ANAESTHETIZING COMPROMISED PATIENTS: A PRACTICAL APPROACH TO A CHALLENGING PROBLEM
Roz Machon BVSc (Hons), MVSc, MS, MACVSc, DACVA

“There are no safe anaesthetic agents, there are no safe anaesthetic techniques, there are only safe anaesthetists.” Robert Smith

Introduction
According to the Confidential Enquiry into Perioperative Small Animal Fatalities (CEPSAF) – a recent, large scale, multi-centre study of anaesthetic and sedation-related mortality in small animals – the risk of anaesthetic-related death in normal individuals is relatively small, with mortality rates of 0.05% (i.e. 1 in 1849) and 0.11% (1 in 895) reported in healthy dogs and cats, respectively. However, anaesthetic-related death rates in compromised patients are far greater – 1.33% (1 in 75) for “sick” dogs and 1.4% (1 in 71) for “sick” cats – a stark reminder of the challenges of anaesthetizing severely compromised patients. CEPSAF also identified (1) preoperative health status, (2) increasing age, (3) extremes of weight, and (4) procedural urgency, as significant risk factors for anaesthetic mortality – factors common to the anaesthetic management of compromised patients. But what makes management of these patients – the very young, the very old, the very sick or severely injured – so challenging? Why are the risks of anaesthesia magnified to such a large degree in this subset of patients, and what can we do to reduce these risks and improve anaesthetic outcome?

Why are the risks of anaesthesia so magnified in compromised patients?
General anaesthesia is a state of unconsciousness produced by drug-induced depression of the central nervous system (CNS). In order to produce “general anaesthesia”, a drug or combination of drugs must induce the “four facets of anaesthesia”: - unconsciousness, amnesia, analgesia, and muscle relaxation; however, we still lack the ability to selectively depress those areas of the brain responsible for these functions. Instead, anaesthetic agents produce dose-dependent depression of the entire CNS in addition to producing both direct and indirect effects on all the major systems of the body – at least to some degree. General anaesthesia also impairs – and in some cases completely obtunds – normal homeostatic reflexes and control systems. This further limits the patient’s ability to recognise, respond to, and compensate for anaesthetic-induced reductions in vital organ function. Put simply, general anaesthesia not only predisposes patients to profound changes in vital organ function but also limits their ability to cope with these insults and “self correct”. Normal, healthy individuals have significant reserves of organ function and are usually well able to tolerate the physiological stresses of anaesthesia and surgery – as long as the insults are short in duration or moderate in degree. In compromised or critically ill patients however, these same “reserves” of organ function are reduced to a variable degree, impairing the ability of these patients to cope with the “normal” depressant effects of
anaesthesia. These patients are intolerant of physiological stresses and insults, irrespective of duration or degree, and are therefore highly vulnerable to the adverse effects of anaesthesia per se.

This already complex situation becomes even more complicated when we also factor in the impact of disease or dysfunction on the patient’s response to individual anaesthetic agents.

Predicting the patient’s response to anaesthetic agents: the interaction of drugs and disease

Although an understanding of basic pharmacology is important when selecting an anaesthetic protocol for a given patient, it’s important to realise disease and dysfunction alter normal pharmacokinetics, thereby changing the manner in which drugs are absorbed, distributed, metabolized and eliminated. Problems such as hypovolaemia, hypoxia, acidosis and hypothermia are common in critically ill patients. These problems not only impair vital organ function – which may itself impact on the patient’s response to anaesthesia – but also alter the manner in which the body “deals with” drugs, making it difficult to predict the patient’s response to a particular agent. For example, a delayed onset of effect following the administration of intravenous agents is common in patients with prolonged circulatory times; while reductions in cardiac output speed the rate of rise of the alveolar concentration of inhalational agents, hastening mask or chamber inductions and producing rapid – often unexpected – changes in anaesthetic depth.

