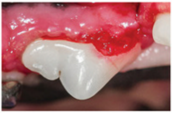
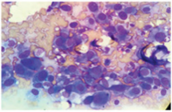
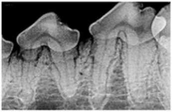
Second Edition

Small Animal Dental Equipment, Materials, and Techniques

Jan Bellows

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This text is personally dedicated to Allison, my wife; our children Wendi, David, and Lauren; our pets present and past – Pepper, Daisy, Chelsea, Lacey, Bailey, Casey, Mollie, Dylan, and Rylee; and to my colleagues, associates, patients, and clients, from whom I have learned so much.

The text is professionally dedicated to Dr. Peter Emily, an educator, friend, and a wonderful person.

Dr. Emily is an accomplished human dentist with a career spanning over 50 years. He received his Doctor of Dental Surgery at Creighton University, Omaha, Nebraska and his Certificate of Periodontology from the University of Pennsylvania. Dr. Emily later went on to receive his postgraduate certification in pediatric dentistry, endodontics, oral surgery, and restorative/prosthetic dentistry from the Dental Division of Denver General Hospital. When Dr. Emily graduated from dental school in the 1960s, the standard operating procedure for animal dentistry was limited to cleaning and extractions.

Through Dr. Emily's efforts, in the mid-1980s, Colorado State University was the first school to offer a course in veterinary dentistry to students and practitioners. He currently holds the position of faculty affiliate of animal dentistry at Colorado State University, College of Veterinary Medicine. He also is a past dental faculty affiliate at the University of Missouri at Columbia, and is director of exotic animal dentistry at the Denver Zoological Gardens.

Dr. Emily is an honorary Diplomate of the American Veterinary Dental College and an honorary Fellow of the Academy of Veterinary Dentistry. Further, Dr. Emily is past president of the American Veterinary Dental Society (AVDS) and was instrumental in the creation of the Academy of Veterinary Dentistry as well as the American Veterinary Dental College (AVDC). He helped develop and administer the initial Academy of Veterinary Dentistry (AVD) entrance exam and the three-part exam for acceptance into the American Veterinary Dental College. Additionally, Dr. Emily designed the logo and the pins for the AVDS, AVD, and AVDC, for the review and assessment exam, and also hand-casts the custom gold medallions for the research and education award.

Dr. Emily became involved with judging show dogs, and with his years of experience shared findings on canine malocclusion and inherited defects in the veterinary literature. When not working in the mouths of people and animals, Dr. Emily serves as the dental consultant and conformation judge for the American Kennel Club. Dr. Emily has also worked extensively on the biomechanics of movement and kinesiology.

The Denver Zoo has also called upon Dr. Emily to perform surgery on the beaks on hornbills and toucans, as well as caring for kangaroos, lions, tigers, wild dogs, polar bears, grizzlies, and orangutans. In the early days, many zoos did not have the proper facilities for working on exotic animals, so improvisation was key. A perfect example of Dr. Emily thinking quickly on his feet was while aiding the Denver Zoo, he used a hydraulic lift of a pickup truck to lift a polar bear during a surgical root canal. Although retired, Dr. Emily continues to work with the Denver Zoo, Siegfried and Roy, Deer Creek Animal Hospital, and on many interesting cases placed in front of this ever-curious innovator and lover of animals.

Dr. Emily has authored and coauthored three veterinary dental textbooks and many dental articles. He has lectured extensively on all phases of animal dentistry for over 40 years to veterinary groups and dog clubs throughout the USA, Europe, Australia, New Zealand, China, Brazil, and Japan. In addition, he has also conducted research and development of veterinary dental medicaments and oral health aids.

Dr. Emily's desire to care for the untreated painful oral conditions in animals housed in wildlife sanctuaries resulted his initial funding and creation of the Peter Emily International Veterinary Dental Foundation (PEIVDF). Together with board-certified veterinary dentists, human dentists, and students, the foundation has treated over 500 animals in 20 sanctuaries.

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About the Author

Jan Bellows is a veterinarian with more than 40 years of experience in small-animal medicine, dentistry, and surgery. He is board-certified by the American Veterinary Dental College and the American Board of Veterinary Practitioners (canine and feline specialties). Dr. Bellows sees dental referrals at All Pets Dental in Weston, Florida.

Foreword

To quote a professor of mine from dental school, "the ultimate function of the musculature and skeletal system of all animals is mobility for food gathering."

Veterinary medicine, for years, has overlooked one of the two basic functions for life. The lion can run to the food, but with broken teeth and advanced dental disease, cannot capture prey or eat – it dies. The lion that has reasonable oral health, but cannot move to the food – dies. Without proper oral health, one of the two functions for survival is compromised. For confirmation of this, we have only to regard the media advertisements, extolling the virtues of exercise (movement), proper diet (eating), and attending to all aspects of oral health.

Until recently, veterinary medicine has treated disease and restored somatic function to the highest level while overlooking dentistry beyond prophylaxis and extraction. In the early days of veterinary dentistry, invitations to present dentistry at conferences were very difficult to attain. When presentations were held, they were poorly attended, with one of the first six-hour lecture series attracting one participant for the entire day.

In the 1980s, veterinary dentistry gained some momentum from a series of continuing education seminars, which presented all disciplines of dentistry in major US cities. For 10 years, the "CE Seminars" consisted of Saturday lectures and Sunday labs. Then, after much persuasion, Colorado State University School of Veterinary Medicine became the first school to offer a course in veterinary dentistry. Veterinary dentistry is now recognized as a viable veterinary specialty. Dental seminars with excellent papers and presentations at major veterinary conferences are well attended. Many schools of veterinary medicine have formal dental curricula.

Many years ago, I was called from CSU to treat a lioness with advanced endodontic disease. To prevent inflicted trauma, all four canines had been brutally cut to the gingiva some 18 years ago. I realized that this was one of thousands of captive exotic animals with advanced dental disease that received little to no treatment, whether due to lack of funding or the availability of an experienced veterinary dentist familiar with exotic animal dentistry. It was from that case (and the memory of so many others) that the Peter Emily International Veterinary Dental Foundation was born. Our foundation now provides dentistry for exotic animals residing in sanctuaries, shelters, and zoos worldwide.

After years of extensive research and writing, Dr. Bellows has presented the field of veterinary dentistry with a very well-constructed second edition of his text, "Small Animal Equipment, Materials, and Techniques." This is a beautifully illustrated well-organized text detailing all phases of companion animal dentistry including the creation of a well-organized and well-equipped dental operatory, as well as a review of all the dental disciplines – it is a comprehensive publication.

Dr. Bellows' dental books are well read throughout the world. All are of the highest quality and very well presented, making this text a must read for all interested in dentistry, from those looking to expand their practice to include veterinary dentistry, to current dental practitioners. Along with his many accomplishments in all phases of veterinary dentistry, Dr. Bellows is an advanced exotic animal dentist for the Peter Emily International Veterinary Dental Foundation – what better credentials could there be?

Peter Emily, DDS, Hon. AVDC

Preface

In 1986, after attending a veterinary dental wet lab in Vero Beach hosted by Dr. Keith Grove, I was hooked. Returning to my general practice in Pembroke Pines, Florida, I realized that nearly all my patients were in dire need of proper dental care. Fortunately, next door to my practice was a human dentist, Dr. Andy Stutz, a pet lover, with a special interest in dog and cat dentistry. Thus started my journey, which still continues daily.

As president of the American Veterinary Dental College (2012–2014) and president of the Foundation of Veterinary Dentistry (2016–2020), I have witnessed a profound transformation of our companion animal dental profession, evolving from the delivery of rudimentary dental services to comprehensive care based on science. As both the veterinarian and the public have recognized this trend, the demand for all-encompassing dental care has grown in an almost exponential manner.

Due in large part to the evolution of the discipline, there needs to be concentration on the pathophysiology of dental diseases in addition to the "nuts and bolts" of how to obtain the proper equipment, materials, and techniques to treat dental problems. The difficulties discovered by practitioners who want to incorporate more dental service into their practice include figuring out how to get started and once started, how to grow to handle the vast amount of dental pathology present in our patients.

The second edition of *Small Animal Dental Equipment, Materials, and Techniques* evolved from a need to inform and share more information with students, veterinarians, technicians, and human dentists. This book's goal is to clearly explain how to choose dental equipment and materials, and how to perform basic and intermediate dental procedures based on examination findings. Some advanced procedures are included for completeness, and are noted as such.

Anyone who is contemplating increasing his or her ability to deliver dental treatment to patients will find the information in this text invaluable. The second edition of *Small Animal Dental Equipment, Materials, and Techniques* takes the mystery away from unfamiliar dental terms and techniques. The reader will learn how to establish an efficient and effective dental operatory and perform many of the day-to-day techniques required to truly raise his or her level of dental care. The reader will also learn about advanced dental procedures that can be performed by specialists to help dogs and cats.

This text does not include *all* dental equipment, materials, and techniques available for patient care. It is more of a primer. I have included what I, along with many of my colleagues, have found general practitioners and dental assistants want to know about the practice of veterinary dentistry.

