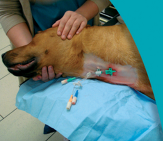
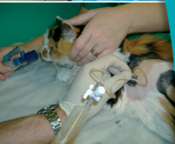
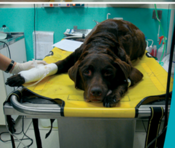

Practical Emergency and Critical Care Veterinary Nursing

Paul Aldridge
and Louise O'Dwyer

Practical Emergency and Critical Care Veterinary Nursing

I dedicate this book to my son Jacob, the brightest star in the sky

Louise O'Dwyer

For my daughters, Ella and Amber

Paul Aldridge

Companion website

This book is accompanied by a companion website:

www.wiley.com/go/aldridge/ecc_vet_nursing

The website includes:

- information charts
- video/slideshow demonstrations

Practical Emergency and Critical Care Veterinary Nursing

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Visit the supporting companion website for this book:
www.wiley.com/go/aldridge/ecc_vet_nursing

Preface

Emergency and critical patients are amongst the most challenging and rewarding of cases to treat. The role of the veterinary nurse and the close relationship with patients is never more important than when nursing these cases. Nurses have a vital role in the outcome of these patients as recovery is dependent on close monitoring and assessing the response to treatment, often noticing subtle changes in clinical signs.

During the 12 years that we have both been involved in emergency care, huge steps forward have been made in both diagnostic procedures and the treatment of patients, and emergency care has become a respected discipline in itself.

We hope this book conveys our enthusiasm for this fascinating area of veterinary medicine, and inspires nurses to become more confident in their clinical skills and abilities. We hope that reading the book will not only teach new skills, but also show how an existing skill set can be applied in an emergency situation.

The layout of the book is such that it could be read completely by nurses studying towards qualifications, or equally kept close at hand within the practice as a reference work, turning to the relevant chapters as the need arises. Each chapter contains a large number of photographs obtained from real life cases, to illustrate clearly the techniques described in the text. Depending on local legislation, some techniques described (e.g. tracheostomy) will be outside the scope of what nurses are permitted to perform; however, we feel their inclusion is essential to provide an understanding of why and how these procedures are performed, and to emphasise the areas of after care that must be closely attended to.

To accompany this book a companion website has been produced (visit **www.wiley.com/go/aldridge/ecc_vet_nursing**). Our aim was to provide access to additional resources, tables and charts that we find useful in the management of our emergency and critical patients. Where such a document exists then reference is made to it at the relevant point of the chapter.

Paul Aldridge and Louise O'Dwyer
July 2012

1 Triage and Assessment of the Emergency Patient

Introduction

Throughout the management of the emergency patient a successful outcome is more likely to be achieved where prompt, appropriate action is taken as dictated by the clinical findings of observation and examination. Nowhere is this more important than on initial presentation where the patient with a life-threatening condition must be identified and receive immediate attention; this process is triage.

Triage is a system of rapidly evaluating patients and allocating treatment to those patients that are in most urgent need, or in the case of one individual case, allocating treatment to the most serious problem first. To gain this information, a rapid, efficient, clinical examination of the major body systems is carried out: respiratory, cardiovascular and central nervous system (CNS). The initial examination of each body system should concentrate on a small number of clinical signs that provide the most important information.

In human medicine, triage is well established and used in busy accident and emergency departments or at the scene of major incidents. The same principles apply in veterinary medicine, whether in a dedicated emergency out-of-hours practice or when dealing with an urgent case in a first opinion practice.

Telephone triage

In many cases the initial contact from the owner of the emergency case will be by telephone. The veterinary nurse is often involved in establishing the urgency of the problem, and vitally whether the animal needs to attend the clinic immediately. From conversation with some owners it will become immediately obvious from the clinical signs described that the case is an emergency and should be seen as soon as possible (see Table 1.1). In other cases the nurse will need to try to determine the nature of the problem, and give advice accordingly. It may be necessary to calm the owner to elicit a concise, relevant history, and caution should be used when assessing an owner's perception of the patient's problem. If there is any doubt about the need to see an animal, it is safest to advise the owner to attend or for a veterinary surgeon to discuss the case with the owner. It is advisable that all patients with a traumatic injury should attend the clinic immediately.

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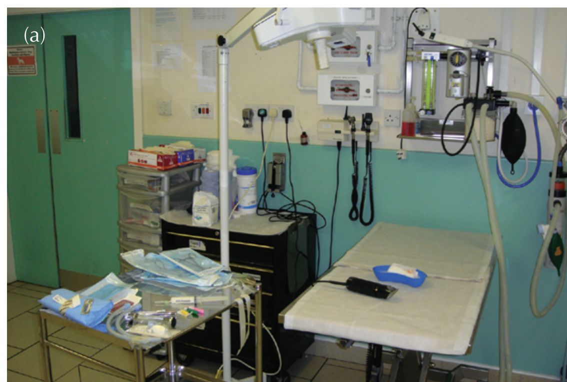
Table 1.1 Examples of owner-reported clinical signs that warrant immediate attendance at clinic

• Respiratory distress • Severe coughing • Weakness or collapse • Neurological abnormalities • Ataxia • Non-weight-bearing lameness • Severe pain	• Abdominal distension • Persistent vomiting or diarrhoea • Inability to urinate • Bleeding from body orifices • Profuse bleeding from wounds • Ingestion of toxins • Dystocia

Figure 1.1 Transport.



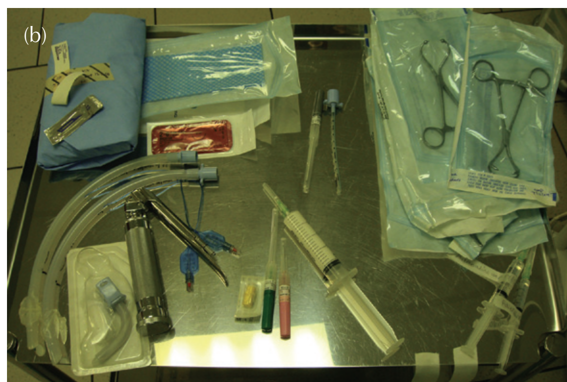


Figure 1.2 (a) Preparing for the arrival of a patient. Information gathered during telephone triage allows equipment to be prepared and so save time once the patient has arrived; in this case a dog with a pharyngeal foreign body. (b) Close-up of the trolley in (a). Equipment includes intravenous access, endotracheal tubes, laryngoscope, surgical kit, tracheostomy tubes, etc.