Acid-base disturbances are another common sequel to disease and injury. Metabolic acidosis alters the portion of unionized, active agent in the bloodstream producing exaggerated responses to seemingly "normal" doses of many injectable anaesthetic agents – most notably thiopentone. Severe weight loss or cachexia (common in patients with chronic disease) reduces the tissue volume available for drug redistribution, thereby increasing the potential for prolonged recoveries in patients maintained with injectable techniques. Cachexia and disease may also reduce plasma protein concentrations – important not only for maintaining oncotic pressure but also for their role in drug transport. Anaesthetic agents vary in their degree of protein binding. For highly protein bound drugs (e.g. diazepam and propofol), the relatively small degree of displacement arising from hypoproteinaemia or administration of another highly-protein bound agent, will greatly increase the amount of “active” drug available, leading to an apparent increase in effect.

Disease and dysfunction may also impair normal metabolism and elimination. Hypoxia, hypothermia and the release of various inflammatory mediators not only depress microsomal enzyme function (and therefore the ability of the patient to metabolize and eliminate anaesthetic agents), but also reduce actual intracellular concentrations of these enzymes. Although hepatic metabolism inactivates the majority of commonly used anaesthetic agents, the effect of some agents (e.g. tramadol) is dependent on the production of active hepatic metabolites. However, many enzyme systems are pH-dependent and become dysfunctional in the face of metabolic acidosis. In fact just getting drugs to their site of metabolism can be problematic for patients with
compromised circulatory function, as reduced hepatic perfusion also reduces the physical delivery of agents to the liver. We tend to think of drug metabolism as a static process but in reality it’s anything but, and can and will change rapidly in response to the patient’s condition.

Although it’s impossible to predict the exact response of a compromised patient to the administration of a given agent, it’s important to remember these patients will not respond “normally”. In fact it is often said that the only predictable thing about the response of a compromised patient to anaesthesia is that their response will be unpredictable! So is it possible to develop a practical approach to the anaesthetic management of compromised patients – irrespective of the nature of their compromise?
A practical approach to managing compromised patients

The selection of an anaesthetic protocol/technique for a compromised patient should be based on: (1) an understanding of the physiologic consequences of the disease or injury process, (2) knowledge of the basic pharmacology of anaesthetic agents and how this may alter in the face of disease or dysfunction, and (3) personal familiarity with the technique. In practice however, this is often easier said than done! Every anaesthetic agent has an individual set of advantages and disadvantages that vary according to the circumstances under which the drug is employed. A particular property that may be beneficial in one patient may prove unimportant in another, or even detrimental in a third! Unfortunately, we are yet to develop the perfect anaesthetic agent: likewise, we still lack an anaesthetic agent that is perfect for all situations. There are both relative and absolute contraindications for all commonly used anaesthetic agents, and these recommendations guide our selection of a particular agent for a particular patient. Clearly, selection of an appropriate anaesthetic protocol for a given patient is important; however, drug choice is not necessarily the “be-all and end-all” determinant of anaesthetic outcome. Instead – given the complexities outlined above – the manner in which drugs are used and the overall approach to managing and supporting a compromised patient become the critical factors, rather than drug choice per se (within reason).

With this premise in mind, it now becomes relatively simple to formulate a practical approach to the anaesthetic management of compromised patients. The crux of this approach is a focus on excellent patient care and management throughout the entire anaesthetic period (i.e. the preanaesthetic assessment and preparation, premedication, induction, maintenance, and recovery phases), with particular attention paid to supporting and minimizing impact on those body systems most compromised in a given patient – rather than a belief that outcome is determined primarily by drug selection – as outlined below. Once again, drug choice is a clearly important part of this process; however, focus should be directed towards avoiding contraindicated agents and employing chosen agents appropriately, rather than trying to select the “perfect” protocol.

1. Preanaesthetic assessment and preparation

The preanaesthetic period is an often neglected but critically important phase of anaesthesia. Successful anaesthetic management of a compromised patient begins with this phase and includes tasks such as: (1) preanaesthetic assessment and preparation of the patient, (2) development of an anaesthetic plan, and (3) preparation of anaesthetic drugs and equipment.