Veterinary educators and our practice oath stress that we do no harm. The veterinarian must appreciate and fully understand the science behind the procedures outlined in this book *before* performing them on clinical cases. Dentistry is not a cookbook recipe endeavor. Often there are procedural complications requiring adjustment. For those who attempt dental procedures without proper equipment, materials, and knowledge, there is the potential to make a patient's condition worse. For that reason, I have included this symbol ! **ADVANCED PROCEDURE** to alert the reader where advanced training and additional equipment and materials are needed. The reader is also advised to practice any operative procedure on cadaver specimens with the support of dental specialists before operating on patients. Proficiency can usually be obtained by working with veterinary dentists, attending veterinary dental hands – on wet labs – coupled with reading, reading, and more reading. Someone with advanced dental training and certification should evaluate and critique results before attempting clinical cases. The reader is advised to contact the American Veterinary Dental College, the Journal of Veterinary Dentistry, and the American Veterinary Dental Forum for a list of continuing education opportunities.

Disclaimer

Dr. Jan Bellows currently has no financial interest in the companies mentioned in this book. The specific products mentioned reflect Dr. Bellows' personal preference and other similar products may exist.

Acknowledgements

Many professionals helped in making this text a reality.

I am grateful to veterinary dentists Drs. David Clarke, Gregg DuPont, Steven Holmstrom, Kevin Stepaniuk, and Christopher Snyder, who after proofreading the text suggested improvements to syntax, spelling, and editorial suggestions to include the finer points the reader needed to embrace in the science and practice of companion animal dentistry. I am also grateful to Dr. Ralph Harvey, a boarded anesthesiologist, for his help in the anesthesia section and Dr. Helen Newman the director at Veterinary Transplant Incorporated for help in the advanced periodontal graft section. Kudos go out to Dr. Shelly Thilenius, currently a dental resident working with Dr. Brook Niemiec; our dental residents Drs. Elizabeth McMorran and David Bellows; general practitioner Paul Dalbery; my human dentist cousin, Laurence "Larry" Grayhills, DMD; Dr. Chris Carter, a Fellow of the Academy of Veterinary Dentistry; and Jeanne Perrone, a certified veterinary dental technician specialist, who were able to add recommendations from their non-boarded veterinary dentist perspectives.

Industry support allowing me to evaluate equipment and materials plus reviewing the manuscript was provided by Jessica Bayer (Merial, BI); Jamie Renner, Andrew Schultz, and Danielle Herberle (Midmark); Jim Merritt (Dental Focus); Ken Zoll (Cislak Manufacturing Inc.); the Henry Schein Company; Charles Rahner (Summit Hill); Charles Brungart (CBi Manufacturing); Dr. Helen Newman (Veterinary Transplant Services); Russell Farrelly (iM3); and Ronald Anderson (Dentalaire). Their input and insight improved each draft, making the final edition user friendly and practical for the general practitioner. The illustrations in the text were graciously provided through the Veterinary Information Network (VIN) by Tamara Rees.

Finally, it was a sincere pleasure to work with the wonderful people at Wiley Publishing in creating this text. Special gratitude goes to Purvi Patel, who made hundreds (thousands) of text suggestions, Sandeep Kumar, the final production editor who made sure and confirmed all i's were dotted and t's crossed; and Erica Judisch, commissioning editor for veterinary medicine, who believed that small animals all over the world would benefit from this work.

1

The Dental Operatory

The dental operatory is the central point where patient, veterinarian, and staff come in contact with equipment, materials, instruments, and techniques necessary to diagnose, treat, and prevent dental disease (Figures 1.1 and 1.2). The challenge is to provide an efficient area for the use and storage of dental supplies, instruments, powered equipment, radiography unit(s), computer(s), suction, illumination, general anesthesia, monitoring devices, as well as a comfortable and safe place for the dental assistant(s) and practitioner(s) to treat patients. To avoid injury and aid efficiency, every effort should be made to decrease floor-based equipment (dental delivery systems, anesthesia delivery units, dental X-ray generators, and intravenous fluid stands).

When a veterinarian works alone (two-handed dentistry), considerable time is spent charting, acquiring instruments, materials, and equipment while the patient is anesthetized. Four-handed dentistry (Figure 1.4a), which is commonly practiced in human dentistry, engages a dental assistant who helps in charting and envisages needs, handing over the instruments and materials in a timely manner. In veterinary dental practice, the patient also must be monitored while anesthetized. Six-handed dentistry includes the practitioner, a dental assistant, and an anesthesia-monitoring assistant, increasing the efficiency of dental procedures performed, often decreasing the anesthetic time (Figure 1.4b).

Space

If the practitioner has the luxury of planning the dental operatory versus retrofitting an already built area, an 8-ft by 10-ft area should be the minimum floor space allocated for one table. A 12-ft by 15-ft space is adequate space for at least two or more tables, storage, anesthesia, and a dental X-ray unit.

The number of operatory tables used for dentistry in a practice often is what limits the amount of dentistry that can be performed. "Dentistry" no longer is an hour or less procedure where primarily calculus (tartar) and plaque are removed from tooth crowns. The comprehensive oral prevention, assessment, and treatment (COPAT) visit includes dental scaling, polishing, irrigation, full-mouth intraoral radiographs, and care to treat pathology uncovered during the assessment. The COPAT visit commonly takes two hours or more to complete. Ideally two or three tables should be planned – one used for patients going under anesthesia, teeth cleaning, and diagnostics, while the other one or two used for dental therapy (Figure 1.3).

The dental operatory should not be located in the same room used for general surgery or surgical pack preparation to protect from contamination of the surfaces through ultrasonic aerosolization.

Electricity, Water, and Drainage

Multiple electrical grounded 110-V receptacles are recommended to power the delivery system, light curing unit, ultrasonic scaler, illumination source, computer and screens, monitoring equipment, and thermal control unit. Monitoring equipment may require a dedicated circuit to prevent interference from the ultrasonic scaler. Three four-plug grounded outlets are usually sufficient for each operatory table.

Water is dispensed under pressure from the high-speed delivery system to clear debris and prevent heat damage to surrounding tissue generated by drilling and to remove debris. A filter is recommended to decrease the sediment thereby increasing the efficiency and the life of dental handpieces. Distilled water can be used in stand-alone units or obtained from a distiller and pumped directly into the delivery system.

Over time, a bacterial biofilm forms along the internal surfaces of water lines. In human dentistry, this biofilm has been implicated for introducing pathogenic bacteria into the oral cavity. A bacterial microfilter and a chlorhexidine flushing system can be installed to decrease this biofilm. Additionally, products can be purchased to shock and clean water lines as indicated.

Small Animal Dental Equipment, Materials, and Techniques, Second Edition. Jan Bellows.

Figure 1.1 Author's multiple station dental operatory in use.

Ergonomics

When planning the dental operatory, attention to the mechanics of delivering dental care is important. Five ergonomic classes of motion are used to define which types of movements are desirable and which movements damage the skeleton and musculature. See Table 1.1.

Class four on a repetitive basis can be damaging and leads to inflammatory joint disease. Class five movements are to be avoided whenever possible.

In human dentistry, the ergonomic objective is to achieve a doctor's range of motion that goes no further than a class three movement and the assistant's range of motion that goes no further than class four during 80% of the procedure time.

Activities that cause excessive reaching, bending, and twisting should be limited. In order to avoid these:

- Instruments and equipment should be arranged where they could be easily grasped. See Figure 1.5.
- Supplies and frequently used equipment should be placed as close as possible to the working area and working height to decrease stretching and bending.
- Sufficient space should be allowed to turn the whole body, using a swivel stool.

Storage and retrieval of instruments, materials, and consumables (gauze, cotton, and suture) are important considerations. Consumables should be close to the operatory field and readily assessable without excessive stretching or bending. Back-up sterilized instrument packs or trays and materials can be stored in the general operatory area.

The Operatory

Ideally, the operatory dry/wet table should be 5–7 ft long, 2 1/2 ft wide, and with a height of 36 in. (head of patient) and 38 in. (tail of patient) angled downward. If possible, two or more dental stations should be planned side by side or nose to nose to allow treatment by the veterinarian on one table while an assistant cleans the teeth and completes diagnostics on the other table for delivery to the veterinarian. Peninsular stations allow the sharing of the dental radiograph unit, computer monitor, scaler/polisher, light cure unit, and dental materials. When multiple tables are used, one can be shorter to accommodate small dogs or cats. Other recommendations include:

