UNIVERSIDADE DE LISBOA

Faculdade de Medicina Veterinária

APPROACH, MANAGEMENT AND PREDICTION OF PROGNOSIS IN THE ACUTE ABDOMEN SYNDROME IN DOGS. STUDY OF PROGNOSIS PREDICTORS IN 28 CASES

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DISSERTAÇÃO DE MESTRADO INTEGRADO EM MEDICINA VETERINÁRIA

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Abstract

APPROACH, MANAGEMENT AND PREDICTION OF PROGNOSIS IN THE ACUTE ABDOMEN SYNDROME IN DOGS. STUDY OF PROGNOSIS PREDICTORS IN 28 CASES

The acute abdomen syndrome is characterized by an acute onset of abdominal pain, usually associated with general signs such as vomiting, diarrhoea, postural and gait changes, anorexia, lethargy and shock. Success results from a proactive approach to management, including rapid stabilization of major body systems, early identification of the inciting problem(s), attention to comorbid conditions, and timely definitive therapy. Herewith comes decision making, whether to take a patient to surgery or manage the patient medically. A thorough and systematic approach requires the use of diagnostic imaging modalities, including radiology and ultrasonography, performing diagnostic peritoneal lavage or abdominal paracentesis techniques, and blood work evaluation, including complete blood count and biochemistry profiles. In some cases, the results of diagnostic tests may lead to surgical *versus* medical management, particularly when a patient fails to respond to medical management alone. In other cases, rapid surgical management is necessary for patient survival.

Also it must take into account the capabilities and equipment of the clinic, as well as the staff skills. This may be extremely effortful, time-consuming and expensive so the owners must be informed about the prognosis for survival as they frequently face the dilemma of euthanasia. In an attempt to make more valid prognostic assessment in cases of acute abdomen syndrome, many individual predictive factors and univariable analysis where investigated.

A retrospective study was carried out on 28 dogs presented with acute abdomen. Medical records were reviewed and information regarding dog signalment, history, clinical and laboratory data, surgical findings and outcome was collected. After analysis, several easily measurable parameters were found to be outcome predictors in dogs with acute abdomen, these being creatinine and alkaline phosphatase values, skin tent evaluation and dehydration.

Keywords: acute abdomen, management, prognosis, outcome predictors, dog.

Resumo

ABORDAGEM, MANEIO E PREVISÃO DE PROGNÓSTICO NA SÍNDROME DE ABDÓMEN AGUDO EM CÃES. ESTUDO DE PREVISORES DE PROGNÓSTICO EM 28 CASOS

A síndrome de abdómen agudo é caracterizada por dor abdominal de início repentino, normalmente associada a sinais clínicos gerais tais como vómito, diarreia, alterações de postura e equilíbrio, anorexia, letargia e choque. O sucesso na resolução desta síndrome resulta de uma abordagem proactiva ao maneio médico, incluindo estabilização rápida dos sistemas vitais, rápida identificação, atenção a situações concomitantes e terapia definitiva realizada atempadamente. Posto isto, a decisão de submeter o paciente a cirurgia ou de o tratar conservativamente tem de ser tomada. Uma abordagem completa e sistemática passa pela imagiologia, incluindo raio-x e ecografia, lavagem peritoneal diagnóstica ou abdominocentese, e análises sanguíneas, incluindo hemograma e bioquímicas. Por vezes, os resultados dos testes diagnósticos podem levar ao maneio médico *versus* o cirúrgico, especialmente quando não há resposta à terapêutica conservativa por parte do paciente. Noutros casos, o maneio cirúrgico urgente é necessário para a sobrevivência do doente.

É também necessário ter em consideração as capacidades e equipamento do centro de atendimento médico veterinário, bem como as competências dos veterinários responsáveis. Isto pode ser extremamente trabalhoso, demorado e caro para os proprietários, devendo estes ser informados acerca do prognóstico, visto que muitas das vezes deparam-se com o dilema da eutanásia. Na tentativa de tornar a avaliação prognóstica mais eficaz na síndrome de abdómen agudo, foram avaliados previsores individuais de prognóstico e realizada a respetiva análise univariada.

Foi realizado um estudo retrospectivo em 28 cães que se apresentaram com abdómen agudo. A anamnese foi feita e a informação sobre os sinais clínicos, os dados do exame físico e laboratoriais, os achados das cirurgias e prognóstico foram colhidos. Após análise, alguns parâmetros facilmente mensuráveis, mostraram contribuir para a previsão do prognóstico em cães com abdómen agudo, sendo estes os valores de creatinina e fosfatase alcalina, a avaliação da prega de pele e a desidratação do animal.

Palavras-chave: abdómen agudo, maneio, prognóstico, previsores de prognóstico, cão.

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List of abbreviations

ALP - alkaline phosphatase

ALT - alanine aminotransferase

AST - aspartate aminotransferase

BUN - blood urea nitrogen

CIALP - corticosteroid induced ALP isoenzyme

CNS – central nervous system

CPCR - cardiopulmonary-cerebral resuscitation

cPLI - canine pancreatic lipase immunoreactivity

CRI - constant rate infusion

CRP - c-reactive protein

CRT - capillary refill time

DPL - diagnostic peritoneal lavage

EDTA - ethylenediaminetetraacetic acid

FAST - focused abdominal sonogram for trauma

FB – foreign body

GDV - gastric dilatation and volvulus

GGT - gamma glutamyl transpeptidase

ICU - intensive care unit

IM - intramuscular

IV - intravenous

KCl - potassium chloride

MAC - minimum alveolar concentration

MMC - mucous membrane color

NaHCO3 – sodium bicarbonate

NSAID - non-steroidal anti-inflammatory drugs

PCV - packed cell volume

SIRS - systemic inflammatory response syndrome

SPI - survival prediction index

SQ - subcutaneous

TS - total solids

VS - veterinary surgeon

Clinical Activities Assisted

The author took a training period of approximately 5 months at Medivet 24 hour Continuous Care and Emergency Centre in Watford, UK, for her curricular practice period, from October 1st 2012 to March 1st 2013. The Watford Branch of Medivet provides general consultations, general surgery, orthopaedic surgery, laparoscopic surgery, a 24-hour emergency care, radiography, ultrasonography, endoscopy, dentistry, diet clinic and dog training.

The training period was supervised by Doctor Guy Carter (MRCVS) and co-supervised by Prof. Doctor Berta São Braz.

Each veterinary surgeon (VS) working at Medivet starts doing ward rounds, observing and discussing all the cases of the hospitalized animals. At the end of their rotation, VS do the ward rounds all together again so that the night veterinarian gets the updates and new cases. The author was present everyday during these rounds.

Then, every VS has a period of consultation and a period of surgery. Rotating through all the different activities, the author was under the supervision of one VS, and called if there was any particularly interesting event or clinical situation, either in consultations, imaging, or in surgery. The routines activities of the clinic consist in: a) internal medicine: consultations of internal medicine and discussion of the hospitalized cases in the hospital; b) intensive care treatment: dogs, cats, rabbits and guinea pigs; c) radiography: head, thoracic, abdominal and limb radiographs to dogs, cats, rabbits; hip dysplasia exam and scoring; pre, intra-surgical and post-orthopaedic surgical evaluation, d) ultrasonography: abdominal, thoracic ultrasonography and echocardiography in dogs, cats, and rabbits; e) endoscopy: rhinoscopy, bronchoscopy, gastroscopy, laparoscopic surgery, f) dentistry: consultations of dentistry, scaling, teeth extractions in dogs and cats. Polishing, cutting and extracting teeth from rodents like rabbits, guinea pigs, chinchillas, etc, g) orthopaedic, dermatology, ophtalmology and obstetric consultations; h) soft tissue and orthopaedic surgery.

During this training, the author was able to attend and assist in general consultation, imaging, care to the hospitalized animals and especially in surgery, where the author has a bigger interest, being the assistant of the surgeon in several surgeries such as: surgical removal of mammary tumours in dog and cats; Several ovarihysterectomy in dogs, cats and rabbits; Several castrations in dogs, cats and rabbits; surgical removal of anal gland tumour, lipomas, mast cell tumour, subcutaneous abdominal and thoracic mass in dogs; perineal, perianal, inguinal and umbilical hernia corrections; forelimb and hindlimb amputations; resection of the head of the femur in dogs and cats; cruciate ligament surgeries; patellar luxation; correction of fractures; scaling, polishing, cleaning teeth in dogs and cats; teeth removal and dental interventions in dogs and cats.

As main surgeon, the author also did: introductory part of consultations, anamnesis, clinical examination, proposal of medical approach and treatment, vaccination; intubation of dogs and cats; collected blood from dogs, cats and rabbits; put catheters in dogs, cats and rabbits;

administered drugs; anaesthetist work; dog castrations, cat castrations, queen ovariohysterectomies; drained and cleaned abscesses. She also trained suturing in recently dead animals.

During the training period, it was also possible for the author to attend to Medivet's CPDs (Continuing Professional Development) concerning: Gastric Dilation Volvulus, Lymphoma, Laparoscopy; and, Pain Assessment, all of them with the duration of 2:30 hours.

Part I – The Acute Abdomen

1.1. Definition

The acute abdomen is defined as any disease process that leads to an acute onset of clinical signs referable to intra-abdominal pathology (Boag & Hughes, 2004), necessitating prompt diagnosis and immediate medical or surgical intervention to prevent deterioration of the patient (Mann, 2009). It is most often a sign of significant and potentially life-threatening abdominal disease but may also be a manifestation of minor intra-abdominal disturbances, or even disease outside the abdomen (Snow & Beal, 2010). Although the patient may present with an acute problem, it is essential that historical questioning establishes whether this may be a chronic problem with acute decompensation (Murphy & Warman, 2007).

Acute abdomen is characterized as a sudden abdominal pain arising from sites within or outside of the abdominal cavity. Pain may arise from the abdominal viscera, parietal peritoneum or may be referred from extra-abdominal sites (Walters, 2000).

Visceral pain is usually characterized by dull aching pain, poorly recognised. The transmition is made by C-fibers within the abdominal organs, mesentery and caudal peritoneum. Activation of stretch receptors within the abdomen, as well as stimulation of the chemoreceptor trigger zone, may initiate nausea and vomiting that may accompany visceral pain. This type of pain occurs secondary to inflammation, ischemia, distension or rupture of abdominal organs. The patient is usually restless and ambulatory in an attempt to relieve discomfort. Parietal pain, also known as somatic pain, can be recognized in a specific area and is often a sharp type of pain that can be immobilizing for the patient. C-fibers and A-fibers, arising in the parietal peritoneum, carry this type of pain. Referred pain shows signs of acute abdominal pain although the source is in the periphery, sharing a common nociceptive segment within the central pathway. Spinal referred pain and neoplasm are among the most common causes of referred pain in patients (Mazzaferro, 2003).

Acute abdomen may be associated with various conditions of the abdominal cavity, including disorders of the hepatobiliary, gastrointestinal or the peritoneum itself. Back pain caused by intervertebral disc disease may also be confused with abdominal pain, and these two conditions must often be differentiated (Dye, 2003).

Diseases causing acute abdomen can affect multiple organ systems, the most important of which are the cardiovascular, respiratory, central nervous and urinary systems (Walters, 2000).

Since many of the conditions responsible for acute abdomen may progress to a state of shock, abdominal pain may not be evident at the time the animal is presented (Mann, 2009).

1.2. Presentation

1.2.1. Primary survey and interventions

The purpose of the primary survey is to establish further the stability of the patient and to recognize and treat any immediate life threatening conditions (Brown & Drobatz, 2007).

On presentation, a primary survey of the severity of the condition should be completed within 30 to 60 seconds, with evaluation of the level of consciousness, airway, breathing, and circulation (Devey, 2010). Assessment of these parameters allows the clinician to classify the patient as stable or unstable. Any patient that cannot be clearly classified into either category should be considered unstable (Brown & Drobatz, 2007).

Particular attention should be paid to the patient's perfusion and hydration status, since hypovolemic shock is one of the most common life-threatening problems (Mazzaferro, 2003). Prolonged hypoperfusion can also instigate changes in cellular metabolism that result in intracellular sodium and calcium accumulation, cell swelling, cell membrane damage, lipid peroxidation, release of detrimental oxygen free radicals and cell death (Brown & Drobatz, 2007).

If pulses are palpable, the heart is beating at least effectively enough to produce a pulse. If pulses are not felt, auscultation for heart sounds or palpation of the chest wall for the precordial impulse at the left intercostal fourth to fifth space at the costochondral junction should be done. If the patient is in lateral recumbency, the heart sounds are loudest on the side next to the table. If the beat is not found and the patient is inconscious, cardiopulmonary-cerebral resuscitation (CPCR) must start (Aldrich, 2005).

A very brief history should be obtained at this time if possible; however, resuscitation should not be delayed in the critical patient while a complete history is obtained (Devey, 2010).

As mentioned, one of the most common life-threatening problems associated with acute abdominal pain is hypovolemic shock, characterized by pale mucous membranes, prolonged capillary refill time and rapid week pulses (Dye, 2003). Hypovolemic shock may occur by salt and water loss, where red blood cells and proteins are concentrated in a smaller volume of plasma, as indicated by an increase in packed cell volume and total solids, besides the signs mentioned above. Haemorrhage also causes hypovolemic shock by a combination of intravascular volume loss and a decrease in red cell mass, such that oxygen delivery to cells is critically low. Because the lost fluid has the same composition as the remaining blood, no changes in packed cell volume or total solids are initially expected. Overtime, redistribution of salt and water from the interstitium replaces a portion of this loss and dilutes the remaining red blood cells and proteins. In trauma, shock is often due to hypovolemia secondary to bleeding. Extensive tissue trauma can also cause enough capillary damage to result in substantial loss of plasma into the tissues and the release of inflammatory mediators from damaged cells (Aldrich, 2007).

Septic shock may occur as well, being recognized by hyperaemic mucous membranes, rapid capillary refill time and bounding/hyperdynamic pulses (Dye, 2003). This happens when there is a systemic inflammatory response to severe infection (sepsis), most commonly caused by bacteria or bacterial toxins; combined with clinical signs of shock (Aldrich, 2007).
More detailed parameters can be seen in annex I.
The physical parameters mentioned above vary as a continuum with the stage of shock. Therefore, those parameters will vary as the disease process worsens or improves (Dye, 2003). These patients will need immediate fluid resuscitation with the aim to prevent more cell damage and to promote healing by optimizing tissue perfusion (Devey, 2010).
For that reason, intravenous access should be obtained as soon as possible. Peripheral veins, such as the cephalic or lateral saphenous vein, are the most common vessels utilized. Central venous access using the jugular or medial femoral vein allows higher drug concentrations to be achieved in the coronary vessels, which is important in cardiopulmonary resuscitation, and allows placement of a larger diameter catheter, facilitating more rapid fluid administration. However, central vessels are more difficult to access compared to the peripheral vessels, making them a second choice in an emergency situation when vascular access must be quick. When a coagulopathy is suspected, jugular venopuncture and catheter placement is contraindicated (Brown & Drobatz, 2007).
The goal of resuscitation is to reverse the signs of shock and provide effective oxygen distribution to the cells. Efforts should be aimed at maximizing haemoglobin levels, blood volume, and cardiac function (Devey, 2010). Oxygen and fluid therapy should be provided, with isotonic crystalloids to normalise circulating fluid volume and maintain systolic arterial blood pressure, provided that there are no contraindications to aggressive fluid therapy. In cases with significant concurrent cardiac, pulmonary or intracranial disease, the benefits of aggressive fluid therapy need to be carefully balanced against the risks (Boag & Hughes, 2004).
According to Boag & Hughes (2004), depending on the severity of the hypoperfusion, crystalloid fluid boluses of up to 60 to 90 mL/kg may be necessary. In some patients, especially those with evidence of vasculitis and hypoproteinemia, fluid resuscitation with synthetic colloids such as hydroxyethyl starch or dextran 70 may be more appropriate. When systemic perfusion parameters have successfully been returned to normal or near normal, a longer-term fluid plan involving the assessment of the degree of dehydration and the requirements for maintenance of on-going fluid losses can be designed. Use of techniques like sublingual capnometry and measurement of central venous oxygen saturation may aid recognition and evaluation of early hypoperfusion (Boag & Hughes, 2005).
Fluid therapy should be tailored specifically for each patient and, ideally, based on perfusion and hydration parameters, and knowledge of the patient's current electrolyte and acid-base status. All patients, particularly those receiving rapid fluid boluses, must be carefully

monitored to guarantee that the therapy is having the desired effect and that unwanted complications, such as pulmonary oedema, do not develop. Occasionally, it is not possible to normalise perfusion parameters with fluid therapy alone and, in these situations, constant rate infusions of catecholamines may be required (Boag & Hughes, 2004).
The fluid deficit can be estimated with the following formula:

Body weight (kg) X estimated % dehydration X 1000 = mL fluid deficit (Egger, 2009)

The fluid deficit can be administered at up to shock rates mentioned above if tachypnea, tachycardia, pale mucous membranes, slow capillary refill time, weak pulses, pulse deficits, hypotension, low pH, low bicarbonate, and elevated lactate are present (Egger, 2009).
Electrolyte disturbances should also be corrected. Serum potassium should be >3.0 and <6.0 mEq/L prior to anaesthesia. Hypokalemia predisposes to hypotension, dysrhythmias, and ileus of the gastrointestinal tract. It should be treated prior to anaesthesia with a second bag with KCl, administered at <0.5mEq/kg/hour. Potassium should not be added to the resuscitation or anaesthesia fluids. Hyperkalemia predisposes to dysrhythmias (first degree AV block, peaked t waves, loss of p waves, wide QRS complexes), cardiac arrest, and death. It should be treated with IV fluids such as sodium bicarbonate ($NaHCO_3$), 50% dextrose and regular insulin, until serum potassium concentration is <6.0 mEq/L again.
Metabolic acidosis results in increased central nervous system (CNS) sensitivity to many anaesthetic drugs and predisposes to vasodilation and myocardial depression. If renal function is normal, metabolic acidosis can be corrected with appropriate fluid resuscitation and improvement in renal perfusion. Severe metabolic acidosis (pH<7.2; HCO_3^- <16) may require the addition of $NaHCO_3^-$ to the fluids. The base deficit can be calculated from the following formula:

Body weight (kg) X base deficit X 0.3 = mL of bicarbonate required (Egger, 2009).