Patient assessment and preparation

(i). Patient assessment: history taking, physical examination and ancillary diagnostic tests

The purpose of a preanaesthetic evaluation is to determine the patient’s physical status and subsequent ability to withstand the stresses of anaesthesia and surgery (i.e. anaesthetic risk). Patient evaluation begins with obtaining a good history and performing a thorough preanaesthetic physical examination – with particular
attention paid to body systems most vulnerable to anaesthetic-induced depression i.e. the cardiovascular and respiratory systems. In normal, healthy animals undergoing elective procedures, weighing the patient, performing a simple “TPR”, auscultating the heart and lungs, and collecting a small blood sample for evaluation of PCV and TPP is often sufficient. Compromised patients however require more extensive examination with further ancillary diagnostic testing (e.g. additional haematology (CBC, biochemistry and electrolytes), urinalysis, electrocardiography, and thoracic radiography and/or other imaging modalities) as is appropriate for their particular disease or disorder — remembering chronic conditions (e.g. cardiac disease) may often pose greater anaesthetic risk than the presenting problem (e.g. a laceration).

Table 1. ASA physical status classification scheme for determining anaesthetic risk

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Normal, healthy patient with no detectable systemic disease.</td>
<td>Patient presenting for an elective procedure e.g. routine ovariohysterectomy.</td>
</tr>
<tr>
<td>II</td>
<td>Patient with mild pre-existing disease or systemic disturbance but no functional limitation.</td>
<td>Skin tumour, cranial cruciate rupture, paediatric or geriatric patient.</td>
</tr>
<tr>
<td>III</td>
<td>Patient with moderate to severe pre-existing systemic disease that limits function but is not incapacitating (i.e. compensated disease).</td>
<td>Mild dehydration, chronic renal failure, compensated heart disease, clinically significant anaemia.</td>
</tr>
<tr>
<td>IV</td>
<td>Patient with severe pre-existing systemic disease that is incapacitating and a threat to life (i.e. uncompensated disease).</td>
<td>Uncompensated heart disease, acute renal failure, compensated shock, uncompensated endocrine disease.</td>
</tr>
<tr>
<td>V</td>
<td>Moribund patient not expected to survive &gt;24 hours with or without surgery.</td>
<td>Severe trauma, uncompensated hypovolaemic shock, sepsis, major head injury.</td>
</tr>
<tr>
<td>E</td>
<td>Designates an emergency procedure</td>
<td>The “E” is added after the appropriate number.</td>
</tr>
</tbody>
</table>

The American Society of Anesthesiologists’ (ASA) grading system for classifying preoperative health status is widely used in human anaesthetic practice and has been adapted for use in veterinary patients (Table 1). This system uses a numerical scale to summarise patient assessment and help identify at-risk patients, with higher numbers indicating “sicker” patients. To date, two publications from the CEPSAF project have specifically examined the association between ASA status and anaesthetic-related death in cats and dogs, although links have also been noted in previous studies. The first paper – a case-control retrospective study examining risk factors for anaesthetic-related death in a population of 6026 referred dogs (Brodbelt DC, Hammond R and Tuminaro D et al.) – reported dogs with high anaesthetic risk status (ASA grade III to V) to have significantly increased odds of death compared with ASA I or II patients. The second paper – a large scale, multi-centre study of nearly 80 000 general anaesthetic and sedative procedures in cats (Brodbelt DC, Pfeiffer DU and Young LE et al.) – also showed a strong association between ASA classification and anaesthetic-related death. In fact, increasing ASA status by one grade (e.g. ASA I/II to ASA III) was associated with a four-fold increase in
the odds of death in this population. This study also demonstrated a link between procedural urgency (i.e. scheduled versus urgent versus emergent procedures) and risk of anaesthetic-related death. The authors surmised that this link reflected factors such as the ability to adequately assess and stabilise patients preoperatively or not, and the tendency for emergent procedures to be performed outside normal working hours in the face of reduced staffing levels and personnel fatigue. Neither paper was able to identify a major association between a single anaesthetic agent or drug class and mortality (although the dog study showed a positive link between acepromazine and reduced risk of death); supporting the view that patient management is more important with respect to outcome than drug selection per se.