The owner should be questioned as to the signalment of the patient (breed, age, sex and approximate weight) and given clear and concise directions as to where they are to attend (this is especially important where phone lines are diverted out of hours and owners maybe unaware their call has been diverted to another site or clinic) and an estimated time of arrival obtained.

Advice may need to be given on transportation of the animal, especially following trauma. If an animal is unable to walk it may need to be carried; it is preferable for a trauma victim to be carried on a board or something rigid, rather than a blanket (see Figure 1.1). In the case of active bleeding, direct pressure on to a clean cloth is safer than the owner applying a tourniquet. Always warn the owner that the animal may be aggressive due to pain.

Knowing the nature of the problem, along with the signalment of the animal, allows a great deal of preparation to occur prior to the patient's arrival (see Figure 1.2); this can save valuable time when initiating stabilisation. For example, equipment for supplementing oxygen or obtaining vascular access can be prepared, or advice can be sought regarding toxic levels, appropriate management and antidotes in cases of intoxication.

Hospital triage

On arrival at the clinic the major body systems are assessed during the triage, and a brief 'capsular' history obtained from the owner (see Table 1.2). See website documents: Triage assessment sheet.

Table 1.2 Questions asked of owners to obtain a 'capsular history'

• Signalment (age, sex, neutered, breed)	• Duration of presenting complaint
• Vaccination history	• Current medication

Table 1.3 Examples of presenting conditions that should be taken immediately to the treatment area on arrival

• Seizures	• Ingestion of toxins
• Trauma	• Excessive bleeding
• Prolapsed organs	• Open fractures
• Dystocia	• Burns (see Figure 1.3)

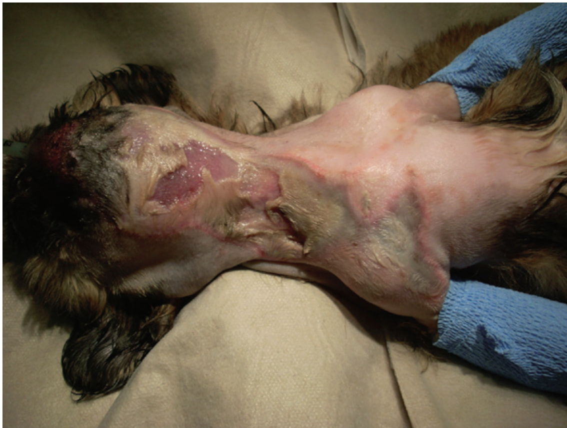


Figure 1.3 Severe burns on a puppy, an example of a patient that should be taken directly to the treatment area.

During assessment, any abnormality detected with a major body system is likely to be life-threatening; therefore measures are immediately taken to start stabilising that condition, prior to completing the rest of the examination. The aim is not to reach a definitive diagnosis, but to start treatment of life-threatening conditions. So, for example, if an animal is immediately noted to be in respiratory distress, oxygen is administered before any other part of the examination is carried out.

Patients with certain presentations should be taken to the treatment area immediately, regardless of major body system findings (see Table 1.3; Figure 1.3).

A useful path to follow in the initial assessment of major body systems is ABCD, where:

A: Airway
B: Breathing
C: Circulation
D: Dysfunction of the CNS.

A and B: Respiratory system

Emergencies involving the respiratory system require rapid assessment, cautious restraint and prompt measures to start stabilisation. Assessment of the respiratory system should begin as the patient is approached by observing their posture, respiratory effort and pattern, and whether any airway sounds are clearly audible.

In the normal patient, both cats and dogs have a respiratory rate of approximately 10–20 breaths per minute (bpm), ventilation involves very little chest movement, and the chest wall and abdomen move out and in together. Whilst open mouth breathing and panting in a dog is considered normal, the same in a cat is always considered to indicate respiratory distress and oxygen supplementation is indicated.

The respiratory system of the patient is assessed by observation, auscultation and palpation.

Airway

In a collapsed patient, assess if the airway is patent by listening for breathing, and looking in the mouth for any obstruction (blood, vomit, foreign bodies). Facial injuries or cervical bite wounds can interfere with the airway by disrupting the larynx or trachea.

Breathing

Observation The patient should be closely observed before moving on to auscultation with a stethoscope. Often, observation alone is enough to determine a respiratory problem exists and dictate the animal should be moved to the treatment area to start stabilisation. Observation should focus on:

- *Respiratory rate:* an increased respiratory rate is termed tachypnoea. If a patient is judged to be

tachypnoeic, the focus should then move to whether there is increased respiratory effort. If there appears to be no increased effort, the tachypnoea may be caused by fear, stress, pyrexia or pain.

- *Respiratory effort:* animals with increased respiratory effort will often alter their body posture to assist them in their efforts to ventilate adequately. The typical picture is of flared nostrils, extended neck and abducted elbows as the animal struggles to draw air in. There will often also be exaggerated chest wall movement and abdominal effort, where the muscles of the abdominal wall are brought into play to assist with breathing. In severe respiratory effort there maybe 'paradoxical' movement of the abdominal wall; where the abdomen moves inwards on inspiration.
- *Respiratory pattern:* in the normal breathing cycle, the time taken for inspiration is similar in length to expiration. Where alterations in this ratio occur it may give clues to the level of the respiratory tract at which a problem is present (see Chapter 9).
- *Symmetrical movement of the chest wall:* rib fractures, and 'flail chest' segments may cause asymmetrical movement of the chest wall.

Auscultation Listening to the patient before using a stethoscope may reveal abnormal respiratory noises such as stertor, or stridor. Stertor refers to 'snoring' types of noise, often caused by vibration of excessive soft tissue in the oropharynx. While this is normal in some breeds of dog, in other patients it may be a sign of inflammation. Stridor is a high-pitched whistling sound, usually associated with air moving rapidly through a narrowed opening.

Auscultation in association with a respiratory pattern is vital in helping to localise the region of the respiratory tract affected (see Chapter 9).

