrophilic intermediate N-acetyl-para-benzoquinoneimine (NAPQ1). This compound is believed to be responsible for cell injury, such as can occur in the liver, but is no longer thought to be the cause of methemoglobinemia. Recent research has indicated that para-aminophenol (PAP) is the likely metabolite leading to development of methemoglobinemia in cats ingesting acetaminophen.

As hemoglobin is oxidized from its normal ferrous state (+2) to a ferric state (methemoglobin, +3), it becomes unable to effectively deliver oxygen to tissues, with catastrophic consequences for the patient. Notably, even under normal circumstances, the feline erythrocyte is vulnerable to oxidative stress because of the relatively large number of sulfhydryl groups present in cat hemoglobin. Further, precipitation of damaged hemoglobin on the erythrocyte membrane leads to the second significant event: development of Heinz body hemolytic anemia. The feline spleen is relatively ineffective at removing Heinz bodies from erythrocyte membranes so they persist, with the net effect of increased erythrocyte membrane fragility, decreased deformability, and development of hemolytic anemia. Whereas methemoglobinemia is potentially reversible, Heinz body formation and damage to the red blood cell membrane is not. Finally, acetaminophen toxicosis may uncommonly cause feline liver necrosis via NAPQ1-mediated damage to hepatocyte membranes and reaction with hepatocellular proteins. However, hepatic damage in cats is usually minimal when compared with that typically seen in humans (and in dogs at very high doses).

Earliest signs of toxicosis include anorexia, vomiting, and ptyalism. The appearance of cyanotic or brown-colored mucous membranes may occur within a few hours of drug ingestion and heralds the onset of significant methemoglobinemia. Edema of the face and paws is common, although the precise cause for these findings remains unclear. As Heinz body hemolytic anemia develops within hours to a few days of drug ingestion, the mucous membranes become pale and sometimes icteric.

Diagnosis

Primary Diagnostics

- History: Because the clinical signs are not always distinctive, a history of acetaminophen administration or potential exposure to the drug is critical to help confirm a diagnosis.
- Clinical Signs: The appearance of cyanotic or brown-colored mucous membranes and facial and paw edema are noteworthy. Other findings may include vocalization, tachycardia, dyspnea, depression, and weakness. Icterus may occur 24–48 hours after drug ingestion.
- Complete Blood Count (CBC): Submitted blood will often have a dark brown color (see Diagnostic Notes below). Typical findings include anemia and the appearance of Heinz bodies on the red cell membrane. See Figure 1.1. Reticulocytes may appear several days later if the cat survives. Heinz bodies and reticulocytes are more easily recognized if a drop of new methylene blue stain is applied to an air-dried blood smear, which is then coverslipped and examined microscopically (see Chapter 314).
- Chemistry Profile: Hepatocellular leakage enzymes may be mildly to severely elevated. Since acetaminophen does not commonly cause significant hepatic necrosis in cats, these elevations could be due to hepatocyte hypoxia. Serum bilirubin is sometimes increased.
- Urinalysis: Chocolate- or red-colored urine may be seen due to methemoglobinuria or hematuria.

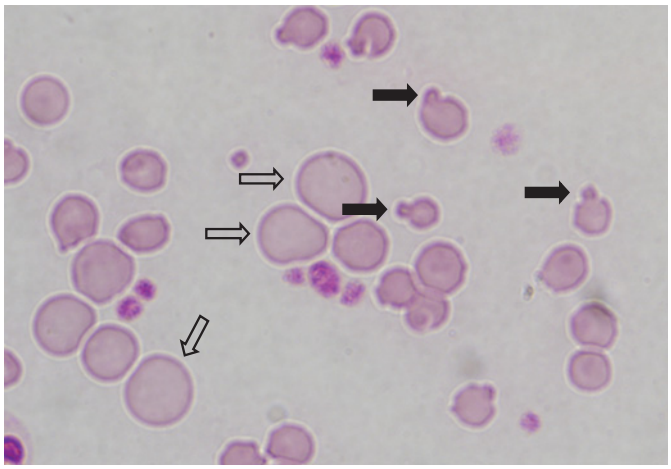


Figure 1.1 Heinz body formation (*closed arrows*) on the red blood cells is one of the diagnostic features of acetaminophen toxicity. The large, non-nucleated erythrocytes (*open arrows*) (macrocytes or reticulocytes) indicate a regenerative anemia. Image courtesy of Dr. Gary D. Norsworthy.

The Feline Patient, Fifth Edition. Edited by Gary D. Norsworthy.

Companion website: www.wiley.com/go/norsworthy/feline

Diagnostic Notes

- In healthy, nonanemic cats, up to 5% of erythrocytes may contain Heinz bodies. As such, detection of occasional Heinz bodies should be considered normal in cats.
- Methemoglobinemia is the usual cause of death. Signs of methemoglobinemia appear when more than 20–30% of hemoglobin is in the form of methemoglobin.
- Methemoglobinemia is sometimes difficult to discern in a blood sample because venous blood is normally dark. As a clinical screening test, one drop of patient blood can be placed on a white paper towel or filter paper next to a drop of normal "control" blood. If the methemoglobin content is greater than 10%, the patient's blood is expected to be noticeably brown when compared to the brighter red of the control blood.
- Acetaminophen serum concentration may be measured and is maximally increased 2–3 hours post-ingestion. In most cases, it is unnecessary and impractical to measure blood levels of the drug.

Therapy

Primary Therapeutics

- Removal of the Toxin: Acetaminophen is rapidly absorbed from the gastrointestinal tract so emesis should be induced only if drug ingestion has occurred within the previous 1–2 hours. Emesis may be induced by apomorphine or xylazine. Use of activated charcoal is controversial; it should be given only if acetaminophen ingestion has occurred within the preceding 2 hours. Because of the risk for aspiration pneumonia, activated charcoal should be used cautiously if the cat is vomiting or if emesis has been induced. If acetylcysteine is given orally, charcoal may bind the drug.
- Acetylcysteine (Mucomyst®): This drug is recommended as a specific antidote. It supplies precursors for replenishment of the antioxidant glutathione. Available solutions are in 10% and 20% concentrations and should be diluted in a 5% dextrose solution for both intravenous and oral routes of therapy. An initial oral or intravenous dose of 130–140 mg/kg should be followed by 70 mg/kg q6h PO or IV for five to seven treatments. It is recommended that intravenous treatments be administered through a 0.2 µm millipore filter over 30–60 minutes. Some have suggested that oral administration may be superior to the intravenous route because of the higher concentration of drug available to the liver via portal circulation. It has been shown that therapy is less effective when started more than 8 hours after ingestion of acetaminophen, though there may still be some benefit appreciated when treating up to 80 hours post-ingestion. The majority of benefit from acetylcysteine is directed toward protection of the liver against oxidative injury and not resolution of methemoglobinemia.

Secondary Therapeutics

- Ascorbic Acid (vitamin C): Vitamin C is an antioxidant which, through nonenzymatic means, is proposed to assist in reduction of methemoglobin back to hemoglobin, though the process is slow. This is an adjunctive therapy and should not be substituted for acetylcysteine administration. Give 30 mg/kg PO for six treatments. Alternatively, give 30 mg/kg q6h IV until methemoglobinemia resolves. Consult a formulary before mixing ascorbic acid with other solutions due to a high likelihood of incompatibility.
- S-Adenosylmethionine (SAMe): SAMe, currently marketed as Denosyl® and Denamarin® by Nutramax Laboratories, demonstrates hepatoprotective and systemic antioxidant properties. SAMe has been shown to increase the cat's resistance to oxidative stress. In one placebo-controlled feline study evaluating oxidant injury caused by acetaminophen, SAMe-treated cats had reduced Heinz body formation and erythrocyte destruction as compared to cats receiving only acetaminophen. However, additional studies need to be done, especially regarding its effect on methemoglobinemia, which did not appear to improve with SAMe therapy in the aforementioned study. At this time, it should be considered an adjunctive treatment.
- Transfusion with Blood or Hemoglobin Solutions: Administration of whole blood may be useful in cats with severe hemolytic anemia and should be considered if the hematocrit falls below 20%. Signs of hypoxemia would also warrant a transfusion, even with a normal hematocrit, as the hematocrit is not a true reflection of the oxygen-carrying capacity of the blood. Oxyglobin®, a hemoglobin solution, appears unlikely to return to the market, at least for the foreseeable future.
- Supportive Therapy: This may include intravenous fluids, electrolytes, and limited handling of the patient.

Therapeutic Notes

- Cimetidine was previously recommended as ancillary therapy. Many toxicologists now consider it contraindicated as it interferes with biochemical pathways that attempt to detoxify the PAP metabolite.
- Corticosteroids are of no value.
- The literature contains varied opinions about the benefit of oxygen therapy because methemoglobin is unable to bind oxygen. However, it is reasonable to consider oxygen support, as long as oxygen administration does not further stress the patient. An oxygen cage is preferred to an oxygen mask.
- Hyperbaric oxygen therapy is efficacious in humans with acetaminophen toxicosis and should be tried if available.
- Though opinions vary, most consider that methylene blue is contraindicated in treatment of this disorder because of the potential to worsen the hemolytic anemia.
- A positive response to therapy is indicated by improvement within 48 hours.

Prognosis

A grave prognosis is indicated when methemoglobinemia and Heinz body hemolytic anemia are severe and unresponsive to appropriate therapy. For cats that recover, no long-term effects have been reported.

Suggested Readings

Court, M.H. (2013) Feline drug metabolism and disposition: Pharmacokinetic evidence for species differences and molecular mechanisms. *Vet Clin North Am Small Anim Pract* 43(5), 1039–1054.

McConkey, S., Grant, D., Cribb, A. (2009) The role of para-aminophenol in acetaminophen-induced methemoglobinemia in dogs and cats. *J Vet Pharm Therapeu* 32(6), 585–595.