1/4 to 1/3 of the bicarbonate deficit should be administered very slowly, over 20 to 30 minutes (rapid bolousing of $NaHCO_3^-$ can cause apnoea). Recheck of the bicarbonate prior to administering more should be done. If renal perfusion is restored, the base deficit is rapidly corrected (Egger, 2009).
Hypoalbuminemia (<2 g/dL) results in a reduction of required dosages of highly protein bound drugs, which should be noted. It also reduces the plasma oncotic pressure. Colloids or plasma administration should be considered (Egger, 2009).
Azotemia results in increased permeability of the blood brain barrier and sensitivity of the CNS to anaesthetics. There tends to be an increased fraction of unbound, active drugs in the

plasma. Hereupon it should be corrected prior to anaesthesia with IV fluids, NaHCO3- (0.5-1 mEq/L), and peritoneal or haemodialysis (Egger, 2009).

Some patients, for example, those with haemoabdomen or other sites of haemorrhage, may benefit from resuscitation with blood products, if available. If this is not possible, resuscitation with a crystalloid fluid should still be aggressive pursued. Unless a patient has severe pre-existing anaemia, the hypoperfusion associated with marked intra-abdominal haemorrhage is more likely to be life threatening than any anaemia occurring secondarily to resuscitation with crystalloid fluids (Boag & Hughes, 2004).

Rapid intubation and ventilator support is required in patients presenting in *extremis*. Hypoglycaemic patients should be treated with dextrose.

Antibiotics may not be indicated in all cases; however, in general the patient should be started on broad-spectrum antibiotics to cover both aerobic and anaerobic gram-positive and gram-negative bacterial infections (Devey, 2010). The intravenous route has been associated with a trend towards increased survival in cases of septic peritonitis (Boag & Hughes, 2004). It has been suggested in the human literature, that early antibiotic therapy within 1 hour of recognition of severe sepsis can improve survival (Dellinger et all, 2004); although cultures should be taken ideally before antibiotic therapy is initiated (Beal, 2005).

If there is sufficient distention of the abdomen to interfere with ventilation, measures should be taken immediately to relieve the distention and dorsal recumbecy should be avoided. Gastric distention with air can be relieved using transabdominal trocarization, insertion of a nasogastric tube, or orogastric intubation. Orogastric intubation should only be performed if the animal is intubated due the risk of regurgitation around the tube and subsequent aspiration. Ideally the stomach should not be decompressed until fluid resuscitation has been addressed since rapidly relieving pressure on the vena cava may cause acute haemodynamic collapse; however, if the patient cannot ventilate effectively, the stomach should be trocarized immediately. Severe abdominal distention secondary to fluid may need to be addressed by emergent drainage (Devey, 2010).

Analgesia is an essential part of the early therapeutic plan (Devey, 2010). Pain control in the emergency patient should be a high priority as it can adversely affect a patient by causing potentially detrimental sympathetic stimulation (Campbell, 2005).

Nonsteroidal anti-inflammatory drugs should be avoided due to their negative effects on splanchnic organs (Devey, 2010). Also, they're not appropriate in any patient where hypoperfusion is suspected, due to the potential for renal damage, or where gastrointestinal ulceration is a possible underlying aetiology (Boag & Hughes, 2004).

Opioids such as butorphanol, hydromorphone, morphine, and fentanyl are recommended. Drugs should be given intravenously since absorption from subcutaneous or intramuscular sites may be unpredictable. Because constant-rate infusions provide constant analgesia and can be titrated to effect, they are ideal in patients with significant pain, in patients who will need to go to surgery (since the constant-rate infusion can be continued intraoperatively and postoperatively), and in patients where it is anticipated significant pain may last a day or more. Providing analgesia via the epidural route is also very effective. Doses may need to be reduced to 25% to 50% of normal since critical patients are often sensitive to the sedative and cardiorespiratory effects. For those patients who do not respond to systemic analgesics, a peritoneal lavage with or without local anaesthetic may be useful, especially in patients with pancreatitis or serositis (Devey, 2010).

In summary, the primary survey reassures identification and immediate treatment of conditions that is life threatening. It also allows identification of unstable patients so that appropriate monitoring can be instituted and potential problems can be anticipated and prevented (Brown & Drobatz, 2007).

1.2.2. Secondary Survey

Following analgesia administration, evaluation of the abdomen might detect ascites or distension, organ abnormalities and localization of the pain. Careful examination of the back should distinguish abdominal pain from referred spinal pain (Rudloff, 2012).

Animals manifest symptoms of pain by guarding the abdomen when it is touched or palpated, by an avoidance reaction, or vocalization (Mann, 2009). Other clinical signs can include abdominal distension, prayer-type posture and restlessness (Walters, 2000), as well as nauseas, changes in gastrointestinal peristalsis, fever, secondary dyspnoea and lack of response to anti-inflammatory or analgesia medication (Tello, 2011).

The prayer-type posture is characterized by the front and forelimbs bowed toward the ground or in sternal recumbency, while the hind end remains elevated in a standing position. This position is a specific sign of significant abdominal pathologic change and should be taken seriously (Beal, 2005). Other animals may adopt a stretched posture in lateral recumbency (Mazzaferro, 2003), reluctance to move, ambulating in a stilted gait or even by taking short, careful steps (Mann, 2009).

Disease processes such as aspiration of vomitus can occur in animals with acute abdominal pain, being the aspiration pneumonia the most common abnormality and is associated with abnormal lung sounds, dyspnoea and hypoxia (Walters, 2000). Vomiting can cause a significant vasovagal response, bradycardia and respiratory arrest (Rudloff, 2012).

A complete and detailed history must be obtained from the owner (table 1) regarding the possible causes of acute abdomen, as in some cases, the patient's signalment may lead to a higher index of suspicion of the etiology of acute abdomen (Mazzaferro, 2003).

Table 1: General and specific questions to ask clients of patients presenting with acute abdomen (adapted from Mazzaferro, 2003).

Categories	Questions
General	What are the most important signs that made you bring your pet here? When did these signs first start? Have the signs been getting worse, staying the same, or improving? Has your animal ever had any other medical problems prior to this? Has your animal ever demonstrated any signs similar to those now?
Toxin	Does your animal have access to any toxins? Does your animal run loose unattended? What is the physical status of other animals in the household? Are they sick? Has your animal ingested rubbish recently?
Foreign body	Does your animal play with or chew on toys? Underwear? Cloths? Other material? Have you noticed anything missing? Do you sew? Does your animal play with string, thread, or yarn?
Vaccination status	Is your animal vaccinated? How many vaccinations has the puppy/kitten received since you first obtained him/her? Does your animal come in contact with other animals? When was your animal last vaccinated?
Medication/Surgery	Is your animal dewormed? Is your animal on any current medication? Did your animal take any human medications, especially pain killers? Did your animal have any abdominal surgery recently?
Appetite	Has there been any change in your animal's appetite? Have you noticed any weight loss or weight gain? Has there been any increase or decrease in water consumption? Do you feed table scraps? If so, what kind and when did your animal last get some? Do you allow your animal to chew on bones?
Trauma	Is there a possibility that your animal has been hit by a car? Does your animal run loose unattended or have access to the street? Does your animal play rough with other animals? Has your animal been in a fight recently to your knowledge?
Urination/Defecation	Have you noticed any change in urination or defecation habits? Have you noticed any diarrhea? Have you noticed any straining to defecate? What is the color of the faeces? Is there blood in the faeces? Does the faeces appear black in color?
Vomiting	When did you first notice vomiting? How many times has your animal vomited? When was the last episode of vomiting? What does the vomitus look like? Is there blood or coffee ground material in the vomitus? What color is the vomitus? Does the vomiting episode have an active abdominal component and retching, or is it passive in nature? Is the vomitus digested or undigested food? Does the animal vomit food and water, or just food? Does the animal vomit soon after eating or at times not related to meals? Does the vomitus smell malodorous, or like faeces?

It is important for the veterinarian to try to distinguish from the history between vomiting and regurgitation. Vomiting is characterized as an active retching process with repeated contractions of the abdominal muscles, which doesn't happen in regurgitation, being more passive, with owners reporting that the animal 'opens its mouth and the food falls out'; this tends to indicate oesophageal rather than gastric or small intestinal disease (Holt & Brown, 2007). The possible use of non-steroidal anti-inflammatory drugs (NSAID) recently (whether prescribed or owner administered) is also significant due to their ulcerogenic potential in dogs (Boag & Hughes, 2004). The clinical importance of vomiting stems from its association with a large and varied group of diseases, and the potentially life-threatening consequences of vomiting, as previously mentioned, like aspiration pneumonia, fluid and electrolyte depletion, acid-base derangement and oesophagitis (Chandler, 2010).

The clinician should recognize the likehood that a given patient has sustained trauma. Trauma associated with acute abdomen is a unique situation and is most often a whole body problem (polytrauma) involving multiple body systems. Similarly, it is not uncommon for trauma-associated acute abdomen to result from multiple injuries, for example, concurrent uroperitoneum and hemoperitoneum (Beal, 2005).

Information regarding the age and sex of the patient might refine the differential diagnoses, e.g. young patients are more likely to have viral or parasitic causes of gastroenteritis, or to have ingested a foreign body. Pyometra and pancreatitis should be considered in older dogs with vomiting and/or diarrhoea (Murphy & Warman, 2007). According to Beal (2005), there is no diagnostic substitute for a complete physical examination.

1.3. Physical Examination

Once life-threatening issues have been identified and addressed, a thorough physical examination should be performed systematically (Dye, 2003). Priority should be placed first on major body systems that apply to the immediate clinical condition at hand and many authors agree that examination of the patient abdomen should occur last, to avoid inadvertently missing important findings that may be present in other organ systems and also the manipulation of a tender abdomen may elicit pain and apprehension that could interfere with further evaluation (Mann, 2009).

Still, the physical examination of the emergency patient is a cycle of examinations. One must keep reviewing essential systems to verify their function and stability while moving forward to finish the examination. Therefore, findings must be confirmed and new abnormalities sought (Aldrich, 2005).

1.3.1. Cardiovascular system

Examination of the cardiovascular system initially involves assessment of the heart rate, pulse rate, deficits and quality, mucous membrane color and capillary refill time (CRT) (Boag & Hughes, 2004). Auscultation and electrocardiogram, the last one if available, are required at this stage (Mazzaferro, 2003). The chest should be carefully ausculted, since cardiac arrhythmias are often seen with acute abdominal conditions including gastric dilatation and volvulus (GDV), mesenteric torsion, hemoabdomen, pancreatitis, and trauma. Arrhythmias can also occur secondary to electrolyte imbalances, hypoxemia, and hypercapnia. It is also important to rule out underlying cardiac disease, which might affect fluid therapy and anaesthesia (Holt & Brown, 2007). During cardiac auscultation, the femoral pulses should be palpated at the same time for character and synchrony (Mazzaferro, 2003).

Blood pressure can be assessed using non-invasive means such as Doppler method or by oscillometric method (Mazzaferro, 2003).

Patients with a severe inflammatory stimulus, such as septic peritonitis or severe acute pancreatitis, and adequate circulating blood volume may demonstrate the classical signs of hyperdynamic systemic inflammatory response syndrome (SIRS) with tachycardia, injected mucous membranes, rapid CRT and strong pulses of short duration. When concurrent hypovolaemia is present, patients may still have injected mucous membranes, but with slow CRT, weak pulses and marked tachycardia. In these patients, an aggressive search for the underlying cause of SIRS should be instituted (Boag & Hughes, 2004).

1.3.2. Respiratory system

Examination of the respiratory system comprises assessment of the airways and evaluation of the animal’s respiratory rate and effort (Boag & Hughes, 2004). For that reason, first observation of the patient should be made from afar (Pachtinger, 2013) The lung fields should be carefully auscultated and any abnormalities characterized. Many animals with an acute abdomen exhibit tachypnea secondarily to pain; however, the possibility of aspiration pneumonia occurring secondary to vomiting or regurgitation should also be evaluated at this time (Boag & Hughes, 2004). Patients who have a traumatic injury may have a pneumothorax or pulmonary contusions (Holt & Brown, 2007).

1.3.3. Nervous system

Mental state is an important physical evaluation since the brain is an obligate user of oxygen and glucose and has few energy stores. Inadequate delivery of oxygen and glucose to the brain results in loss of the normal mental state in seconds (Aldrich, 2005).

The musculoskeletal system should be evaluated for evidence of traumatic injury, back pain, or body wall herniation (Holt & Brown, 2007). Initial neurological assessment should include an evaluation of the patient's gait, mentation and posture, and spinal palpation. Once the patient has been stabilized, and if indicated, this should be followed up with a more complete neurological evaluation. Pain occurring secondarily to spinal cord disease (commonly intervertebral disc extrusions) can easily be confused with abdominal pain, but usually these patients do not have other serious major body system abnormalities. Neurological signs, such as hindlimb weakness or proprioceptive deficits, especially in chondrodystrophoid breeds, should prompt a more thorough neurological evaluation (Boag & Hughes, 2004).

1.3.4. Abdominal examination

Finally, abdominal examination can proceed. Visual inspection of the external abdomen should occur first (Mann, 2009). Abnormalities detected visually can include distension (e.g. caused by an effusion or gastric dilation), deformity (e.g. occurring secondarily to a mass or hernia), subcutaneous swelling (e.g. resulting from cellulitis associated with urine leakage) and bruising (Boag & Hughes, 2004). Haemorrhage in the umbilical or periscrotal tissue may indicate hemoabdomen (Rudloff, 2012).

The abdomen should be carefully auscultated for borborygmi before palpation, because abdominal palpation can irritate the intestines and change the bowel sounds. Auscultation should be performed for 2 to 3 minutes, as bowel sounds may be decreased in the anorexic patient. Increased borborygmi are noted with acute enteritis, acute intestinal obstruction, and intoxications. Decreased borborygmi may be noted with ileus, chronic obstruction, peritonitis, or ascites.

Percussion of the abdomen can be used to detect a gas-distended abdominal viscus or free abdominal fluid (Dye, 2003). Abnormal bowel sounds are not pathognomonic for any disease process. Additionally, early in the course of acute abdomen such as post trauma or early peritonitis, bowel sounds may remain normal (Mazzaferro, 2003). Pressing gently on the side of the abdomen and watching carefully for a fluid wave effect can be performed, evaluating the ballottement of the abdomen. Abdominal viscera floating in intra-abdominal fluid may rebound against the examiner's hand (Mazzaferro, 2003), revealing a fluid wave in dogs with abdominal effusion or tympanic abdominal distension in dogs with gaseous gastric distension. In contrast, while severe non-iatrogenic pneumoperitoneum may cause abdominal distension, it is not usually tympanic (Boag & Hughes, 2004).

Following percussion, abdominal palpation should be performed superficially at first to detect and localize pain, and then the abdomen should be palpated more deeply. If palpation is initially performed too vigorously in the painful animal, the patient may tense the abdomen (splint), making abdominal palpation more difficult (Dye, 2003). Some animals, especially nervous patients, may resist to abdominal palpation and also splint. In such cases, stroking the animal before palpation and beginning the examination gently will help the clinician to identify these patients and allow a complete abdominal palpation. The examination should, when appropriate, proceed to deeper palpation, although this may be precluded in cases of severe, diffuse abdominal pain (Boag & Hughes, 2004).

Deep palpation allows the evaluation of the size and consistency of structures within the cranial, mid-, and caudal abdomen (Mazzaferro, 2003). It also may allow detection of an abdominal mass or intestinal foreign body (Dye, 2003). If possible, the animal's forelimbs are held off the ground during palpation to allow the cranial abdominal contents to slide caudal to the last ribs (Holt & Brown, 2007).

Performing the physical examination in this manner can potentially lead to a revised list of differential diagnoses or even a presumptive diagnosis. Cranial abdominal pain can be associated with hepatobiliary disease, pancreatitis (with localized pain especially to the right quadrant), gastroduodenal ulceration, or perforation. Caudal abdominal pain may be associated with diseases of the urogenital system such as prostatitis, pyometra, uterine rupture, or urethral obstruction, and with obstipation as well. Diffuse pain is often associated with peritonitis, but may also be observed with gastrointestinal foreign bodies or obstruction (Mazzaferro, 2003).