(ii).  Patient stabilization: can the procedure be postponed?
Preanaesthetic stabilization is a crucial component of patient management, and may include strategies such as medical therapy (e.g. an appropriate course of antibiotics) or other strategies (e.g. IV volume resuscitation, oxygen therapy, pain management, or evacuation of free air/fluid from the chest, etc) aimed at improving patient status and/or vital organ function prior to anaesthesia. Maintaining a normal dosing schedule for patients already receiving chronic medications (e.g. endocrine or cardiac therapy) is also important in this regard. Few surgical procedures are truly emergent and most can be delayed until vital organ function has been stabilised (at least to some degree); however, judging the adequacy of therapy and deciding on appropriate “end-points” can sometimes be easier said than done.

Correction of volume deficits appears critical – although the best approach to managing problems such as hypovolaemic shock is controversial. Colloidal support should be considered in patients with a TPP < 4.5 g/dL, while patients with a PCV of < 15-20% should be transfused with either packed red cells or whole blood to replace oxygen transport capabilities. Critical haemoglobin concentrations (i.e. the value below which oxygen delivery is unable to meet tissue oxygen demand) may be as low as 3-5 g/dL (i.e. a PCV of 9-15%). However, acidosis and circulating inflammatory mediators decrease the affinity of red blood cells for oxygen and prevent the cells from folding as they pass through small capillaries, thereby reducing oxygen delivery, while general anaesthesia per se increases the critical oxygen delivery value as a consequence of cardiopulmonary depression. Most authors suggest PCV values of > 15-20% are therefore more appropriate, prior to anaesthesia.

(iii).  Fasting
Although routine fasting should be performed if possible, patients with obstructive gastrointestinal disease, heavily pregnant animals and those presenting for emergent procedures should always be treated as if they have a “full stomach”. Problems such as hypotension, hypovolaemia, hypothermia and sympathetic nervous system activation also slow gastric emptying, and care should be taken to minimise the risks of vomiting or regurgitation with subsequent aspiration in patients presenting with these problems. This can be achieved by
inducing patients in a “head up” position with a rapid IV induction technique, followed by swift intubation – with the ET tube secured and the cuff inflated before allowing the patient to relax into lateral or sternal recumbency.

**Development of an anaesthetic plan**

While this lecture focuses on the importance of overall patient management, rather than drug choice per se as the key to successful outcome, development of an anaesthetic plan remains an important albeit often difficult task. Anaesthetic agents should be chosen according to the needs of the individual patient (i.e. current physical status, pertinent history, concurrent disease or injuries, and the procedure to be performed), and the knowledge and experience of the veterinarian. While it may be satisfactory to simply modify protocols used for normal animals in some compromised patients (e.g. an otherwise healthy geriatric dog); we still lack the perfect anaesthetic protocol for every patient and are left to decide which agents or techniques will cause the least amount of harm in an individual – particularly in the face of marked compromise. Choosing a protocol (i.e. premedication, induction and maintenance agents) for a given patient can be difficult, particularly in severely ill animals with multiple problems. All agents have both positive and negative effects: some drugs should be used with extreme caution if at all in severely compromised animals while others may be beneficial when used carefully or at reduced doses in select cases. As a rule however, agents that are cardiopulmonary sparing, reversible and can be titrated to effect are particularly useful.

A good first step in formulating an anaesthetic plan is to ask yourself: - “What factors or concerns are important in this patient i.e. “What are the patient’s problems? What “things” do we need to avoid or minimize, and likewise, what might be helpful or beneficial in this patient” (e.g. avoiding agents that cause tachycardia in a patient with marked cardiac disease, but providing appropriate analgesia for a painful patient or ensuring excellent sedation in an aggressive patient)? Writing a list of these “patient concerns and considerations” is helpful as it aids drug selection – in particular, helping you to eliminate or cross a particular agent off your list of “possible drug choices” – and also acts as a reminder of the various monitoring and support strategies that may be important in a particular patient (e.g. appropriate airway support in a severely brachycephalic animal). We are yet to develop the perfect anaesthetic agent, and in some cases it may seem as if every agent is contraindicated! In difficult cases, it is helpful to write a list of all available agents (i.e. under the headings of “premeds”, “induction agents” and “maintenance agents”) and simply begin “crossing them off”, starting with the agents you’d least like to use until you’re left with one or two “preferred” options (a far easier approach than trying to choose an “ideal” agent from a whole bunch of bad options). The final step in the development of a suitable anaesthetic protocol for a given patient is to ask yourself: - “What dose of each drug does this patient require, and how should I best administer this?”
These considerations aside, the “best” anaesthetic protocol may be one with which you are familiar, rather than the technique with the "best" anaesthetic agents. Familiarity may breed contempt, but it also begets know-how and expertise. For this reason, it’s prudent to develop a “personal repertoire” of different anaesthetic techniques – including those suitable for patients with a variety of problems – to allow yourself as big a range of “familiar” options as possible.