Webb, C.B., Twedt, D.C., Fettman, M.J., et al. (2003) S-adenosylmethionine (SAMe) in a feline acetaminophen model of oxidative injury. *J Fel Med Surg* 5(2), 69–75.

Norsworthy's Notes

Brown is the unique key to diagnosing this disease: mucous membranes, serum, and/or urine. Toxic amounts are absorbed within 2 hours after ingestion so prompt treatment is essential for a good outcome. The use of acetylcysteine greatly increases response.

CHAPTER 2

Acne

Jason B. Pieper

Overview

Acne is an uncommon dermatologic condition in cats. It is an idiopathic disorder of follicular keratinization and glandular proliferation with an age range from 6 months to 17 years (median age 4 years). In a study of 22 cats with acne, the most common skin lesions noted were comedones (Figure 2.1) (73%), alopecia (68%), crusts (55%), papules (45%), and erythema (41%). With chronic cases, edema, cysts, and scars can develop (Figure 2.2). The most common body location is the chin, while the lower and upper lips may be involved. Pruritus is infrequent (35%) and may be due to concurrent allergies. *Malassezia pachydermatitis* is uncommonly found (18%) in affected cats. Bacteria are present in most patients (45–100%). The bacteria commonly isolated include *Pasteurella multocida*, coagulase-positive *Staphylococcus*, and β-hemolytic *Streptococcus*. Histopathologic findings in cats with acne include lymphoplasmacytic periductal inflammation, sebaceous gland duct dilatation, follicular keratosis with plugging and dilatation, folliculitis, pyogranulomatous adenitis, and furunculosis.

Diagnosis

Primary Diagnostics

- History and Clinical Signs: Clinical signs and appearance are extremely suggestive of the diagnosis. See Figures 2.1 and 2.2.
- Histopathology: Histopathologic findings are classic for acne (see description).

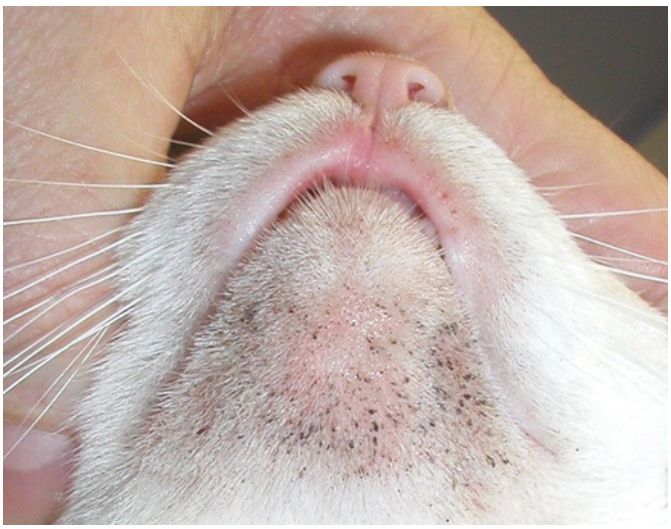


Figure 2.1 Comedones are an early clinical sign of acne. Image courtesy of Dr. Gary D. Norsworthy.

The Feline Patient, Fifth Edition. Edited by Gary D. Norsworthy.

Companion website: www.wiley.com/go/norsworthy/feline

Therapy

Primary Therapeutics

- Secondary infections should be treated with systemic antibiotics for 3–6 weeks (for severe cases). In chronic cases, a 10–14-day course of systemic prednisolone (1–2 mg/kg/day) is beneficial after the bacterial infection is resolved.
- Topical medications can be extremely beneficial for treating feline acne. The chin should be clipped and cleaned prior to applying these topical medications. Examples of topical medications that have been used include salicylic acid pads (i.e., Stridex® pads), benzoyl peroxide 5% gel, 0.01–0.025% tretinoin cream or lotion, 0.75% metronidazole gel, clindamycin ointment, and mupirocin ointment.

Therapeutic Notes

- Hot packing of the chin with a warm, moist cloth for 30 seconds prior to treatment often makes the topical treatment more effective.

Prognosis

The prognosis is good for feline acne. Intermittent, lifelong, symptomatic treatment is often necessary to keep the clinical signs under control. Feline acne is primarily a cosmetic concern except when a secondary infection is present. Bacterial skin infections often require systemic therapy to achieve control of acne.

Figure 2.2 Chronic acne results in severe folliculitis and furunculosis. Image courtesy of Dr. Gary D. Norsworthy.

Suggested Readings

Jazic, E., Coyner, K.S., Loeffler, D.G., et al. (2006) An evaluation of the clinical, cytological, infectious and histopathological features of feline acne. *Vet Derm* 17(2), 134–140.

Scott, D.W., Miller, W.H. (2010) Feline Acne: A Retrospective Study of 74 cases (1988–2003). *Jpn J Vet Derm* 16(4), 203–209.

Norsworthy's Notes

Acne is very common in my feline practice and often viewed by the client as a dirty chin from messy eating. My drug of choice is clindamycin lotion applied after clipping and hot packing the chin. Always tell the owner that recurrence is to be expected.

CHAPTER 3

Acromegaly

Sharon Fooshee Grace

Overview

Acromegaly is an increasingly recognized disorder of cats caused by a functional growth-hormone (GH) secreting tumor of the anterior pituitary. The disease is characterized by overgrowth of cartilage, bone, viscera, and soft tissue, and insulin-resistant diabetes mellitus. Most affected cats are middle-aged to older male neutered Domestic Shorthairs.

Severe insulin-resistant diabetes mellitus is the most common and important clinical manifestation. GH exerts significant diabetogenic activity through its ability to create peripheral insulin resistance. Some acromegalic cats require 30–130 units of insulin per day to control concurrent diabetes. Historical and clinical findings include polyphagia, polyuria, polydipsia, weight gain despite poorly controlled diabetes, enlargement of the head, widened interdental spaces, inferior prognathism, large club-shaped paws, rapid growth of toenails, thickened skin, degenerative arthritis, thickening of pharyngeal tissues, and organomegaly (especially cardiac, hepatic, and renal). Cats presented late in the course of disease may show signs of heart disease or failure (systolic murmur, pulmonary edema, pleural effusion) and chronic renal failure.

Diagnosis

Primary Diagnostics

- Change in Physical Appearance: Owners often fail to recognize gradual changes in their cat's appearance. Where possible, it is helpful to compare the appearance of the cat to a photograph taken several years before onset of signs to evaluate for changes consistent with acromegaly. See Figure 3.1. Lack of physical changes does not preclude a diagnosis.
- Minimum Data Base (complete blood count, chemistry profile, urinalysis): Hyperglycemia and glucosuria are consistent findings. Other possible findings include hyperphosphatemia, hyperproteinemia, hypercholesterolemia, and mild increases in liver enzymes. Proteinuria can precede development of azotemia, which usually occurs late in the course of disease.
- Insulin-like Growth Factor-1 (IGF-1, Somatomedin C) Level: This is a commercially available test that provides an indirect assessment of GH levels. It is currently available through the endocrine laboratory at Michigan State University (1-517-353-1683). The normal range is 12–92 nmol/l. An elevated IGF-1 alone is not diagnostic of acromegaly nor does a normal value eliminate it as a potential diagnosis; false-positive and -negative results have been reported.
- Growth Hormone Assay: Measurement of serum GH can provide additional information in suspect cats; however, a commercially available test is not currently available.
- Computed Tomography (CT) or Magnetic Resonance Imaging (MRI): At present, advanced imaging techniques are the most reliable means for detecting a pituitary mass. Pituitary imaging is also helpful in defining the size and progression of the tumor. See Figure 3.2. The presence of a mass is not diagnostic of a GH-secreting tumor because other types of pituitary tumors occur in cats (i.e., adrenocorticotropic hormone [ACTH]-secreting pituitary tumor). However, the likelihood that a pituitary tumor is secreting GH rises significantly if clinical signs of acromegaly are present and if

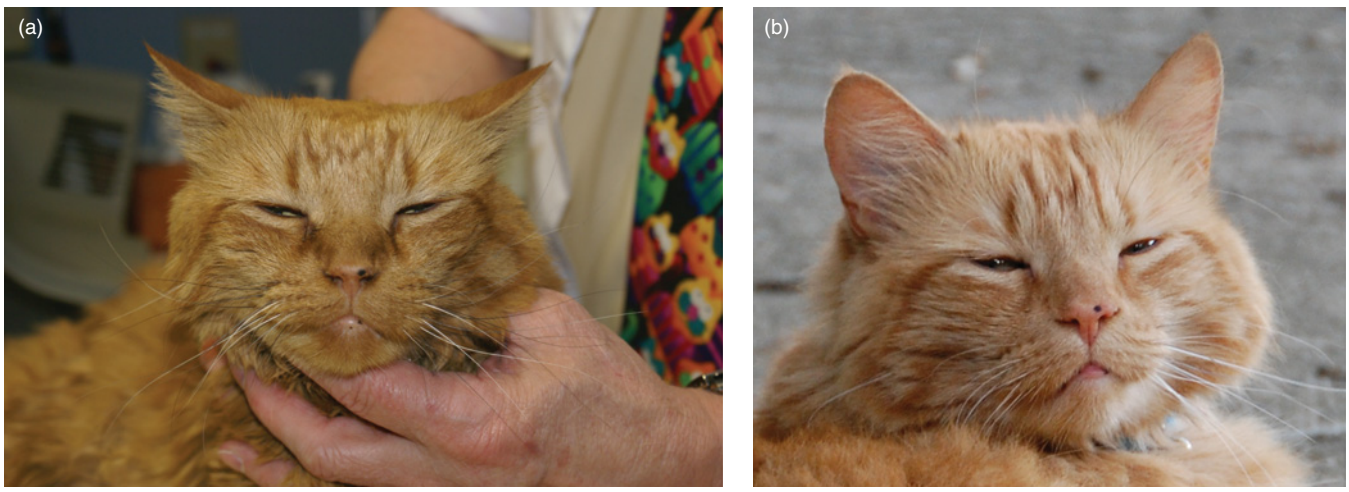


Figure 3.1 (a) This female cat was not regulated on 18 units of protamine zinc insulin twice daily. Compared to a prior photograph (b) her cheek bones and mandible are more prominent. Her IGF-1 was elevated. Although advanced imaging was not performed, the changes in her facial conformation and her abnormal IGF-1 made a tentative diagnosis of acromegaly very plausible. Images courtesy of Dr. Gary D. Norsworthy.