Although physical examination will not necessarily provide a definitive diagnosis, nor will it necessarily dictate a particular therapeutic measure, it will help the clinician to select the most appropriate diagnostic tests and will keep the clinician abreast of changes in patient status (Mann, 2009).

A guide to the physical examination of the abdomen can be seen in annex II.

1.3.4. Rectal examination

Rectal examination should be performed in all animals to assess the pelvis, pelvic urethra, medial iliac lymph nodes and the character and color of the faeces (Boag & Hughes, 2004). The presence of diarrhoea, melena, or haemorrhage should be noted. Abnormalities including pelvic fractures, loss of anal tone, anal sac tumours, prostatic enlargement or pain, sublumbar lymph node enlargement, and masses or uroliths within the pelvic urethra may be identified. A faecal sample for parasites and pathogenic bacteria detection should be collected (Holt & Brown, 2007). In male dogs, the prostate gland should be palpated; in older, large-breed dogs, this may require concurrent abdominal pressure to push the prostate caudodorsally towards the pelvic brim. Rectal temperature should always be taken. Depending on the underlying cause of the acute abdomen and the degree of hypoperfusion, the patient may be hypo-, hyper- or normothermic (Boag & Hughes, 2004).

1.3.5. Other elements of the examination

Other important areas to assess during the physical examination include the vulva of intact female dogs, with possible presence of a vaginal discharge; undescended testicles in male dogs, and the oral cavity in all patients to look for evidence of ingestion of caustic substances or string foreign bodies that may become anchored around the tongue (Boag & Hughes, 2004).

A thorough palpation of peripheral lymph nodes and evaluation of the skin for the presence of masses must be performed (Holt & Brown, 2007).

1.4. Differential diagnoses

After a thorough physical examination, diagnosis may be made, depending on the primary cause. In some cases, surgery is required before definitive diagnosis is achieved. Etiology of abdominal pain can be observed in Table 2. Displacement, obstruction or distention, inflammation or infection, perforation or rupture, and/or vascular compromise in any of these systems can result in somatic or visceral pain and the presentation of an acute abdomen.

Table 2: Differential diagnoses for the acute abdomen (adapted from Beal, 2005).

Systems	Etiology
Urologic	**Bladder:** Disruption*, Neoplasia, Urolithiasis, Obstruction*, Infection
	Urethra: Disruption, Neoplasia, Urolithiasis, Obstruction
	Ureter(s): Disruption, Neoplasia, Urolithiasis, Obstruction
	Renal pelvis: Disruption, Urolithiasis, Infection (pyelonephritis)
	Kidney Infection: Neoplasia, Acute nephritis, Renal ischemia
Haemolymphatic	**Spleen:** Neoplasia*, Torsion, Infarction, Splenitis, Abscess, Hematoma, Laceration
	Lymph nodes: Reactive lymphadenopathy, Lymphadenitis, Neoplastic infiltrate
Genital	**Male – Prostate:** Prostatitis, Abscess, Cyst, Neoplasia **Testicular torsion** (abdominal)
	Female – Uterus: Pyometra*, Torsion, Acute metritis, Neoplasia, Dystocia, Rupture **Ovary(ies):** Ovarian neoplasia, Ovarian cyst
Peritoneum/ Retroperitoneum/ Vascular	**Peritonitis:** Septic*, Chemical (Uroperitoneum*, Bile), Pancreatitis* **Hemoperitoneum*** **Hemoretroperitoneum** **Disseminated neoplasia** **Vascular:** Mesenteric avulsion, Mesenteric volvulus, Mesenteric artery thrombosis, Portal vein thrombosis
Gastrointestinal	**Stomach:** Gastric dilatation-volvulus (GDV)*, Gastric dilatation (GD)*,

	Ulceration/perforation, Gastroesophageal reflux, Neoplasia, Obstruction*, Foreign body*, Ischemia, Acute gastritis
	Small bowel: Obstruction*, Foreign body*, Ulceration/perforation, Gastroduodenal intussusception, Intussusception, Ischemia, Neoplasia, Enteritis*, Ileocecocolic intussusception
	Large bowel: Neoplasia, Torsion, Ulceration/perforation, Ischemia, Colitis, Obstruction, Ileus, Cecal inversion, Typhlitis
Hepatobiliary	**Hepatic:** Hepatic lobar torsion, Hepatic hematoma, Hepatic abscess, Hepatitis, Laceration, Cholangiohepatitis
	Biliary: Biliary obstruction, Cholecystitis, Gallbladder mucocele, Cholelithiasis, Biliary disruption (Common bile duct, Gallbladder, Hepatic duct)
Pancreatic	Pancreatitis*, Abscess, Neoplasia, Pseudocyst, Necrosis caused by ischemia
Mesenteric	**Mesentery:** Rent with herniation, Neoplasia
Body wall/ skin and subcutaneous tissue	**Body wall:** Prepubic tendon avulsion, Penetrating injury, Hematoma, Hernia, Abscess, Neoplasia
	Skin and subcutaneous tissue: Penetrating injury, Abscess
Referred pain	Intervertebral disc disease*, Discospondylitis, Spinal neoplasia, Fracture/luxation, Pelvic trauma

Note: Common conditions are indicated by an asterisk.

1.5. Diagnostic tests

The main aim when doing the diagnosis of a patient with an acute abdomen is to quickly identify those animals that require surgery. Initial diagnostic assessment should include a combination of blood analysis (with haematology, biochemistry and clotting profile), urinalysis, abdominal imaging (radiography and ultrasound) and, where appropriate, abdominal fluid analysis (Boag & Hughes, 2004).

1.5.1. Laboratory evaluation

Laboratory analysis of blood and urine may be useful to provide supportive or confirmatory data about the underlying aetiology of the acute abdomen, but more importantly, it should be performed in all patients to provide a current picture of their haematological and metabolic status and, thus, aid stabilization (Boag & Hughes, 2004). As already mentioned, the amount of information obtained from this analysis can be tremendous, and should not be underestimated, since when combined with a thorough history and physical examination, can often provide a diagnosis as well as a prognosis (Brown & Drobatz, 2007).

In emergency situations such as emergent celiotomy, waiting for laboratory tests results can be detrimental to the patient's well-being (Mann, 2009). In such circumstances an emergency minimal data should include determinations of packed cell volume (PCV), total solids (TS) via refractometer, blood urea nitrogen or creatinine, and glucose. Ideally it should also include electrolytes, blood gas (venous or arterial) and albumin, since TS often do not correlate with albumin in the critically ill patient (Devey, 2010) and should be performed before fluid therapy is instituted. It also allows initial stabilization and fluid therapy to be fitted specifically for each individual animal (Boag & Hughes, 2004). The remaining tests can be done later on pre-treatment samples (Mann, 2009).

PCV and TS should be interpreted together, and combining with clinical findings. They provide information about the hydration status, as well as an estimate of red cell content in the blood. Changes in these two parameters often parallel each other, but an alteration in the normal ratio of PCV to TS gives additional useful information (Brown & Drobatz, 2007).

An elevated packed cell volume and total solids may suggest dehydration, as total body fluid loss results in concentration of red blood cells and plasma proteins, whereas a decreased packed cell volume may suggest blood loss or metabolic diseases. In acute haemorrhage, the packed cell volume may not yet accurately reflect blood loss caused by splenic contraction or volume depletion in an attempt to restore circulating volume and increase oxygen-carrying capacity of the blood, improving tissue oxygen delivery (Dye, 2003).

A decrease in PCV with normal TS suggests an increase in destruction or a decrease in production of red blood cells (Brown & Drobatz, 2007). For example, anaemia on chronic disease and bone marrow disorders that cause non-regenerative anaemia are characterized by a decreased PCV with normal TS. In patients with vasculitis, most commonly due to septic peritonitis, protein loss into abdomen causes a fall in total protein levels without affecting the PCV (Dye, 2003). A decreased PCV with haemolysed or icteric serum suggests haemolytic anaemia, although hepatic and post-hepatic causes if icterus cannot be ruled out.

An alteration in the PCV:TS ratio characterized by an increased PCV but a normal to decreased TS can be seen with severe dehydration accompanied by concurrent protein loss. The perfect example occurs in patients with severe haemorrhagic gastroenteritis, who can have a PCV as high as 70%, but normal TS. Hypoproteinemia can result from haemorrhage, loss into the pleural or peritoneal spaces or loss from the body through the gastrointestinal tract (protein-losing enteropathy) or kidney results in panhypoproteinemia An increase in PCV with normal TS is seen in patients with polycythaemia, which is relatively rare (Brown & Drobatz, 2007). Serial PCVs should be obtained in the bleeding patient (Dye, 2003).

According to Brown & Drobatz (2007), PCV and TS also help guiding fluid and diuretic therapy. The absolute values determine the choice of fluid to be delivered when correcting hypovolaemia or dehydration. A change in PCV and TS is expected following aggressive fluid or diuretic therapy, and these parameters should be measured frequently to help monitor response (Brown & Drobatz, 2007).

Examination of the microhaematocrit tube following centrifugation can provide additional information. A large buffy coat indicates a high white blood cell count. The colour of the serum may provide clues to the disease process. Lipaemic serum may also occur, for example with pancreatitis, postprandial lipaemia, or may be associated with hyperadrenocorticism. Haemolysed serum may be due to the collection technique or intravascular haemolysis (Brown & Drobatz, 2007).

A complete blood count with microscopic evaluation of a blood smear should be performed in order to complete a manual differential, estimate the number of platelets (being especially important in animals that may go under surgery), and to evaluate both white and red blood cell morphology (Devey, 2010). The number and morphology of each cell type should be evaluated and recorded. Examination of the red blood cells is most important in patients with anaemia or if there is a suspicion of blood loss. Signs of regeneration such as polychromasia or anisocytosis help to differentiate the anaemia as regenerative or non-regenerative (Brown & Drobatz, 2007).

Particularly attention for toxic changes or left shifts in neutrophils should be taken (Boag & Hughes, 2004); although, the absence of a leukocytosis or a left shift does not rule out inflammation or infection. Leucopenia can be due to decreased production or sequestration of white blood cells. Decreased production can result from viral infections such as parvovirus, or from the administration of immunosuppressive drugs. White blood cell sequestration resulting in leucopenia occurs in patients with severe infections or extensive tissue necrosis, for example those with peritonitis, necrotizing pancreatitis or bite wounds. Transient leucopenia can also be seen in hypothermic patients (Brown & Drobatz, 2007).

Blood cultures should also be considered in septic patients (Dye, 2003).

Many of the conditions that can cause an acute abdomen can also lead to disseminated intravascular coagulation (eg. ruptured hemangiosarcoma, sepsis, pancreatitis). An initial manifestation of this is a mild to moderate thrombocytopenia (Boag & Hughes, 2004). In that manner, coagulation parameters, including prothrombin time, activated partial thromboplastin time, fibrin degradation products, and D-dimers, are potentially useful in ruling out the presence of disseminated intravascular coagulation (Mazzaferro, 2003); and should always be evaluated in patients with suspected liver dysfunction, SIRS, or sepsis (Devey, 2010).

Early identification of a coagulopathy should alert the surgeon to the possibility of increased risk of bleeding and allow the need for blood products to be assessed and, where necessary, a potential donor animal to be identified (Boag & Hughes, 2004). The decision to administer a blood transfusion should be based on the patient's clinical condition and not solely on the laboratory evaluation (Dye, 2003).

The blood gas analysis provides useful information regarding ventilation and perfusion (Devey, 2010); and may be indicated to evaluate for hypoxemia and acid-base disorders (Dye, 2003).

A complete biochemical profile and urinalysis is indicated in every patient as part of a more complete workup (Devey, 2010). Serum biochemical analysis may provide useful information about the underlying cause (Boag & Hughes, 2004) and may help localize to a specific organ, giving important information about the patient's acid-base balance and electrolyte status (Mann, 2009).

A urine sample should be obtained via cystocentesis unless pyometra is suspected (Mazzaferro, 2003). Collection should also be performed prior to fluid therapy for the measurement of specific gravity. If this is not possible, a urine sample should still be obtained at the earliest opportunity for specific gravity, dipstick and sediment analysis (especially to detect the presence of bacteriuria or pyuria) (Boag & Hughes, 2004). The specific gravity must be interpreted in the light of any administered fluid therapy. A sterile aliquot of the urine sample should be saved for bacterial culture and susceptibility, if appropriate (Mazzaferro, 2003). Urinalysis mainly when interpreted in conjunction with serum blood urea nitrogen and creatinine levels, provides essential information about an animal's renal concentrating ability and other urinary tract abnormalities (Boag & Hughes, 2004).

A faecal examination including a faecal occult blood, direct smear, faecal flotation, Giardia, and parvovirus tests may be indicated (Devey, 2010).

Ultimately the choice of tests will vary based on the presenting complaint (Devey, 2010).

1.5.2. Radiography

The rapid availability of abdominal radiography makes it an essential tool for evaluation of animals with acute abdominal pain (Walters, 2000), being commonly used for assessment of a patient with acute abdominal distress and abdominal pain (Bischoff, 2003).

Chest radiographs should be evaluated preoperatively in every trauma patient and in any patient in which pneumonia or metastases is a potential concern (Devey, 2010). Additionally, gas dilation of the thoracic oesophagus should alert the clinician to explore the possibility of a megaesophagus, keeping in mind the fact that sedation or anaesthesia can also result in gas dilation of the oesophagus (Bischoff, 2003).

Abdominal radiographs should be performed on all patients with acute signs relating to the intestinal tract other than those clearly requiring emergency surgery, such as perforating abdominal injury (Dye, 2003).

With only few exceptions, two orthogonal radiographic views of the abdomen should be taken. One exception is an animal with a suspected trauma, particularly trauma of the spinal cord, in which a lateral radiograph should be viewed before further manipulation of the patient is performed (Bischoff, 2003). In critically ill patients, measurements should be taken and machine settings adjusted before positioning the animal on the table (Walters, 2000). Other exception is when the animal has concurrent respiratory distress or severe hypovolaemia, when placing him in dorsal recumbency may be life threatening. Animals with severe hypovolaemia should be stabilized with intravenous fluid therapy before ventrodorsal radiographs are taken (Walters, 2000); and finally in postoperative abdomen with peritonitis confirmed on abdominal fluid analysis (Mann, 2009). Specific disease's patterns can be seen in table 3.

Table 3: Radiographic patterns and differential diagnoses (Murphy & Warman, 2007, reproduced with permission from the BSAVA Manual of Canine and Feline Emergency and Critical Care. © BSAVA).

Decreased serosal detail: - Loss of intra-abdominal fat , e.g. cachexia - Free peritoneal fluid/ascites, e.g. peritonitis (septic/non-septic), haemoabdomen - Localized loss of detail in the right cranial quadrant ± lateral displacement of the duodenum can be consistent with pancreatitis
Organomegaly
Mass
Gaseous gastrointestinal tract distension: - Gastric dilation/volvulus - Ileus - Focal bowel loop distension
Evidence of full or partial gastrointestinal obstruction, e.g. gravel sign, plicated small intestine
Radiodense foreign bodies
Abnormalities of the diaphragm or body wall, e.g. ruptured diaphragm, hernia
Free air/pneumoperitoneum: - Hollow viscus rupture - Non-surgical causes of pneumoperitoneum, recent abdominal surgery, open-needle abdominocentesis
Occasionally pneumothorax/pneumomediastinum results in pneumoretroperitoneum or, more rarely, pneumoperitoneum

Evaluation of abdominal radiographs should be completed with a systematic approach and the identification of basic Roentgen signs (changes in size, shape or margination, opacity, number, location, function) (Bischoff, 2003); summarizing, should be critically reviewed for the presence of free air, fluid, masses, abnormal organ position, focal or diffuse bowel loop distension and loss of detail. Abdominal radiography is less worthwhile in patients with large volumes of peritoneal fluid due to the loss of intra-abdominal contrast (Walters, 2000). It may be useful to obtain opposite lateral views or a standing lateral view to highlight air or fluid (Walters, 2000), especially in cases of abdominal effusion that would otherwise have little abdominal detail (Mann, 2009). Another example is when a gastric volvulus is suspected but compartmentalization is not visible on the right lateral, a left lateral view should be taken (Devey, 2010).

In the absence of a history of recent abdominal surgery, within the previous three weeks, penetrating injuries or abdominocentesis, the presence of free gas is an indication for emergency abdominal surgery once the patient has been stabilised (Walters, 2000). As for air bubbles within solid organs often indicate a necrotizing process and the presence of gas-forming bacteria. A loss of detail on the x-rays suggests the possibility of peritonitis, and an abdominocentesis is indicated immediately (Devey, 2010).