A stethoscope should then be used to ausculate the chest wall, comparing identical areas on the left side of the chest to the right side, and similarly comparing ventral lung fields to dorsal. This comparison allows abnormalities to be more easily detected. Breath sounds may be reduced or absent where pleural disease exists (pneumothorax, pleural effusion, diaphragm rupture), or increased sounds where airway disease is present. The presence of wheezes suggests airway narrowing, and 'crackles' suggest the presence of fluid in alveoli.

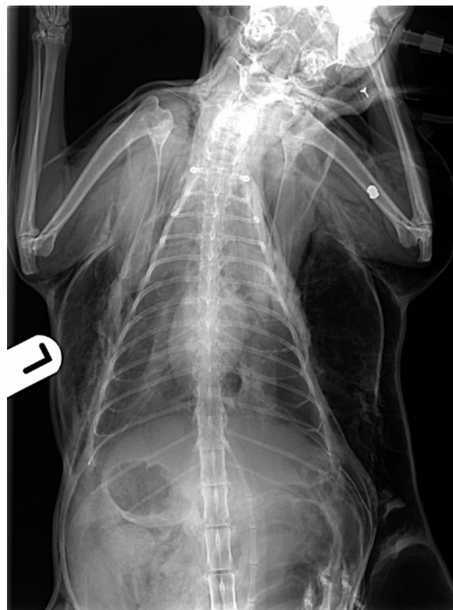


Figure 1.4 Pronounced subcutaneous emphysema in a cat following thoracic trauma from an airgun pellet.

Palpation Gentle palpation of the chest wall may be useful for detecting obvious trauma or subcutaneous emphysema. Subcutaneous emphysema is a build up of air below the skin, and can be associated chest wall defects or tracheal trauma (see Figure 1.4).

Definitive treatment for the cause of respiratory compromise should be provided as soon as possible. Careful auscultation and observation of the breathing pattern will often determine the location of the cause of dyspnoea, be it upper or lower airway, or pleural space disease. This can be essential, as often dyspnoeic animals have little or no physiological reserve. The ability to establish a working diagnosis based on history and examination alone is often the difference between life and death in dyspnoeic animals.

C: Cardiovascular

During initial assessment of the cardiovascular system, the aim is to gauge the effectiveness of the

heart in pumping blood to perfuse body tissues, and also whether that perfusion is delivering oxygen to the tissues. Poor perfusion leads to reduced oxygen delivery to tissues, known as 'shock'. Left uncorrected, shock will lead to cell death, and greatly increased morbidity and mortality in emergency patients.

Decreased cardiac output may be due to reduced circulating volume (hypovolaemia), or be due to heart failure and arrhythmias.

There is no direct method of measuring the amount of oxygen delivered to tissues; examination concentrates indicators of cardiovascular performance, or perfusion parameters. Many of the signs used to detect reduced cardiac output and poor perfusion arise as a result of compensatory measures by the body; measures aimed at preserving blood flow to the heart and brain at the expense of other tissues such as skin, gastrointestinal tract, muscles and kidneys. Compensatory measures include increased heart rate and contractility, and vasoconstriction of arterioles leading to capillary beds in less 'vital' tissues.

Mucous membranes

Mucous membranes are normally pink in colour; this is most commonly assessed on the gums. Cats' mucous membranes tend to be lighter in colour than dogs'. Commonly seen changes in mucous membrane colour are outlined in Table 1.4 (see Figure 1.5).

Table 1.4 Commonly observed colour changes in mucous membranes and their possible causes (see Figure 1.5)

Colour observed	Possible cause
Pale, white or grey	Poor perfusion, or anaemia
'Brick red' or 'injected'	Vasodilation, systemic inflammatory response
Blue or purple	Cyanosis: low oxygen saturation of haemoglobin
Yellow	Increased blood bilirubin levels
Brown	Formation of methaemoglobin, e.g. paracetamol poisoning
Cherry red	Carbon monoxide poisoning

Capillary refill time

Capillary refill time (CRT) is again assessed on the gums. Digital pressure is applied with a fingertip to blanche the mucous membrane, and then when the finger is removed, the time taken for colour to return is measured. A normal CRT is 1–1.75 s.

A prolonged refill time may be due to decreased cardiac output and vasoconstriction causing reduced peripheral perfusion.

A rapid capillary refill is likely due to increased perfusion of the mucous membrane caused by vasodilation, which can indicate systemic inflammation.

Pulse

Palpation of femoral and distal (metatarsal) pulses will reveal pulse rate and rhythm, and also gives an impression of stroke volume (the amount of blood pumped with each beat).

Pulses should be easily palpated (except in obese animals), and should feel 'full'; terms such as these refer to the quality of the pulse, which may take some practice to appreciate. When judging the quality of the pulse the force and the duration of the pulse need to be assessed. The pulse is a wave of blood travelling down the artery that represents the output of the heart. If the duration of the wave, as well as its height is considered, a better idea of stroke volume is gained. As cardiac output drops, it becomes more difficult to palpate the metatarsal pulse.

Irregular pulses may be due to cardiac arrhythmias, or conditions such as pericardial effusion.

Heart

Auscultation of the heart should be carried out at the same time as palpating an artery, this allows any pulse deficits (an audible heart beat without an output) to be detected. The heart rate can be counted (see Table 1.5). A rapid heart rate (tachycardia) may be detected with cardiac disease, cardiac arrhythmias, sepsis or shock due to reduced blood volume. It must be remembered that whilst tachycardia is a normal finding in hypovolaemic dogs, cats often develop a slow heart rate (bradycardia) if hypovolaemic.