Preparation of anaesthetic drugs and equipment
Time invested in ensuring anaesthetic machines, breathing circuits, patient monitors and ancillary equipment are available and functioning correctly (e.g. pressure checking machines, checking the laryngoscope light is working, or having a range of ET tubes checked and ready to use), is time well spent. Emergencies can occur during any phase of anaesthesia, and as the boy-scouts say, it pays to “be prepared”. If you prepare for the worst, it generally won’t happen: - ensuring emergency drugs are readily available (with appropriate doses pre-calculated for a given patient), is helpful.

2. Premedication
Premedication offers many benefits including analgesia, calming, promoting a smooth induction and recovery, reducing the subsequent dose of induction and maintenance agents, and offsetting potentially adverse drug and physiological effects. Although all drugs have both positive and negative effects, the benefits of judicious premedication far outweigh the disadvantages: premedication should therefore be considered in every patient. Small IV doses of opioids and/or benzodiazepines (diluted in saline and administered very slowly via an IV catheter) are often effective premedicants in severely compromised cats and dogs because they allow titration of the desired response. However, these agents may compound ventilatory impairment, and patients should be monitored closely as relatively minor postural changes (e.g. moving from a sitting position to sternal recumbency) have been associated with ventilatory embarrassment in patients with respiratory compromise. Hypovolaemia, shock or hypothermia may result in the delayed absorption of drugs administered subcutaneously: IM or IV administration (as just outlined) may be preferable in patients presenting with these problems.

3. Induction
Factors influencing the selection of an induction technique for a given patient were outlined previously. While drug selection is clearly important, the manner in which anaesthetic agents are employed is of greater importance with respect to outcome (within reason). Accurate dosing is essential, as compromised patients are intolerant of even small overdoses. Body weight should be measured – not “guestimated” – and dose rates carefully calculated, remembering requirements may be markedly reduced in severely compromised patients. Administration technique is also important. Injectable agents should be administered slowly in small increments (i.e. given “to effect”) via a pre-placed IV catheter (as opposed to a bolus technique), while
Inhalant concentrations should be substantially reduced in most cases. When employing mask inductions, vaporizer settings should be increased in small increments, remembering these agents produce potent, dose-dependent cardiopulmonary depression (particularly in cats). Gentle handling is crucial, and every effort should be made to minimise stress.

Pre-oxygenation for several minutes immediately prior to induction is highly recommended in all compromised patients but vital in those with respiratory or cardiovascular compromise. Although mask inductions may therefore seem like “a good idea” in patients with respiratory compromise, rapid injectable techniques are far preferable in this patient subset because they permit rapid intubation and immediate control of ventilation and oxygenation. Attachment of monitors (e.g. ECG and pulse oximeter) prior to inducing anaesthesia can also provide useful information during the induction phase, although care should be taken to avoid undue stress. Most anaesthetic agents depress normal cardiopulmonary homeostatic reflexes (e.g. the baroreceptor reflex and hypoxic pulmonary vasoconstriction), making patients particularly vulnerable to positional-induced changes in arterial blood pressure and oxygenation. Major positional changes (e.g. rolling a patient into dorsal recumbency) should therefore be made slowly with appropriate monitoring of cardiopulmonary function.

Patients with predominantly unilateral thoracic disease or injury benefit from being positioned “good lung up” immediately after induction and may be intolerant of other positions.