The Feline Patient, Fifth Edition. Edited by Gary D. Norsworthy.

Companion website: www.wiley.com/go/norsworthy/feline

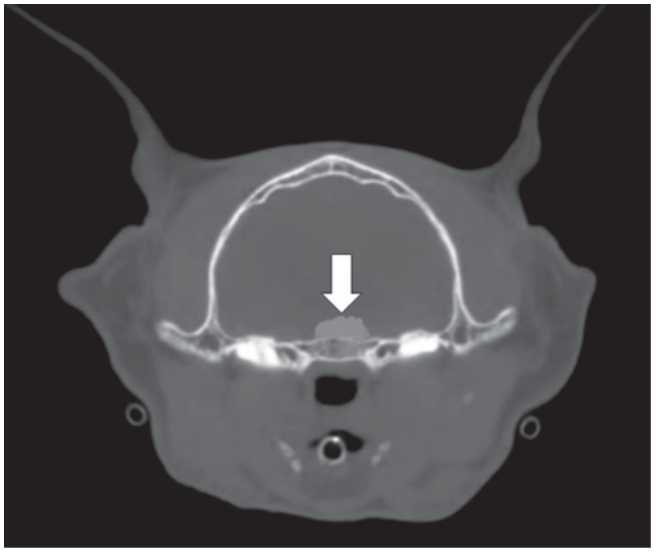


Figure 3.2 A large pituitary mass can be seen at the tip of the arrow. This CT scan is typical for a cat with acromegaly. Image courtesy of Dr. Gary D. Norsworthy.

hyperadrenocorticism is ruled out via lack of clinical signs and results of adrenal testing (see Chapter 100).

Secondary Diagnostics

- Radiographs: Survey radiographs of the chest, abdomen, and bones may reveal cardiomegaly, pulmonary edema, pleural effusion, hepatomegaly, splenomegaly, renomegaly, degenerative arthropathy, and a periarticular periosteal reaction.
- Echocardiography: This may reveal hypertrophic changes in the septum and left ventricular free wall.
- Adrenal Function Testing: Adrenal function should be evaluated to eliminate hyperadrenocorticism as a cause of insulin-resistant diabetes mellitus. The low-dose dexamethasone suppression test is the preferred test for confirmation of hyperadrenocorticism in cats (see Chapter 100).
- Thyroid Testing: Hyperthyroidism is common in elderly cats and may be a cause of insulin resistance in cats with naturally occurring diabetes mellitus. All geriatric cats should be evaluated with a total T4 value. However, the presence of unregulated diabetes can lower total T4 values.

Diagnostic Notes

- GH assays that have been designed for humans will not accurately assess feline GH levels. A GH test for cats is not available.
- Hypertension is a common problem in humans with acromegaly but appears infrequently in cats with the disease.

Therapy

Primary Therapeutics

- Radiation Therapy: Radiation therapy offers the best chance for control of the disease. Results have varied from minimal to dramatic shrinkage of the tumor. Unfortunately, it is common for the tumor to regrow and signs to recur after cessation of therapy (6–18 months).
- Medical Therapy: Drugs that lower circulating GH levels (e.g., dopamine agonists or somatostatin analogues) have been tried with mixed results; most cats fail to demonstrate a positive response. Therapy is not generally recommended unless other management techniques (high-dose insulin, managing other secondary conditions, radiation therapy) have been attempted and are not successful.

Secondary Therapeutics

- Insulin: Increasing doses of insulin will be required to manage insulin-resistant diabetes mellitus.

Therapeutic Notes

- Monitoring for secondary conditions (e.g., renal disease, cardiac disease) and provision of appropriate therapy will be necessary in most cases of feline acromegaly.
- Surgical and cryohypophysectomy have been reported in several cats. Availability of the procedures is limited. Outcome is variable and highly dependent upon skill of the surgeon.

Prognosis

Many cats will do well for 1–2 years without specific treatment for acromegaly if the diabetes is managed reasonably well. One study of 14 acromegalic cats reported a mean survival time of 22 months and a median survival time of 21 months. Most cats will eventually die or are euthanized from secondary conditions (congestive heart failure, renal disease, etc.).

Suggested Readings

Berg, R., Nelson, R., Feldman, E., et al. (2007) Serum insulin-like growth factor-I concentration in cats with diabetes mellitus and acromegaly. *J Vet Intern Med* 21(5), 892–898.

Dunning, M., Lowrie, C., Bexfield, N., et al. (2009) Exogenous insulin treatment after hypofractionated radiotherapy in cats with diabetes mellitus. *J Vet Intern Med* 23(2), 243–249.

Mayer, M., Greco, D., LaRue, S. (2006) Outcomes of pituitary tumor irradiation in cats. *J Vet Intern Med* 20(5), 1151–1154.

Niessen, S. (2010) Feline acromegaly: An essential diagnosis for the difficult diabetic. *J Fel Med Surg* 12(1), 15–23.

Niessen, S., Petrie, G., Gaudiano, F., et al. (2007) Feline acromegaly: An underdiagnosed endocrinopathy. *J Vet Intern Med* 21(5), 899–905.

Peterson, M., Taylor, R., Greco, D., et al. (1990). Acromegaly in 14 cats. *J Vet Intern Med* 4(4), 192–201.

Norsworthy's Notes

The acromegalic cat is usually presented because it is diabetic. Regulation becomes almost impossible, with required doses of insulin often over 20 units twice daily. A dose of more than 10 units twice daily should cause one to screen for acromegaly using the IGF-1, which, unfortunately, is not 100% sensitive or specific.

CHAPTER 4

Actinomycosis

Sharon Fooshee Grace

Overview

Actinomycosis is a suppurative to pyogranulomatous disease caused by infection with the filamentous, Gram-positive, nonacid-fast bacterium *Actinomyces* spp. It is an anaerobic or facultative anaerobic organism found as a saprophytic inhabitant of mucous membranes, most notably the oral cavity. Endogenous species are not normally considered highly pathogenic. Disease will usually not develop until the organism is inoculated into a wound in association with other bacteria (typically, other commensal organisms from the oral cavity).

Though it is occasionally seen in cats, few cases have been detailed in the literature. However, several different species of the organism have been recovered from cats. Establishment of infection in cats is thought to most commonly occur through bite wounds, although other modes are possible. It spreads locally by dissection through normal tissue planes; hematogenous dissemination is possible but uncommon.

This disease has a variety of presentations that are clinically indistinguishable from other infectious diseases, particularly nocardiosis. Affected cats most often have cutaneous/subcutaneous and thoracic disease (empyema, pyothorax). Cutaneous/subcutaneous lesions may appear acutely or peracutely and are often around the head or neck. One case had local extension of a subcutaneous abscess into the spinal canal. Wounds often become chronic and non-healing and may be abscessed or produce draining tracts with a serosanguinous to purulent exudate which is yellow to reddish-brown in color. See Figure 4.1. Abscesses may have a foul odor, which is suggestive of an anaerobic infection. Drainage sometimes contains grossly visible clusters of bacterial macrocolonies called "sulfur granules." Occasionally, cutaneous lesions are nodular in appearance and devoid of drainage. See Figure 4.2a. The lung and pleural space may become involved by aspiration or inhalation of infected material, direct extension from more superficial disease, or perhaps through a bite wound to the chest. Respiratory infection may involve the lung itself or only the pleural space, and clinical signs are consistent with pulmonary or pleural disease.

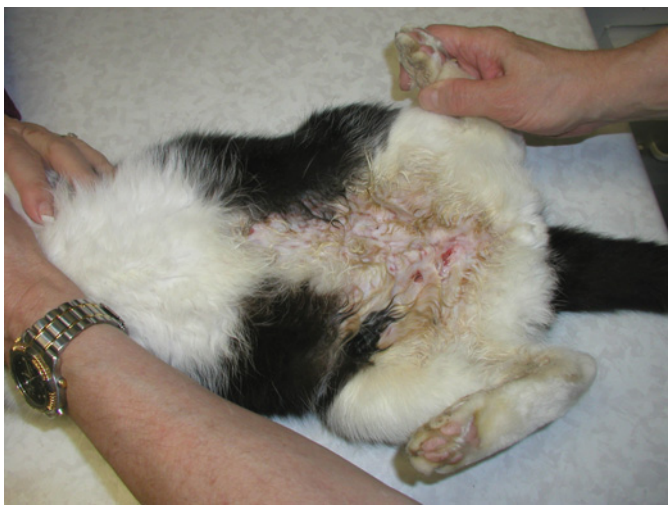


Figure 4.1 Multiple draining fistulas are seen on the ventral abdomen of this cat with actinomycosis. Image courtesy of Dr. Gary D. Norsworthy.

Important differential diagnoses for actinomycosis include but are not limited to nocardiosis (Chapter 153), mycobacteriosis (Chapter 147), leprosy (Chapter 128), plague (Chapter 172), sporotrichosis (Chapter 206), dermatophyte kerion (Chapter 47), dermatophilosis, and panniculitis (Chapter 165).