According to Walters (2000), radiography is also the technique of choice for detecting intestinal obstruction and foreign material in the gastrointestinal tract. The intestine should be evaluated for obstructive patterns and linear foreign bodies. If findings are not conclusive, a radiograph can be repeated in 3 to 4 hours to determine if the gas and/or foreign body is moving (Devey, 2010). Graham et al. (1998) formulated a quantitative index for normal intestinal diameter and evaluated its usefulness in predicting small animal obstruction. A ratio of the maximum small intestinal diameter (SI) and the height of the body of the fifth lumbar vertebra at its narrowest point (L5) was used. A value of 1.6 for SI/L5 is recommended as the upper limit of normal intestinal diameter. The model showed that obstruction is very unlikely if the SI/L5 value is less than this. Higher values were significantly associated with obstruction.

Contrast procedures including barium series, intravenous urography, cystography (single and double contrast), and angiography may also be helpful in the evaluation of acute abdominal disorders and provide further diagnostic information. When preparing the patient for a contrast procedure, the patient's clinical status and the purpose of the procedure should always be considered (Bischoff, 2003).

Contrast radiography may be contraindicated in animals with frequent vomiting due to the risk of aspiration pneumonia (Boag & Hughes, 2004). Barium should be avoided if bowel perforation is suspected; water-soluble iodinated contrast agents should be used instead (Dye, 2003), to avoid barium contamination of the peritoneal cavity (Boag & Hughes, 2004), which may worsen peritonitis (Holt & Brown, 2007). However, if perforation is present, it is an absolute indication for exploratory celiotomy in which case lavage of the peritoneal cavity using copious amounts of an isotonic solution can be performed (Boag & Hughes, 2004).

Studies made with barium are superior to those obtained with water-soluble contrast agents (Boag & Hughes, 2004).

Intravenous urography and retrograde urethro- or vaginourethrography may be needed to localise obstruction, discontinuity or other physical abnormalities of the urinary system (Boag & Hughes, 2004).

1.5.3. Ultrasonography

Abdominal ultrasonography can be used to assess the abdominal organs, especially when free peritoneal fluid makes radiographic interpretation difficult (Holt & Brown, 2007) and it is particularly useful for excluding obstructive processes (Garcia et al., 2011). It also allows the operator to evaluate the entire organ, rather than only its silhouette (Beal, 2005). The organs that can be evaluated using ultrasound include the liver, biliary system, pancreas, stomach, small intestine, kidney, urinary bladder, uterus, and prostate (Cruz-Arámbulo & Wrigley, 2003). Abdominal ultrasound is also capable of detecting small quantities of free peritoneal fluid that otherwise might be unobserved. As little as 4mL/kg body weight of free fluid can be seen on ultrasound examination. Large amounts of free fluid are easily visualized as anechoic areas separating the abdominal organs (Walters, 2000).

Positioning the animal in dorsal recumbency facilitates the identification of small amounts of peritoneal fluid within the abdomen, although it is not advisable in cardiovascularly unstable patients (Walters, 2000). Areas demanding close observation for fluid are around and between liver lobes in the cranioventral abdomen, between the body wall and the spleen, and at the apex of the bladder, where it forms an angular anechoic or hypoechoic region (Walters, 2000). Fluid may accumulate locally in certain diseases processes, such as pancreatitis (Walters, 2000). Retroperitoneal fluid accumulation can be indicative of haemorrhage or ureteral leakage (Walters, 2000).

Fluid visualized with ultrasound frequently can be safely aspirated with ultrasound guidance and should be evaluated by cytological and biochemical analysis (Walters, 2000), being this method the quickest for diagnosing septic peritonitis (Boag & Hughes, 2004).

Abnormalities of the diaphragm and abdominal wall can also be seen in abdominal ultrasonography (Holt & Brown, 2007).

Doppler ultrasonography can be used to assess for the presence or absence of blood flow (Beal, 2005).

According to Beal (2005), the diagnostic utility of abdominal ultrasonography is quite operator dependent because when performed by clinicians without extensive training and experience, misdiagnosis is extremely common.

A technique called FAST (focused abdominal sonogram for trauma) has been adapted from the human medical field and applied to dogs that had sustained trauma in an effort to identify abdominal fluid accumulations. This technique calls for transverse and longitudinal views taken from four sites around the abdomen, including the subxiphoid, ventral midline over the bladder, and areas over the most gravity-dependent areas of the right and left flanks. The technique showed to be sensitive for the diagnosis of abdominal fluid accumulations after trauma when performed by clinicians with minimal ultrasonographic training (Boysen et all, 2003).

1.5.4. Abdominocentesis and diagnostic peritoneal lavage

Abdominocentesis consists in the percutaneous removal of abdominal fluid for diagnostic and therapeutic purposes (Walters, 2003). The ease and simplicity of this technique make it an excellent choice; however, it often requires the presence of a relatively large quantity of abdominal fluid to be successful (Walters, 2000).

Given the extensive list of potential causes of acute abdominal pain, abdominocentesis can be helpful in making a definitive diagnosis more rapidly (Connally, 2003). Abdominal effusion is a clinical finding in several animals with acute abdomen because of alterations in capillary hydrostatic pressure, oncotic pressure, vascular permeability, lymphatic drainage, or any combination thereof (Beal, 2005).

Abdominal paracentesis and diagnostic peritoneal lavage (DPL) are sensitive indicators of gastrointestinal or urinary tract trauma, often providing the clinician with a definitive diagnosis before overt clinical signs become evident as well as helping to determine whether surgery is indicated or not (Walters, 2003).

Abdominal radiographs should be considered as a first option, diagnosing patients with suspected abdominal effusion, before any other invasive diagnostic method is performed such as abdominocentesis. Paracentesis techniques may inadvertently induce a pneumoperitoneum, or introduce air into the abdominal cavity, creating confusion as to whether this air was present before the procedure (e.g. by rupture of a hollow viscus) or if this free air is iatrogenic (Walters, 2003).

If septic abdomen is suspected, abdominal radiography and/or ultrasound should be considered as a first wave diagnostic to help localize fluid and possibly its etiology. Ultrasound is highly sensitive to detect very small amounts of abdominal fluid and can be a useful tool in guiding fluid collection (Walters, 2003).

Blind abdominal paracentesis without the assistance of ultrasound is contraindicated in animals with suspected pyometra due to the risk of uterine rupture and spilling suppurative uterine debris into the peritoneal space (Walters, 2003).

Restraint might be needed to perform abdominocentesis or DPL depending on the temperament and the status of the patient. If the patient is depressed, lethargic, or obtunded, a muzzle only may be enough. However, if the patient is intractable, chemical restraint should be considered to avoid patient and/or clinician injury (Walters, 2003).

If simple paracentesis fails to provide results, a four-quadrant paracentesis may be useful (Walters, 2003), being this technique critical to optimize the chances of obtaining free abdominal fluid (Walters, 2000).

Initially, the ventral aspect of the right cranial quadrant is used. This diminishes the chance of splenic or urinary bladder puncture. This is also where free abdominal fluid pools as a result of gravity and diaphragmatic movement. The needle can be either attached to a syringe (closed-needle abdominocentesis) or left unattached (open-needle abdominocentesis). The advantage of open-needle abdominocentesis is supposed to be that fluid can flow freely and the lack of suction reduces the chance of omentum or viscera occluding the needle. Turning the needle gently can help to liberate fluid into the needle hub. If no fluid is obtained at this site, then the four-quadrant approach can be used with the same procedure being repeated at each of four sites – right cranial, right caudal, left caudal, left cranial. Centesis of the left cranial quadrant should be performed with caution due to the risk of splenic puncture. A strict aseptic technique should be observed (Boag & Hughes, 2004).

Contraindications to abdominocentesis are few, but include severe coagulopathy or thrombocytopenia, severe organomegaly, distension of an abdominal viscus and previous abdominal surgery if there is a risk that adhesions may fix the bowel to the abdominal wall (Boag & Hughes, 2004).

Limitations to paracentesis include false positive and false negative taps. An important cause of false positive results for a haemorrhagic effusion or bacterial peritonitis occurs due to needle or cannula penetration into abdominal viscera or into the lumen of hollow organs. Limitations of both techniques are that neither is capable of diagnosing diseases within the retroperitoneal space (Walters, 2003).

Complications with abdominocentesis are rare but may occur and include introduction of infection where one previously did not exist; spreading of infection from a localized lesion such as pyometra or abscess; laceration of a hollow viscus, inducing peritonitis; induction of a haemoperitoneum by lacerating a vessel (Walters, 2003).

DPL is performed in patients in which simple or four-quadrant paracentesis has failed to provide a diagnostic sample, in patients with inexplicable abdominal pain or fever, or when peritonitis is highly suspected (Walters, 2003).

DPL is more sensitive than abdominocentesis alone. Because of its sensitive diagnostic ability, DPL should be performed in most cases of blunt and penetrating abdominal injury when single or four-quadrant abdominal paracentesis has yielded a negative tap (Walters, 2003).

In many cases, to perform the conventional DPL procedure, patients will require sedation, analgesia, and use of local anaesthetic agents (Walters, 2003). A simpler and less invasive technique for which sedation is rarely required is yet known. This involves clipping and aseptically preparing the animal's abdomen just caudal to the umbilicus. An over-the-needle catheter is placed into the abdomen and warm isotonic crystalloid solution is infused using gravity flow or injection with gentle pressure. A total of 10 to 20mL/kg is used. The catheter is then removed and the abdomen gently palpated to allow dispersion of the fluid. After 20 to 30 minutes, a single or four-quadrant abdominocentesis is performed. Generally, only a small portion of the infused fluid is retrieved (Boag & Hughes, 2004).

Any fluid retrieved should be evaluated as described below. Care should be taken in interpreting samples obtained by DPL, as they will be dilute, thus affecting cell counts and biochemical analysis (Walters, 2003).

1.5.5. Cytology and fluid analysis

The aim of performing cytology and fluid analysis of any effusion is to obtain a rapid and accurate diagnosis, such that appropriate therapy can be instituted within an acceptable period of time, thereby minimizing patient morbidity and mortality (Connally, 2003).

In many cases, analysis and cytology of the abdominal fluid provide valuable information necessary for deciding whether medical or surgical intervention is most appropriate; so on any sample collected via abdominocentesis, fluid analysis and cytology should be performed (Connally, 2003).

Fluid analysis begins with appropriate sample collection. Collected samples should be saved in a sterile ethylenediaminetetraacetic acid (EDTA) tube to prevent clot formation that may alter cell count, regardless of whether haemorrhage is apparent grossly. The EDTA samples will undergo cytological examination, and total protein content and total nucleated cell count will be determined. A portion of the sample should also be saved in a sterile tube with no additives for biochemical evaluation if indicated, and in culture media appropriate for aerobic and anaerobic culture and antibiotic susceptibility testing if bacterial culture is indicated. Samples should always be collected as aseptically as possible to prevent sample contamination by non-offending microorganisms (Connally, 2003).

The fluid should be examined grossly first. If bloody fluid is taken from abdominal paracentesis, then it should be collected and monitored for clotting. Free blood in the peritoneal cavity should not clot, while blood obtained from unintentional puncture of an organ or vessel will clot if no coagulopathy is present. PCV and total solids should be evaluated with bloody effusions. The PCV of the abdominal effusion will be similar to the peripheral venous PCV if the haemorrhage is recent. If haemorrhage stops and fluid therapy is instituted, a wider discrepancy may be seen between abdominal effusion PCV and peripheral venous PCV. The peripheral PCV will become lower as a dilutional effect of treatment and the abdominal PCV will continue the same. Active haemorrhage usually results in parallel changes in the peripheral and abdominal fluid PCV (Walters, 2000).

Tests that can aid to obtain a definitive diagnosis can be performed on the supernatant, including creatinine, urea nitrogen, lipase, amylase, cholesterol, triglyceride levels, albumin, globulin, and bilirubin (Connally, 2003). These tests, even though useful, are not completely fool proof. They must be evaluated in conjunction with the clinical evaluation of the animal and the results of other diagnostic tests (Walters, 2000).

The characteristics of common causes of abdominal effusion in the acute abdomen can be found on annex III.

Classification of the collected abdominal fluid, based on its cell count and protein content is described in Table 4.

Table 4: Classification of the collected abdominal fluid, depending on its cell count and protein content (adapted from Connally, 2003).

	Transudate	Modified transudate	Exudate
Cell count	< 1.5 cells/μL	1.000 – 7.000cells/μL	> 5.000 cells/μL
Protein Content	< 2.5 g/dL	2.5 – 7.5 g/dL	> 3.0 g/dL

Transudates and modified transudates are not usually associated with acute abdominal pain (Connally, 2003). If abdominocentesis of an emergency patient yields a transudate, congestive heart failure, liver failure, and hypoproteinemia should be considered as differential diagnoses. Modified transudates may result from chronic transudation of fluid. Although the total cells count is generally low, macrophages or mesothelial cells are the predominant cell type presents (Connally, 2003).

Transudates usually arise due to reduced absorption or increased production of fluid, secondary to hypoproteinemia, overhydration, or lymphatic or venous congestion. In general, they're not associated with acute abdominal pain (Connally, 2003).

Any cell type may be present in an exudative effusion; however, the typical exudate contains primarily phagocytic cells. Exudates arise due to chemotaxis of inflammatory cells, altered vascular permeability, and leakage of plasma proteins. Other causes of exudative effusions include rupture or penetration of a visceral organ or vessel, exfoliation of neoplastic cells, and leakage of a chylous fluid (Connally, 2003).

After the smear has been stained and dried, it should first be evaluated at low power using the 4x and/or 10x objective. This degree of magnification allows the clinician to assess the adequacy of staining and to identify areas of high cellularity or areas with unique staining features. In addition, larger objects, including some crystals, parasites, and plant debris, may be seen while scanning at low magnification. Magnification can then be increased to the 10x objective. At this degree of magnification, the clinician can gain an impression of the overall cellularity and cellular composition. When an area of increased or unique cellularity is identified, the smear is viewed with the 40x objective. At this magnification, individual cells are examined and compared with other cells, and most microscopic organisms can be seen. A differential cell count can also be made at this stage. Finally, the smear should be evaluated using the 100x (oil-immersion) objective, so organisms and cellular inclusions can be definitively identified, as well as cellular morphology (Connally, 2003).

Fluid with white blood cells greater than 1000 cells/μL in a patient that has not recently had an exploratory laparotomy and that contains many degenerative neutrophils is suggestive of peritoneal inflammation or suppuration with possible sepsis; then the exploratory laparotomy is indicated. Other indications for surgical exploration of the abdomen include the presence of intracellular bacteria, a finding that is suggestive of bacterial peritonitis, and vegetable fibers that indicate visceral perforation with leakage of bowel contents. Patients with chemical peritonitis secondary to biliary rupture or uroabdomen will often benefit from medical stabilization. Surgery can be performed later when the patient's cardiovascular status is more stable, rather than on an emergency basis (Connally, 2003).

1.5.6. Endoscopy

When available, endoscopy can be used for both diagnostic and therapeutic purposes. It is a useful technique for helping removal of oesophageal or gastric foreign bodies and, in stabilized critically patients, it can be used to facilitate gastrostomy tube placement. Endoscopy is also an excellent minimally invasive diagnostic technique for evaluating mucosal lesions in the gastrointestinal tract. The oesophagus can be examined with endoscopy but biopsies are difficult because of the rough nature of the mucosa. Gastric and intestinal biopsy samples should be collected and submitted for histopathology even if the tissue looks grossly normal. Due to the superficial nature of endoscopic biopsy samples, deeper lesions can be missed and full-thickness biopsies may be required if a diagnosis is not reached (Murphy & Warman, 2007).

1.6. Anaesthesia

Several animals with acute abdomen may also be in shock or on the verge of going into shock, as mentioned before. The sympathetic nervous system is stimulated in the emergency situation in an attempt to maintain blood flow and oxygen delivery to the tissues. Almost all anaesthetics blunt the response of the sympathetic nervous system. Therefore, the patient that is in compensatory shock may decompensate when given a sedative or anaesthetic agent. In addition to interfering with the cardiovascular system, sedatives and anaesthetics can compromise the respiratory system, which could be detrimental to a patient that is in respiratory distress (Campbell, 2005).

The anaesthetics protocol for patients with an acute abdomen should be carefully instituted. As previously said, many of these patients are already hypotensive, and many anaesthetic drugs can contribute further to hypotension and decreased organ perfusion (Dye, 2003). When anaesthetized, these patients have limited ability to respond to hypovolaemia with vasoconstriction, increased contractility, and increased heart rate (Egger, 2009).

Most of the debilitated patients will not require preoperative sedation. However, patients that are less debilitated may benefit from pre-anaesthetic sedation, as it can decrease sympathetic tone associated with pain and stress and can also drop the required dosage of induction agents and the minimum alveolar concentration (MAC) of inhalant anaesthetics (Dye, 2003).

Patients with severe respiratory distress may benefit from a light sedation to relieve the stress of restrain. Opioids such as buprenorphine, oxymorphone, fentanyl or butorphanol, may be used safely in most critical patients as a pre-anaesthetic, but reduced dosages should be considered to minimize cardiovascular effects and respiratory depression (Dye, 2003). Morphine and hydromorphone should be avoided in biliary obstruction as they can cause spasm of the biliary sphincter; also they should avoided in gastric or intestinal obstruction, since that they induce vomiting (Egger, 2009).

Intravascular volume, acid-base and electrolyte status must be normalized prior to anaesthesia (Egger, 2009).