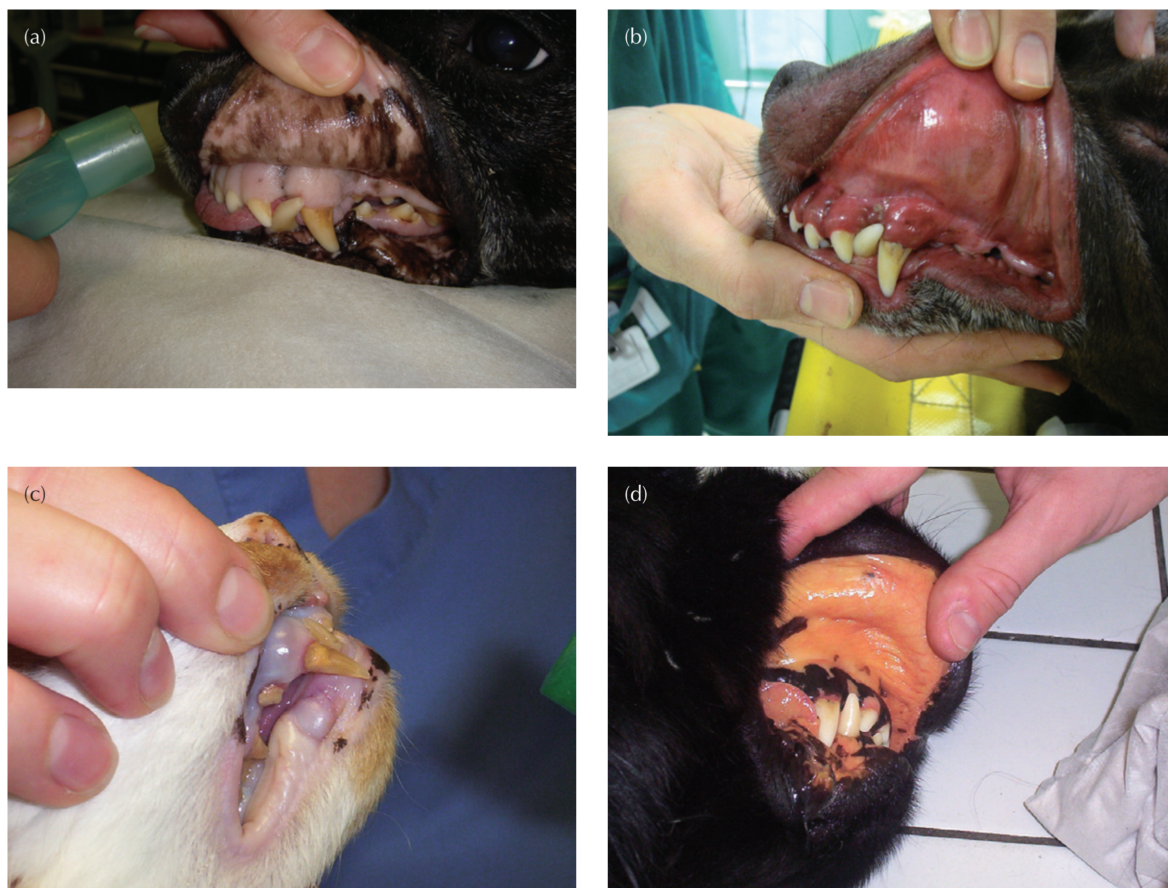


Figure 1.5 (a) Pale mucous membranes in an anaemic animal. (b) Brick red mucous membranes in a patient with systemic inflammatory response. (c) Blue tinged mucous membranes in a cyanotic cat. (d) Icteric mucous membranes. The yellow colour is caused by raised levels of bilirubin.

Table 1.5 Changes in heart rate and their possible causes

Normal heart rates	**Dogs:** 60–100 bpm (depending on size) **Cats:** 160–200 bpm (higher if stressed)
Causes of tachycardia	Cardiac disease Cardiac tachyarrhythmias Sepsis Hypovolaemic shock Fear Stress Pain
Causes of bradycardia	Hyperkalaemia Increased intracranial pressure Cardiac arrhythmias Hypovolaemic shock in cats

Heart sounds are often very quiet in severe hypovolaemia, and muffled where pericardial effusions are present. Any audible murmurs should be noted.

If indicators of poor tissue perfusion are detected on triage, stabilisation measures need to be taken immediately. Continued poor perfusion leads to cell death and release of free radicals and inflammatory mediators.

Most animals with abnormal perfusion have some degree of hypovolaemia. Recognising hypovolaemia based on the physical examination of perfusion parameters is an essential skill (see Table 1.6). With practice, the degree of hypovolaemia present can be estimated, and the same parameters used to measure response to treatment (see Chapter 3).

Table 1.6 Changes in perfusion parameters seen in hypovolaemia

Clinical parameter	Mild hypovolaemia	Moderate hypovolaemia	Severe hypovolaemia
Heart rate*	120–140	140–170	170–220
Mucous membrane	Normal, or pinker	Pale pink	Pale/white/grey
Capillary refill	Brisk (<1 s)	Normal (1–2 s)	Slow or not detectable
Pulse amplitude	Increased	Decreased	Very decreased
Pulse duration	Mildly reduced	Reduced	Very reduced

*Heart rates refer to dogs, cats often have a slow heart rate when hypovolaemic.

D: Dysfunction of the central nervous system

The CNS should be briefly assessed through observation and palpation. Observation should begin as soon as the patient is approached: posture, level of consciousness, and interaction or response to their surroundings should be noted. The patient should be ambulatory with normal gait and proprioception. (Any patient that is in lateral recumbency, non-responsive or showing neurological abnormailities such as twitching or seizure activity should be triaged immediately and taken to the treatment area for further assessment.)

Depressed mentation can be due to poor oxygen delivery to the brain, but if this seems more severe than would be indicated by examination of the respiratory and circulatory system, then the suspicion of CNS involvement is increased.

The patient's pupils should be assessed to ensure they are symmetrical and equal in size, that a pupillary light reflex (PLR) is present (see Chapter 15) and that there is no obvious dilation (mydriasis) or constriction (miosis).

Following assessment of the major body systems, a brief examination of the rest of the body should be performed.

Abdominal palpation After examination of the major body systems, the abdomen can be palpated. Palpation should reveal any abdominal distension or pain. Where distension is present it may be possible to differentiate between gaseous distension and fluid effusion. The caudal abdomen should be checked to ensure the urinary bladder is not distended.

Body temperature Core body temperature is usually assessed by a rectal thermometer reading. Readings taken may actually be lower than core temperature if the thermometer tip is within faeces or gas in the rectum.