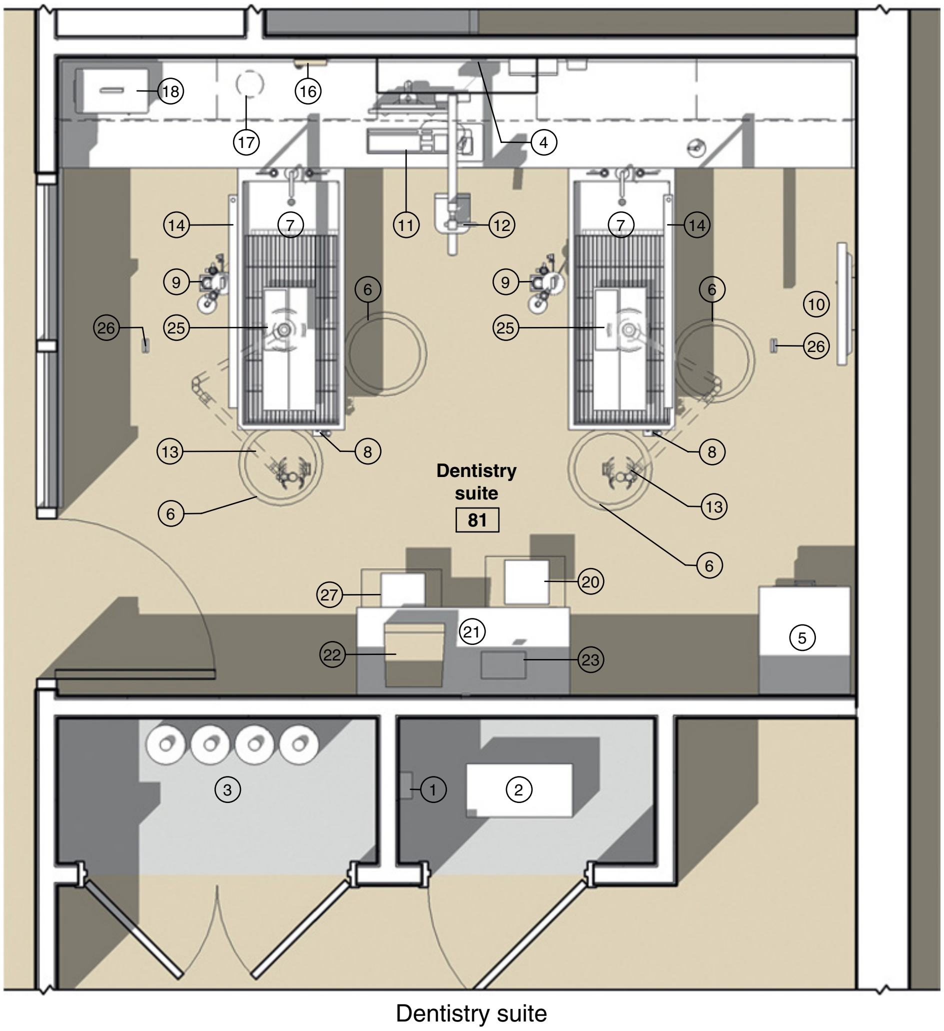
- The working end of the table should be placed opposite from the faucet.
- Room beneath the table should be provided for the practitioner or assistant's legs/knees with access on three sides (Figure 1.6).
- An instrument and material layout area should be located within three feet of the patient's head to minimize the reach for dental instruments without the need to leave the chair or stool (Figure 1.7).

Adjustable Stools/Chairs

Dental procedures can be time-consuming; some practitioners and dental assistants perform dental care standing (Figure 1.8), while others prefer sitting at the patient's head treating dental pathology (Figure 1.9).

Good posture is essential. The average human head weighs 15 pounds. Humans essentially carry a bowling

(a)



(b)

Figure 1.2 (a and b) Dentistry suite. *Source:* Courtesy of Warren Chase Freedenfeld, AIA, Rauhaus Freedenfeld & Associates.

(a)

(b)

Figure 1.3 (a) Two-operatory table setup. *Source:* Courtesy of Dr. Susan Crowder. (b) Two-operatory table setup. *Source:* Courtesy of The Animal Medical Center in New York City, note all support equipment off the floor. (c) Author's four-table dental operatory (All Pets Dental, Weston, Florida).

(c)

Figure 1.3 (Continued)

(a) (b)

Figure 1.4 (a) Four-handed dentistry. *Source:* Courtesy of Dr. Susan Crowder. (b) Six-handed dentistry. *Source:* Courtesy of Dr. Brook Niemeic.

Table 1.1 Five ergonomic classes and movement.

Class	Movement
1	Finger only
2	The wrist and hand
3	The elbow in adduction
4	Abduction or elevation of the elbow and shoulder
5	Rotation of the trunk at the waist

ball on their shoulders. Ideally the "bowling ball" (head) needs to be above the shoulders with a head tilt angle less than 20°. As the head tilt angle increases, the strain on the muscles holding the cervical spine increases. The continued neck muscle strain will create the chronic neck pain or injuries. The declination (look-down) angle of telescopic loupes should allow users to achieve the comfortable neck posture (small head tilt).

The dental assistant and practitioner need to be close to the dog or cat's oral cavity. The nature of veterinary dental care makes intermittent forward leaning virtually unavoidable. This forward lean results in the operator's thighs positioned parallel to the floor with the pelvis rolled backward, promoting flattening of the lumbar curve which may have detrimental effects upon both the spinal musculature and intervertebral discs. To decrease the forward lean effect, the thighs should be at approximately a 10° slope relative to the floor, and the pelvis should be canted downward toward the floor; this requires a chair or stool with a seat that will tilt downward. Additionally, the front edge or tip of the stool should be beveled to prevent the compromise of the circulation to the legs and lower body. This "waterfall" tilting-seat feature as well as saddle-style stools enable the hip angle to open to greater than 100°, which helps maintain the low back curve while enabling close positioning to the patient.

The veterinarian or dental assistant's height determines the proper stool adjustment height. It is recommended that a shorter operator have a stool hydraulic adjustment range from 16 to 21″ and a taller individual have a range of 21–26″ (Figure 1.10).

Built-in Desk

A built-in desk or comfortable writing surface for note-taking should be provided as well as sufficient space for instrument and material storage within easy reach from a seated position (Figure 1.11).

Powered Dental Delivery Systems

Electric

Most electric micromotors lack water irrigation. If used without water-cooling, iatrogenic thermal damage can

Figure 1.5 Dental operatory where the shelves of dental materials are located within easy reach. *Source:* Courtesy of Dr. Ed Eisner.

Figure 1.6 Self-contained dental delivery system. *Source:* Courtesy of Midmark.

Figure 1.7 Large instrument and material layout area. *Source:* Courtesy of Dr. Susan Crowder.

Figure 1.8 Doctor standing during dental procedures. *Source:* Courtesy of Dr. Eric Davis.

Figure 1.9 Veterinarian sitting on a saddle-style stool. *Source:* Courtesy of Dr. Fraser Hale.

result on the gingiva and tooth-supporting structures unless an assistant sprays water on the field to cool the bur. Additionally, micromotors operate below 30,000 rpm with high torque, causing excessive vibrations that make accurate work difficult. New-styled human dental electric high-speed handpieces introduced into veterinary dentistry operate at high torque and are water-cooled.

Air/Gas-Driven

Compressed air or gas is commonly used to power handpieces and the air–water syringe. The advantages over electric motorized systems lie in the capability of precise cutting at higher speed and water-cooling to prevent thermal damage to the pulp and surrounding bone.

Compressed air delivery systems consist of the compressor, storage tank, water hook up, assembly delivery, and foot pedal. In nitrogen-powered systems the compressor and storage tanks are replaced by the nitrogen source (Figure 1.12). Nitrogen gas (and oil-less compressors) can provide clean oil-free power, which may extend the life of the handpiece. There is no electrical requirement or compressor noise with compressed nitrogen-driven systems. Additionally, nitrogen-driven delivery systems require less maintenance than compressor-driven units. The typical cost of nitrogen is less than $4.00 USD per procedure. Nitrogen is not recommended for power air-driven sonic scalers because of the large volume of gas needed.

Figure 1.10 Proper stool tilt and back positioning. *Source:* Courtesy of Midmark.

Figure 1.11 Multiple writing surfaces in the dental operatory. *Source:* Courtesy Dr. Ed Eisner.

Figure 1.12 Nitrogen-powered delivery system.

Compressor

Compressors are either air- or oil-cooled. Air-cooling reduces the amount of contaminants (oil) in the line but is generally noisier and usually more expensive than oil-cooling. Modified refrigerator oil-cooled "silent" compressors are used in smaller self-contained delivery systems. Unfortunately, when operating an oil-cooled compressor, small particles of oil become mixed with the compressed air, which might contaminate tooth surfaces, interfering with materials setting properly. Oil-free filters are available to prevent contamination.

Compressors are attached to the dental delivery unit or located remotely in a nearby cabinet, closet, attic, or outside the clinic. The advantages of distant compressors include: less noise in the operatory, the ability to attach multiple stations to one larger compressor, and space savings in the immediate operatory area.

The compressor size is an important consideration. When the compressor is too small, it will run almost continuously during use and may overheat. The capacity of the compressor should be of sufficient size to handle the number of operatories (locations where dentistry will be performed) and handpieces simultaneously in the practice. Capacity is the compressor output in cubic feet per minute (cfm), and can usually be found in the product literature. As a rule of thumb, each operatory needs approximately 2 CFM and should be able to maintain an end-user pressure of 30–80 psi.

Storage Tank

The storage or air tank holds air generated by the compressor. This stored air is used to power the dental handpieces and air/water syringe. Air tanks come in sizes. The larger the tank size, the less "work" the compressor needs to do. Pressure inside the air storage tank varies by manufacturer between 80 and 120 psi. When maintenance pressure is reached, the compressor turns off. When the tank pressure drops below 60 psi, the compressor turns on to refill the tank with compressed air.

Assembly Delivery System

The assembly delivery system (control panel) contains the air/water supply syringe, tubing for the handpieces, pressure gauge(s), switches for turning water on and off, needle valve to adjust water flow, and either a switch to change from the high- to low-speed handpiece or self-regulated toggles. The control panel may be part of a cart or mounted on the dental table. The foot pedal starts and stops the system, and in some units controls handpiece speed and contains a toggle to disable water irrigation.

The three-way air/water syringe produces a stream of air, water, or a mixture, for rinsing debris from the teeth and drying as needed during dental procedures (Figure 1.13a and b).

A separate air-conditioned location for a stand-alone compressor and suction equipment should be provided when multiple operatories are planned. The remote compressor and suction unit should be located away from the dental suite due to the excessive noise and heat they generate (Figure 1.14).

