Advanced Monitoring and Procedures for Small Animal Emergency and Critical Care
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To Dr. Janet Aldrich, who taught me that thinking and knowing are different, and that the former is far more important.

To Dr. Steve Haskins, who showed me that listening is the teacher’s most important skill.

To my parents, Robbie and Mike, who taught me that caring is always worth it.

And to my husband Mike, who gives selflessly over and over and over again.

I love and thank you all.

–Jamie M. Burkitt Creedon

First and foremost this book is dedicated to my parents, Dr. Harold Davis, Sr., and Barbara Davis, and my sister, Deborah Davis-Gillespie, for their love, support and guidance. To Thomas J. Bulgin, DVM, for giving me my start as a veterinary assistant and Gary L. Reinhardt, DVM, and Steve C. Haskins, DVM, DACVECC, for their mentorship. To each current and past member that I have served with on the board of directors for the Veterinary Emergency and Critical Care Society. To the veterinary technicians and nurses that I have talked to around the world and former veterinary students of U.C. Davis: I have enjoyed sharing my knowledge and experiences with you. Finally, to the co-founding and charter members of the Academy of Veterinary Emergency, and Critical Care Technicians: it was an honor, pleasure, and a joy to work with you in developing the first veterinary technician speciality academy.

–Harold Davis
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The disciplines of small animal emergency medicine and critical care have grown significantly in the past decade. There are many references available that describe the diagnosis and medical treatment of problems encountered in small animal emergency and critical care practice. However, none is dedicated specifically to the daily hands-on practice of the specialties: for instance, the placement and maintenance of arterial catheters and the interpretation of direct pressure waveforms they provide, or the nursing care required to maintain a patient on long-term mechanical ventilation (what do all those buttons on the ventilator do, anyway?). We believe the veterinary community would benefit from a single reference written by informed, experienced people to improve and expand the standard of care, and we hope this textbook serves that purpose. The experienced veterinarian and veterinary technician contributors to Advanced Procedures and Monitoring for Small Animal Emergency and Critical Care have provided herein a well-referenced textbook that we believe contains useful information on the “non-medicine” aspects of ECC practice, from practice design to technical procedures and nursing care to interpretation of monitoring results.

There is no small animal specialty in which cooperation between all healthcare team members is more important than in emergency and critical care. Thus, some chapters are authored by a veterinarian, others by a veterinary technician, and some by pairs. The interdependence of all members of the ECC healthcare team requires that veterinary technicians understand why clinicians ask them to do what they do, and that veterinarians understand proper ECC nursing care and technical procedures. The book’s contributors come from around the world, from both university and private practice. We aimed to provide the best-referenced, highest-quality textbook that we could. Contributors congenially answered our frequent “Do you have a reference for this?” inquiries and high-quality image requests, so that the reader could have confidence in the recommendations contained herein and see illustrations of how to perform procedures or interpret results. When high-quality references or guidelines were unavailable, these qualified authors made recommendations based on their experience; in such cases, such personal recommendation is noted in the text for transparency.

The textbook is organized roughly by organ system or general topic, but there is considerable overlap in some areas. For instance, some authors of device insertion chapters included a maintenance section, and maintenance of that device may also be covered in another chapter specifically on insertion site maintenance or artificial airway maintenance, and so on. Standardized protocols are included for procedures for which they were deemed useful and appropriate. These protocols are based on best-available evidence and guidelines, and where such citations were unavailable or inappropriate, they are based on author experience. We hope these protocols will help raise and equalize the standard of care across our profession, and serve as the backbone for a protocol book to use in your emergency or critical care practice.

We welcome corrections and ideas for future versions of this textbook. Should further editions follow, we are committed to their currency and relevancy, and thus will continue to push for best-practice, evidence- and guideline-based recommendations. Lastly, we would like to thank each contributor; we believe they did an amazing job stepping up to the challenges that this unique textbook posed.