High body temperatures are common in emergency presentations. Pyrexia is an increase in body temperature above the normal range (due to an increase in the body temperature regulatory set point, so the body is still controlling the body temperature) commonly seen with infection. Hyperthermia is an increase in temperature over and above the regulatory set-point. This occurs due to excessive heat production (e.g. from muscle activity in a seizuring animal) or an inability to thermoregulate (e.g. inability to pant in a dog with laryngeal paralysis). Body temperatures over 40°C (104°F) are of concern; temperatures of over 42°C (107°F) are life-threatening.

Low core body temperature can be associated with hypovolaemia. If a reading of 36°C or below is obtained, the patient should be assessed again to double check no other signs of poor perfusion are present.

Comparing the core body temperature with the temperature of the patient's extremity can be another indicator of poor perfusion. The patient's rectal temperature is compared with a reading obtained from the web of the toes. While the extremities are expected to be at a lower temperature, a difference of greater than 4°C often indicates reduced blood flow, and hence reduced transfer of heat to the extremities.

Summary of triage

Triage aims to evaluate the major body systems quickly, allowing rapid intervention where hypoxia, poor perfusion and other life-threatening conditions are detected. The same skills can then

Figure 1.6 Placing an intravenous catheter prior to gathering a 'minimum database' from a patient admitted to the clinic.

Table 1.7 A mnemonic for areas covered by an emergency secondary evaluation

	A CRASH PLAN!
A	Airway
C	CVS/Circulation
R	Respiratory
A	Abdomen
S	Spine
H	Head
P	Pelvis/rectal exam
L	Limbs
A	Arteries
N	Nerves

be applied to ensuring the patient is responding to administered treatment.

Once admitted to the clinic, a standard protocol should be followed: oxygen supplementation where required, an intravenous catheter is placed and a 'minimum database' is usually obtained from the patient, the details of which will vary from practice to practice, but usually include rapid clinical pathology such as packed cell volume (PCV) and total solids by refractometry, blood glucose measurement, urine specific gravity and 'dipstick', and electrolyte analysis where available (see Figure 1.6). Blood lactate levels can be obtained; this is useful in assessing reduced oxygen delivery to tissues (see Chapter 3).

Secondary evaluation

Once any life-threatening conditions have been stabilised, a more thorough secondary examination can be carried out, systematically covering body systems (see Table 1.7). At this point a detailed history can be obtained from the owner.

More in-depth diagnostic procedures can be performed, such as imaging, allowing an ongoing treatment and nursing plan to be formulated to deal with each specific problem in order of priority. A written hospital order sheet covering fluid therapy, feeding, medication, diagnostics and nursing requirements should be produced for each patient.

2 Monitoring the Critical Patient

Introduction

Close monitoring of the critical patient is essential to determine the effectiveness of any treatment, and to assess the degree of improvement in condition. Just as importantly, changes can be detected that indicate deterioration is imminent; this allows intervention to prevent a crisis before it occurs.

The most useful information is provided by observing a 'trend' in the monitored vital sign, rather than a single one-off measurement. To make spotting an ongoing trend easier, a recording sheet or graph is required, with the data entered at specified intervals (see Figure 2.1). How often these parameters are monitored will depend on the severity of the problem and the perceived risk of deterioration. Which parameters are to be monitored also depends on the patient; this should be decided by the clinical team and recorded in the animal's nursing plan (see Table 2.1). It is far safer to frequently re-assess a few relevant parameters than to repeatedly run a whole bulk of tests that take so much time to complete that deterioration may take longer to detect.

Individual practices often have a standardised 'minimum database' of information that is gathered from emergency cases on admission. Where specific problems are suspected from physical examination, more specific monitoring can be performed and further laboratory information may be required, e.g. clotting times, slide saline autoagglutination, blood gases, lactate levels.

Organ function

Respiratory system

Regular auscultation of the chest fields should be performed (see Practical techniques, Chapter 7) to detect any change in lung sounds. Lung sounds that have become muffled may indicate worsening pleural disease; an increase in lung sounds can indicate a worsening of lung or airway pathology.

Respiratory rate is useful as an indicator of respiratory disease. An increased rate could indicate a developing pneumothorax for instance, although an increase in respiratory rate (tachypnoea) can also be seen with pain, pyrexia, fear or abdominal distension.

An assessment of respiratory effort can be made by observation of the patient. Changes in posture can be indicative of increased effort: standing

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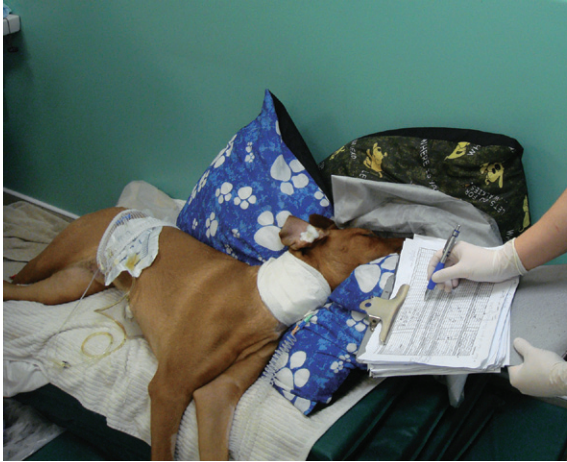

Figure 2.1 Recording clinical parameters on a suitable recording chart allows important trends to be spotted.

Table 2.1 Examples of areas that are monitored in critical patients

- **Organ function:**
  Respiratory system
  Cardiovascular system
  Central nervous system
  Urinary system
  Gastrointestinal system
- **Fluid and electrolyte balance:**
  Hydration status
  Fluids 'in' vs. fluids 'out'
- **Body temperature**
- **Clinical pathology**
  Biochemistry
  Haematology
  Coagulation profile
- **Pain scoring**
- **Recumbency care**

rather than sitting, extended neck, flared nostrils, open mouth breathing and increased abdominal movement may be seen.

Respiratory function can be considered adequate if partial pressures of both carbon dioxide and oxygen are within normal limits. The method of choice to monitor this is arterial blood gas analysis. Samples are usually obtained via an arterial catheter (see Chapter 3). Blood gas analysis measures the arterial partial pressure of oxygen (PaO2) (see Figure 2.2).