The patient must be pre-oxygenated by mask before anaesthetic induction to minimize hypoxia caused by respiratory depression before intubation (Dye, 2003).

Anaesthetic induction by mask requires a very deep anaesthetic plane which potentiates hypotension before intubation can be done, leaving the airway unprotected. It can also be more stressful to the patient. For these reasons, mask induction should generally be avoided (Dye, 2003).

Once intubated, the patient may be maintained on an inhalant anaesthetic. It is important to know that all inhalant anaesthetics produce a dose-dependent cardiovascular depression. Intravenous fluids should be continued intra-operatively. The use of colloids and blood products should be considered. External heat should be provided using a forced air or circulating water blanket. Monitoring every 5 minutes with electrocardiogram, blood pressure, pulse oximetry and capnography is essential in critical patients (Dye, 2003) because their status can change dramatically from minute to minute (Campbell, 2005). In thoracic trauma, anaesthesia can still be safely performed, although positive pressure ventilation is mandatory, because of the loss of diaphragmatic integrity. In addition, a small amount of positive end-expiratory pressure may be beneficial to help recruit collapsed alveoli (Rozanski & Chan, 2005).

A balanced anaesthesia technique that uses different drug types to reduce the overall amount of anaesthetics needed is a safe approach to general anaesthesia in the emergency patient (Campbell, 2005).

Drug doses for sedation, analgesia, and routes of administration in the emergency patient can be found in annex IV.

1.7. Treatment

1.7.1 Medical management *versus* surgical management

A thorough knowledge of the underlying aetiology causing an acute abdominal crisis allows the veterinary surgeon to prepare and plan the appropriate surgery, estimate the required postoperative needs of a patient, and discuss the expected outcome with the owner. Yet, in many instances, it may be inappropriate to pursue a complete diagnosis prior to surgical intervention, which can often be as much for diagnosis purposes as it is for definitive treatment. Consequently, the clinician has to be prepared for a large spectrum of possibilities at the time of surgery. That said, acute abdominal pain does not justify an exploratory laparotomy before careful evaluation and stabilisation of the patient. It is essential that disease processes that can be managed medically and those that require surgical management are differentiated prior to exploratory laparotomy, which can be seen in table 5.

Table 5: Diseases processes that can be managed medically *versus* those that require surgical management (adapted from House & Brockman, 2004).

Non-surgical conditions	Surgical emergencies	
Pancreatitis Viral enteritis Haemorrhagic enteritis Non-perforating gastrointestinal ulceration Hepatitis Pyelonephritis	Gastric dilatation-volvulus Septic peritonitis Intra-abdominal intractable haemorrhage Ruptured pancreatic or prostatic abscess Pyometra Urethral obstruction that cannot be managed by catheterisation Intestinal foreign body	Intussusception Upper gastrointestinal obstruction Intestinal perforation Penetrating abdominal wounds Splenic or testicular torsion Mesenteric torsion

Some patients cannot be completely resuscitated until surgery is performed, making the need for surgical intervention obvious. However, in some cases the decision to go to surgery may not be so straightforward. If there is any doubt, it may be better to perform an exploratory laparotomy rather than wait and have the patient deteriorated. Even when surgery is indicated, a decision to delay the operation may be appropriate if surgery is not required as part of resuscitation and if it is determined that a delay will help to decrease morbidity or mortality. Acute abdominal conditions that require emergency surgery include conditions such as trauma-related disease, gastrointestinal obstruction or ectopia, peritonitis, torsion, abdominal masses, and vascular compromise (Devey, 2010). Other indications for exploration in the animal with acute abdominal pain involve lack of diagnosis in a detiorating patient, bacteria seen within white blood cells in abdominal or DPL fluid, as well as plant fibbers in abdominal or DPL fluid, greater than 2000 cells/mm^3 on DPL, failure to respond to medical treatment for pancreatitis, free abdominal air, to obtain biopsies, and when feeding tube placement that bypasses stomach is needed (Rudloff, 2012). The need and provision for enteral access should be part of the initial surgical plan. It can be achieved via oesophagostomy, gastrostomy or jejunostomy tubes. Tube placement should be as towards the oral cavity as possible and is dictated by the disease process (House & Brockman, 2004). Clients should be warned about the possibility of a “negative” exploration, one in which a definitive cause for acute abdomen cannot be identified. However, even a negative exploration may have diagnostic value after biopsies ate taken (Beal, 2005).

1.7.2. Symptomatic management

1.7.2.1. Acid blockers

Drugs that block secretion of gastric acid are an important element of treatment of oesophageal and gastric ulceration. Two classes of drugs are available, the first being histamine receptor antagonists, e.g. ranitidine; and the other is proton pump inhibitors, such as omeprazole (Murphy & Warman, 2007).

1.7.2.2. Antidiarrhoeals

Infectious and obstructive disease must be excluded before antidiarrhoeals are introduced. Opioids, such as loperamide or diphenoxylate, increase intestinal transit time and reduce intestinal fluid loss by increasing segmental contraction. Antispasmodics (butylscopolamine) may reduce discomfort and pain associated with acute abdomen but could potentiate ileus by reducing gut motility. Intestinal protectants or adsorbents, e.g. activated charcoal, have also been used for many years in general practice to treat acute diarrhoea (Murphy & Warman, 2007).

1.7.2.3. Anti-emetics

Anti-emetics are indicated in patients with protracted vomiting causing fluid and electrolyte imbalances. They should not be used in patients with potential gastrointestinal obstruction, toxin ingestion (since they may prevent elimination of the toxin) or severe hypotension. Anti-emetics may act via peripheral or central mechanisms. Metaclopramide is the most commonly used anti-emetic. It has a central anti-emetic action in the chemoreceptor trigger zone and also a peripheral prokinetic effect, which can reduce emesis by increasing lower esophageal sphincter tone and gastric emptying. The central nervous system side effects appear to be less common if the drug is given in a constant rate infusion (CRI). Being particularly useful in patients with gastrointestinal ileus and persistent vomiting, e.g. patients recovering from parvovirus infection or abdominal surgery (Murphy & Warman, 2007).
Maropitant citrate is another antiemetic commonly used and is a selective neurokinin type-1 receptor antagonist that acts by blocking the binding of substance P within the emetic centre and chemoreceptor trigger zone. It is used for prevention and treatment of acute emesis in dogs and also for the prevention of emesis due to motion sickness (Lesman et al., 2013).

1.7.2.1. Mucosal protectants

Mucosal protectants aid the barrier function of the oesophagus and stomach when mucosal deficits are present. They can act as cytoprotective agents, chemical diffusion barriers or both. The complex of aluminium hydroxide and sucrose octasulphate, also known as sucralfate is one example. It binds to gastro-oesophageal erosions or ulceration and forms a barrier to gastric acid penetration, thus aiding healing (Murphy & Warman, 2007).

1.7.2.1. Prokinetics

Prokinetics can stimulate motility in part of or the entire gastrointestinal tract. These drugs are indicated when there is a need to improve motility in patients with ileus, once electrolyte abnormalities have been corrected and gastrointestinal obstruction excluded. The most commonly used are metoclopramide, histamine antagonists such as ranitidine and erythromycin (Murphy & Warman, 2007).

1.7.3. Surgical management - general surgical principles

According to Beal (2005), before starting surgical exploration, wounds or crushing injuries over the abdomen warrant special consideration. They frequently follow the iceberg analogy. What is seen on the surface is a small component of what lies beneath. Evaluation of this type of patient should always include surgical explorations of those wounds. For example, all bite wounds should be explored surgically, opened to allow adequate exposure for exploration, debrided, lavaged, closed using appropriate drainage techniques, or left open to heal by second intention. Even nonpenetrating wounds can result in severe intra-abdominal injury.

Thorough surgical exploration requires a ventral midline incision in the abdomen extending from the xiphoid process to the pubis. Excision of the falciform fat may help visualisation of the cranial abdomen (House & Brockman, 2004). In addition, a paracostal incision may occasionally facilitate removal of large cranial abdominal masses or hepatic surgery (Dye, 2003). The use of suction, to remove free fluid, and abdominal retractors is essential to achieve adequate exposure and visualisation of all organs (House & Brockman, 2004). Therefore, free fluid should be collected (before being suctioned) for analysis and culture/sensitivity if these samples have not yet been performed (Dye, 2003).

A careful and systematic approach to exploration of the abdomen is essential to identify all abdominal pathology. According to House & Brockman (2004) and Dye (2003) it is better to start exploration in the cranial abdomen and progress caudally, systematically evaluating all organs; however in patients with acute, life-threatening conditions (such as GDV or bleeding splenic mass), it may be necessary to address the primary condition initially (detorse and decompress the stomach, perform splenectomy), and only then perform a complete abdominal exploration. It is usual to identify concurrent conditions such as splenic infarction or evidence of metastasis to the liver within the abdomen that may require further treatment or affect the patient's prognosis (Dye, 2003).

The abdomen should be explored in a consistent manner to be certain that no abnormalities are overlooked. As previously mentioned, exploration of the abdomen should begin cranially and then move in a caudal direction. Cranial exploration should include examination of the diaphragm and the entire liver. Reflection of the left lateral and medial liver lobes towards the right with caudal retraction of the fundus of the stomach and spleen reveals the gastric cardia and abdominal oesophagus, left aspect of the diaphragm, cranial pole of the left kidney and left adrenal gland. The quadrate, right medial, right lateral, caudate and papillary processes of the caudate lobe are inspected visually and gently palpated. The gall bladder, cystic and common bile ducts should be carefully evaluated. The ability to express the gall bladder does not necessarily demonstrate potency of the common bile duct, as reflux of bile into the hepatic ducts can also lead to gall bladder emptying (House & Brockman, 2004).

The stomach is traced to the pylorus and proximal duodenum. The gastric limb of the pancreas is closely associated with the dorsal leaf of the greater omentum. Visualisation is achieved by reflection of the greater omentum ventrally and cranially or by creating a window in the omental bursa. Elevation of the descending duodenum reveals the right kidney, right adrenal gland and portal vein. The right ovary and uterine horn are visualised in female dogs. The duodenal limb of the pancreas is inspected. The duodenum is traced to the duodenocolic ligament and beyond to the jejunum. Therefore the intestinal tract is examined from the duodenum to the descending colon. The loops of intestine are gently pulled from the abdomen onto moistened laparotomy sponges or drapes. The wall of the intestine is gently palpated to appreciate any regions of thickening. The mesenteric vessels and lymph nodes are also examined at this time (Dye, 2003).

Elevation of the descending colon reveals the caudal pole of the left kidney, and the left ovary and uterine horn in female dogs. Elevation of the bladder reveals the ureters entering the caudal and dorsal bladder trigone and both vas deferens in male dogs (House & Brockman, 2004).

Once exploration of the abdomen is complete, the primary problem, if identified, should be addressed (Dye, 2003).

The mainly goals of surgery, when facing GDV, are to normalise the gastric anatomy, evaluate the organs for viability, resect non-viable tissue and firmly fix the stomach in its normal position to prevent recurrent volvulus. Preoperative stabilisation and postoperative care of the patient have the biggest influence on survival (House & Brockman, 2004), being associated with rapid deterioration and high mortality if it is not managed appropriately (Tivers & Brockman, 2009).

The stomach is detorsed, then decompressed and lavaged via orogastric tube. Approximately 10% of GDV patients have gastric necrosis that may require partial gastrectomy. A gastropexy is performed to prevent recurrence. Various types of gastropexy have been described, including circumcostal, belt loop, incisional, and tube (Fossum et al., 2007).

According to Dye (2003), a ventral midline incisional gastropexy is the easier, most rapidly performed and does not enter into the gastric lumen. It is performed by incorporating approximately 5 cm of the seromuscular portion of the ventral stomach wall near the pyloric antrum into the cranial abdominal closure. A continuous suture pattern of slowly absorbable or non-absorbable suture material is used to perform the gastropexy. Since the gastropexy site is located cranially, it generally does not interfere with subsequent abdominal surgeries. However, if future cranial abdominal surgery is performed, a paramedian or paracostal approach may be required.

The spleen should be evaluated for viability, and splenectomy performed if indicated. Viability of the spleen is assessed by close examination of splenic arteries and veins (House & Brockman, 2004). The spleen may be non-viable because of thrombosis or avulsion of the splenic vessels or secondary to torsion. Often, the spleen will regain a normal appearance once it is returned to its normal position in the abdomen and should be re-evaluated in five to ten minutes. However, if splenic necrosis is present with splenic torsion, splenectomy should be performed without correcting the torsion, or possible release of toxins, inflammatory mediators and thrombi from the splenic vessels may occur, worsening the cardiovascular status of the animal (Dye, 2003). Torsion of the spleen may occur when the spleen becomes hyper-mobile because of congenital absence or weakness of one or more of the ligaments, holding the spleen in its normal position in the left cranial abdomen. Acquired wandering spleen may occur during adulthood due to injuries or laxity of the ligaments (Simeonova et al., 2007).

A portion of the left limb of the pancreas may very occasionally be involved in the torsed pedicle. In such cases, partial pancreatectomy may be required with close inspection of the vascular supply to the pancreas, stomach and liver (House & Brockman, 2004).

In the presence of gastrointestinal foreign bodies, the stomach or intestines are isolated using laparotomy sponges or drapes, and a gastrotomy and/or enterotomy is performed to remove the foreign material. The bowel is closely inspected for viability, perforations, or strictures before closure. Careful closure of the stomach or intestines is then performed. In some cases, resection and anastomosis of the intestine may be required (Dye, 2003).

When closing an enterotomy or intestinal anastomosis, 3-0 to 4-0 monofilament absorbable suture with a swaged-on taper or tapercut point needle should be used in a simple interrupted, full thickness, appositional pattern (Fossum et al., 2007). The sutures are placed approximately 2 mm from the edge of the intestine and 2 to 3 mm apart (Fossum et al., 2007). Following closure of the enterotomy or anastomosis, digital pressure may be used to occlude the lumen of the bowel proximal and distal to the site. The lumen can then be distended with saline using a syringe and small gauge needle. The site should be observed for leakage, and additional sutures should be placed if leakage is observed (Fossum et al., 2007).

A patch of omentum or serosa from an adjacent loop of intestine may be placed over the suture line to enhance healing. Using a serosal or omental patch provides support to the repair, promotes formation of a fibrin seal, increases resistance to leakage, and supports blood supply to the region. An omental patch is created by using a vascularized segment of omentum and suturing it to the intestine near the enterotomy site. The sutures are placed to engage the serosa, muscularis, and submucosa, but do not penetrate the lumen of the intestine. Similarly, a serosal patch is created by bringing a loop of intestine adjacent to the enterotomy site and suturing it over the affected area. Care should be taken to avoid stretching, twisting, or kinking of the intestine or the mesenteric vessels (Dye, 2003).

Linear foreign bodies may pose a challenge to the veterinary surgeon. The linear material can become embedded in the mucosa if present for a long period of time, requiring intestinal resection. Laceration of the mesenteric border of the intestine may occur during attempts to remove the object. Often, multiple enterotomies are required to remove linear foreign bodies (Fossum et al., 2007).

For removal of linear foreign bodies with a single gastrotomy or enterotomy, a technique using a feeding tube catheter has been described (Fossum et al., 2007). In this, an incision is made into the stomach or proximal intestine in which the object is lodged. The object is sutured to a soft rubber feeding tube catheter. The catheter is then advanced into the distal intestine. The gastrotomy or enterotomy is closed, and the catheter and foreign body are gently milked down the intestinal tract and out through the anus. This technique may reduce the number of enterotomies required for linear foreign body removal (Fossum et al., 2007).

Intussusception causes a variable degree of intestinal obstruction and compromises intestinal wall integrity. Small intestinal intussusceptions most commonly occur at the ileocolic junction and result in moderate to severe intestinal obstruction and vascular compromise. They may be manually reduced or require ileocolic resection and bowel anastomosis (House & Brockman, 2004).

Abdominal neoplastic masses will require removal, with resection of the diseased bowel followed by bowel anastomosis, paying careful attention to haemostasis. Biopsy of the liver and mesenteric lymph nodes should be performed to evaluate for metastasis (Dye, 2003).

Acute abdominal disease may appear following abscess formation in, or adjacent to, many organs, such as the pancreas, genitourinary tract, especially the uterus and prostate, and hepatobiliary system. Migration of foreign bodies can occasionally cause peritoneal contamination and peritonitis. Removal of the septic focus by either organ removal, like the uterus, or abscess wall debridement, combined with copious amounts of sterile saline, is fundamental. Placement of omentum within the abscess cavity is encouraged as a means of improving local drainage, facilitating phagocytosis and enhancing local blood supply (House & Brockman, 2004).

In haemoperitoneum, surgical intervention is indicated when the volume of haemorrhage is sufficient to affect peripheral PCV, when is progressive over time and when the source of the abdominal haemorrhage can be successfully ligated or resected (House & Brockman, 2004).

A new approach to these patients is known as hypotensive therapy and the goals in that approach is to avoiding remove any possible clot formed in the traumatized areas, reaching sub-normal values of blood pressure when using products as fresh frozen plasma or fresh plasma. The end-point treatment is systolic pressures lower than 90mmHg or mean pressures lower than 60mmHg (Tello, 2011).