Jamie M. Burkitt Creedon
Harold Davis
Advanced Monitoring and Procedures for Small Animal Emergency and Critical Care
SECTION I

Introduction
The concept of triage finds its origin in the French military. The word comes from the French verb *trier*, meaning to sort. In human medicine the goals of triage have varied over the years depending upon the situation. After World War II triage came to mean the process of identifying those soldiers most likely to return to battle after medical care. Following the Korean and Vietnam conflicts the goals of triage came to mean the greatest good for the greatest number of wounded. In times of disaster, the goals of triage are similar to the military. Daily human emergency room triage began in the 1960s and has evolved into a method to separate efficiently those patients stable enough to wait for treatment from those who require immediate medical attention. In veterinary medicine we have adopted the goals of our counterparts in the human emergency room. Thus, we prioritize cases by medical urgency when presented with multiple emergencies at the same time.

Triage occurs both by telephone and in the hospital. A client often calls the hospital seeking advice for the care of his or her pet; the receptionist or veterinary technician must ascertain useful information about the pet in a short period of time. In addition the receptionist or technician should have the knowledge required to provide the appropriate advice. The information obtained during the telephone conversation will also be useful in preparing for patient arrival. On initial presentation to the hospital the veterinary technician is usually first to receive the patient and therefore to perform basic triage. This person must determine whether the patient needs immediate care and, in the case of simultaneous patient arrivals, prioritize treatment based on medical need.

### Telephone triage

In theory, telephone triage requires clinic staff to determine the urgency of a pet’s problem and to provide advice based on that determination. However, because the client may not possess the training to give an accurate account of the pet’s problem(s), it is generally safest to recommend the client take the pet to a veterinarian for evaluation. Particularly, any patient experiencing breathing difficulty, seizures, inability or unwillingness to rise, or traumatic injury should be seen by a veterinarian without question.

At the beginning of the telephone conversation staff should establish the animal’s signalment (breed, sex, age, and weight) if possible. Questions asked of the owner should be basic and straightforward. They should address the patient’s level of consciousness, whether or not the patient is breathing, experiencing seizures, or has obviously broken or exposed bones (see Table 1.1). Based on the owner’s responses, advice can be given on first aid, assuming that the problem can be clearly defined and is simple. See Table 1.2 for a list of problems requiring attention by the veterinary health care team without delay.

Information gathered during the phone conversation can aid the veterinary technician in preparation for the arrival of the patient at the hospital. Simply knowing the animal’s breed or approximate weight can enable the technician to pre-select appropriate sizes for vascular catheters, fluid bags, and endotracheal tubes.

Owners should be instructed on safe transport for the animal. Animals that have suffered trauma are often in pain, and owners should be instructed on how to
Triage begins when approaching the patient. Visually assess breathing effort and pattern; presence of blood or other foreign material on or around the patient; and the patient’s posture and level of consciousness (LOC). Note if there are airway sounds audible without a stethoscope. Note whether or not the animal responds as you approach. If the animal is conscious, ask the owner about the patient’s temperament and take the appropriate precautions regarding physical restraint or muzzling. Physical restraint and muzzling should be performed with extreme caution in patients with respiratory distress, as such steps can cause acute decompensation and respiratory arrest. If time permits, a brief history should be obtained.

The ABCDEs

A reasonable and systematic approach to triage is the use of the ABCDEs of emergency care, which are: (A) airway,
(B) breathing, (C) circulation, (D) dysfunction of the central nervous system, and (E) examination (see Fig. 1.2). Patients with respiratory distress or arrest, signs of hypovolemic shock or cardiac arrest, altered LOC, or ongoing seizure activity should be immediately taken to the treatment area for rapid medical attention. Conditions that affect other body systems are generally not life-threatening in and of themselves, but their effects on the three major body systems may be life-threatening. For example, a fractured femur bleeding into a limb can lead to life-threatening hypovolemia. The following is a list of problems that also require immediate medical attention:

- Exposure to toxins (ingested or topical)
- Excessive bleeding
- Open fractures
- Snake bite