Pulse oximetery provides an estimate of the percentage of available haemaglobin that is carrying oxygen (oxygen saturation, SpO2) (see Figure 2.3). It does not reveal how the actual amount of oxygen is carried in the blood; this depends on the haemaglobin content. Oxygen saturation gives an idea of the efficiency of gaseous exchange from the inspired air in the alveoli into the body's tissues. Care is required with the placement of the pulse oximetery probe, if left in place for too long it tends to compress tissue and give a false reading. Conscious animals can have the probe placed on toe webs, lips or ears rather than on the tongue.

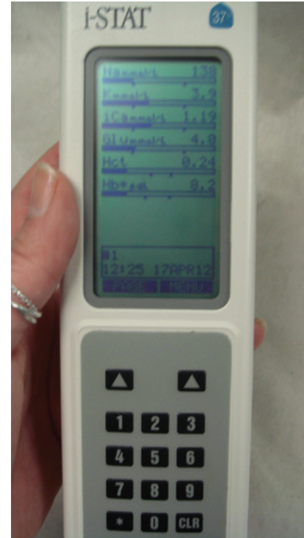

Figure 2.2 Performing blood gas analysis with a hand-held device.

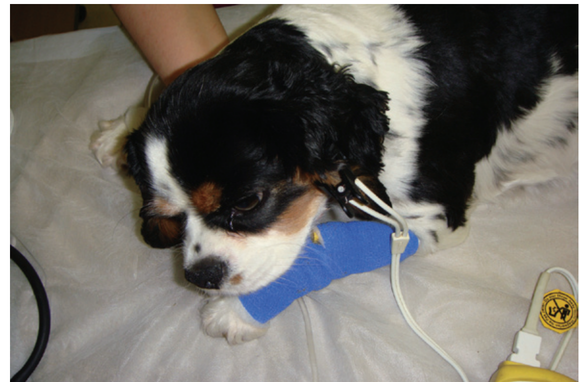

Figure 2.3 Pulse oximetry in a critical patient. The probe has been placed on the pinna.

Any animal with a reading of less than 95% SpO2 should receive oxygen supplementation. SpO2 values of 90% correspond to a PaO2 of 60 mmHg. Because of the nature of the oxygen

saturation curve, below 60 mmHg there is a rapid drop in oxygen saturation, so aiming for an SpO2 of 95% or above gives some margin of safety.

Cardiovascular system

Heart rate and rhythm

Heart rate can be measured by palpation of an apex beat, palpation of a pulse or auscultation with a stethoscope. Where abnormal rhythms are detected, a continuous electrocardiogram (ECG) should be carried out, and abnormalities recorded. While an ECG is useful to investigate rhythm disturbance, it only shows electrical activity. Just because there is a waveform does not mean there is an output at that point; it is always important to check pulses at the same time as auscultating the heart.

Pulses

Pulses are commonly palpated on the femoral artery, but familiarity with palpating a metatarsal pulse is valuable. Much useful information is gathered from the rate, strength and characteristics of the palpable pulse.

A pulse should be present for each heart beat (see Figure 2.4). If this is not the case, or there are variations in pulse strength, then an ECG is necessary to identify rhythm disturbances.

Pulse rate and character are essential in detecting hypovolaemia and the response to treatment. Increasing pulse rate and decreasing amplitude are evidence of worsening hypovolaemia. The distal metatarsal pulse becomes non-palpable with moderate hypovolaemia, but should return if effective therapy is instituted (see Figure 2.5).

Importantly, what is palpated as the pulse amplitude is the difference between diastolic and systolic pressures (i.e. an animal with a systolic pressure of 100 mmHg and a diastolic pressure of 60 mmHg would have a similar pulse amplitude to an animal with 70/30 mmHg blood pressure); it cannot accurately measure actual blood pressure. Therefore the pulse needs to be considered in conjunction with measures of tissue perfusion and blood pressure readings.

Mucous membranes and capillary refill time

The mucous membrane colour (see Table 2.2) and capillary refill time (CRT) can help to give an idea of tissue perfusion and vasomotor tone. The oral mucosa is normally used as it is easiest to access. CRT tends to vary with an individual's technique.

A normal CRT is usually 1–1.75 s. A slower CRT suggests reduced blood flow in the tissue, often resulting from vasoconstriction with hypovolaemia, or heart failure. A more rapid CRT suggests increased blood present in the tissues; this may be due to vasodilation seen in sepsis.

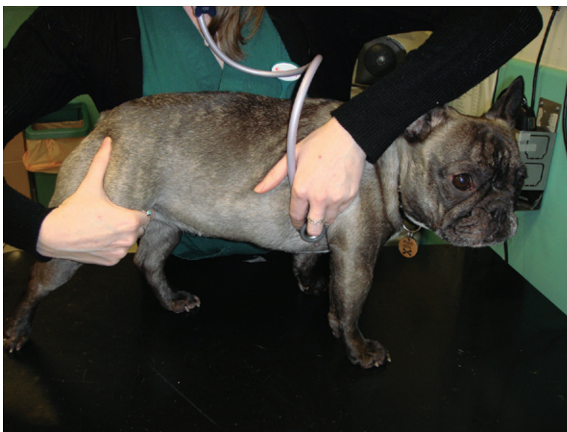

Figure 2.4 Auscultating the heart whilst palpating the femoral pulse allows any pulse deficits to be detected.

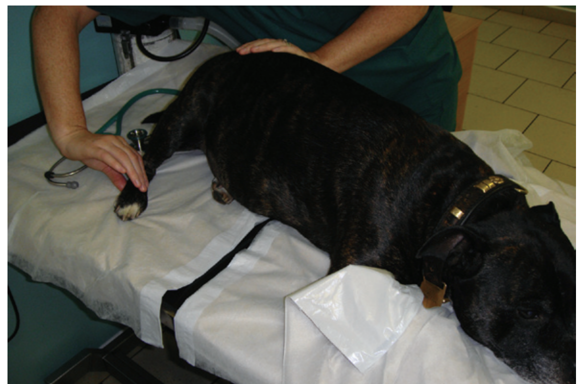

Figure 2.5 Palpating a distal pulse on the hind limb of a patient.