No cases of human actinomycosis have been reported from direct contact with an infected cat, although it may be transmitted through the bite wound of an animal.

Diagnosis

Primary Diagnostics

- Cytology and Gram Staining: Specimens for cytology may be collected by aspiration of abscesses, nodules, or body cavity fluid; impression smears may be made from the discharge of draining tracts. The organisms, easily visualized microscopically, are filamentous and occasionally branched. They sometimes stain irregularly, giving a beaded appearance. A variety of inflammatory cells may be present but neutrophils typically predominate and macrophages are variably present. See Chapter 284. A polymicrobial infection is usually noted. In contrast, exudate from lesions of nocardiosis does not usually contain a mixed bacterial population. Fibrous masses without drainage may yield little diagnostic material. On Gram-stain, the organisms are Gram-positive.
- Culture: Because actinomycosis (variably anaerobic or facultative anaerobic) is clinically indistinguishable from nocardiosis (an aerobe) (see Chapter 153 and Figure 284.1), both aerobic and anaerobic cultures of should be submitted. Culture for actinomycosis is often unrewarding because anaerobes are difficult to grow in culture, although some species are facultative anaerobes and may grow aerobically. Other organisms are likely to grow in addition to *Actinomyces* because it is usually a mixed bacterial infection, but they may complicate isolation of *Actinomyces*.
- Biopsy/Histopathology: Histologic study of tissue reveals a suppurative to pyogranulomatous reaction. There may be a core of neutrophils encapsulated by granulation tissue containing macrophages, plasma cells, and lymphocytes. Organisms may not be evident with routine hematoxylin/eosin stain and special stains may be needed.
- Acid-fast Staining: A small amount of exudate can be smeared onto a microscope slide and submitted for acid-fast staining with Ziehl–Niessen stain. *Actinomyces* is a nonacid-fast organism.

Secondary Diagnostics

- Complete Blood Count/Chemistry Profile/Urinalysis: There are no laboratory abnormalities specific for actinomycosis. However, this information is helpful in evaluating the cat's overall health.
- Retroviral Testing: All cats with nonhealing wounds or pyothorax should be tested for feline leukemia virus and feline

The Feline Patient, Fifth Edition. Edited by Gary D. Norsworthy.

Companion website: www.wiley.com/go/norsworthy/feline

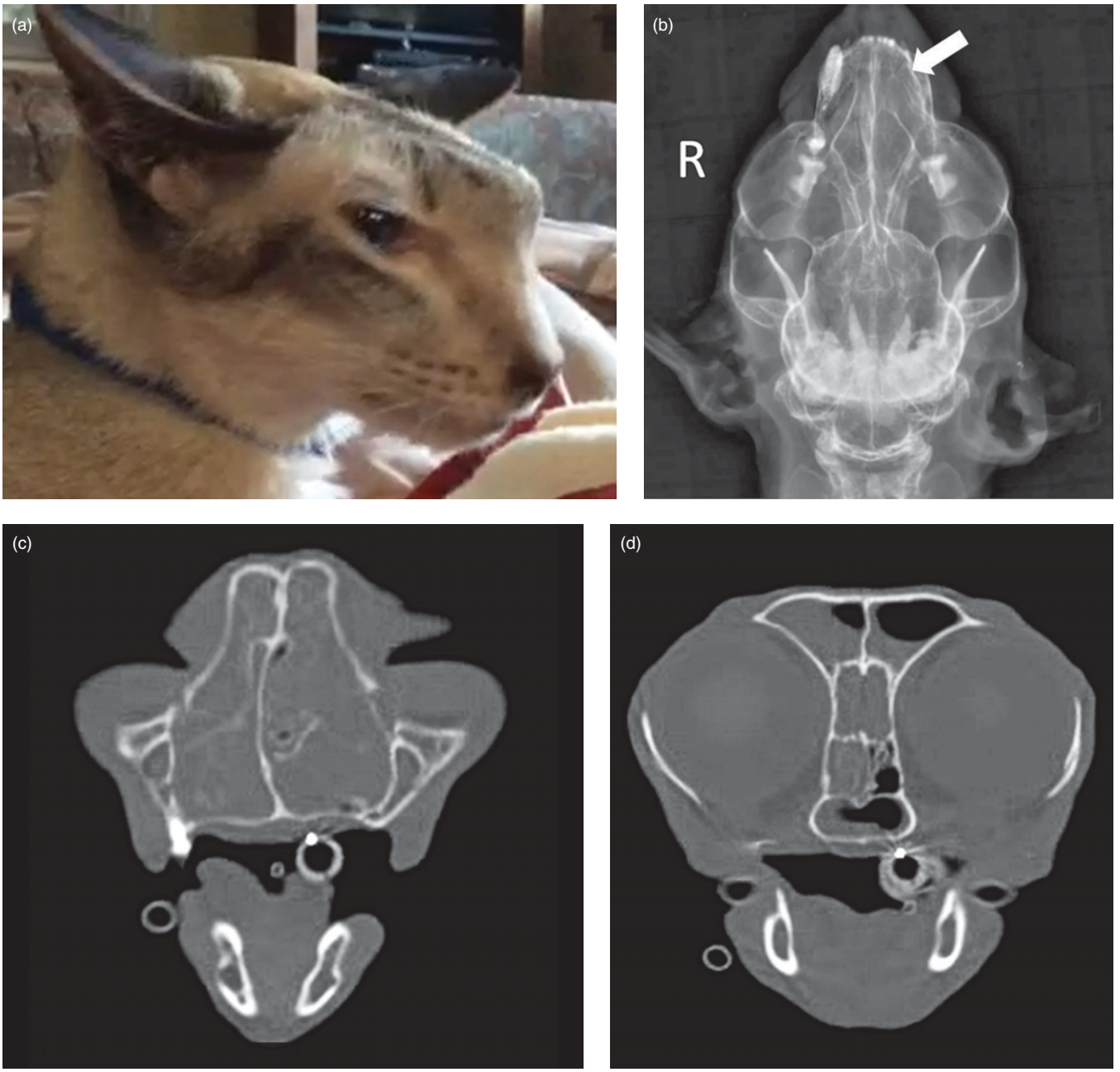


Figure 4.2 Actinomycosis was diagnosed in this cat with nasal disease based on histopathology and growth on an aerobic culture. (a) The infection caused a swelling over the nose on the midline. (b) Radiographs showed increased density in the nasal cavity, especially on the left (*arrow*). (c) A CT scan showed significant turbinate damage and displacement of the nasal septum from left to right and (d) disease in the frontal sinuses. Images courtesy of Dr. Gary D. Norsworthy.

immunodeficiency virus. There is no evidence that retroviral infections predispose cats to actinomycosis.

- Diagnostic Imaging: Radiographs are indicated if pleural or peritoneal involvement is suspected. Abdominal ultrasound may be needed to investigate possible abdominal abscesses. Computerized tomography (CT) scans or radiographs are helpful if nasal disease is present. See Figure 4.2b–d.

Diagnostic Notes

- It is important to distinguish actinomycosis from nocardiosis because different antibiotics are required to treat the two diseases.

Therapy

Primary Therapeutics

- Antibiotics: If the animal is stable and not anorexic or vomiting, initial therapy may be given by the oral route. Antibiotics must be administered for weeks to months beyond clinical resolution of disease to prevent relapse. Penicillins are the drugs of choice, with amoxicillin considered the preferred medication at 20–40 mg/kg q6h IM, SC, or PO. Amoxicillin may be best tolerated if given with food; this will not impair absorption. Other antibiotics may be used for cats intolerant of penicillins. Clindamycin may

be given (5–11 mg/kg q12h PO). Several other drugs are reported to have efficacy, including doxycycline, tetracycline, erythromycin, and first-generation cephalosporins. Antibiotics are not a substitute for drainage of free fluid and abscesses.

- Surgery: Where possible, focal lesions should be surgically debrided and adequate drainage established.
- Thoracic or Abdominal Drainage: Pyothorax should be addressed with a thoracic drainage system and saline lavage twice daily (see Chapter 274). This therapy should be continued until evacuated thoracic fluid is clear and no organisms are found on cytologic examination of the fluid. This normally requires 4–10 days. Some have advocated thoracic lavage with fluids containing sodium penicillin (not potassium penicillin). Surgical exploration of the abdomen will likely be required for abdominal infections.

Therapeutic Notes

- Drug penetration into granulation tissue can be problematic.
- In some cases, the course of therapy has extended beyond a year.

Prognosis

Prognosis is variably reported from guarded to good in cats with actinomycosis.

Suggested Readings

Sykes, J. (2012) Actinomycosis and nocardiosis. In: *Infectious Diseases of the Dog and Cat*, 4th edn (ed. C.E. Greene), pp. 484–495. Elsevier, St. Louis.

Sykes J. (2014) Actinomycosis. In: *Canine and Feline Infectious Diseases* (ed. J.E. Sykes), pp. 399–408. Elsevier, St. Louis.

Thomovsky, E., Kerl, M. (2008) Actinomycosis and nocardiosis. *Compend Contin Educ* 10(3), 4–10.

Norsworthy's Notes

As with any disease that produces draining tracts, aggressive diagnostics (biopsy and histopathology with aerobic and anaerobic cultures of material taken within the biopsy site) are usually less expensive in the long term than multiple therapeutic trials that take weeks to declare ineffective while the cat continues to decline. Get the diagnosis first, and then treat specifically.

CHAPTER 5

Adenocarcinoma and Carcinoma

John Metcalfe Thomason

Overview

Carcinomas are neoplastic tumors that arise from epithelial tissue, and tumors that develop from the glands and ducts of glandular tissue are considered adenocarcinomas. With so much epithelial or glandular tissue in the body, both carcinomas and adenocarcinomas can originate in many locations. The most common feline carcinoma is squamous cell carcinoma (SCC), and adenocarcinomas will commonly arise from the nasal cavity, lung, gastrointestinal tract, pancreas, liver, urinary tract, and mammary glands. Clinical findings are extremely variable and highly dependent on tumor location. Unfortunately, there are few studies that document carcinoma and adenocarcinoma behavior in cats, therefore much of our understanding is extrapolated from dogs. However, there are significant differences in tumor prevalence, behavior, and prognosis between these species.