- Burns
- Prolapsed organs
- Wound dehiscence
- Dystocia
- Trauma

![Triage Algorithm](image-url)
Airway and breathing

Expedient respiratory system assessment and rapid correction of abnormalities is critical. First, patenty of airway and breathing effort should be assessed. This is done by visualization, auscultation, and palpation. When looking at the animal, an experienced individual can determine if the animal has increased breathing rate or effort. Some animals with respiratory distress may assume a posture with the head and neck extended and the elbows abducted (held away from the body). Additional concerning signs include absent chest wall motion, exaggerated breathing effort, flaring of the nares, open mouth breathing and paradoxical breathing. When sustained high breathing effort leads to respiratory fatigue, paradoxical breathing can occur, which is characterized by opposing movements of the chest and abdominal walls during inspiration and expiration. Cyanosis, a blue or purplish tint to the mucous membranes, usually indicates hypoxemia and warrants immediate medical intervention. The chest wall may be palpated to assess chest wall integrity. Crepitus about the body may indicate subcutaneous emphysema, which can be caused by tracheal tears or chest wall defects.

Some assessment questions the triage technician should consider:

- Is the patient having difficulty breathing?
- Are breath sounds auscultable?
- Are facial injuries interfering with the airway?
- Has a bite wound disrupted the larynx or trachea?
- Is subcutaneous emphysema present?
- What color are the mucous membranes?
- Does respiratory distress get worse with patient position change?
- Is there evidence of thoracic penetration or a flail chest?

Circulation

Many of the signs suggestive of decreased cardiac output are a result of a compensatory sympathetic reflex, which helps maintain arterial blood pressure. Clinical signs suggestive of decreased cardiac output include: tachycardia, pale or gray mucous membranes, prolonged capillary refill time, poor pulse quality, cool extremities, and decreased mentation. Decreased cardiac output may be due to hypovolemia as a result of blood or other fluid loss (internally or externally; active or historical), trauma, or cardiac disease.

Circulation is assessed by visualization, palpation, and auscultation. The focus of the cardiovascular assessment is the six perfusion parameters (see Table 1.3).

Table 1.3 The six perfusion parameters

<table>
<thead>
<tr>
<th>Parameter</th>
</tr>
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<tbody>
<tr>
<td>Mucous membrane color</td>
</tr>
<tr>
<td>Capillary refill time</td>
</tr>
<tr>
<td>Heart rate</td>
</tr>
<tr>
<td>Pulse quality</td>
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<tr>
<td>Extremity temperature</td>
</tr>
<tr>
<td>Mentation</td>
</tr>
</tbody>
</table>

Mucous membrane color

After assuring it is safe to do so, evaluate the mucous membranes by examining the color of the gums (see Fig. 1.3). As an alternative in the fractious animal or patients with pigmented gums examine the conjunctiva, penis, or the vulva. The normal color of pink is a result of oxygenated hemoglobin in red blood cells in the capillary bed. Mucous membrane color may vary with circulatory related problems. Mucous membrane color may be pale or white due to blood loss anemia or vasoconstriction. Brick red or injected mucous membranes are a result of vasodilation and can be seen with hyperthermia or sepsis. Cyanotic or blue mucous membranes are an indicator of severe hypoxemia. The absence of cyanosis does not rule out hypoxemia. Icteric or yellow mucous membranes are due to the breakdown of red cells (hemolysis) or liver disease. Methemoglobinemia results in brown or chocolate-colored mucous membranes.

Capillary refill time (CRT)

Evaluation of CRT is done by applying digital pressure to the surface of the mucous membranes and forcing the blood from the capillary bed and observing the return
of color. Normal CRT is 1–2 seconds. A shortened CRT (<1/2 second) is suggestive of vasodilation. A prolonged capillary refill time (>2 seconds) is also a result of peripheral vasoconstriction and causes decreased peripheral perfusion.