Uroabdomen may require repair of a ruptured bladder or nephrectomy and ureterectomy in the case of an avulsed ureter (Dye, 2003). Uroabdomen has severe metabolic consequences, but induces minimal chemical peritonitis. Bacterial peritonitis may occur if there is an associated urinary tract infection. It may be managed in the short term by drainage of the urine from the abdomen, by abdominocentesis, and by placement of a transurethral catheter while the patient's metabolic status is stabilised. Bladder tears occurring secondarily to urethral obstruction will require removal of the obstruction, primary bladder repair and a period of urinary diversion. If a urethral obstruction cannot be relived by retrograde hydropulsion or the passage of a urinary catheter, a urethrotomy may be necessary. Tube cystotomy can be used to deliver either short or long-term urinary diversion, following any of these procedures (House & Brockman, 2004).

Bile peritonitis is generally caused by rupture of the gallbladder and requires cholecystectomy, followed by copious lavage of the abdomen (Dye, 2003).

If the cause of the acute abdomen is not identified definitively following exploration of the abdomen, biopsies should be obtained from the liver, mesenteric lymph nodes, gastrointestinal tract, pancreas, and kidneys. Bile and abdominal fluid may be obtained for cytology and culture and sensitivity (Dye, 2003).

If the patient is not expected to be willing or able to ingest food following surgery, or if a part of the gastrointestinal tract will not be functional, placement of a feeding tube should be strongly considered. Oesophageal feeding tubes are quickly placed, and there is no risk of peritonitis with premature removal. Gastrotomy tubes may be placed surgically or endoscopically. A jejunal feeding tube may be most appropriate for patients who are vomiting or have diseases affecting the pancreas or upper gastrointestinal tract (Fossum et al., 2007).

A jejunal feeding tube may be placed through a gastrotomy tube either at surgery or with endoscopic guidance. This allows for enteral nutrition in the vomiting patient without stimulation of the pancreas. If the vomiting resolves, the jejunal tube can be removed and the gastrotomy tube used for feeding (Dye, 2003).

If abdominal contamination has occurred because of surgery or the underlying problem, copious lavage of the abdomen should be performed prior to closure to remove bacteria and debris. Bacterial culture and sensitivity should be performed prior to closure. The most important treatment for peritonitis is identification and correction of the underlying cause (Dye, 2003). Reduction of the intra-abdominal bacterial burden and removal of foreign material is largely achieved by peritoneal lavage using copious amounts of warm physiological saline solution, and should be continued until the returning fluid is clear. The addition of antibiotics or antiseptics to the lavage solution is not necessary. If the omentum has become grossly diseased, omentectomy may be indicated to prevent on-going abdominal contamination (House & Brockman, 2004).

However, if an established peritonitis is present, peritoneal drainage should be considered. Both open peritoneal drainage and the use of intra-abdominal drains have been reported in the veterinary literature. Therefore, the choice is made based mostly on an individual surgeon's preference. (House & Brockman, 2004).

Open peritoneal drainage facilitates continued drainage of necrotic debris from the peritoneal cavity and gives the surgeon the opportunity to explore the abdomen again at the time of definitive closure. It also creates an unfavourable environment within the peritoneal cavity for proliferation of anaerobic bacteria. The disadvantage of open peritoneal drainage is the additional resources required to manage the abdominal bandage. An inability to adequately manage the open peritoneal cavity can lead to ascending nosocomial infections and/or abdominal herniation (House & Brockman, 2004).

Open peritoneal drainage is achieved by closure of the cranial and caudal portions of the incision, but central 7 to 10 cm are left open or closed loosely with a continuous suture pattern in the linea alba. The subcutaneous tissue and skin are closed cranially and caudally, but not centrally. A sterile dressing is placed over the abdominal incision, and a circumferential bandage is placed over the abdomen. The bandage should be changed at least once to twice daily or more frequently as strikethrough occurs. In some instances, the patient may be sedated or anaesthetized daily for abdominal lavage. The abdominal fluid should be evaluated daily; if the peritonitis is resolving, the fluid will grossly appear clear. Inflammatory cells will be present, but should lack degenerative changes, and no bacteria or plant material will be observed. With resolving peritonitis, the patient's attitude and condition should also improve. The abdomen is left open for an average of 4 days. A complete abdominal exploratory and lavage of the abdomen followed by bacterial culture and sensitivity should be performed before definitive closure (Dye, 2003).

The use of peritoneal drains decreases the need for the additional nursing that is required for open peritoneal drainage while still providing the benefits of postoperative drainage. If intra-abdominal drains are used, appropriate selection and placement of the drains is important for effective drainage to be achieved. Continuous closed suction drains are ideal. To avoid obstruction by omentum, drains need to be positioned in the abdomen. Two drains are placed in the cranial abdomen between the liver and the diaphragm and two in the caudal abdomen. These need to be bandaged postoperatively to prevent their premature removal by the patient. The drains have to be handled aseptically to reduce the risk of inducing an ascending nosocomial infection (House & Brockman, 2004).

The decision to close an open abdomen, or to remove peritoneal drains, is based on the volume and character of the fluid retrieved from the abdomen. Weighing of the abdominal bandage before application and following removal provides an estimate of the volume of peritoneal exudate. A significant reduction in the volume of exudate, a chance in its character from turbid to clear, as well as the absence of bacteria and a decrease in toxic neutrophils on cytological examination, are indications for abdominal closure or drain removal. The exudation will never completely resolve, especially if drains have been used, as they themselves incite an inflammatory reaction. At the time of definitive abdominal closure, all intra-abdominal surgery sites should be carefully inspected (House & Brockman, 2004).

1.8. Prognosis and postoperative care

Given the broad spectrum of critical conditions that can lead to the acute abdomen syndrome, it becomes difficult to determine prompt prognosis. That is to say, the occult nature of the cause and also the multi-organ effects remain a challenge for the clinician (Walters, 2000).

Rapid physical examination and assessment of the patient's cardiovascular status are critical to initiating appropriate and often aggressive medical management as diagnostic tests are being performed and/or while preparing for surgery, when needed. With treatment followed by intensive monitoring and follow-up care, there's a better chance of achieving a positive outcome (Mazzaferro, 2003). Early detection of hypotension, hypoxia, hypercapnia, or changes in neurologic status facilitates timely intervention and may help to improve outcome (Syring, 2005).

The postoperative care requirements of animals with acute surgical abdominal disease frequently represent a greater challenge than the surgical procedure itself. Regardless of the underlying aetiology and definitive surgical procedure, animals with acute abdominal disease often necessitate intensive postoperative care to optimize their recovery (House & Brockman, 2004). Many of these patients remain haemodynamically unstable and are at risk of several postoperative complications, systemic inflammatory response syndrome or multiple organ failure. Maintenance of the patient's intravascular fluid volume with either crystalloid or colloidal solutions, or blood products is necessary to maintain cardiac output and peripheral perfusion. Parameters that should be measured as part of regular assessment of an individual patient include heart rate, respiratory rate, urine output, rectal temperature, central venous pressure and peripheral arterial pressure, PCV, total solids, electrolytes and arterial blood gases (House & Brockman, 2004). These parameters may need to be reassessed every 15 to 30 minutes, especially if the patient is unstable (Dye, 2003). Jugular, peripheral veins, such as cephalic vein in the upper limb or saphenous vein in the hind limb, and urinary catheters are ideal for facilitating patient monitoring. If the use of peripheral veins and jugular catheters is not viable, urine output provides a valuable estimation of renal perfusion. Urine output should be over 1 to 2 ml/kg/hour. Volumes lower than this indicate reduced arterial blood flow to the kidneys and hence the need for intervention (House & Brockman, 2004). Re-evaluation of neurologic status should be recorded after resuscitation, hourly initially and then every 4 to 8 hours depending on patient stability (Syring, 2005). Continuous electrocardiography and blood pressure monitoring should ideally be performed. Direct arterial pressure monitoring using an arterial catheter is ideal, but may not always be available. Indirect methods such as oscillometry or Doppler ultrasound may be used; however, normal blood pressure may not indicate normal tissue perfusion because of compensatory peripheral vasoconstriction. Therefore, other parameters mentioned above, including heart rate, pulse quality, extremity temperature, mucus membrane color, and capillary refill time, must also be used to assess tissue perfusion. Tachycardia may be caused by postoperative pain or may reflect hypotension. If the patient is hypertensive, the tachycardia is most likely caused by pain and should respond to administration of analgesics (Dye, 2003). Patients with tachycardia and hypotension require treatment with fluid boluses and possibly administration of synthetic colloids or blood products. Inotropic support may also be required for hypotensive patients (Dye, 2003).

Crystalloid administration is the mainstay of fluid therapy and should be continued postoperatively. The rate of fluid administration depends on the patient's cardiovascular status and on-going fluid losses. Electrolyte imbalances will also need to be monitored and addressed (Dye, 2003). In animals with peritonitis, fluid infusion rates must be tailored to the perceived needs of the individual patient based on changes in mucous membrane pallor, capillary refill time, peripheral arterial pulses, urine output, PCV, total solids and arterial blood gases. Colloids may be beneficial in patients that remain hypotensive despite crystalloid therapy and when adequate volumes of plasma are not available. However, colloids can potentially cause coagulopathies, volume overload and exacerbation of peripheral and pulmonary oedema if there is significant leakage of the colloid into the interstitial space. Fresh frozen plasma is the colloid of choice in cases of peritonitis. Many patients with peritonitis are hypoproteinaemic due to the large amount of protein lost in the peritoneal exudate. The use of plasma has several advantages, including colloidal support and supplementation of plasma proteins such as clotting factors and proteinase inhibitors. However, normalisation of serum protein levels is not a realistic goal of plasma transfusions (House & Brockman, 2004). Blood products are indicated in patients with a PCV less than 30% or when evolving hypoproteinemia or coagulopathies. Central venous pressure can be used to evaluate the adequacy of fluid resuscitation (Dye, 2003).

Provision of adequate analgesia is essential for both the welfare of the animal and to avoid the adverse physiological effects of persistent pain, which may be related with immune suppression, delayed wound healing, increased tissue catabolism and ventilation or perfusion mismatch. Ideally, each patient should be submitted to an analgesia strategy that is pre-emptive and multimodal (House & Brockman, 2004). Low doses of opioids, particularly fentanyl, can be useful in critical patients, as most cardiovascular effects are dose dependent. Epidural anaesthesia and local anaesthetic blocks can also be used to control pain, with minimal risk to the patient (Dye, 2003). The use of multiple agents results in a slower onset of action, but provides superior analgesia and is more cardiovascularly sparing, for example the morphine-lidocaine-ketamine drug combination is widely used (Muir et al., 2003).

Clinical signs of pain may include tachycardia and hypertension, as mentioned above, thrashing, vocalization, restlessness, and panting. It is important to distinguish pain from dysphoria, which is vocalization and agitation that may occur following drug administration, particularly with opioids. Administration of a tranquilizer or reversal of the drug can alleviate the signs of dysphoria. Partial reversal of morphine with the agonist-antagonist butorphanol may provide some on-going analgesia, but reversal of the dysphoria (Dye, 2003).

Most patients are hypothermic postoperatively. Drying the animal may facilitate warming, and supplying external heat using circulating warm water or forced air-heating pads. Intravenous fluids may also be warmed. An incubator may be an effective means of warming smaller patients (Dye, 2003). Because a cold, humid, dirty or noisy environment contributes to stress and anxiety, which in turn lowers the threshold to pain sensation, it is important that the patient be made comfortable, clean, warm and dry. Stabilization of fractures and primary treatment of wounds and burns also reduce pain. Tender loving care is of most importance (Mathews & Dyson, 2005).

Several animals recovering from acute surgical abdominal disease are suffering from bacterial sepsis or have compromised immune function. If antibiotic use is indicated, empirical therapy should be initiated but modified according to aerobic and anaerobic culture and sensitivity results. Critically ill patients are susceptible to infectious complications, but prophylactic antibiotic courses should be avoided as they do not influence the incidence of nosocomial infections and will select for more resistant bacteria. Typical antibiotic choices are second-generation cephalosporins or ampicillin, fluoroquinolones, metronidazole combinations (House & Brockman, 2004).

In patients with peritonitis, broad-spectrum antibiotic coverage is indicated. Gram-negative rods and anaerobic bacteria are most common when gastrointestinal perforation has occurred, and this should be considered when choosing antibiotics for these patients (Dye, 2003).

Early and adequate nutritional support is also essential in critically ill patients to maintain animal's defences against injury mechanisms and to restore or maintain a positive nitrogen balance, preventing depletion of energy stores and protein catabolism (Dye, 2003). Enteral feeding is associated with fewer complications and is preferable to parenteral nutrition, when possible. Alimentary nutrition (eg. Oesophageal, gastric or jejunal) has positive effects on enterocyte viability and intestinal wall integrity, including maintenance of intestinal mucosal thickness, villous height, and intestinal barrier integrity. Calorific requirements are calculated on an individual patient basis as a factor of resting energy requirement, and depend on the disease process (House & Brockman, 2004).

The identification and interpretation of trends in any parameter enables the clinician to maximise patient care (House & Brockman, 2004). Postoperative patients may develop or redevelop acute abdomen with pain that is perhaps more severe than expected after surgery or not responsive to appropriate analgesic techniques. In these scenarios, diagnostic testing should be initiated just as described previously to move proactively to identify the underlying cause (Beal, 2005). Records of patients including those that died or were euthanized should be regularly reviewed to assess team performance and to make improvements where necessary (Devey, 2013).

The plan must take into account the needs of the patient, the client's needs and financial capabilities, the immediate and overall prognosis and the capabilities of the emergency staff and facility (Brown & Drobatz, 2007).

Part II – Evaluation of signalment, clinical and laboratory variables as prognostic indicators in dogs with acute abdomen syndrome

1. Introduction/Objectives

As previously mentioned, acute abdominal syndrome comprises by multiple diseases that are manifested with acute abdominal pain, often life threatening, and that require immediate decision for medical or surgical treatment. Any delay could be fatal so the exact diagnosis may be neglected in order to save time. The approach to the animal is to discern the acute abdominal syndrome, to stabilize the vital organ's function, and to make a prompt decision for medical or surgical treatment. Also it must take into account the capabilities and equipment of the clinic, as well as the staff skills. This may be extremely effortful, time-consuming and expensive so the owners must be informed about the prognosis for survival as they frequently face the dilemma of euthanasia. In an attempt to make more valid prognostic assessment in cases of acute abdomen syndrome, many individual predictive factors were analysed by univariable analysis.

The aim of this study is to identify and evaluate which of the most readily available clinical and laboratory parameters could serve as prognostic indicators in dogs with acute abdomen treated medical or surgically, regardless of the underlying disease process. In order to achieve possible predictors of outcome in dogs with acute abdominal syndrome, a retrospective study was made including all the cases with acute abdomen seen by the author, during her training period.

2. Material and methods

2.1. Study population and inclusion criteria

The present retrospective study was made using the database from the clinic where the author did her training. All dogs of any breed, gender or age with acute abdominal pain referred to Medivet at Watford in UK, between October 1st 2012 and March 1st 2013 were included.

The criteria for inclusion was any case reporting acute abdominal pain referred to Medivet-Watford from other Medivet branches or lodged directly to the Watford hospital. Animals that were euthanatized in the course of the treatment were also included. A total of 28 cases having acute abdomen syndrome were included in the study.

2.2. Data collection

Blood samples were collected for evaluation of blood and serological parameters. All samples were processed straightaway. For clinical follow-up, samples were collected and processed within 24 hours after collection, and were chilled at 4°C until time of manipulation. The same occurred with the collection of urine and faeces, when justified.

2.3. Examinations

All animals were examined straightaway after been admitted and signalment data, clinical and laboratory parameters were noted (Table 6). The variables were chosen to reflect the function of vital organ systems, the severity of underlying physiologic derangement, and the extent of physiologic reserve. Some variables were serially measured each day during routine monitoring. The values considered for this study were the first ones measured, at presentation.

Radiographic, ultrasound and/or endoscopic investigations were also performed in order to make a correct diagnosis. Based on the results, a decision for conservative or surgical treatment was made in all cases.

Table 6: Variables recorded within 24 hours of admission to Medivet-Watford.

Signalment	Clinical variables	Laboratory variables
Breed	Rectal temperature (ºC)	Haemoglobin (g/dl)
Gender (Male/Female)	Heart rate (beats/minute)	Haematocrit (%)
Age (years)	Pulse quality (strong, weak)	Red blood cells (10^9/ml)
Weight (Kg)	Respiratory rate (respirations/minute)	White blood cells (10^6/ml)
Body condition (good, medium, poor)	Mucous membrane color (MMC) (normal, abnormal)	Lymphocytes (%)
	Capillary refill time (<2seconds, >2seconds)	Platelets (10^6/ml)
	Skin tent (normal, decreased)	Total solids (g/l)
	Pain (low, moderate, severe)	Albumin (g/l)
	Enlarged abdomen (yes, no)	Blood urea nitrogen (BUN) (mmol/l)
	Vomiting	Creatinine

(yes, no)	(µmol/l)
Diarrhoea (yes, no)	Glucose (mmol/l)
Normal faeces (yes, no)	Total bilirubin (µmol/l)
Peristalsis (yes, no)	Alanine aminotransferase (ALT) (IU/L)
Organ involved (hollow, solid)	Aspartate aminotransferase (AST) (IU/L)
Ileus (strangulating, non-strangulating)	Alkaline phosphatase (ALP) (IU/L)
Time elapsed from the beginning (<24h, >24h)	canine Pancreatic Lipase Immunoreactivity (cPLI (+/-)
Previously treatment (yes, no)	Calcium (mmol/l)
Neoplasm (yes, no)	Potassium (mmol/l)
Organ rupture (yes, no)	Amylase (IU/L)

Categorical variables were also included in the analysis. Each animal was categorized as medical *versus* surgical admissions. Surgical cases could be admitted prior to surgery or as post-operative patients. Animals were also categorized as having chronic or acute disease, to distinguish from a real acute issue or exacerbation of a chronic one. Chronicity was defined as a failure of a major organ persisting for longer than one month.