Table 2.2 Observed changes in mucous membrane colour (see Chapter 1 for images)

Colour observed	Possible cause
Pale, white or grey	Poor perfusion, or anaemia
'Brick red' or 'injected'	Vasodilation, systemic inflammatory response
Blue or purple	Cyanosis: low oxygen saturation of haemoglobin
Yellow	Increased blood bilirubin levels
Brown	Formation of methaemoglobin, e.g. paracetamol poisoning
Cherry red	Carbon monoxide poisoning

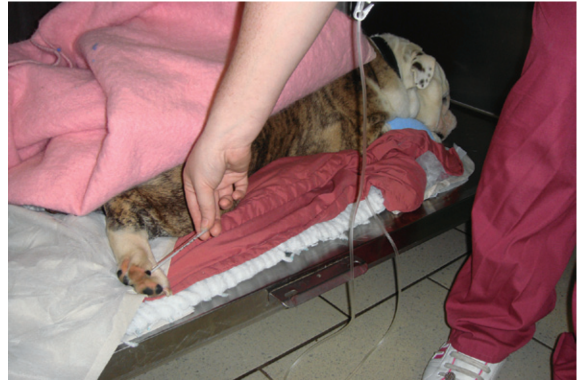

Figure 2.6 Measuring toe web temperature. While the extremities will always be colder than the core body temperature, a difference of more than 4°C suggests reduced perfusion.

Mucous membranes are normally pink, although healthy cats often have paler membranes than dogs.

Tissue perfusion

The sole aim of the cardiovascular system is to deliver oxygenated blood to the tissues of the body. All tissues need a supply of oxygenated blood. Monitoring assesses the delivery of this blood to the capillary beds of the tissues. A range of parameters can help to form an overall picture of perfusion:

1) Mucous membrane colour
2) Capillary refill time
3) Peripheral pulse
4) Toe web temperature vs. core temperature (see Figure 2.6)
5) Urine output (1.0 ml/kg/hour)
6) Blood lactate levels
7) Arterial pressure.

A systolic arterial pressure of 90 mmHg (equivalent of 60–70 mmHg mean arterial blood pressure) is required for adequate flow to vital organs. It is most practical to use a Doppler system and cuff (non-invasive, indirect measurement) (see Figure 2.7). Alternatives include invasive, direct measurement via an arterial catheter.

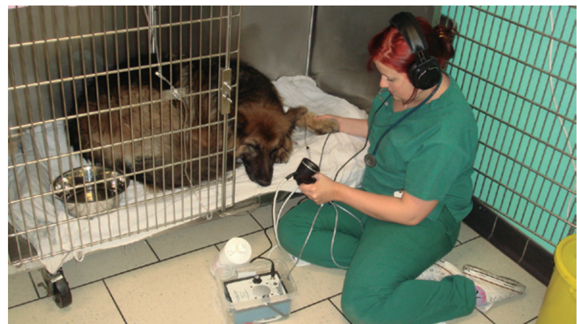

Figure 2.7 Indirect measurement of systolic arterial blood pressure using a Doppler system.

Central venous pressure

In cases that require fluid therapy, but there is a risk of fluid 'overload' if too much fluid is administered, it is useful to measure central venous pressure. This gives an idea of venous 'filling' and how much fluid is returning to the heart. Examples of typical cases would be anuric/oliguric renal failure, or animals in heart failure.

A central catheter is required, and the pressure reading can be taken using a manometer, or the central catheter can be connected to a pressure transducer and the wave form constantly monitored (see Practical techniques at the end of the chapter).

Central nervous system

An animal may have altered mentation because of conditions inside the skull, such as brain injury, or due to more global conditions such as hypovolaemia, hypoglycaemia or development of a systemic inflammatory response. By monitoring neurological status, and recording findings, it is possible to spot trends quickly that will highlight any deterioration or improvement in the patient's condition.

The use of a scoring system allows an accurate record to be kept of the animal's status. While there is still some subjectivity involved, allocating an overall score allows a trend to be spotted, and provides continuity from one team member to another. The Small Animal Coma (SAC) scoring system tends to be used (see Chapter 14). This is an adaptation of the Glasgow Coma Score (GCS) that is used in human medicine. In the SAC system, a score is allocated from 1 to 6 for each of 'motor activity', 'brainstem function' and 'level of consciousness', giving a maximum score of 18.

Urinary system

Monitoring urine specific gravity and output allows quick and simple assessment of kidney function. Normal urine output is considered to be 1–2 ml/kg/hour. If urine output is at or above this level it is assumed renal perfusion is adequate, and therefore it is likely that perfusion of other organs is also adequate. In animals with an indwelling urinary catheter, a closed collection system (see Chapter 12) provides a means of measuring urine volume. In other animals litter or bedding can be weighed to estimate the urine of volume expelled.

Gastrointestinal system

Patients that are systemically ill can develop vomiting, diarrhoea or ileus. Any vomiting should be recorded, along with any defecation and its nature. Vomiting and diarrhoea will lead to alterations in fluid requirement.

The animal's appetite should be recorded, and food consumed accurately recorded to ensure sufficient requirements. Ileus can be assessed by auscultating the abdomen for the presence of gut sounds.

Fluid balance

All animals receiving fluid therapy need ongoing monitoring to assess effectiveness of therapy, and to prevent under or over-dosing. Important consideration must be given to determining what the patient's fluid needs are; is the patient hypovolaemic, dehydrated, or both? Hypovolaemic animals need rapid fluid administration, whereas dehydrated animals required correction of their fluid deficit over 24 hours. Physical assessment of perfusion parameters and hydration parameters should be carried out frequently (see Chapter 4).

Patients receiving intravenous fluid therapy need to have their fluid input compared with their fluid output. Fluid input is easily measured by recording the number of fluid bags administered, or more accurately with an infusion pump. Other inputs to consider are any oral fluids or food, and intravenous drugs. Fluid output includes urine, faeces, vomit and any effusions. Urine output can be measured via a urinary catheter, or in animals that are not catheterised disposable bedding can be weighed before and after urination to estimate volume (1 gram = 1 ml urine). Cat litter trays can be weighed in the same way. Volumes of vomit and faeces can be estimated. Volume of effusions can be more difficult to determine, but outputs from thoracic and abdominal drains are easily recorded, as are wound effusions collected in active suction drains. Dressings can be weighed to estimate effusions in situations such as burns, or open abdominal drainage. Some fluid outputs are not measurable, e.g. loss of water as vapour in expired breath; these losses are termed 'insensible' losses, and are usually estimated at 20 ml/kg/24 hours.