All carcinomas and adenocarcinomas will be locally invasive, but the metastatic rate and location of metastasis is highly variable and depends on the type of tumor. For example, nasal adenocarcinoma slowly metastasizes to the regional lymph nodes and eventually the lungs, whereas pancreatic adenocarcinoma rapidly metastasizes to mesenteric lymph nodes and liver. In highly metastatic tumors, patients may present with clinical signs attributable to the metastatic lesions instead of the primary tumor. In some cases, carcinomas and adenocarcinomas can aggressively spread throughout a body cavity (thorax or abdomen), creating a condition known as carcinomatosis (see Chapter 29). With the aggressive spread of carcinomatosis, it can be difficult to identify the tissue of origin.

Adenocarcinoma is one of the most common tumors that develop in nasal cavity of cats, but nasal lymphoma, SCC, and undifferentiated carcinomas will also occur. Patients with nasal adenocarcinoma will commonly present with sneezing, nasal discharge, abnormal respiratory noises, and decreased appetite (see Chapter 149). Radiation therapy is the most common and effective treatment modality for nasal adenocarcinoma.

Primary feline lung tumors are uncommon to rare, with pulmonary metastatic tumors occurring more frequently. Adenocarcinomas are the most common primary lung tumor in cats, but carcinomas (SCC and undifferentiated) can also occur. Pulmonary adenocarcinomas can be classified based on location (bronchial, bronchoalveolar, or alveolar carcinoma). Patients with primary lung tumors will demonstrate respiratory signs, but tumor growth is usually advanced before any clinical signs are observed. Unlike dogs, cats do not readily develop a cough, and the identification of a pulmonary tumor may be completely incidental. Other clinical signs of pulmonary tumors include weight loss, decreased appetite, lethargy, wheezing, cyanosis, hemoptysis, and lameness (see Chapters 56 and 166). Cytological or histopathological evaluation is required to obtain a diagnosis, and samples can be obtained via bronchoscopy with bronchoalveolar lavage, lung aspiration, or a complete or partial lung lobectomy.

Carcinomas and adenocarcinomas will develop throughout the entire gastrointestinal tract. SCC is the most common oral tumor in cats and commonly invades bone, but it has a low metastatic rate (see Chapter 155). Salivary gland cancer is rare in cats, but the most common tumor type is adenocarcinoma, which can arise from the major or minor salivary glands. Male cats are twice as often affected as female cats, and Siamese cats have a higher risk for development of salivary gland adenocarcinoma than other breeds. At the time of diagnosis, cats may have advanced disease, with 39% of cats having regional lymph node involvement and 16% of cats having distant metastasis. In the esophagus, SCC is the most common tumor. Female cats are more likely to develop this tumor than males, and it is locally invasive. However, it will metastasize to the local lymph nodes.

Although containing a large amount of glandular tissue, feline gastric adenocarcinoma is rare, and lymphoma is the most common gastric tumor. A variety of tumor types, carcinomas, sarcomas, and round cell tumors can be identified in the feline intestines, with lymphoma being the most common intestinal tumor and adenocarcinoma being the second most common tumor. Siamese cats may be overrepresented in cases of intestinal adenocarcinoma. The small intestine is the most common location of adenocarcinoma formation, but they rarely develop in the colon.

Carcinomas are the most common neoplasia in the feline exocrine pancreas and can originate from the ductal epithelium (carcinoma) or acinar cells (adenocarcinoma). Aggressive infiltration and metastasis to the liver and lymph nodes are common. Pancreatic tumors may present like pancreatitis and require additional diagnostic tests (pancreatic lipase immunoreactivity levels, ultrasound, and cytological or histopathological evaluation) to obtain an accurate diagnosis. On abdominal ultrasound, a single mass greater than 2 cm is more predictive of neoplasia than nodular hyperplasia. Bile duct carcinoma (cholangiocarcinoma) and hepatoceullar carcinoma are the most common hepatic tumors in cats.

Although uncommon to rare, carcinomas and adenocarcinomas can occur in other organs. Lymphoma is the most common renal tumor, but renal carcinoma and adenocarcinoma can develop in cats. These tumors metastasize rapidly and have been associated with a paraneoplastic polycythemia. Like dogs, transitional cell carcinoma (TCC) is the most common urinary bladder tumor in cats. Unlike dogs, feline TCC will commonly occur in male cats and develop in the apex of the urinary bladder. Mammary adenocarcinoma (see Chapter 135) and cutaneous squamous cell carcinoma (see Chapter 207) are common feline tumors.

Diagnosis

Primary Diagnostics

- Imaging: Other than cutaneous or subcutaneous carcinomas, radiography is usually the first diagnostic test needed to identify the tumor. However, more advanced imaging modalities, such ultrasound, computerized tomography, or magnetic resonance imaging, will better define tumor margins, determine the presence and extent of metastasis, aid in sample collection (aspirate and biopsy), and assist in surgical planning or radiation therapy.
- Cytology: Carcinomas will exfoliate well, and a diagnosis of a carcinoma can be made on cytology alone, but the exact type of carcinoma may not be able to be identified. The cytological features of carcinomas are outlined in Chapters 282 and 291.

The Feline Patient, Fifth Edition. Edited by Gary D. Norsworthy.

Companion website: www.wiley.com/go/norsworthy/feline

- Histology: Cytology may be non-diagnostic, and incisional or excisional biopsy must be performed to obtain a diagnosis. The biopsy technique will depend on tumor location, and some of the more common biopsy techniques include ultrasound-guided aspiration/biopsy, laparoscopy/thoracoscopy, or exploratory laparotomy/thoracotomy. If surgical resection is required, previous biopsy sites and tracts should be completely excised during surgery. Either cytological or histopathologic examination is required to obtain a definitive diagnosis.

Diagnostic Notes

- Effusions and some tumor types, for example urinary tract and prostate, may include cells that, based on cytological appearance alone, are notoriously difficult to accurately define as benign or malignant. Histopathology is required to obtain an accurate diagnosis of these tumors.
- Unfortunately, aspiration or biopsy of some carcinomas has been associated with seeding of tumor cells along the needle tract or surrounding tissues. Care should be taken to minimize the number of times needles are inserted into the tumor and the smallest gauge needle that provides an effective diagnosis should be used for the procedure.

Therapy

Primary Therapeutics

- Surgery: Surgery is the most common and effective treatment modality for carcinomas and adenocarcinomas. In cases with a single tumor with no detectable metastatic lesions, surgery can be curative. However, depending on tumor location, surgical procedure, and presence of metastatic lesions, surgery may not be feasible.
- Radiation Therapy: Radiation therapy is a viable treatment option, especially as an adjuvant therapy following incomplete resection of the primary tumor. Additionally, radiation therapy can be a primary treatment option for tumors that are not amenable to surgical resection, such as nasal adenocarcinoma. Although effective, radiation therapy may cause significant and debilitating side effects, and consultation with a veterinary oncologist is recommended.
- Chemotherapy: Carcinomas and adenocarcinomas have variable responses to chemotherapy but may be considered in patients with tumors that are high grade, incompletely excised, or not amendable to surgical resection. The chemotherapy treatment protocol is dependent on the type of tumor.
- COX-2 Selective NSAIDs: Although not classified as a chemotherapy agent, COX-2 selective NSAIDs can be an effective treatment modality in cats. However, NSAIDs are associated with undesirable side effects, and patients should be closely monitored.

Therapeutic Notes

- Consultation with a veterinary oncologist regarding a specific case may provide an ideal therapeutic plan with an accurate prognosis.

Prognosis

The prognosis for cats with carcinoma or adenocarcinoma is dependent on the type and location of tumor and the ability to effectively treat the tumor, especially complete surgical excision. Tumors that can be surgically resected and have no detectable metastatic lesions will usually have a good prognosis.

Suggested Readings

Kosovsky, J.E., Matthiesen, D.T., Patnaik, A.K. (1988) Small intestinal adenocarcinoma in cats: 32 cases. *J Am Vet Med Assoc* 192, 233–235.

Liptak, J.M., Withrow, S.J. (2007) Cancer of the gastrointestinal tract. In: *Small Animal Clinical Oncology*, 4th edn (eds S.J. Withrow & D.M. Vail), pp. 455–510. Saunders Elsevier, St. Louis.

Withrow, S.J. (2007) Tumors of the respiratory system. In: *Small Animal Clinical Oncology*, 4th edn (eds S.J. Withrow, D.M. Vail), pp. 511–539. Saunders Elsevier, St. Louis.

Norsworthy's Notes

These tumors can be found almost anywhere in the body, are largely resistant to chemotherapy and radiation therapy, and are best treated with wide surgical excision if wide margins are possible and if they have not metastasized. In many cases, adenocarcinoma and carcinoma are not diagnoses with happy outcomes.

CHAPTER 6

Amyloidosis

Andrew Sparkes

Overview

Amyloidosis is a diverse group of diseases characterized by deposition of inert, insoluble, extracellular protein fibrils (amyloid) that have a distinctive three-dimensional conformation. Although more than 25 chemical types of amyloid have been identified in man and animals, they all share the morphology of being composed of non-branching fibrils, approximately 7–10 nm thick and of variable length (β-sheets). Histologically, amyloid deposits in tissues are amorphous and demonstrate apple-green birefringence when stained with Congo red.