Suction

Suction is most helpful during oral surgery and an option available on most dental delivery systems (Figure 1.15). When suction is added, a larger compressor is often required. Frasier or disposable plastic suction tips are preferred for oral surgery. Having suction also enables procedures to be performed in dorsal recumbency with a decreased risk of water entering into the patient's lungs. Procedures performed in dorsal recumbency reduce the need to rotate patients from one lateral position to the next.

(a) (b)

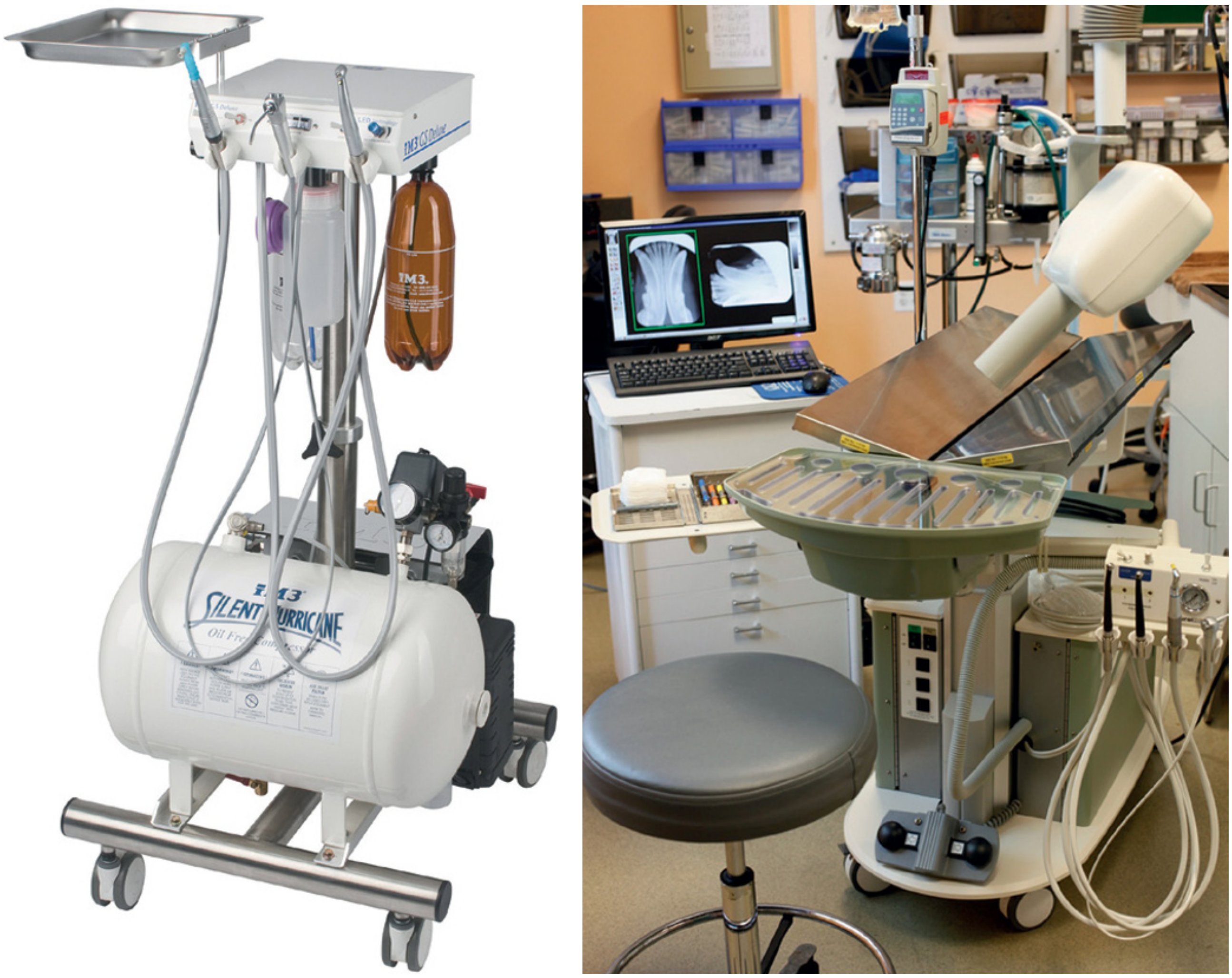


Figure 1.13 (a) Self-contained dental delivery system with a large air compressor storage tank. *Source:* Courtesy of iM3. (b) Dental delivery system incorporated into the treatment table. *Source:* Courtesy of Dr. Ira Luskin.

Storage

Equipment and materials are often stored in two locations. The primary storage is within easy reach of the operator for frequently used instruments and materials, while a secondary locations stockpiles items for resupply. A series of cabinets and drawers can be utilized for this purpose (Figure 1.16).

Storage of equipment and materials require careful organization. Allowing hand instruments to be combined in group drawers results in confusion, wasted time, and damaged/blunted and unsterilized instruments. A better option is to have entire or sections of drawers dedicated to a dental specialty (Figure 1.17). The periodontal section can contain sterilized packs of hand instruments and supplies to perform gingival examinations and surgery. Other drawer sections can be arranged in a similar fashion, with endodontic, oral surgery, restorative, and orthodontic compartments. Oversized drawers can be used for larger pieces of equipment and supplies.

Cassettes are available to hold sterile instruments needed for each procedure. Advantages of using the cassette system include having all the sterilized instruments needed in one area for each procedure (Figure 1.18).

Waste containers, including hazardous materials containers, can be built into the cabinetry.

Lighting

Proper lighting and magnification are necessary to ensure a complete and thorough oral examination and provide efficient delivery of small animal dental treatment. Operator-worn telescopic loupes provide excellent

Figure 1.14 Dental air compressor unit positioned to power multiple delivery systems. *Source:* Courtesy of Midmark.

Figure 1.15 Suction unit for multiple workstation suction. *Source:* Courtesy Midmark.

Figure 1.16 Chair-side dental storage. *Source:* Courtesy of Dr. Fraser Hale.

Figure 1.17 Drawer containing sterilized instruments to perform periodontal, endodontic, exodontia, and dental scaling.

magnification while ceiling-mounted surgical spotlights, headlamps, and fiber-optic/LED handpieces provide optimal illumination and magnification. The ceiling light source should be 25–30 in. (approximately an arm's length) from the oral cavity. The light should illuminate the area to be treated without projecting shadows of the operator's hands on the oral cavity (Figure 1.19).

Figure 1.19 Ceiling-mounted spotlight.

Dental Loupes (Telescopes)

Head-mounted spotlights accompanied by 2.5×–4.0× magnifying dental telescopes (loupes) with 15–22 in. of focal distance can also be used to light the field and assist dental diagnostics and treatment. Loupes enable users not only to see small structures clearly but also to work safely when the loupes are ergonomically fitted with proper declination angles and working distances. Non-ergonomically designed loupes or improper working distance selection may encourage excessive head tilt, resulting in neck and back pain. The safe head tilt angle should be less than 20°.

Ergonomic loupes allow the clinicians' eyes to look downward without bending their neck beyond a safe

Figure 1.18 Cassette holding wing-tipped elevators.

range. If the declination angle of the oculars is not steep enough, the clinician's neck may be bent at an extreme angle to compensate. Holding the head in an unnatural position causes strain in the muscles and spine (Figure 1.20). Veterinary assistants can also benefit using illuminated dental loupes to evaluate the success of their teeth cleaning. As the strength of magnification increases, the depth of field and field of view decrease. Clinicians who choose to wear low-powered magnification will see the entire mouth; in contrast, users of the higher-power loupes allow a detailed close-up of two or three teeth.

The two common types of loupes are front-lens-mounted (FLM) which has the flip-up option and through-the-lens (TTL) type (Figure 1.21a and b). Front-lens-mounted loupes are oculars mounted on the front of a pair of eyeglasses. For users requiring glasses, an individual vision prescription can be placed in the lens.