4. Maintenance

The basic approach to selecting a maintenance agent/technique for a given patient has already been reviewed. Although inhalational agents are the preferred maintenance technique in most compromised animals, some patients are intolerant of inhalant-induced cardiopulmonary depression and may benefit from dose reduction strategies. Concurrent opioid administration (via CRI or intermittent “slow bolus” administration) and/or local anaesthetic techniques may be particularly useful. Adjunctive analgesic techniques such as lidocaine or ketamine CRIs may also be useful; however, little is known about their effects in severely compromised cats and dogs.

The role of an anaesthetist during this phase is to “watch over” the patient: - to assess anaesthetic depth, monitor vital organ function and obtain information that can be used to maximise patient safety and minimise risk. Good patient monitoring requires an understanding of basic physiology and, in particular, how anaesthetic agents adversely affect vital organ function. It also requires a basic knowledge of the technology underpinning various monitoring devices, and an understanding of what these devices can and can’t tell you about patient wellbeing (e.g. a pulse oximeter provides little if any information about the adequacy of ventilation although it’s a wonderful indicator of oxygenation). Anaesthetic depth and vital organ function are intimately linked in the sense that anaesthesia affects vital organ function in a dose-dependent manner, while vital organ function is itself a measure of anaesthetic depth: both factors must be evaluated when monitoring.
anaesthetised patients. Patient monitoring should be continuous in severely compromised animals with the results recorded on an anaesthetic chart at 5-min intervals. Use of an anaesthetic record is important to outcome, as studies have shown these to encourage regular monitoring and assessment, and to allow earlier recognition of changes in vital organ function than would have occurred otherwise.

Patient support forms the other, equally important arm of intraoperative management, and involves preventative strategies aimed at supporting vital organ function and offsetting the adverse effects of anaesthesia per se. Focus should be directed towards airway support (e.g. intubation and care to prevent obstruction in recovery), support of oxygenation and ventilation (e.g. delivery of an enriched oxygen mixture and the use IPPV), support of circulatory function (most notably the delivery of IV fluids and aggressive treatment of hypotension), and thermal support. Volume support is critical in compromised patients and should always be administered (using a fluid type and administration rate suitable for the patient’s disease process), irrespective of the duration of anaesthesia. CEPSAF identified intraoperative fluid therapy as a significant risk factor for anaesthetic-related death in cats, with cats receiving IV fluids being nearly four times as likely to die as those that did not. While residual confounding may have influenced this finding (i.e. elderly, emergent or critically ill cats were more likely to receive IV fluids during anaesthesia than young, healthy cats scheduled for routine procedures, but were also more likely to die), excessive administration resulting in volume overload may also have played a role. This finding highlights the importance of accurate volume delivery in very small patients, particularly those with cardiopulmonary compromise. But is there any evidence to suggest patient monitoring and support can positively affect anaesthetic outcome?

Studies investigating critical incidents in anaesthetised people have conclusively demonstrated the use of minimum monitoring standards (i.e. a set of published guidelines or recommendations that document the baseline level of acceptable care) to significantly reduce patient morbidity and mortality. Routine monitoring of arterial blood pressure (ABP), arterial saturation (i.e. SpO2 via pulse oximetry) and end-tidal CO2 values (ETCO2) is now considered a minimum standard in human anaesthesia. A study of critical incidents in anaesthetised people showed a monitor of some sort was the first indicator of a problem in 52% of reported incidents and complications. The authors of this study were able to predict the theoretical “usefulness” of various monitors in a typical anaesthetic procedure. Based on these predictions, pulse oximetry would have detected 82% of all problems and would have warned of nearly 60% of problems prior to the potential for organ damage. The addition of capnography would have raised these figures to 88% and 65% respectively, while the addition of ABP monitoring would have resulted in detection of 93% of complications, providing warning of 65% of these before the potential for organ damage had occurred. These findings have recently been supported in the CEPSAF study examining risk factors for anaesthetic-related death in cats, which showed a significant (p < 0.001) reduction in the odds of death when pulse rate and pulse oximetry were routinely monitored in these patients.
5. Recovery