Amyloid fibrils have the potential to form when there is an accumulation of an amyloidogenic protein (increased synthesis or decreased degradation). Some normal proteins may can form amyloid fibrils if present in high enough concentrations; other proteins may become amyloidogenic as a result of genetic mutation (leading to production of an abnormal, amyloidogenic protein) or as a result of post-translational events that affect the protein. Over time, accumulation of amyloid in tissues can lead to interference with their structure and function and thus lead to development of disease.

A variety of amyloid-related diseases have been identified and described in cats. Importantly, these include:

- Diabetes Mellitus*:* Many diabetic cats have an accumulation of amyloid in their pancreas, which is derived from the hormone amylin that is co-secreted with insulin from β cells. Amylin is an amyloidogenic protein in a few species including man and cats, and pancreatic amyloidosis plays a part of the pathogenesis of humans with type-2 diabetes. Although pancreatic amyloid is often found in diabetic cats, it is also found in healthy age-matched cats, and its role in feline diabetes needs further exploration.
- Alzheimer-like Pathology in Aging Cats: Studies have demonstrated amyloid plaques and fibrils in the brains of aging cats, which bear close resemblance to the changes seen in humans with Alzheimer's disease and related neurodegenerative disorders. Importantly cats appear to develop similar neurofibrillary tangles that are considered important in the pathology of Alzheimer's. Affected cats suffer neuronal loss and the changes are likely to be related to the development of cognitive dysfunction.
- Prion Diseases: These are a form of amyloidosis. Although no longer recognized in cats, the emergence of bovine spongiform encephalopathy led to its spread to cats in the form of feline spongiform encephalopathy in the 1990s.
- Immunoglobulin Light-chain Associated Amyloidosis: As in other species, cats with plasmacytomas may produce excessive immunoglobulin light-chain fragments, and these may be amyloidogenic (AL amyloid). Generally, the amyloid appears to be deposited locally and predominantly within the neoplastic tissue.
- Reactive (Secondary) Amyloidosis (AA-amyloid): This is the most commonly described form of amyloid in veterinary medicine and is well recognized in cats. The amyloid is derived from serum amyloid-A (SAA), an acute phase protein produced in the liver. In reactive amyloidosis, amyloid deposits have been found in the liver, spleen, adrenals, small intestine, stomach, endocrine and exocrine pancreas, thyroids, parathyroid, heart, tongue, and kidneys. Despite the generalized nature of the deposits, the heaviest deposits usually occur in the liver (leading to spontaneous hepatic rupture) or the kidneys (leading to chronic renal disease as the deposits are primarily in the medullary interstitial space).

Reactive amyloidosis may occur sporadically secondary to inflammatory or neoplastic diseases in any breed of cat and recently has been associated with chronic feline immunodeficiency virus infection. Predispositions have been described in Abyssinian cats and in Oriental Shorthair cats. Familial amyloidosis in Abyssinian cats has been well characterized in the United States, where AA-amyloid accumulates in a wide variety of tissues, but clinical signs relate to accumulation in the renal medullary interstitium that leads to chronic renal disease. Affected cats have typically developed renal disease at around 1–5 (average 3) years of age, but some older cats that die of other causes have also been found to have subclinical renal amyloidosis. It has been suggested that this might be inherited as an autosomal dominant trait with incomplete penetration.

Many publications have now appeared identifying systemic amyloidosis in Siamese and Oriental cats. In contrast to Abyssinians, in many of these cats the liver is most severely affected, although widespread amyloid deposits are typical; this may include renal amyloidosis, and, thus, concomitant chronic renal disease may also be present. Heavy amyloid accumulation in the liver leads to dramatic friability of the liver with spontaneous or easily induced rupture evidenced by recurrent or catastrophic bleeding episodes into the abdomen.

Current research suggests that affected Siamese and Oriental Shorthair cats have genetic mutations resulting in amino acid substitutions in the serum AA protein that renders it more amyloidogenic. But similar to the situation in Abyssinians, for the disease to develop there probably also needs an inflammatory process(es) to increase the production of SAA in most cases. Further studies are necessary to clarify the heritability of the disease in these breeds.

The clinical signs in cats with systemic amyloidosis can be diverse. There may be progressive chronic kidney disease (that may develop at a relatively young age), although the rate of progression is variable. When hepatic amyloidosis predominates, there may be mild to profound elevations in liver enzymes, and cats often present with recurrent bouts of lethargy associated with acute onset anemia (due to abdominal hemorrhage), or acute death, or life-threatening anemia due to a catastrophic hemorrhagic event. Clotting times are prolonged in some affected cats.

Diagnosis

- Radiographs: In cases of hepatic amyloidosis, abdominal radiographs may show an irregular hepatomegaly. See Figure 6.1.
- Ultrasound: Hepatic ultrasound may show a diffuse increase in echogenicity, and there may be a speckled or "sparkling" (hyperechoic) appearance. See Figure 6.2. Additionally, following an acute episode of hemorrhage, ascites (hemoperitoneum) may be detectable on ultrasound.
- Histopathological examination of appropriate biopsies, stained with Congo red, is recommended for a diagnosis of amyloidosis. Additional investigations, including immunohistochemistry, are necessary to characterize the type of amyloid present.

The Feline Patient, Fifth Edition. Edited by Gary D. Norsworthy.

Companion website: www.wiley.com/go/norsworthy/feline

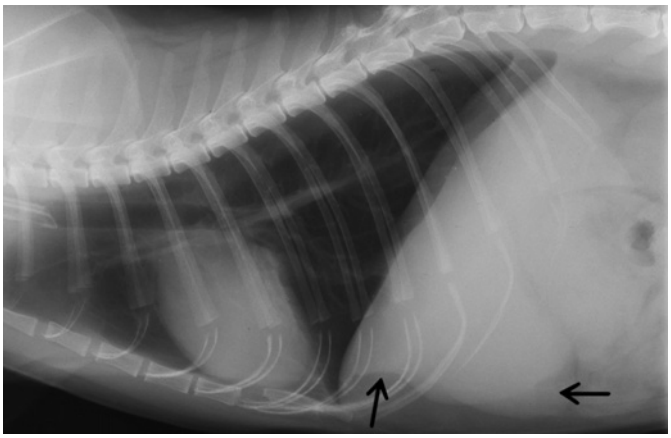


Figure 6.1 Lateral radiograph of a cat with severe hepatic amyloidosis. Irregular hepatomegaly (*arrows*) is evident.

- Due to the potentially very friable nature of the liver and the risk of hemorrhage (if affected by amyloidosis), in suspected cases hepatic biopsies may be best performed at laparotomy rather than "blind" or ultrasound-guided needle biopsies.
- Although biopsy material is preferable for confirmation, in some cases a diagnosis of amyloidosis may be possible from fine-needle aspirates from affected tissues.
- Recent investigations suggest urine concentrations of serum amyloid A may become elevated in Abyssinian cats before the onset of other clinical signs of amyloidosis, but the value of this as a diagnostic test requires further investigation.

Therapy

- Amyloidosis is not a curable disease, and efforts should be made to identify and treat any concomitant diseases that may be predisposing to amyloid deposition (e.g., infectious/inflammatory diseases) and to managing the effects of the amyloidosis.

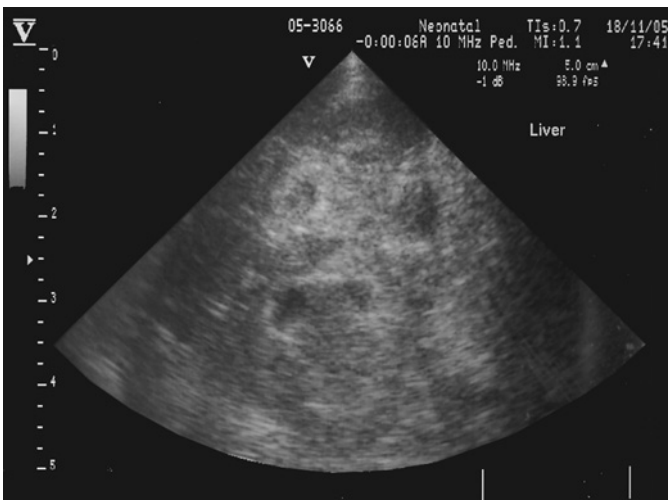


Figure 6.2 Hepatic ultrasound of the same cat showing that the normally homogenous echo-pattern has been replaced by a mixed echogenic pattern.

- Medical treatments have been attempted, but it is unclear whether any of these approaches have any genuine clinical benefit:
  - Vitamin K therapy: Give 10 mg/cat q7d PO, especially if there is evidence of prolonged clotting times.

  Prednisolone: Give at anti-inflammatory doses (1–2 mg/kg q24-48 h PO) to manage underlying inflammatory disease.
  - Colchicine: Give 0.03 mg/kg q24–48 h PO as it may reduce SAA production in other species (but there is no data on its efficacy in cats).
- Supportive Therapy: When chronic kidney disease develops, standard supportive treatments should be considered (see Chapter 193). If severe hemorrhage occurs, blood transfusion may be considered. Cats with hepatic amyloidosis should have a lifestyle that will minimize the risk of even mild abdominal trauma.
- Prevention of systemic amyloidosis may be possible through selective breeding programs. Because many cats with systemic amyloidosis develop disease at a relatively young age, breeding from older healthy cats may be beneficial. Current research is aiming to identify underlying genetic abnormalities (and thus diagnostic tests) in affected breeds/lines of cats.

Prognosis

The prognosis for cats with clinical systemic amyloidosis is grave. Currently there is no known effective treatment, and the disease is progressive, usually leading to death from renal disease or liver rupture.

Suggested Readings

Asproni, P., Abramo, F., Millanta, F., et al. (2013) Amyloidosis in association with spontaneous feline immunodeficiency virus infection. *J Fel Med Surg* 15(4), 300–306.