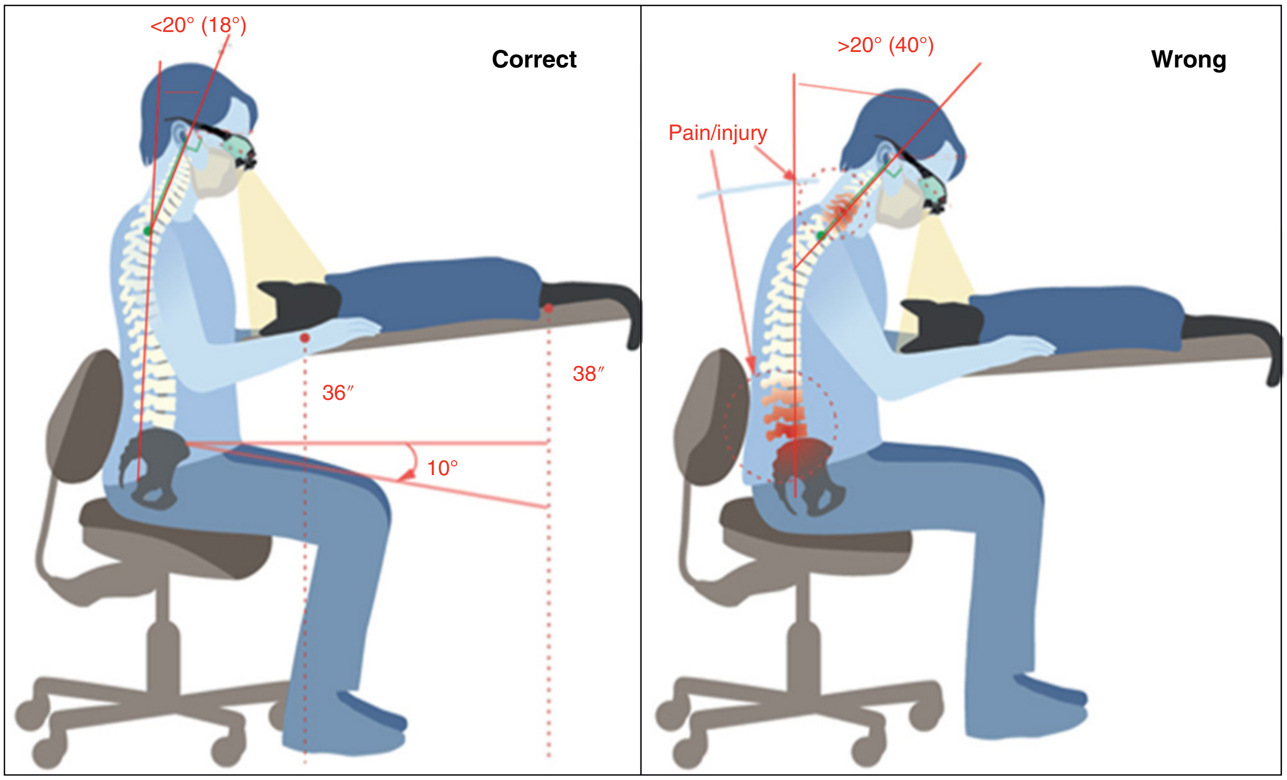


Figure 1.20 Improper head angulation causing neck pain (left) and improper head position (right).

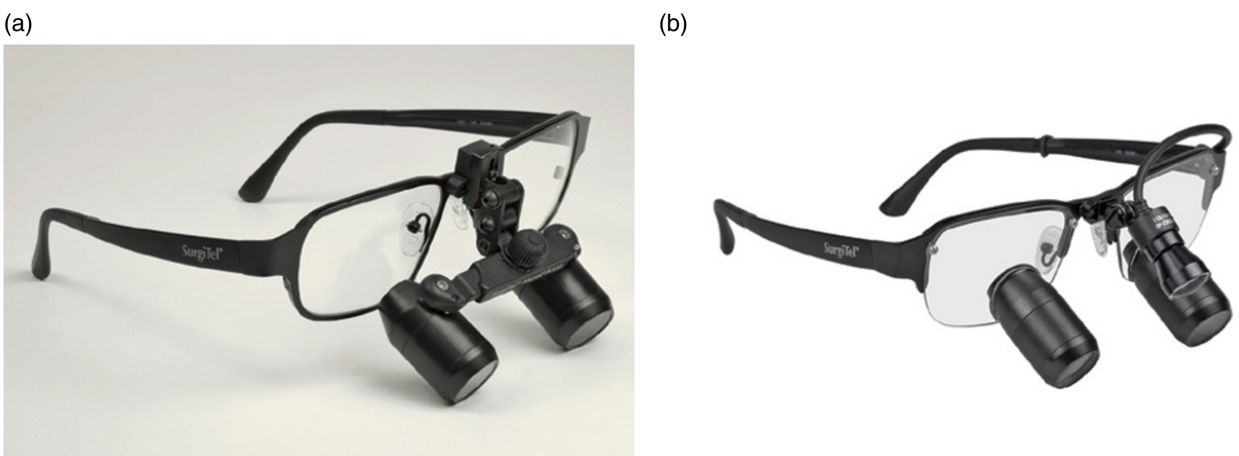


Figure 1.21 (a) Front lens-mounted loupes and (b) through the lens-mounted loupes with head lamp. *Source:* Courtesy of SurgiTel.

Because the magnification on a through the lens loupe sits closer to the eye, the field is usually wider than with a front-lens-mounted model. The customization of the loupes decreases utility in practice since the loupes cannot be shared between individuals (Figures 1.22 and 1.23).

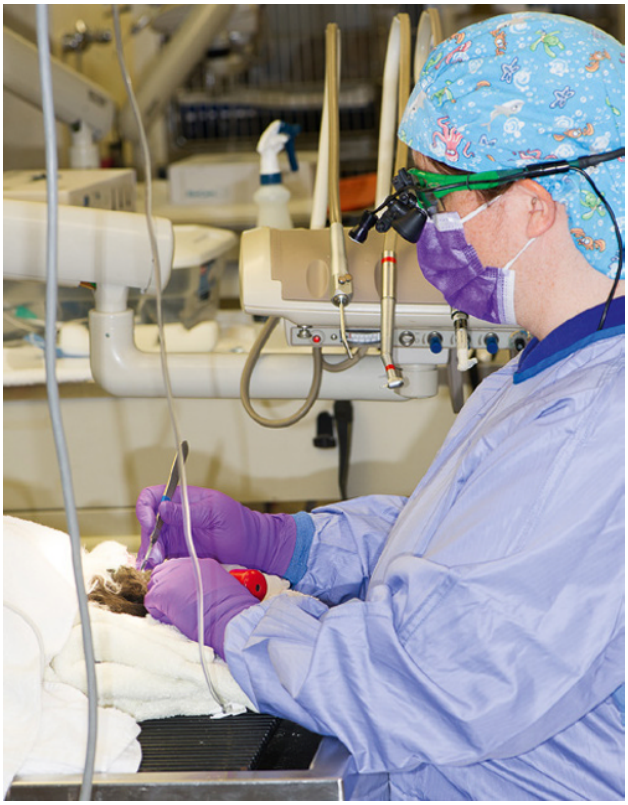


Figure 1.22 Properly fitted telescopic loupes resulting in functional head tilt.

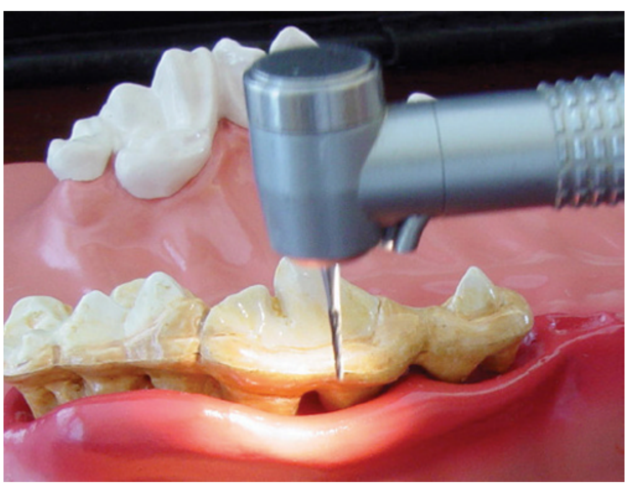


Figure 1.23 Fiber-illuminated high-speed handpiece.

Radiography

Intraoral radiography is mandatory to properly evaluate dental cases. Human dental patients help their doctors diagnose lesions based on expressed feelings of pain, and pressure. Even with this assistance, radiographs and often advanced dental imaging are needed to fully evaluate the presence and extent of dental lesions.

Skull and dental radiographs may be obtained with the standard veterinary radiography X-ray generator and cassettes, but it is far from optimal. The location and fixed nature of whole-body veterinary units require animal patients to be moved from the dental table to the radiograph area. With most oral surgical procedures, patient relocation would have to be performed multiple times, adding time and inconvenience. Skull films lack adequate details to diagnose oral diseases accurately due to decreased resolution, superimposition of anatomic structures, and difficulty determining the proper location of pathology.

Intraoral images can be obtained by three methods:

1) Captured on small films and processed using developer and fixer chemicals (analog).
2) Captured using a phosphor plate system coupled with a computer, acquisition software, and monitor, termed CR (computed radiography).
3) Captured using digital sensor coupled with a computer, acquisition software, and monitor, termed DR (digital radiology).

The three methods produce high-quality, diagnostic images suitable for veterinary dental needs although the latter two are preferred due to timesaving, image storage, ease of viewing, and lack chemical handling – all translating into more efficient workflow.

To provide intraoral digital radiology in a practice, three pieces of equipment are needed:

1) X-ray generator which can be handheld, ceiling, wall, cabinet, or floor-mounted. (Figures 1.24–1.26). Most dental radiography generators operate on 110 V. A separate 30-amp circuit is recommended.
2) Digital capture equipment (sensor or phosphor plate).
3) Computer with imaging software and a high-quality monitor to view the images.

CR (Computed Radiography) Technology

Photosensitive phosphor (PSP) technology utilizes an X-ray sensitive plate that replaces film. The exposed plate is placed into a scanning device that records the latent image and converts it to a digital file in a computer. Phosphor plates are available in sizes 0,1, 2, 4, 5, and 6. While the plate is relatively flexible, the processing

Figure 1.24 Floor stand X-ray generator, sensor, and monitor. *Source:* Courtesy of Midmark.

equipment can be bulky. The plates have a finite life span and depending on the manufacturer need replacing after approximately 10,000 exposures of use or when scratched or damaged, at a cost of $60–100 USD each (Figure 1.27).

DR (Digital Radiography) Technology

Direct imaging sensors communicate with a computer either through a direct connection through a USB port, or wireless technology. The digital sensor replaces film in the patient's mouth. Sensors are available in three sizes similar to analog film numbers 0, 1, and 2 (Figure 1.28). The image can be viewed on screen within seconds without additional handling or processing. A typical sensor requires replacement after approximately five years of use or 20,000 exposures. They cost between $5,000 and $12,000 USD.