Recovery begins as administration of maintenance agents ceases but only ends once the patient is fully alert and responsive – a period that may vary from 20 min to greater than 24 hrs. CEPSAF documented the majority of small animal, anaesthetic-related deaths actually occur during the recovery phase, providing evidence that this period is the time of greatest risk for anaesthetised cats and dogs. Postoperative deaths accounted for 47% of all anaesthetic-related deaths in dogs and 61% of those in cats enrolled in the study, with many animals dying during the initial 3 hrs of recovery. Although difficult to pinpoint a definitive cause of death in every case, many deaths were thought to be due to respiratory or cardiovascular complications – often occurring during periods when patients weren’t being observed.

The care of recovering patients is a huge topic, clearly beyond the scope of this lecture; however, CEPSAF identified some risk factors pertinent to the care of compromised patients that warrant mention. The first of these was a positive link between intubation and anaesthetic-related death in cats (i.e. cats that were intubated had a greater risk of dying (almost two-fold) than those that were not) suggesting laryngeal trauma, swelling or spasm may play an important role in post-anaesthetic deaths in this species, and prompting the need for careful assessment and monitoring of airway patency following extubation. Low body weight and small size were also linked with an increased risk of anaesthetic-related death in both cats and dogs, and it was suggested these patients might have been particularly vulnerable to the down-stream effects of hypothermia. The cost of the body’s efforts to re-warm can be dramatic: in people, postoperative shivering has been shown to increase oxygen consumption by over 800% and may be sufficient to physically disrupt sutured wounds! While normal patients are remarkably tolerant of the demands of shivering, these same stresses may overwhelm the cardiopulmonary reserves of compromised patients with disastrous consequences.

Although it may be tempting to imagine the adverse effects of anaesthesia on vital organ function “disappear” as soon as we switch off the vaporizer, in reality this is far from the case. Anaesthetic-induced changes in vital organ function may extend well into the recovery period – a time when patient monitoring and support techniques may not be as vigilant or rigorous as during the maintenance phase. Continued monitoring and support of vital organ function is essential during the recovery process – particularly in compromised patients – and may include strategies such as continued monitoring of vital organ function (including the use of various monitoring devices), on-going IV fluid or oxygen therapy, thermal support and maintenance of immediate IV access. Appropriate pain management is also crucial. Recognition of pain – particularly in cats – can be challenging. Despite the development of various pain “scales” and assessment tools, there is no recognised “gold standard” for pain assessment in small animals and no real means of readily comparing one pain assessment tool with another. Physiologic parameters including heart and respiratory rate, ABP, mucous membrane colour, rectal temperature and circulating levels of various “stress substances” (e.g. cortisol and beta-endorphins) are neither consistent nor reliable indicators of pain because they are not sufficiently specific.
to differentiate pain from other stressors or disease processes. Although useful, all pain scales rely to some extent on the recognition and/or interpretation of various behaviours (which may prove particularly difficult in compromised animals), have a subjective component, and are subject to observer error and bias. In contrast, a positive response to analgesic administration may be easier to assess and may serve as a pragmatic indicator of the presence of pain.

**Conclusion**

The over-riding goal of a good anaesthetist is to monitor and support the patient throughout the *entire* anaesthetic period; ensuring the patient is pain-free, that vital organ function is well maintained and above all, that the patient suffers no harm. However, general anaesthesia is not a benign process and anaesthetic-associated complications occur commonly, even in normal, healthy animals receiving optimal care and support. The key concept of this lecture is the view that because the perfect anaesthetic agent is nonexistent, patient outcome is determined more by the overall approach to patient *management* rather than the selection of an individual anaesthetic agent *per se* (within reason). Choice of an appropriate anaesthetic protocol for a given patient is clearly important (and can be aided by making a list of “patient concerns and considerations” as outlined). However, appropriate care during the preanaesthetic assessment and preparation phase, judicious premedication, careful consideration as to the manner in which drugs are employed, attentive anaesthetic monitoring and aggressive intraoperative patient support, plus dedicated recovery care, are the crucial contributors to a successful outcome when anaesthetising critically ill or otherwise compromised cats and dogs.
Reference and further reading list