Heart rate
Heart rate is a nonspecific parameter. It is usually measured by auscultation of the heart, palpation of the apex beat, or palpation of an artery. Increase in heart rate (tachycardia) may be caused by hypovolemia (the tachycardia is a compensatory mechanism), hypoxemia, hypotension, drugs, fever, excitement, exercise, and pain. Tachycardia is generally defined as a heart rate >160 beats per minutes (bpm) in the dog or 200 bpm in the cat. Decrease in heart rate (bradycardia) may be caused by increased vagal tone, severe electrolyte disturbances and hypothermia, drugs, or disturbances of the cardiac conduction system. Bradycardia is generally defined as a heart rate <60 bpm in the dog and 140 bpm in the cat. Auscultation of the heart also provides information about rhythm and murmurs. Auscultation of the heart and palpation of an artery should occur simultaneously, so that pulse deficits (the difference between heart and pulse rate; they should be the same) can be determined. Pulse deficits are suggestive of arrhythmias.

Pulse quality
Palpation of the artery provides information about the animal’s heart rate and rhythm. The femoral or dorsal pedal arteries are the commonly palpated arteries. In addition, pulse quality is an indicator of stroke volume, the amount of blood pumped out of the heart with each beat. Palpating a peripheral pulse is feeling the difference between the systolic and diastolic pressures and duration of the waveform. Ideally, the pulse should be full, regular, and strong, indicating a normal stroke volume. A thready pulse is defined as a narrow waveform and a weak pulse refers to a small amplitude pulse difference, both of which are indicative of a decreased stroke volume. Bounding pulses have a large pulse pressure difference and wide waveforms usually associated with increased stroke volume and vasodilation.

Extremity temperature
The paws, limbs, or ears should normally feel warm to the touch. Cool extremities are a result of vasoconstriction.

Mentation
As previously mentioned, evaluation of mentation starts from afar. Observe the attitude of the patient without stimulation. If the patient has an altered mental state, it is assessed for its response to touch, sound, and painful stimuli. An inappropriate mental state can be a result of inadequate perfusion or a primary brain problem.

Some assessment questions the triage technician should consider:

- Is the patient’s mentation normal?
- Is there evidence of hemorrhage?
- Is there swelling associated with an extremity or evidence of a fracture?
- Are the mucous membranes pale?
- Is the capillary refill time prolonged?
- Are the pulses weak and rapid?
- Is the heart rate abnormal?
- Are the extremities cold?

Dysfunction or disability of the neurological system
Dysfunction or disability refers to the neurological status of the patient. This may be assessed through visualization and palpation. A cursory neurologic exam is performed focusing on the patient’s LOC, pupillary light reflex, posture, and response to pain (superficial and deep). Depressed mentation may be a result of poor oxygen delivery or trauma to the brain. Seizure activity may be due to intra- or extracranial causes.

A patient that is recumbent, has an abnormal posture, or is not seen to ambulate or make voluntary movements should be assumed to have spinal trauma and stabilized on a backboard (see Fig. 1.4) until proven otherwise.

Figure 1.4 A patient with suspected head and spinal trauma restrained on a backboard. The cranial end of the board is elevated slightly because of suspected increased intracranial pressure.
Some assessment questions the triage technician should consider:

- Is the animal bright, alert, and responsive or obtunded (depressed but rousable), stuporous (roused only with painful stimulation), or comatose?
- Are the pupils dilated, constricted, of equal size, and responsive to light?
- What is the posture of the animal?
- Are there any abnormal breathing patterns?
- Does the animal respond to painful stimuli?
- Is there obvious seizure activity?

**Examination**

Finally, a rapid whole-body examination is performed. The goal is to determine and address any additional problems.

Some assessment questions the triage technician should consider:

- Are there lacerations, wounds, or punctures?
- Is there bruising and is it getting worse?
- Are there any fractures?
- Is the abdomen painful or distended?
- Is there evidence of debilitation or other signs of disease?

**Summary**

In some emergencies, minutes count. The triage performed by the veterinary technician should be rapid and efficient. The goal is rapid recognition of and intervention for life-threatening conditions such as hypoxemia and inadequate perfusion. A systematic approach to patient assessment is essential for the best possible patient outcome.

**Reference**

Emergency medicine can be defined as “the diagnosis and treatment of unforeseen illness or injury.”¹ The practice of emergency medicine takes place in primary care clinics during regular business hours or when veterinarians are on call, in dedicated “after-hours” freestanding emergency clinics, and in multispecialty referral hospitals. No clinical veterinary practice is immune to the realms of emergency medicine, as vaccines can cause anaphylactic reactions, anesthesia-related cardiopulmonary arrests can occur, and without warning clients may present a pet with a traumatic injury or critical illness.