Once the fluid inputs and outputs have been established, they can be compared. Any large discrepancies should be investigated. In a hypovolaemic patient we would expect the 'ins' to be much greater than the 'outs' as the deficit is corrected. In a patient with normovolaemia, the 'ins' should be slightly greater than the 'outs'. Patients should also be weighed accurately at least twice a day; any large gains or losses are likely to be caused by fluid imbalance.

Figure 2.8 Using a hot air blanket to warm a hypothermic patient.

Body temperature

Prolonged abnormal body temperatures can cause potentially fatal organ dysfunction. Abnormal body temperatures interfere with a patient's homeostatic mechanisms, and so delay return to normal health. Critically ill animals are less able to regulate their body temperature. Where active warming is employed in hypothermic animals, care must be taken not to cause overheating, or localised burning (see Figure 2.8).

Clinical pathology

Blood glucose

As well as the obvious cases where blood glucose levels are important, such as monitoring a diabetic ketoacidosis patient, control of blood glucose levels are essential in other critical patients. Hypoglycaemia is commonly seen in hypovolaemia, sepsis, hyperthermia and liver disease. The use of handheld glucometers makes glucose level testing quick and easy, and allows rapid adjustment of glucose supplementation via intravenous fluids.

Packed cell volume and total protein

Trends in packed cell volume (PCV) and total protein (TP) can be interpreted together to give information regarding fluid balance or ongoing haemorrhage. Changes in both may be in the same direction, but alterations in the ratio give extra information:

- *Increase in PCV and TP:* dehydration
- *Decrease in PCV and TP:* aggressive intravenous fluid therapy (IVFT), haemorrhage (later, after interstitial fluid moves into intravascular space, initially no change or even increased PCV with decreased TP, due to splenic contraction)
- *Decreased PCV, normal TP:* increased destruction of red blood cells.
- *Increased PCV, decreased TP:* dehydration with protein loss, e.g. haemorrhagic gastroenteritis (HE).

PCV and TP are important in guiding fluid therapy and choice of fluid, e.g. colloid, crystalloid.

Electrolytes

Electrolyte disturbances are common in critical patients, either because of their presenting complaint or as a result of fluid therapy or drug administration. Electrolytes should be repeatedly checked during hospitalisation. Most isotonic crystalloids used for fluid maintenance (e.g. Hartmann's solution) have insufficient potassium levels for maintenance requirements.

Pain scoring

Pain

It can frequently be difficult to assess pain accurately based on behaviour in a debilitated or nervous animal. Equally, physical manifestations of pain may make the measuring of other parameters difficult. Indicators of pain can be subtle, and can include the following:

- Tachycardia, cardiac arrhythmias
- Pale mucous membranes
- Depression, aggression, restlessness
- Changes in posture and facial expression
- Vocalisation
- Hypotension or hypertension
- Anorexia.

As well as being a welfare issue, pain and fear lead to high levels of blood cortisol which will have detrimental effects of the immune system and healing. Pain may lead to poor respiratory function and reduced ventilation.

The role of pain scoring has long been established in human medicine. Applying similar schemes directly to veterinary patients can be difficult as verbal feedback and description from the patient is required. Veterinary pain scales have been devised that attempt to score pain based purely on observable parameters and behaviours, examples include the Melbourne Veterinary Pain Scale and the Modified Pain Scale (see Chapter 6).

Recumbency care

Most emergency and critical care patients are recumbent for at least some of their hospital stay. The emphasis must be on proper and attentive care during this period to ensure comfort and prevent associated complications.

Lateral recumbency can lead to the collapse of lung lobes (atelectasis) reducing gaseous exchange; this tends to be more common in larger dogs. Another threat to repiratory function is aspiration pneumonia secondary to regurgitation or vomiting. Recumbent patients need to be turned regularly, or maintained in sternal recumbency.

Tip

When turning patients, they should not be moved from lateral recumbency straight into the opposite lateral recumbency; this leads to a potentially atelectic lung being uppermost, while the normal lung is being compressed, reducing ventilation. Rather, the patient should be placed in sternal recumbency for a period in between.

Close attention should be paid to patient hygiene, with regular bedding changes to prevent soiling with urine and faeces and associated dermatitis. Soft, adequately padded bedding is essential to prevent decubital ulcers formed due to localised pressure over prominences of the body (most commonly the greater trochanter and the lateral elbow).

Practical techniques

Central venous pressure (see Figure 2.9)

Central venous pressure (CVP) is very useful for monitoring the effects of fluid therapy in critical patients. It is used to detect hypovolaemia and hypervolaemia, which is particularly important when dealing with shocked patients and those with heart or kidney disorders.

Normal CVP values in dogs and cats are 0–10 cmH_2O (usually 1–6 cmH_2O).

As well as using CVP to assess hypovolaemia, it can be used for other conditions including assessment of intravascular volume, cardiac function, vein tone and intrathoracic pressure. When a decrease in CVP is seen this is usually the result of hypovolaemia but other causes are possible.

Technique

The measurement of CVP is a relatively simple technique that consists of placing a central catheter into the jugular vein. This catheter can also be used for fluid therapy, medication administration, blood sampling, etc.

Measurement of CVP using a manometer

Equipment

- Central catheter (of sufficient length to reach the right atrium)

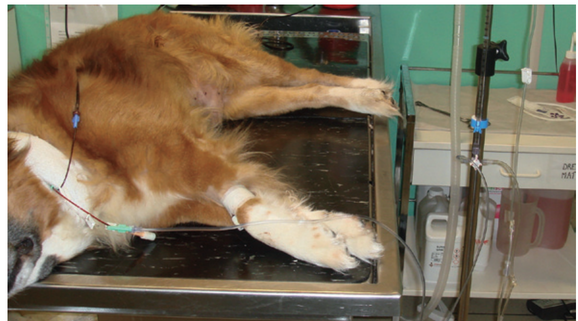

Figure 2.9 Measuring central venous pressure (CVP).