Beatty, J.A., Barrs, V.R., Martin, P.A., et al. (2002) Spontaneous hepatic rupture in six cats with systemic amyloidosis. *J Small Anim Pract* 43(8), 355–363.

Chambers, J.K., Tokuda, T., Uchida, K., et al. (2015) The domestic cat as a natural animal model of Alzheimer's disease. *Acta Neuropathol Commun* 3, 78–92.

Gunn-Moore, D.A., McVee, J., Bradshaw, J.M., et al. (2006) Ageing changes in cat brains demonstrated by beta-amyloid and AT8-immunoreactive phosphorylated tau deposits. *J Fel Med Surg* 8(4), 234–242.

Nelson, R.W., Reusch, C.E. (2014) Animal models of disease: classification and etiology of diabetes in dogs and cats. *J Endocrinol* 222(3), T1–9.

Paltrinieri, S., Sironi, G., Giori, L., et al. (2015) Changes in serum and urine SAA concentrations and qualitative and quantitative proteinuria in Abyssinian cats with familial amyloidosis: a five-year longitudinal study (2009-2014). *J Vet Intern Med* 29(2), 505–512.

Zini, E., Lunardi, F., Zanetti, R., et al. (2016) Endocrine pancreas in cats with diabetes mellitus. *Vet Pathol* 53(1), 136–144.

Norsworthy's Notes

Fortunately, this is a very uncommon disease, but it should be a primary differential with renal or hepatic disease in Abyssinians and Oriental Shorthairs, especially young cats in those breeds.

CHAPTER 7

Anal Sac Disease

Gary D. Norsworthy and Anne Romeo

Overview

The anal sacs are located lateral to the anus in the 4- to 5-o'clock and 7- to 8-o'clock positions. They are positioned between the internal and external anal sphincters, and contain sebaceous and apocrine tubular anal glands, which secrete a malodorous substance that is used for scent marking, individual recognition, and defense purposes. This substance is temporarily stored in the paired anal sacs (paranal sinuses), which empty voluntarily when the cat feels threatened or involuntarily with bowel movements. If the sacs are not emptied periodically, the anal gland secretion desiccates and thickens. See Figure 7.1. At this stage, the anal sacs are said to be impacted; the cat exhibits pain when defecating and may experience tenesmus. The cat responds by licking or biting at the tail head region. If infection occurs within the sacs, pain will increase. Abscess formation may follow, resulting in expulsion of purulent material through a draining tract over one or both anal sacs. See Figure 7.2. Thus, the three stages of anal sac disease are impaction, infection, and abscessation. See Web Figures 7.1 to 7.3.

An unrelated anal sac condition is incompetence of the anal sac sphincters. When affected, cats spontaneously release normal anal sac material involuntarily. Although uncommon and of no health threat to the cat, this condition is not well tolerated by owners of indoor cats.

Rarely, anal sac adenocarcinoma occurs. See Web Figure 7.4.

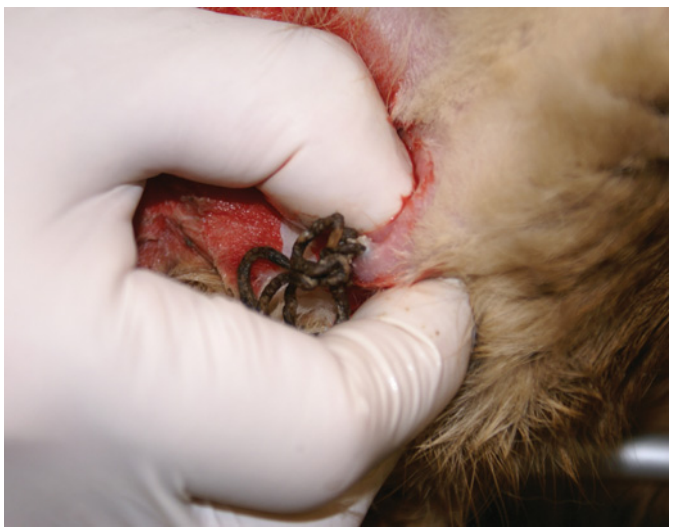


Figure 7.1 Desiccated, thick anal sac material was expressed from the right anal sac of this cat. This is the first step in anal sac disease.

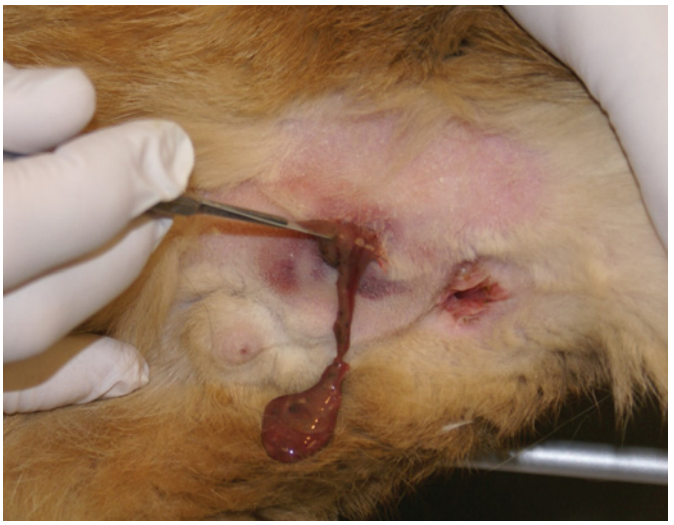


Figure 7.2 The left anal sac of the cat in Figure 7.1 was abscessed. It was surgically opened with an incision over the abscess. Blood tinged purulent material drained freely.

Diagnosis

Primary Diagnostics

- Clinical Signs: The signs of tenesmus, licking at the perineal region, and a draining tract are characteristic of anal sac disease. Spontaneous release of anal sac material is characteristic of anal sac sphincter incompetence.

Diagnostic Notes

- Anal sac disease of dogs usually produces scooting. Scooting is not a common finding in cats with anal sac disease.
- Some cats with anal sacculitis may lick the perineal area, the flanks, and the caudal thighs, producing a symmetrical pattern of alopecia.

Therapy

Primary Therapeutics

- Manual Expression: This procedure should permit removal of thickened secretions. Anesthesia or sedation is often required because of the cat's tight anal sphincter and small anal size. The first phalanx of one's index finger or thumb is inserted into the anus. The anal sac is squeezed between it and the other mentioned digit. See Figure 7.1.
- Irrigation: An antiseptic solution, such as dilute chlorhexidine, is used to flush remaining dried debris from ruptured anal sac abscesses. Sedation of the cat generally is required.

The Feline Patient, Fifth Edition. Edited by Gary D. Norsworthy.

Companion website: www.wiley.com/go/norsworthy/feline

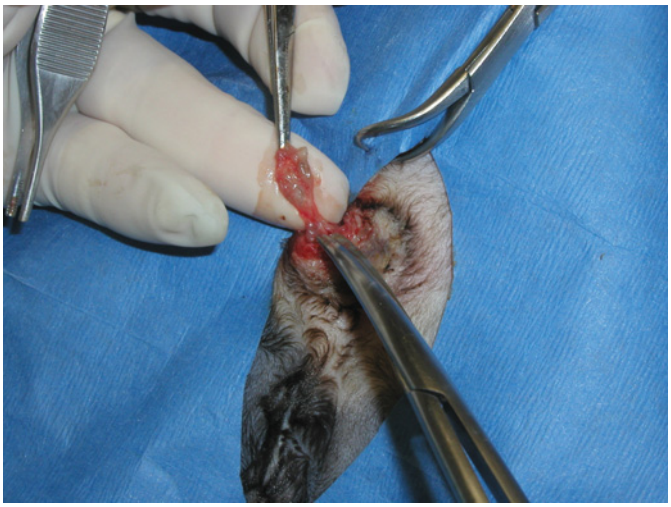


Figure 7.3 Anal sacculectomy is indicated after more than one anal sac infection or for cats with incompetent anal sac sphincters. One or both anal sacs are carefully dissected from the surrounding tissues.

- Antibiotic Instillation: Local treatment with antibiotics is indicated. Drugs expected to be effective against *Escherichia coli*, *Streptococcus fecalis*, and *Clostridium* spp. should be considered.
- Systemic Antibiotics: Systemic antibiotics with the characteristics above speed recovery and should be given for 7–14 days.

Secondary Therapeutics

- Surgical Drainage: Anal sac abscesses that have not drained spontaneously should be opened surgically to establish drainage through the skin. See Figure 7.2.
- Anal Sacculectomy: This procedure should be considered in recurrent cases but should not be performed until infection is resolved. See Figure 7.3. It is the treatment of choice for incompetent anal sphincter disease. Fecal incontinence is a possible sequel, but it occurs infrequently if careful dissection is performed. If it occurs, it usually resolves spontaneously in 7–21 days.

Prognosis

The prognosis is good; however, aggressive therapy as outlined should occur.

Suggested Readings

Zoran, D.L. (2005) Rectoanal disease. In: *Textbook of Veterinary Internal Medicine*, 6th edn (eds S.J. Ettinger & E.C. Feldman), pp. 1408–1420. Elsevier Saunders, St. Louis.

Norsworthy's Notes

Anal sac disease is not as common as in dogs; routine expression of the anal sacs is not recommended as this may damage the sacs and predispose the cat to more anal sac disease. Impaction, infection, and abscessation may occur. Anal sacculectomy should be considered if more than one event occurs. Fecal incontinence occasionally occurs but generally resolves in 1–3 weeks following surgery.