A computer and separate monitor, tablet, or laptop computer in the treatment area can be used to capture and display the images (Figures 1.29 and 1.30).

Most commercially available monitors have resolutions of 1024 × 768 (pixel matrix size). High-performance monitors have pixel matrices as high as 2048 × 2048. Gray-scale monitors commonly used with dental digital imaging systems have a luminance that ranges from 86 to 240 cd/m^2. A large-screen LED or plasma television can also be used to display images with high-definition resolution.

General Anesthesia

Anesthesia allows the practitioner and assistants to carry out dental procedures in a safe and effective manner minimizing the risk of injury. According to the American Veterinary Dental College, dental procedures performed without general anesthesia, termed "anesthesia-free dentistry" (AFD), or "non-anesthetic dentistry" (NAD) increase the risk for both the patient and the operator and therefore cannot be recommended. A properly fitted cuffed endotracheal tube must be used for patient safety. The inflated cuff prevents the contaminated oral environment, including bacteria-laden aerosols and water, from entering the respiratory system. It also aids in patient oxygenation, anesthetic delivery, and decreases operator-inhaled anesthetic gases.

When evaluating the risk associated with an anesthetic case, the patient's physical condition must first be properly assessed, scoring their risk status based on medical history, concurrent disease(s), physical condition, and age. This risk status ranges from ASA1 for an animal in excellent health to ASA 5 for a patient that is critically ill. Dental procedures are normally performed on patients with a risk status of ASA 1–3; however, ASA 4 patients are also treated when necessary.

ASA Scoring

ASA1	Normal, healthy patient
ASA2	Mild systemic disease without functional limitation
ASA3	Mild systemic disease with functional limitation
ASA4	Severe systemic disease that is a constant threat to life
ASA5	Moribund, not expected to survive 24 hours

To make anesthesia for dental procedures as safe as possible, the veterinarian must be able to work with:

- A patient that has been evaluated preoperatively with a physical examination, as well as hematological, urologic, radiographic, electrocardiographic, and ultrasound examinations where indicated by age and/or condition.

Figure 1.25 Wall-mounted X-ray generator to service two treatment tables. *Source:* Courtesy of The Animal Medical Center, in New York City.

Figure 1.26 Handheld X-ray generator.

- Safe and effective preanesthetic and anesthetic agents and intravenous fluid administration.
- Certified inspected anesthetic equipment
- A monitoring and recording system that accurately measures the patient's physiologic parameters and response to anesthesia.
- A well-trained and dedicated veterinary assistant or nurse to monitor and communicate the effects of anesthesia while the veterinarian performs the dental procedure and during recovery. For more complicated cases, the clinician should consider hiring an anesthesiologist or a veterinarian that specializes in anesthesia or referral as available and appropriate.

Incorporating the anesthetic delivery system on the operatory console or mounted on the wall decreases floor clutter (Figure 1.31). Canister or active suction anesthetic scavenger systems are required.

Patient Monitoring Devices

Anesthesia safety requires patient monitoring. Monitoring varies from simple observation of respiration and noting mucous membrane color, to advanced technologies. Parameters include respiration, electrocardiography

Figure 1.27 CR processing system. *Source:* Courtesy of iM3.

Figure 1.28 Three digital sensors – from right to left sizes 0, 1, and 2.

(EKG), pulse oximetry, blood pressure, temperature, and CO_2 levels. Often, the advanced warning systems on monitors alert the clinician to adjust anesthesia, avoiding problems before they become critical. Space must be allowed for these monitoring devices as well as storage of wires and connectors.

The American College of Veterinary Anesthesia and Analgesia (ACVAA) and the American Animal Hospital Association (AAHA) Anesthesia Guidelines recommend specifically monitoring:

- *Circulation*: to ensure that blood flow to tissues is adequate (blood pressure)
- *Oxygenation*: to ensure adequate oxygen concentration in the patient's arterial blood (pulse oximetry)
- *Ventilation*: to ensure that the patient's ventilation is adequately maintained (capnography)
- *Temperature*: to help avoid hypothermia, which is common in anesthetized patients and a source of trouble for perfusion and ventilation

The ACVAA also recommends having a trained veterinary technician at the patient's side, responding to feedback from the monitoring using their hands-on clinical expertise to manage the patient's proper anesthetic depth, while maintaining an anesthetic record of

Figure 1.29 Right maxillary canine and premolars imaged on computer monitor in the dental operatory.

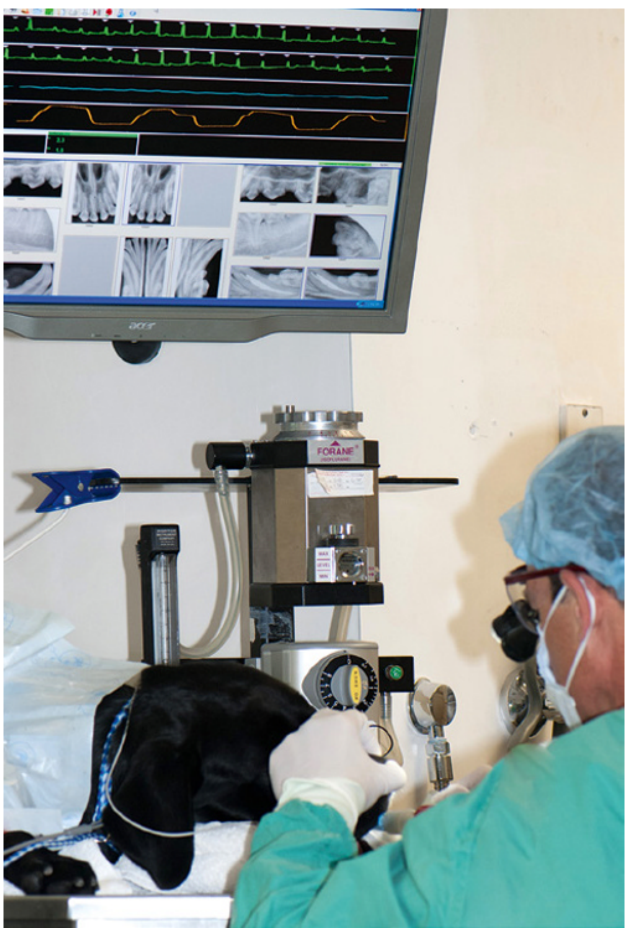


Figure 1.30 Computer monitor displaying patient's EKG and full mouth dental radiographs.

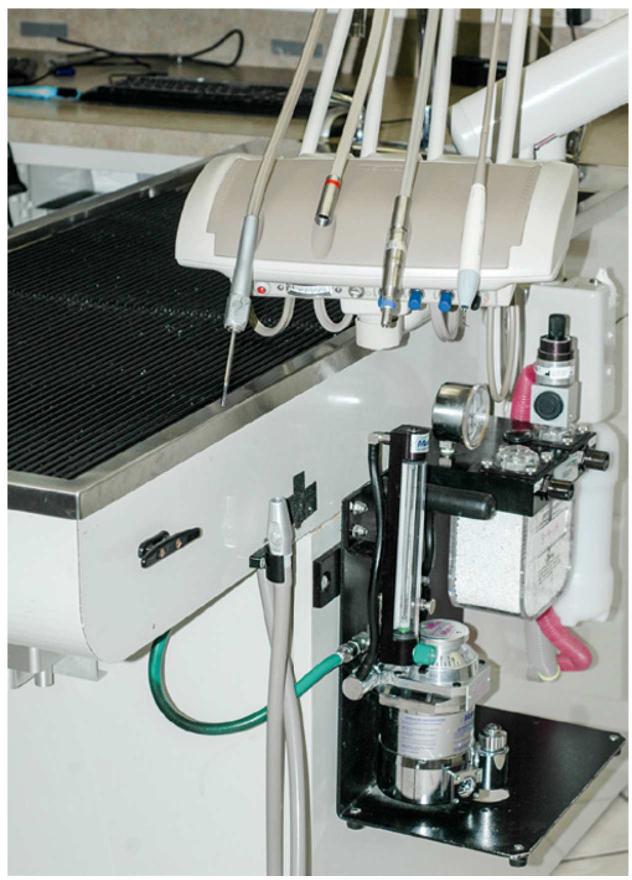


Figure 1.31 Anesthesia delivery unit attached to the treatment table.

Figure 1.32 (a) Stationary multiparameter monitor. *Source:* Courtesy of Midmark. (b) Portable multiparameter monitor. (c) Multiparameter monitor with additional Pleth Variability Index predicts fluid responsiveness in critically ill patients, methemoglobin (%SpMet), and hemoglobin (SpHg). (d) Portable monitor used in recovery – note premature ventricular beat at beginning of strip.

significant events and trends. The technician continuously relays information to the veterinarian who is apprised of the patient's condition and progress throughout the procedure.

During anesthesia, the patient should have minimal jaw tone and no palpebral reflex. The femoral pulse should be palpable, and the mucous membrane reperfusion time should be two seconds or less. Breathing (either spontaneous or controlled) during balanced anesthesia should be even and regular.

An ideal monitor includes invasive and noninvasive blood pressure, end-tidal carbon dioxide, pulse oximetry, EKG, and temperature. Though many veterinary hospitals have accumulated a variety of devices, oftentimes single-parameter monitors, it would be wise to migrate to a five-in-one multiparameter monitor for all anesthetic procedures (Figure 1.32a–d).

Choosing a monitor that has been designed specifically for use on animals can make a significant difference in performance and accuracy. Such monitors add layers of customization for use on companion animals.