2.4. Statistical methods

The data analysis was performed using the statistical analysis program R (Institute for Statistics and Mathematics, 2012). The relationship between signalment, clinical and laboratory parameters and outcomes were evaluated by means of logistic regression analysis.

First, differences in the distribution of independent variables between survivors and non-survivors were established. As mean values of vital signs expressed as continuous variables have little clinical value, since excess mortality is only observed either above and/or below their normal ranges, continuous variables were converted into categorical variables.

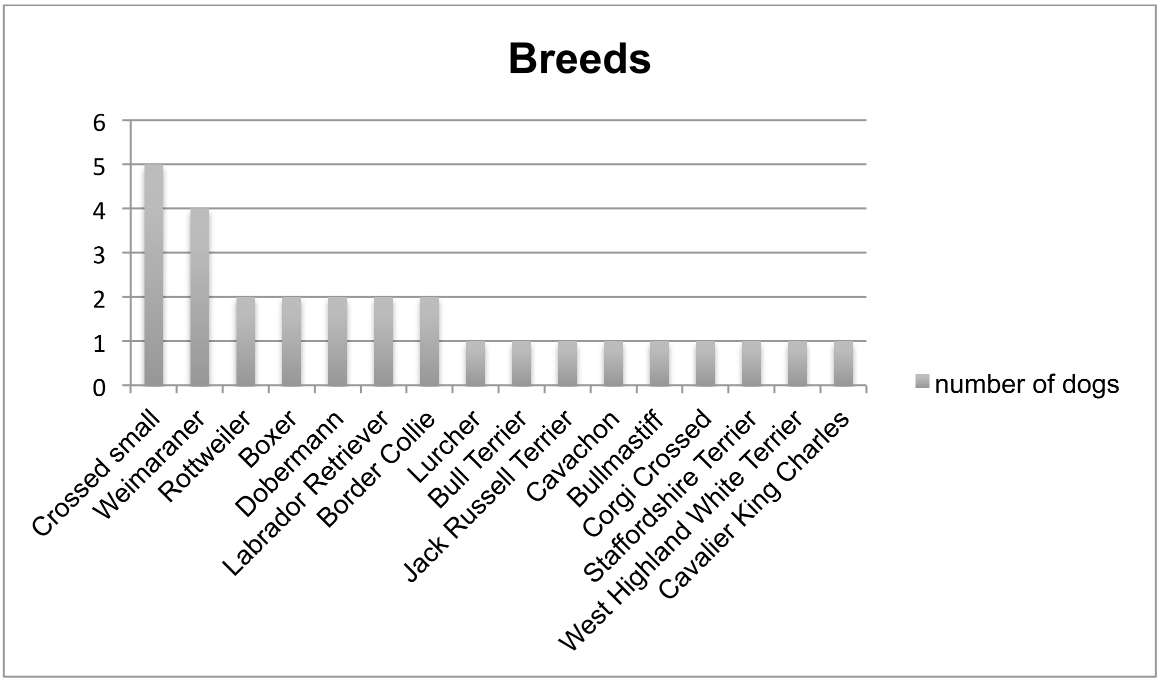
The effects of single risk factors on death were further examined with simple linear regression. After this analysis, all variables that showed a statistically significant relationship to outcome were further investigated.

In all analysis, significance level was assumed at $p<0.05$.

3. Results

An evaluation of the population was made. With a total of 28 animals evaluated in this study, information regarding breeds can be seen in graphic 1.

Graphic 1: Distribution of the number of animals on the basis of breeds (absolute frequency).



Regarding the gender of the dogs, 17 were male and 11 female. The age ranged from 2 months to 14 years (mean 5,5 years) and the weight was between 4,20 kg and 54,95 kg (mean 21,85 kg).

As this is a retrospective study, it was possible to reach a diagnosis in all cases. Animals were included in the survival group if resolution or improvement of the underlying cause was achieved. The diagnoses of all survival and non-survival cases are described in table 7.

Table 7: Diagnoses of survivors and non-survivors among the 28 cases presenting with acute abdomen.

Diagnoses	Survivors	Non-survivors
Gastroenteritis	1	
Leptospirosis		1
Mesenteric torsion + Peritonitis		1
Acute pancreatitis	1	
NSAID overdose	1	
Pancreatic neoplasm		1
Oesophageal foreign body (FB)	3	1
Intestinal neoplasm		2
GDV		2
Inguinal hernia		1
Acute hepatitis	1	
Intestinal FB	4	
Intervertebral disc extrusion/herniation/prolapse	1	
Gastric FB	1	
Diaphragmatic rupture - trauma	1	
Post-op haemorrhage	2	
Gastric ulceration	1	
Chronic hepatitis	1	
Urethral obstruction	1	
Total	19	9

Outcome was defined as survivor or non-survivor 15 days after admition to the hospital. Re-examination of the survivor patients was made by the hospital's clinicians, the referring clinician, or by a telephone conversation with the owner to confirm outcome.

Descriptive analysis of signalment, clinical and laboratory variables in survived and non-survived dogs with acute abdomen, using simples linear regression can be found in table 8.

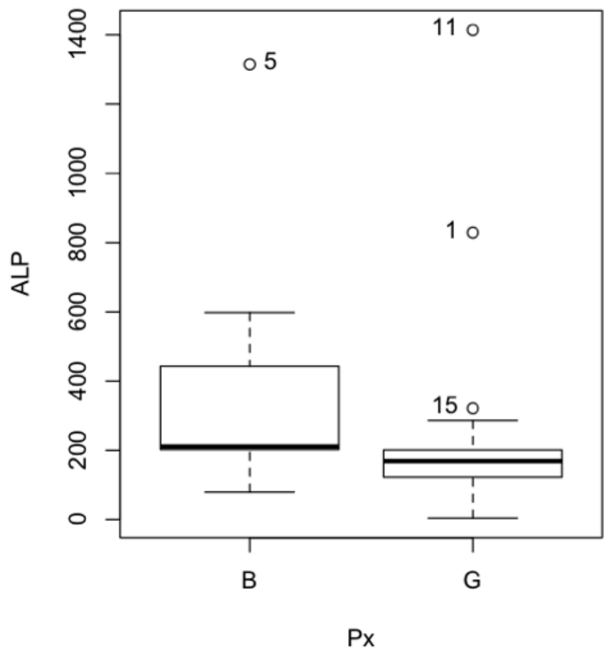
Table 8: Descriptive analysis of the numerical variables investigated.

	Survivors		Non-survivors		P – value
Parameters	**n**	**Mean ± SD**	**n**	**Mean ± SD**	
Signalment					
Age	19	4,68 ± 3,57	9	7,36 ±4,81	0,117
Weight	19	21,28 ± 14,63	8	23,20 ± 19,02	0,767
Clinical Variables					
Heart Rate	19	122,84 ± 34,61	9	148,88 ± 44,71	0,300
Respiration Rate	18	32,56 ± 8,68	8	38,00 ± 23,69	0,995
Temperature	19	38,50 ± 0,92	9	38,41 ± 1,52	0,842
Laboratory Variables					
Albumin	19	28,19 ± 8,70	9	24,11 ± 2,80	0,140
ALP *	18	268,66 ± 334,02	7	413,57 ± 429,12	0.044 *
ALT	18	307,56 ± 619,67	7	309,71 ± 417,80	0,659
Amylase	19	1382,84 ± 531,21	9	1200,33 ± 659,05	0,424
AST	17	96,41 ± 41,97	7	145,29 ± 66,89	0,447
BUN	19	8,21 ± 2,83	9	7,25 ± 2,29	0,160
Calcium	19	2,57 ± 0,28	9	7,26 ± 2,29	0,226
Creatinine *	18	105,33 ± 35,03	7	127,57 ± 48,78	0,047 *
Glucose	19	6,07 ± 2,56	9	3,95 ± 0,91	0,217
Haematocrit	19	43,88 ± 8,10	8	46,13 ± 16,38	0,996
Haemoglobin	19	13,79 ± 3,36	8	10,16 ± 3,46	0,995
Potassium	19	4,84 ± 0,74	9	4,34 ± 1,18	0,862
Lymphocytes	17	4,02 ± 2,07	6	4,87 ± 2,50	0,347
Platelets	19	317,32 ± 131,31	8	361,25 ± 173,77	0,995
Total Bilirubin	17	11,29 ± 4,51	9	9,22 ± 6,76	0,076
Total Solids	19	65,11 ± 10,74	9	61,11 ± 16,24	0,995
Red Blood Cells	4	8,00 ± 3,39	0	________	________
White Blood Cells	7	19,62 ± 9,41	1	35,63 ± 9,41	0,999

* Statistically significant numerical variables. Units of every variable can be seen in table 6.

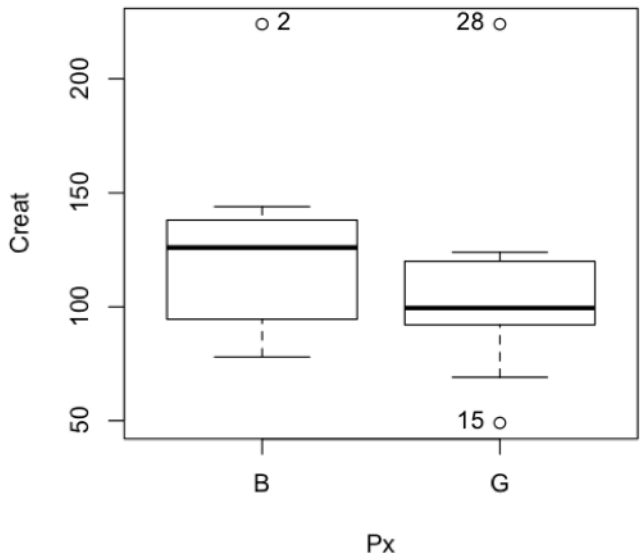
Only variables with p-value < 0,05 were considered. As for red blood cells count, the data collected wasn't enough to get results. Univariable analysis of all the parameters investigated above retained the ALP and creatinine as statistically significant predictors of outcome in dogs with acute abdomen, meaning that these variables can have influence upon survival. The mean value of ALP for good prognosis is 268,66 and 413,57 for bad prognosis, with a p-value of 0.044. As for the mean value of creatinine, 105,33 in dogs with good prognosis and 127,57 in bad prognosis, having a p-value of 0,047. Graphic 2 and 3 show in detail the distribution of the mentioned variables.

Graphic 2: Distribution of alkaline phosphatase (ALP) values according to good or bad prognosis.



Px - Prognosis
B – bad
G - good

Graphic 3: Distribution of creatinine values according to good or bad prognosis.



Px - Prognosis
B – bad
G - good

Table 9: Descriptive analysis of the categorical variables.

	Survivors		Non-survivors		P – value
Parameters	**n**	**Ratio (%)**	**n**	**Ratio (%)**	
Signalment					
Body condition					
good	19	18/19 (94,74%)	9	4/9 (44,44%)	0.998
medium		1/19 (5,26%)		0	
poor		0		5/9 (55,55%)	
Gender	19				
female		9/19 (47,37%)	9	2/9 (22,22%)	0,214
male		10/19 (52,63%)		7/9 (77,77%)	
Clinical Variables					
CRT					
<2s	19	17/19 (89,47%)	9	0	0,996
>2s		2/19 (10,52%)		9/9 (100%)	
Diarrhoea					
yes	19	3/19 (15,79%)	9	4/9 (44,44%)	0,115
no		16/19 (84,21%)		5/9 (55,55%)	
Enlarged abdomen					
yes	19	0	9	8/9 (88,88%)	0,997
no		19/19 (100%)		1/9 (11,11%)	
Faeces (normal)					
yes	19	6/19 (31,58%)	9	5/9 (55,55%)	0,231
no		13/19 (68,42%)		4/9 (44,44%)	
Ileus					
strangulating	18	3/18 (16,66%)	9	2/9 (22,22%)	0,727
non-strangulating		15/18 (83,33%)		7/9 (77,77%)	
MMC					
normal	19	18/19 (94,74%)	9	2/9 (22,22%)	0,001*
abnormal		1/19 (5,26%)		7/9 (77,77%)	
Neoplasm					
yes	19	0	9	3/9 (33,33%)	0,994
no		19/19 (100%)		6/9 (66,66%)	
Organ involvement					
hollow	17	14/17 (82,35%)	9	8/9 (88,88%)	0,117
solid		3/17 (17,65%)		1/9 (11,11%)	

Over 24 hours yes no	19	 10/19 (52,63%) 9/19 (47,37%)	9	 5/9 (55,55%) 4/9 (44,44%)	0,885
Pain low moderate severe	19	 5/19 (26,32%) 10/19 (52,63%) 4/19 (21,05%)	9	 0 5/9 (55,55%) 4/9 (44,44%)	0,995
Peristalsis yes no	19	 19/19 (100%) 0	9	 6/9 (66,66%) 3/9 (33,33%)	0.993
Previous treatment yes no	19	 4/19 (21,05%) 15/19 (78,95%)	9	 2/9 (22,22%) 7/9 (77,77%)	0,944
Pulse quality strong weak	19	 19/19 (100%) 0		 1/9 (11,11%) 8/9 (88,88%)	0,999
Rupture yes no	19	 4/19 (21,05%) 15/19 (78,95%)	9	 2/9 (22,22%) 7/9 (77,77%)	0,944
Skin tent normal abnormal	19	 18/19 (94,74%) 1/19 (5,26%)	9	 4/9 (44,44%) 5/9 (55,55%)	0,001*
Vomiting yes no	19	 11/19 (57,89%) 8/19 (42,10%)	9	 3/9 (33,33%) 6/9 (66,66%)	0,232
Laboratory Variables					
cPLI positive negative	8	 3/8 (37,5%) 5/8 (62,5%)	5	 1/5 (20%) 4/5 (80%)	0,512

* Statistically significant numerical variables. Units of every variable can be seen in table 6.

As for categorical variables, frequency distribution of all the parameters investigated above retained the MMC and skin tent as statistically significant predictors of outcome in dogs with acute abdomen, having influence upon survival. 18 out of 19 dogs (94,74%) that survived had normal MMC and only 1 had abnormal MMC (5,26%). Concerning non-survivors, 7 out of 9 dogs had abnormal MMC (77,77%) and the other 2 had normal MMC. The p-value for MMC is 0,001.

Regarding skin tent, the results for the survivors group was the same as the MMC with a 94,74% of the survivors with normal skin tent and only 5,26% with abnormal. In the non-survivors group, 4 of the 9 dogs had normal skin tent (44,44%) and the other 5 had abnormal skin tent (55,55%). The p-value for skin tent is also 0,001.
Extension of the processes causing acute abdomen and the management option were also studied. Extension was considered for distinguish from a chronic agudization or a true acute problem. Distribution of the variables can be seen in table 10.

Table 10: Summaries of extension and management of the processes causing acute abdomen.

Summary	Extension		Management	
	Chronic	**Acute**	**Medical**	**Surgical**
n	7	21	13	15
%	25	75	46,43	53,57

There were 7 cases (25%) of agudization of a chronic disease that included 2 cases of intestinal neoplasm, 1 with mesenteric torsion, 1 with pancreatic carcinoma, 1 with chronic hepatitis, 1 with intervertebral disc disease and 1 with recurrent urethral obstruction. As for real acute processes there were 4 oesophageal foreign bodies, 4 with intestinal foreign bodies, 2 with GDV, 2 with post-op haemorrhage, 1 with acute gastroenteritis, 1 with leptospirosis, 1 with acute pancreatitis, 1 with gastric foreign body, 1 with gastric ulceration, 1 with acute hepatitis, 1 with NSAID overdose, 1 with inguinal hernia and another 1 with diaphragmatic hernia.
Concerning the management of the acute abdomen, 13 cases were treated medically including post-op haemorrhages (2) gastroenteritis (1), leptospirosis (1), acute pancreatitis (1), pancreatic carcinoma (1), intestinal neoplasm (1), acute and chronic hepatitis (1 of each), gastric ulceration (1), gastrointestinal foreign body (1), NSAID overdose (1), urethral obstruction (1). The other 15 cases treated surgically were the 4 oesophageal FB, 3 intestinal FB, 2 GDV, 1 mesenteric torsion, 1 intervertebral disc disease, 1 gastric FB, 1 inguinal hernia, 1 intestinal neoplasm and 1 diaphragmatic hernia.