The Veterinary Emergency and Critical Care Society (www.veccs.org), whose mission includes “To promote the advancement of knowledge and high standards of practice in veterinary emergency medicine and critical patient care,” provides guidelines for emergency practice.² In looking to these standards along with applicable state board regulations, a practice should define for its patients, clients, the public, and for itself expectations for its emergency practice.

The practice of emergency medicine differs from primary care and other specialty practices by the urgency and breadth of the patients’ conditions. Depending on the degree a practice wishes to diagnose and treat unforeseen illnesses and injuries, varying degrees of adaptations in the physical plant, equipment, inventory, staffing, and hospital systems are needed.

**Hospital design and flow**

When creating a floor plan concept for an emergency facility, a great deal of thought should be given to the specific aspects of the emergency practice. Good “flow” is essential to good design. Flow represents the natural movements of patients, clients, doctors, and staff in the daily activity of the practice;³ arranging for such movement is almost like choreographing a dance. Thought should be given to dynamic situations such as how best to move clients from the lobby to examination rooms to discharge, and how most efficiently to move a large dog from x-ray to a surgical preparation area and then into a surgical suite.

In larger facilities the idea of a hub and spoke concept⁴ can be applied to the flow of a practice. The hub can be a centralized space such as the treatment area. The spokes from the hub may be clinical areas such as the in-house laboratory, radiology, surgery, patient wards, isolation ward, and pharmacy. In even larger facilities, multiple hub and spoke areas may exist, such as one for the intensive care unit (ICU) and one for the emergency service. Industry-specific publications such as *Veterinary Economics* commonly address veterinary and emergency facility design.
Accessible to the (emergency) entrance of the facility, the client waiting area must be large enough to accommodate a simultaneous influx of many clients and their pets. While benches or more utilitarian styles of seating may work well in a primary care practice where wait times are short, the client presenting a pet for an emergency may spend hours in the emergency practice lobby. Comfortable, well-padded chairs, a beverage service in the form of a water cooler or vending machine, and a restroom that is easily accessible to the client should be considered (see Fig. 2.1).

**Reception area**

This is the area where clients are initially received and usually discharged. Ideally, some degree of privacy should exist for the discharge area where financial or sensitive communication is taking place.

**Security**

Emergency practices have more security concerns than day practices because they are open during non-business hours and may be perceived to be rich in cash and narcotics. To provide a safe environment for staff and clients, enhanced security measures should be considered.

An alarm system can be installed in the facility that can notify a monitoring service or the police if the alarm is triggered. In continuous operations, “panic” buttons can be placed, whereas door, window, motion, and other

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**Table 2.1** Area approximation for a small dedicated emergency clinic

<table>
<thead>
<tr>
<th>Space</th>
<th>Dimensions</th>
<th>Area (Sq Ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lobby</td>
<td>15’ × 20’</td>
<td>300</td>
</tr>
<tr>
<td>Client bathroom</td>
<td>8’ × 8’</td>
<td>64</td>
</tr>
<tr>
<td>Reception area</td>
<td>10’ × 10’</td>
<td>100</td>
</tr>
<tr>
<td>Triage area</td>
<td>8’ × 10’</td>
<td>80</td>
</tr>
<tr>
<td>Exam room 1</td>
<td>10’ × 11’</td>
<td>110</td>
</tr>
<tr>
<td>Exam room 2</td>
<td>10’ × 11’</td>
<td>110</td>
</tr>
<tr>
<td>Exam room 3</td>
<td>10’ × 11’</td>
<td>110</td>
</tr>
<tr>
<td>Treatment room</td>
<td>30’ × 20’</td>
<td>600</td>
</tr>
<tr>
<td>Isolation ward</td>
<td>10’ × 10’</td>
<td>100</td>
</tr>
<tr>
<td>Surgical suite</td>
<td>15’ × 10’</td>
<td>150</td>
</tr>
<tr>
<td>Radiology</td>
<td>10’ × 8’</td>
<td>80</td>
</tr>
<tr>
<td>Staff bathroom</td>
<td>10’ × 9’</td>
<td>90</td>
</tr>
<tr>
<td>Staff break area</td>
<td>12’ × 10’</td>
<td>120</td>
</tr>
<tr>
<td>Administrative office</td>
<td>12’ × 10’</td>
<td>120</td>
</tr>
<tr>
<td>Utility/laundry room/</td>
<td>14’ × 8’</td>
<td>112</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>~2200 sq.ft.</td>
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**Table 2.2** Area approximation for a 24-hour emergency practice