Blood Pressure (BP)

Proper perfusion of the patient's vital organs is paramount during anesthetic procedures. Hypotension is the most common perianesthetic complication observed in veterinary patients. Since perfusion is affected directly by medication choice, anesthetic depth, and blood volume (i.e. hydration), continuous blood pressure monitoring to avoid hypotension is critical. While the gold standard for continuous BP monitoring is direct arterial pressure, it is an invasive technique making it impractical for most clinical situations.

For best results, the technician should set the oscillometric BP monitor's high and low alarm limits, cycle the readings automatically every five minutes, and select appropriate cuff size and placement. As a rule of thumb, the cuff width should be 40% of the circumference of the patient's limb.

The cuff is placed on the limb so that it is snug and at the heart level (Figure 1.33). Tape should not be used to secure the cuff as it may suppress the signal and cause inaccurate measurements. The best sites for cuff placement in dogs are located just below the hock, as well as the carpal or tarsal pads. The best site during anesthesia in cats is to place the cuff around the forelimb between the elbow and carpus (median artery).

Normal ranges for anesthetized dogs and cats are:

- Systolic: 90–150 mmHg
- Diastolic: 40–60 mmHg
- Mean: 60–90 mmHg

Autoregulation of tissue perfusion is typically maintained with mean arterial pressures above 60 mmHg. For safety, a minimum mean arterial pressure of 70 mmHg is indicated. Sustained SAP over 170 mmHg can result in severe consequences such as blindness, stroke, hemorrhage, and death. When MAP falls below 60 mmHg, blood flow to the brain, heart, lungs, liver, and kidneys may be too low to adequately perfuse these essential organs. Treatment of hypotension includes decreasing the reliance on inhalant anesthetic, increasing the rate of fluid administration, and giving an inotrope (e.g. dopamine or dobutamine by intravenous infusion to effect). If these treatments are ineffective, blood, colloids, and administration of hypertonic saline (5 ml/kg) usually will return blood pressure to normal.

End-Tidal Carbon Dioxide ($ETCO_2$)

Arterial concentration of CO_2, measures the CO_2 produced in the cells, a function of metabolism. CO_2 is eliminated by the lungs and CO_2 transported from the cells to the lungs is a function of circulation. End-tidal carbon dioxide ($ETCO_2$) is the concentration of CO_2 in the exhaled breath during exhalation and $ETCO_2$ monitoring through capnography is often called the "anesthesia disaster early warning system." Vitally important, it is the only parameter that thoroughly reflects a patient's ventilatory status, and it can signal problems within two breaths.

Capnography gives a graphic and a numerical readout of the CO_2 concentration in a patient's exhaled gases (Figure 1.34a and b). It provides a means to assess

Figure 1.33 Blood pressure cuff placement. *Source:* Courtesy of PetMap.

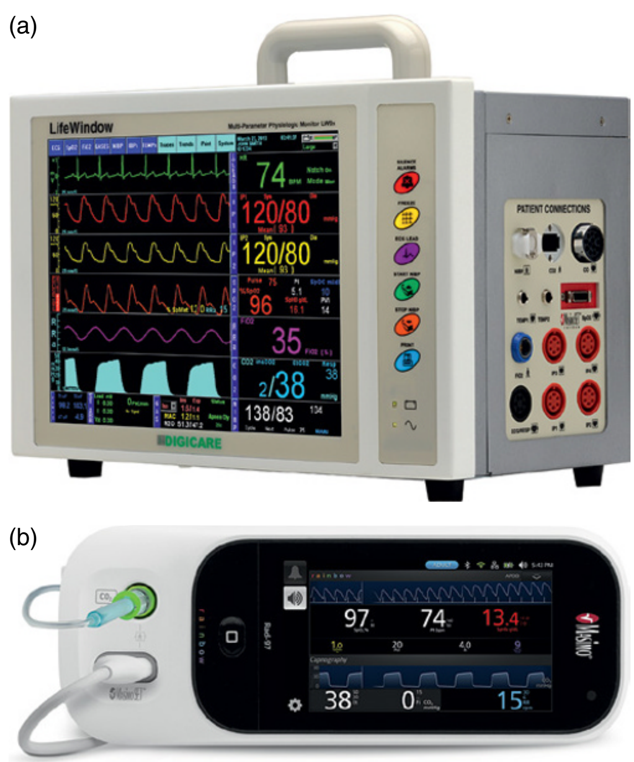


Figure 1.34 (a) Multiparameter monitor including capnography. (b) Pulse oximeter and CO_2 monitor.

ventilation, integrity of the airway, and the breathing circuit, as well as cardiopulmonary function. A capnogram is the graphic portrayal of the changing concentration of exhaled CO_2 during the respiratory cycle. A normal waveform should have a baseline of zero during inspiration (i.e. inspiratory baseline). This is followed by an expiratory upstroke that contains initially little or no CO_2 and moves the curve upward until it levels out at a plateau. CO_2 concentration continues to increase until it reaches its maximum just before the onset of inhalation (i.e. inspiratory down stroke).

The height, frequency, shape, rhythm, and baseline position of the waveform are monitored during anesthesia. CO_2 concentration in the sample is reflected by the wave height. Changes in the standard waveform should alert the veterinarian to a problem with the patient, the airway, or the anesthetic circuit. Normal readings are in the range of 35–45 mmHg (Figure 1.35a–e).

Increased CO_2 readings may be a sign of faulty check valves, exhausted soda lime, mild-to-moderate patient airway obstruction, and hypoventilation. Decreased CO_2 readings may be a sign of hyperventilation, esophageal

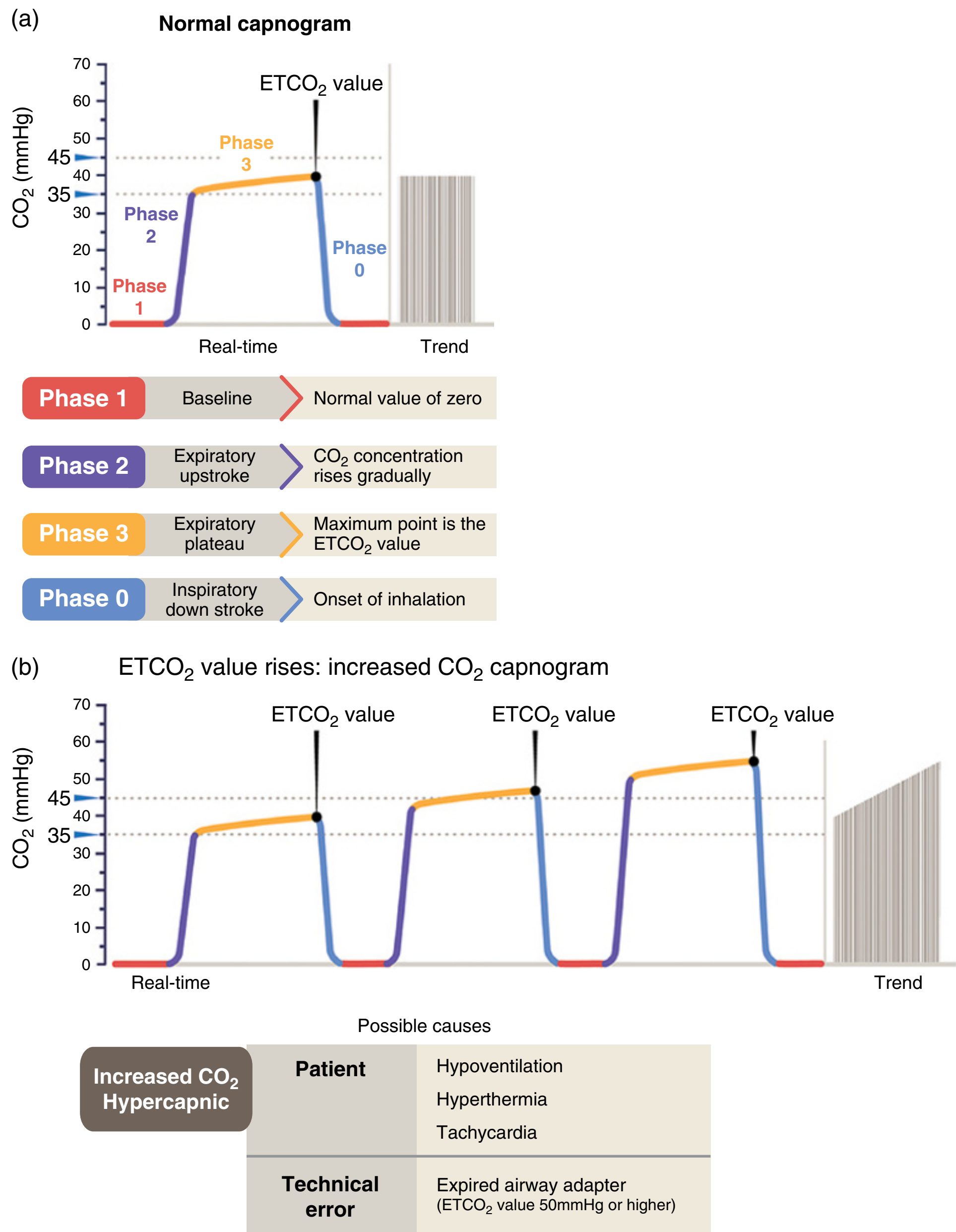
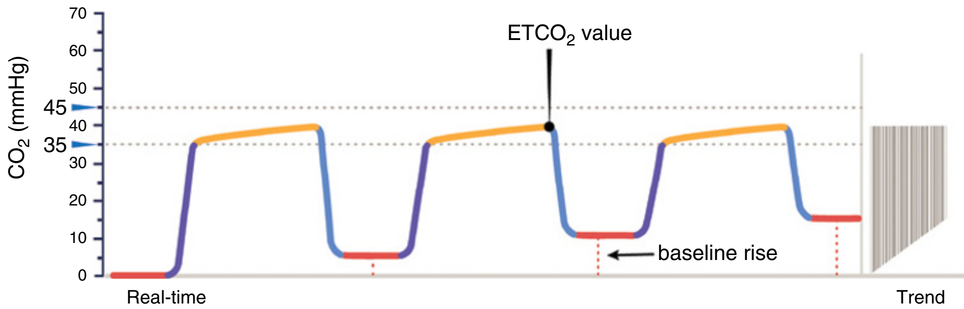


Figure 1.35 (a–e) Capnogram illustrations. *Source:* Courtesy of Tamara Rees – Veterinary Information Network.