CHAPTER 8

Anaplasmosis (Ehrlichiosis)

Sharon Fooshee Grace

Overview

Although molecular technology has greatly expanded our understanding of bacterial organisms in recent years, it has also created confusion as large numbers of bacteria have been reclassified and renamed. In 2001, the families *Rickettsiaceae* and *Anaplasmataceae*, members of the order *Rickettsiales*, underwent major reorganization. The genera *Ehrlichia* and *Wolbachia* were moved from the family *Rickettsiaceae* to the family *Anaplasmataceae*. The genus *Rickettsia* remained in the family *Rickettsiaceae*. Additionally, species within the genus *Ehrlichia* were significantly reorganized: *E. phagocytophila*, *E. equi*, and *E. platys* now reside in the genus *Anaplasma*; *E. risticii* and *E. sennetsu* have been moved to the genus *Neorickettsia*. Feline ehrlichiosis continues to be an area of active research, but little is known about this disease in cats.

The family *Anaplasmataceae* contains obligate intracellular organisms that parasitize leukocytes, erythrocytes, platelets, and endothelial cells. *Ehrlichia phagocytophila*, the granulocytic *Ehrlichia*, has been renamed *Anaplasma phagocytophilum*. This is a tick-borne organism found in many parts of the world, including the United States. Cats are not infected with tick-transmitted diseases as often as dogs, a finding which has been attributed by some to the fastidious grooming behavior of cats. Ticks are likely removed by cats before the 24–48-hour window required for transmission of most tick-transmitted diseases.

A. phagocytophilum is transmitted transtadially by nymph and adult forms of *Ixodes scapularis* (the deer tick or black-legged tick) or *Ixodes pacificus* (the western black-legged tick). The deer tick is common in the eastern, southeastern, and midwestern United States; depending upon geographic location, it feeds primarily on mammals, birds, or lizards. The western black-legged tick is found in the western United States. Larval forms feed on the white-footed mouse and other small rodents while nymphs and adults have a diverse range of hosts, including white-tailed deer, dogs, cats, and humans.

The disease, formerly called ehrlichiosis, is now called feline granulocytotropic anaplasmosis or simply anaplasmosis. At present, very little is known about the pathogenesis of the disease, although it is likely similar to infection in other species. In the limited number of cases described in the literature, fever is the most consistent finding. Other reported findings are variably present and have included lethargy, weight loss, vomiting, lameness (polyarthritis), and ocular discharge. Most cats have vague, non-specific signs of illness. It is now suggested by the American College of Veterinary Internal Medicine that potential blood donor cats living in endemic areas be screened for *Anaplasma* and have (ideally) polymerase chain reaction (PCR) and seronegative status.

This organism has public health significance as humans are known to be susceptible to the organism. However, there is no evidence that human infection has resulted from contact with a cat.

Diagnosis

Primary Diagnostics

- History: The few cats reported with disease have had access to the outdoors.
- Complete Blood Count/Biochemical Profile/Urinalysis: Thrombocytopenia, the presence of morulae in neutrophils, mild hyperglycemia, and hyperglobulinemia have been reported in infected cats. The organism has been found to rarely infect eosinophils.

Secondary Diagnostics

- Serology: Published studies have utilized immunofluorescent assays and enzyme-linked immunosorbent assay (ELISA) methodology to detect antibodies against the organism.
- Polymerase Chain Reaction Test: PCR testing is available. Consult the diagnostic laboratory prior to sample submission for additional details on sample collection and shipping.

Diagnostic Notes

- Clinical illness may develop prior to seroconversion. Therefore, a single negative antibody test does not exclude infection.

Therapy

Primary Therapeutics

- Antibiotics: Reported cases have appeared to improve when treated with doxycycline (5–10 mg/kg q24h PO) for 21–28 days. The duration of therapy best suited to treat the disease is unknown.

Therapeutic Notes

- Inadequate duration of therapy or selection of antibiotics without efficacy against *A. phagocytophilum* may result in incomplete response to treatment or relapse.
- Antibodies may persist beyond the end of treatment, in some cases for months.

Prevention

The disease can be prevented if tick-control measures are implemented. Cats going outdoors should be treated with topical acaricidal products approved for cats.

Prognosis

Little is known about the disease in cats but, based on cases reported to date, prognosis is generally good if the cat is treated with doxycycline.

Suggested Readings

Allison, R., Little, S. (2013) Diagnosis of rickettsial diseases in dogs and cats. *Vet Clin Pathol* 42(2), 127–144.

Billeter, S., Spencer, J., Griffin, B., et al. (2007) Prevalence of *Anaplasma phagocytophilum* in domestic felines in the United States. *Vet Parasit* 147(2), 194–198.

The Feline Patient, Fifth Edition. Edited by Gary D. Norsworthy.

Companion website: www.wiley.com/go/norsworthy/feline

Lappin, M.R., Breitschwerdt, E.B., Jensen, W.A., et al. (2004) Molecular and serologic evidence of *Anaplasma phagocytophilum* infection in cats in North America. *J Am Vet Med Assoc* 225(6), 893–896.

Savidge, C., Ewing, P., Andrews, J., et al. (2015) *Anaplasma phagocytophilum* infection of domestic cats: 16 cases from the northeastern USA. *J Fel Med Surg* 18(2), 85–91.

Norsworthy's Notes

This disease has clinical signs that could occur in many infectious diseases, including systemic fungal infections. The key is practicing in an endemic area on cats with tick exposure and fever. This would be one of those "zebra" diseases in almost all locales.

CHAPTER 9

Anemia

Sharon Fooshee Grace

Overview

Anemia is a reduction below normal of the number of circulating red blood cells (RBCs) and hemoglobin. It is important to note that the cat's RBC count is normally lower than that of dogs, and they tend to have a less vigorous marrow response to anemia.

There are numerous causes of anemia in the cat. Historical findings depend on the chronicity of the anemia, with acute, rapidly progressing anemias causing more severe signs than chronic, slowly progressing anemias. Many cats with slowly developing anemias will have hematocrits (HCTs) below 10% with minimal clinical signs. Cats may demonstrate mild or severe decreases in activity and mild or severe increases in respiratory effort with more rapidly developing anemias. Physical examination may reveal pale mucous membranes, increased ventilatory effort (especially with stress), a soft systolic heart murmur, tachycardia, and weakness. Many severely anemic cats exhibit pica, often manifested as eating clay-type kitty litter. In examining the anemic cat, particular attention should be given to the size of the peripheral lymph nodes and the spleen, as common neoplastic, infectious, and immune causes of anemia often lead to enlargement of these organs

The initial step in the evaluation of any anemia involves defining the anemia as regenerative or nonregenerative. Circulating reticulocytes (immature red blood cells) should be counted whenever the HCT is less than 20% to assess bone marrow responsiveness. The cat is unique in that two types of reticulocytes may be present. Aggregate reticulocytes are more reflective of a recent regenerative response and contain numerous dark-staining clumps of ribosomes, whereas punctate reticulocytes contain small clumps or specks of ribosomal material. The presence of aggregate reticulocytes is the most reliable indicator of a regenerative response.

Regenerative anemias are associated with three main categories of causes: blood loss, hemolysis, or sequestration. Nonregenerative anemias are caused by decreased production of erythrocytes; the underlying cause may be a disease of the bone marrow or may be secondary to an extramedullary disorder.

TABLE 9.1: Known Causes of Anemia in Cats

Regenerative	Hemolysis
	Erythrocyte parasites: *Mycoplasma haemofelis* and *Candidatus* Mycoplasma haemominutum (formerly known as *Hemobartonella felis*) *Cytauxzoon felis*, *Babesia* spp.
	Immune-mediated destruction (drug-induced, idiopathic, paraneoplastic, toxicity)
	Microangiopathic hemolysis (DIC)
	Oxidative injury (zinc, methylene blue, acetaminophen, benzocaine, phenazopyridine, onions)
	Neonatal isoerythrolysis
	Blood Loss
	Trauma or surgical loss
	Coagulopathy
	External loss (urinary tract, trauma, epistaxis)
	Internal or poorly visualized loss (gastrointestinal, peritoneal, pleural
	Sequestration
	Splenic disease with splenomegaly
Nonregenerative	Intramedullary
	Hematopoietic neoplasia with or without feline leukemia virus or feline immunodeficiency virus infection
	Lymphoproliferative neoplasia
	Myelodysplasia
	Myeloproliferative neoplasia
	Red blood cell aplasia
	Extramedullary
	Chronic inflammatory disease (e.g., fungal disease, feline infectious peritonitis, etc.)
	Chronic renal disease
	Neoplasia
	Poor nutrition or starvation

Diagnosis

Differential Diagnoses

There are many known diseases that cause anemia in cats. They are classified and listed in Table 9.1.

Primary Diagnostics

- Complete Blood Count (CBC): A CBC should be performed if anemia is suspected. Diagnosis of anemia requires identification of erythrocyte numbers or a HCT lower than normal for the individual laboratory. The blood smear should be evaluated for the presence of young red blood cell types (Figure 9.1, Web Video 9.1 and Figure 91.1), red blood cell parasites, Heinz bodies (see Chapter 88) and other morphologic changes, and cytopenias. Because of the small size of feline erythrocytes, spherocytosis (indicative of immune-mediated destruction) is not detectable on feline blood smears.
- Reticulocyte Count: Aggregate and punctate reticulocytes are counted (see Chapter 314) and the percentage that is aggregate reticulocytes is recorded (Figure 9.2). After 5–6 days and with sufficient anemia to stimulate erythrocyte production, the percentage of aggregate reticulocytes should be 1–5%. The feline regenerative response is more subtle than that of the dog with a comparable anemia. Additionally, some peculiarities of the feline erythron occasionally make it difficult to interpret the significance of a response; a veterinary clinical pathologist should be consulted, as needed. The reticulocyte count should be corrected for the HCT:
  - Corrected reticulocyte count = (reticulocyte %) × (patient's HCT/37.5%*)

  (*37.5% = normal hematocrit)

The Feline Patient, Fifth Edition. Edited by Gary D. Norsworthy.

Companion website: www.wiley.com/go/norsworthy/feline