<table>
<thead>
<tr>
<th>Space</th>
<th>Dimensions</th>
<th>Area (Sq Ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lobby</td>
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<td>875</td>
</tr>
<tr>
<td>Client bathroom</td>
<td>8’ × 8’</td>
<td>64</td>
</tr>
<tr>
<td>Reception area</td>
<td>15’ × 10’</td>
<td>150</td>
</tr>
<tr>
<td>Check out area</td>
<td>10’ × 12’</td>
<td>120</td>
</tr>
<tr>
<td>Check out lobby</td>
<td>12’ × 15’</td>
<td>180</td>
</tr>
<tr>
<td>Triage area</td>
<td>8’ × 10’</td>
<td>80</td>
</tr>
<tr>
<td>Exam room 1</td>
<td>10’ × 11’</td>
<td>110</td>
</tr>
<tr>
<td>Exam room 2</td>
<td>10’ × 11’</td>
<td>110</td>
</tr>
<tr>
<td>Exam room 3</td>
<td>10’ × 11’</td>
<td>110</td>
</tr>
<tr>
<td>Exam room 4</td>
<td>10’ × 11’</td>
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<tr>
<td>Exam room 5</td>
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<tr>
<td>Consultation room</td>
<td>12’ × 12’</td>
<td>144</td>
</tr>
<tr>
<td>Treatment room</td>
<td>30’ × 40’</td>
<td>1200</td>
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<tr>
<td>Wards</td>
<td>15’ × 25’</td>
<td>375</td>
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<tr>
<td>Isolation ward</td>
<td>12’ × 12’</td>
<td>144</td>
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<tr>
<td>Laboratory</td>
<td>15’ × 20’</td>
<td>300</td>
</tr>
<tr>
<td>Surgical suite</td>
<td>15’ × 10’</td>
<td>150</td>
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<tr>
<td>Surgical preparation area</td>
<td>20’ × 12’</td>
<td>240</td>
</tr>
<tr>
<td>Radiology</td>
<td>12’ × 11’</td>
<td>121</td>
</tr>
<tr>
<td>Staff break area</td>
<td>12’ × 10’</td>
<td>120</td>
</tr>
<tr>
<td>Staff bathroom</td>
<td>10’ × 10’</td>
<td>100</td>
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<tr>
<td>Administrative office</td>
<td>10’ × 10’</td>
<td>100</td>
</tr>
<tr>
<td>Administrative office</td>
<td>10’ × 10’</td>
<td>100</td>
</tr>
<tr>
<td>Administrative office</td>
<td>10’ × 10’</td>
<td>100</td>
</tr>
<tr>
<td>Conference room</td>
<td>25’ × 15’</td>
<td>375</td>
</tr>
<tr>
<td>Doctors’ office/library</td>
<td>15’ × 20’</td>
<td>300</td>
</tr>
<tr>
<td>Server room</td>
<td>8’ × 8’</td>
<td>64</td>
</tr>
<tr>
<td>Utility/laundry room</td>
<td>14’ × 12’</td>
<td>168</td>
</tr>
<tr>
<td>Storage room</td>
<td>10’ × 12’</td>
<td>120</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>~6250</td>
</tr>
</tbody>
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**Figure 2.1** Lobby. Since clients may spend hours in an emergency practice lobby, it should be furnished with comfortable, well-padded chairs, beverage service, and an easily accessible restroom.