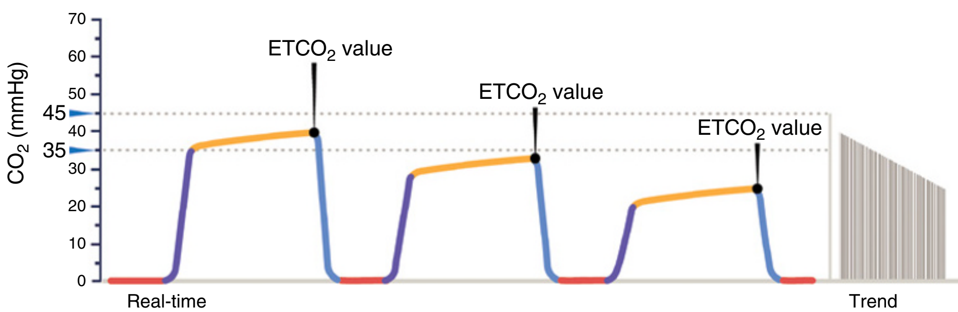
(c) Baseline of inspired CO_2 rises: rebreathing capnogram



Possible causes

Increased Baseline CO_2	**Technical errors**	Expiratory valve faulty Exhausted soda lime Poor inspiratory flow Short expiratory time CO_2 absorber system faulty

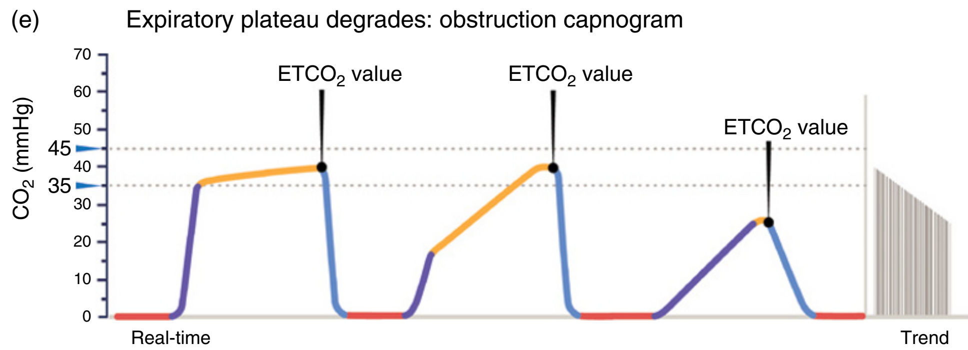
(d) $ETCO_2$ value sinks: decreased CO_2 capnogram



Possible causes

Decreased CO_2 Hypocapnic	**Patient**	Hyperventilation Reduced cardiac output Bradycardia Hypothermia/reduced metabolic rate Cardiovascular arrest
	Technical errors	Air sampling leakage Extubation Obstruction of the endotracheal tube Excessive dead space (too long ET tube or adult system used in a very small patient) High O_2 flow rate (example when using a capnograph in a non rebreather system that has a high O_2 flow)

Figure 1.35 (Continued)



Possible causes

Decreased CO_2, Expiratory Plateau	**Patient**	Airway foreign body Bronchospasm
	Technical errors	Artificial airway obstructed Expiratory branch of breathing circuit blocked

Figure 1.35 (Continued)

intubation, extubation, disconnection from the breathing circuit, obstruction of the endotracheal tube, and cardiopulmonary arrest (Figure 1.36).

The device used to measure CO_2 should be a key consideration in choosing equipment for patient monitoring. If selecting a mainstream device, ensure that the probe has no moving internal parts (solid state) so that it endures the rigorous environment of a busy veterinary practice. When using a side stream device, pay close attention to the sample rate; sample rates of 50 mm/min or less are recommended for small dogs and cats. If CO_2 monitoring is not in your practice's budget, check that the monitor purchased allows upgrading later.

Figure 1.36 In the circuit CO_2 monitor.

Pulse Oximetry (SpO_2)

The pulse oximeter is designed to noninvasively calculate oxygen saturation of hemoglobin using light absorption in tissue. Most oxygen transported to the tissues is carried on the hemoglobin molecule. Hemoglobin travels through the blood in two primary forms: oxyhemoglobin and reduced hemoglobin (deoxyhemoglobin). A probe from the oximeter emits red and infrared lights, which are detected by a photodetector that is placed across an arterial bed. Reduced hemoglobin does not absorb a significant amount of infrared light, but it absorbs red light well and produces a large plethysmographic signal. Conversely, oxyhemoglobin absorbs infrared light and generates a strong signal, whereas the red light passes through and generates a weak signal. In this way, pulse oximeters can calculate the amount of each form of hemoglobin present in arterial blood.

Oxygen saturation in an anesthetized patient should be maintained between 95 and 100%, particularly if the

Figure 1.37 Tail base pulse oximeter probe.

patient is breathing 100% oxygen. Saturation readings of 90% or less indicate desaturation, hypovolemia, cardiac disease, pulmonary disease, vasoconstriction, or shock. A patient with an abnormal reading may have an underlying cause that should be determined and corrected by increasing the oxygen flow rate and mechanically ventilating the patient until the saturation returns to normal or other underlying causes are identified and corrected. Possible causes include decreased oxygen flow rate, hypoventilation, diffusion impairment, or shunt. Pulse oximetry readings may be unreliable if the animal has excessive movement, poor perfusion, irregular heart rhythm, anemia, methemoglobinemia, or vasoconstriction.

Since excessive hair can prevent accurate readings in animals, one of the most effective placements of the SpO_2 probe is on the tongue. Dental procedures by their nature involve movement and instruments in the mouth. Other areas for probe placement include the prepuce, vulva, ear, metacarpus, metatarsus, digits, tail, and rectum.

Reflectance sensors are inexpensive alternatives to the lingual sensors, and are perfect for dental cases. These are applied to the bottom of the tail close to the anus or the area behind the large metatarsal footpad held in place by a snug-fitting elastic bandage. Rectal probes are available, but may be unreliable because of interference from fecal matter (Figure 1.37).

Electrocardiography (EKG)

EKG readings performed before and during anesthesia give the veterinarian information regarding heart rate, rhythm, and abnormal complexes. Lead II is used primarily to monitor the rate and rhythm. Continuous monitoring of the EKG waveform enables early recognition of electrical changes associated with disorders of conduction. Unfortunately, the electrocardiogram gives minimal information on cardiac contractility and tissue perfusion. The presence of normal-appearing complexes does not indicate that the patient's tissues are adequately perfused. In cases of electromechanical dissociation, the EKG appears normal but there are no pulses. For these reasons, the EKG should be used with another form of monitoring (end-tidal CO_2 and/or blood pressure) for patient evaluation during anesthesia.

For some monitors, EKG signals can be acquired through esophageal probes. Because they typically also measure temperature, this can be an effective method of reducing the number of connections to the patient, thereby simplifying patient setup and perioperative lead management. The esophageal probe is inserted until the distal electrode reaches the area dorsal to the heart base. Care is taken to avoid placement of the probe through the lower esophageal stricture in order to reduce regurgitation. If the EKG tracing appears small, the probe may not be inserted far enough. If inserted too deep, the tracing may appear inverted.

Respiration

Inhalant and injectable anesthetics, opioids, and alpha$_2$-agonists are likely to cause ventilatory suppression. Respiration rate (RR) is the number of breaths per minute. An elevated RR rate may indicate a progression from moderate to light anesthesia or other pulmonary pathology, and is one of the first signs of arousal from anesthesia. Electronic monitoring of RR and other signs of arousal during dental procedures can help avoid bite trauma to staff, radiograph sensor/plate, and monitoring equipment.

The gold standard for evaluating ventilation is the carbon dioxide (CO_2) monitoring parameter. Viewing the capnographic waveform can also demonstrate the quality of the patient's breath. In the absence of capnography, respiration is often monitored subjectively by watching the anesthesia bag, the chest wall, and condensation of the ET tube. This may not be practical because of the surgical blanket, and auscultation of breath sounds is not particularly reliable because the low tidal volume seen during anesthesia may render the respiratory sounds inaudible. Many patient-monitoring systems default respiration readings to impedance respiration using the indirect method of deriving respiration from the up and down movement of the patient's chest via the EKG leads. This indirect method is neither accurate nor reliable in all but the largest veterinary patients. If capnography is available, the default source for RR should be switched to CO_2. Apnea monitors with loud alarms are also very helpful to alert those monitoring patient anesthesia that adjustments are indicated (Figure 1.38).