4. Discussion

Descriptive analysis made on this study showed that breed, gender, age, weight, body condition, rectal temperature, heart rate, pulse quality, respiration rate, capillary refill time, degree of pain, enlarged abdomen, presence of vomiting, diarrhoea, peristalsis, solid or hollow organ involvement, type of ileus, time elapsed from the beginning, previously applied treatment, presence of neoplastic process or ruptured organ, as well as all laboratory variables apart from ALP and creatinine did not differ significantly between animals with good or bad prognosis. Otherwise, mucous membrane colour (p=0,001) and skin tent (p=0,011), as well as ALP (p=0,044) and creatinine (p=0,047) values, are parameters with a significant influence on the outcome of acute abdominal disease.

Other studies found out different prognostic variables statistically significant, for example Küplülü et al. (2009) found out in pyometra cases that the elderly azotaemic dogs having BUN levels over 10,71 mmol/l and creatinine levels over 132,6 µmol/l would more likely to succumb within 3 days after surgery.

Mackenzie et al. (2010) reported that the only preoperative risk factor increasing the overall mortality rate following surgery for GDV was the presence of cardiac arrhythmias while the factors associated positively with postoperative mortality were postoperative cardiac arrhythmias, splenectomy, or splenectomy with partial gastric resection. Still regarding GDV, Evans & Adams (2010) studied mortality and morbidity due to GDV syndrome in pedigree dogs in the UK, concluding that 16 breeds, mainly large/giant have increased risk of morbidity and/or mortality. Breeds at greater risk of GDV mortality are the Bloodhound, Grand Bleu de Gascogne, German longhaired pointer and Neapolitan mastiff. Regarding morbidity, breeds at greater risk are the Grand Bleu de Gascogne, bloodhound, otterhound, Irish setter and Weimaraner. In the present study both cases diagnosed with GDV syndrome died and they were a Weimaraner and a Bullmastiff, which is in line with Evans & Adams (2010) results.

Junius et al. (2004) did a retrospective study with 12 dogs presenting with mesenteric volvulus and concluded that all the animals had abdominal distension and shock and that if laparotomy was done immediately, prognosis was not as bad as known, since 5 of the 12 dogs did survive. However, the only case in the present study presenting with mesenteric volvulus did not survived, also presenting with shock and distended abdomen.

A retrospective study of 208 cases with gastrointestinal foreign bodies, evaluated predilection sites of obstruction and investigated clinical factors associated with a poor outcome, concluding that a longer duration of clinical signs, the presence of a linear foreign body, and multiple intestinal procedures were associated with significantly increased mortality (Hayes, 2009). In our study, 1 case presented with a gastric non-linear foreign body and with a history of more than 24 hours, but with a excellent prognosis. Three of the cases presenting with signs of obstruction were diagnosed with intestinal foreign bodies, one with history over

24 hours and the other 2 came to the hospital within the first 24 hours. None of them had linear foreign bodies and only single accesses to the intestine were done and all the 3 survived.

In a retrospective study of 15 dogs with spontaneous gastroduodenal perforations authors tried to identify related risk factors, concluding that there was a trend towards improved survival for animals with perforation of the gastric fundus or body compared to pyloric or duodenal perforation, although the difference was not statistically significant. Previous administration of NSAIDs was the only identified predisposing factor in 10 of the 15 dogs (Cariou et al., 2009). One of the author's cases presented with gastric fundus ulceration but non-perforating, had no history of previous administration of NSAIDs and had a good outcome.

Galezowski et al. (2010) investigated the role of C-reactive protein (CRP) as a prognostic indicator in dogs with acute abdomen syndrome and found out that initial serum CRP concentrations were not predictive of outcome in dogs with acute abdomen syndrome but persistent elevations over 48-72 hours were associated with poor prognosis. In a retrospective study of 102 dogs with GDV authors studied the relationships between plasma lactate concentration as a predictor of gastric necrosis and survival and found out that 99% of the dogs with plasma lactate concentration < 6.0mmol/L survived and in contrast with only 58% of survival when plasma lactate concentration was bigger than 6.0mmol/L. Also median plasma lactate concentration in dogs with gastric necrosis was higher (6.6mmol/L) than concentration in dogs without gastric necrosis (3.3mmol/L). Therefore, authors concluded that preoperative plasma lactate concentration is a good predictor of gastric necrosis and outcome for dogs with GDV and may assist in determining prognosis (de Papp et al., 1999). Unfortunately both CRP and plasma lactate concentrations were not collected in any studied case. Hardie et al. (1995) studied patients' submitted to high-risk laparotomies and detected significant differences between survivors and non-survivors only for the parameters age, total protein, and platelet counts but not for PCV, albumin, ALP, and bilirubin, which is in contrast with the author's study regarding namely ALP. Grimes (2011) found out that low preoperative plasma protein and albumin concentrations were associated with septic peritonitis and death following gastrointestinal surgery in dogs with acute abdominal pain. The same investigators found out that biliary tract surgery and preoperative septic peritonitis were risk factors for lethal outcome, whereas diagnosis of foreign body was protective. In a retrospective study involving 19 dogs with generalized peritonitis and treated by open abdominal drainage a statistically significant difference between survivors and non-survivors regarding ALT and gamma glutamyl transpeptidase (GGT) was found, but without any connection with other studied signalment data, clinical, haematological parameters, and duration of abdominal opening (Winkler, 2007). Simeonova et al. (2013) proposed a new severity scoring system in dogs with acute abdominal syndrome treated surgically, and identified mortality predictors such as presence of neoplastic process, organ rupture, abdominal distension, and solid organ involvement. None of these variables were considered as risk factors in the present study.

The substantial variety of factors connected with death presented in above-mentioned studies and the difference between them and the prognostic indicators in this study is due to completely different designs. Each study assessed the diseases individually, except the last one mentioned that considered the acute abdomen as a syndrome, but only considered surgically treated patients. In the present study, medical and surgical patients were considered, regardless of the underlying disease process.

As already mentioned, mucous membrane colour, skin tent, ALP and creatinine values, had a significant influence on the outcome of acute abdominal disease.

Mucous membrane colour was evaluated as normal or abnormal. The determinants of the colour of unpigmented mucosa are volume (which is controlled by pre-capillary sphincter tone), and composition of blood in the underlying capillary bed, depending on haemoglobin concentration and haemoglobin saturation with oxygen. The normal colour is light to dark pink. A pale to white colour is caused by a deficit of volume or of haemoglobin. A red colour suggests an increased volume of blood in the capillary bed because of vasodilation, as in sepsis. Cyanosis, which is represented by a blue-grey colour, is caused by the presence of deoxygenated haemoglobin at a rate of at least 5 mg/dL and its absence is not a reliable indicator that deoxygenated haemoglobin is not present. Icterus is indicated by a yellow colour, which is caused by the presence of bilirubin at a rate greater than 2 mg/dL. Cherry-red mucous membranes can be associated with carbon monoxide poisoning (Aldrich, 2005).

Mucous membrane colour is one of the six parameters that needs to be taking into account when assessing shock, the other ones being mental state, capillary refill time, pulse quality, pulse rate, and extremity-central temperature difference. These six parameters are often abnormal in specific patterns in patients suffering from shock (Aldrich, 2005).

It is then understandable that this parameter influences the outcome directly in animals with acute abdomen. In addition to being easily variable with different diseases, is also one of key parameters in shock. As already mentioned, both hypovolemic shock and septic shock can easily be present in the acute abdomen syndrome, so this parameter can be useful as predictor of outcome.

Dehydration is the condition resulting from loss of water from the body, but the term is usually taken to mean a loss of salt and water in an approximately isotonic concentration. Common sources of these losses are gastrointestinal and renal. Losses in the body into a third space occur with losses into the gastrointestinal tract, pleural and peritoneal spaces, and interstitium. The interstitial and intravascular volumes are normally in equilibrium across the capillary bed, such that losses from one compartment result in a decrease in volume in

the other. Because of compensation for vascular volume losses, they are often difficult to detect until they are large.
Hydration state is assessed by skin tent, or elasticity and it depends, in part, on the amount of salt and water as well as fat in the skin and subcutaneous tissues. Normally hydrated thin patients have decreased skin tent, and obese patients have increased skin tent. Puppies have increased total body water, and their skin tent is normally greater than that of an adult. All these factors contribute to the difficulty of assessing hydration by skin tent, yet it is still the best physical examination parameter to make this assessment. However, experience and proper technique help to improve this assessment. Other options for hydration evaluation are moistness of mucous membranes, corneas and conjunctivae but these can be altered more easily in light of the effects of other conditions (Aldrich, 2005).
Although hypovolaemia is the loss of intravascular volume and dehydration the loss of interstitial fluid, they can be both present, which is very commonly seen in the acute abdomen (Holt & Brown, 2007). Moreover, dehydrated animals are likely to have decreased intravascular volume and electrolyte abnormalities (Posner, 2007).
Dehydration is present in a large range of diseases. A history suggestive of extracellular fluid deficits may include gastrointestinal losses such as vomiting, diarrhoea or bowel obstruction; sepsis, trauma or chronic diuretic administration (Massat, 2007).
As already mentioned, it is very common to see patients with acute abdomen in shock, whether hypovolemic, septic or distributive. Animals presenting with shock besides having abnormal MMC, may also be 10% to 15% dehydrated, so fluid resuscitation with at least 50% of the loss corrected should be achieved before profound chemical restraint or anaesthesia is performed (Mathews & Dyson, 2005). Hypovolaemia results in reduced venous return, cardiac output and tissue perfusion. Anaesthetized patients have limited ability to respond to hypovolaemia with vasoconstriction, increased contractility, and increased heart rate (Egger, 2009). Also, hypovolaemia in dogs is associated with intense portal vasoconstriction. This vasoconstriction causes breakdown of the intestinal mucosal barrier, allowing increased endotoxin to be absorbed from the intestines. Other example, the NSAID are not appropriate in any patient where hypoperfusion is suspected, due to the potential for renal damage (Boag & Hughes, 2004).
Another parameters along with skin tent that were expected to be statistically significant in affecting outcome would be the haematocrit ($p=0,996$) and total solids ($p=0,995$) as they reflect dehydration status quantitatively. The explanation for this has not occurred is possibly because of the small number of patients included in the studied cohort as well as the subjective assessment of skin tent. In this case, assessment of skin tent might have been overrated.
Alkaline phosphatase is found in the microsomal and biliary canalicular membranes of hepatocytes and is normally secreted in bile. It is released in response to certain stimuli,

being bile retention the strongest stimulus for accelerated production of this enzyme. Unlike AST and ALT, ALP is in low concentration in hepatocytes and biliary epithelium and is membrane-associated, so simply leaking out of damaged cells does not account for increased serum activity. Measurable ALP activity is also detectable in nonhepatobiliary tissues of dogs; including osteoblasts, intestinal mucosa, renal cortex, and placenta; but serum activity in healthy adult dogs arises only from the liver, with some contribution by the bone isoenzyme in young, rapidly growing dogs less than 15 weeks old.

Certain drugs can elicit striking increases up to 100-fold in serum ALP activity in dogs. The most common are anticonvulsants and corticosteroids (Bunch, 2003). In dogs, interpretation of ALP is complicated by the presence of a corticosteroid induced ALP isoenzyme (CIALP) that may be induced by endogenous and exogenous steroids. The CIALP can be quantified by electrophoretic separation methods or levamisole inhibition assay (Hall & German, 2005). Besides drugs and hepatic causes such as cholangiohepatitis, chronic hepatitis, cirrhosis, hepatic tumour; extrahepatic diseases associated with acute abdominal pain that can increase ALP are diaphragmatic hernia, pancreatitis and septicaemia (Gough, 2007).

Liver-specific enzymes were not considered statistically significant to interfere with outcome in this study. ALT mean values between animals with good prognostic (307,56) and bad prognostic (309,71) did not differ much, which reflects the elevated p-value (p=0,659). As for AST mean values for good prognosis were slightly lower (96,41) than the bad prognosis ones (145,29), but still the difference wasn't big enough to p-value (p=0,447) be considered. This might have happened since after an acute hepatic insult, ALP release is delayed compared with that of ALT, because of the need for induction of synthesis. In dogs, ALP begins to rise 8 hours after biliary obstruction, and increases 15-fold in 2-4 days. Peak activity 100-fold above normal is reached in 1-2 weeks, and then activity reaches a plateau at a lower level. ALP is also usually the last enzyme to return to the reference range after an acute insult as impairment of bile flow is usually the last functional disturbance to resolve and increased synthesis may persist beyond resolution of the injury (Hall & German, 2005).

Creatinine production is relatively constant and proportional to muscle mass, therefore animals with a large muscle mass produce more creatinine each day than do animals with a small muscle mass. Muscle trauma and inflammation do not increase the production of creatinine. In comparison with the urea nitrogen concentration, the creatinine concentration is relatively unaffected by the dietary protein level, however it can increase after ingestion of meat and subsequent absorption of creatinine from gastrointestinal tract. It diffuses throughout body compartments more slowly than urea does and is mostly excreted by the kidneys. Because the production of creatinine is relatively constant, since is freely filtered by the glomeruli and is not significantly resorbed or secreted by the renal tubules, an increase in the serum creatinine concentration is indicative of decreased renal excretion, which can be seen in acute and chronic renal failure. However, pre-renal and post-renal factors influence renal function and, therefore, the excretion of creatinine (Grauer, 2003).

Different conditions usually present in the acute abdomen can cause a decrease in renal blood flow, such as hypovolaemia (e.g. dehydration) or hypotension (e.g. anaesthesia), being pre-renal factors of increased creatinine. Post-renal failure is also a cause of increased serum creatinine values which might be caused by obstruction or rupture of the lower urinary tract, which are both causes of acute abdomen (Gough, 2007). Therefore, increased serum creatinine values interfere with the outcome of a patient with acute abdomen, since the causes associated to those increased values might have bad prognosis if not treated immediately, also it is a parameter easily affected when facing acute abdominal syndrome, with so many possible causes.

Both MMC and skin tent, are a subjective assessment, varying from clinician to clinician and also depending on the clinician experience. Still, they carry important diagnostic value, and are a crucial part in the physical examination. As for ALP and creatinine, they are both quantitative parameters, reducing the chance of misinterpretation and error.

Evaluating the remainder descriptive analysis of categorical variables, both CRT and enlarged abdomen parameters should also be statistically significant, since 100% of the dogs from non-survivors group had CRT >2 seconds, while the survivors group had 89,47% of normal CRT (<2 seconds). 88,88% of the non-survivors had enlarged abdomen, whereas 100% of the survivors group did not have enlarged abdomen. Again, the p-value was not significant as expected, probably because of the small number of patients included in the study.

As for neoplasms 100% of the survivors did not have any type of neoplasm, however 33,33% of the non-survival animals died from neoplasm, which corresponds at 3 of the 9 dogs that did not survived. Concerning organ involvement, 24 of the 28 cases (85,71%) did not involve a solid organ. All the non-survivors dogs had pain from moderate to severe, with no cases of low pain. 100% of the survivors group had normal peristalsis and strong pulse quality, rather than the 88,88% of the non-survivors group with weak pulse quality.

King et al. (2001) tested the value of additional serial measurements to the survival prediction index (SPI) in 63 critically ill dogs and investigated whether time trajectories add predictive information beyond measurements at a single point in time. The main objective was to see if variables measured after the admission date might predict outcome more accurately than variables measured on the day of admission to the intensive care unit (ICU). The study showed that there was no benefit to repeat calculations later in hospitalization. Hereupon, measurements of the parameters included in this study were considered exclusively once, as previously mentioned, corresponding to the first ones measured when the animal was admitted. Besides that, in most of the non-survivors patients, another data collection was not made because of death or euthanasia.

Concerning the extension of the diseases causing acute abdominal pain, 25% of the cases corresponded to agudization of a chronic disease. This reflects the importance of the clinical history and how it should be carefully asked to the owner, to try to get as much information as possible regarding the underlying problem. It is also crucial to try to collect data until at least 6 months before the acute abdomen episode, so that clinical signs that may lead the clinician towards a chronic issue, for example polyuria, will not be unnoticed (King, 2001).

The other 75% corresponded to true acute processes, with episodes happening within the past 6-48 hours before admission. Although the time elapsed from the beginning wasn't considered a statistically significant predictor of outcome, it is expected to influence outcome massively, since time contributes to deterioration of the patient, which may be irreversible.

Regarding acute abdomen management 13 cases were treated conservatively, which corresponds to 46,43% of the total cases. The remaining 15 cases had to go through surgery, corresponding to 53,57% of the population studied. The decision to perform exploratory surgery was based on a culmination of historical and physical examination findings, appropriate laboratory data, and results of imaging studies and ancillary diagnostic tests. In most cases, a presumptive diagnosis was made, and clear indication for surgical intervention was identified before abdominal exploration. But when symptoms were persistent or severe and diagnosis was not established, surgical exploration was also made.

If there was any doubt, exploratory laparotomy was made rather than wait and have the patient deteriorate. Even when surgery was indicated, delay of the operation was made, if surgery was not required as part of resuscitation and if it was determined that a delay would help to decrease morbidity or mortality.

King et al. (1994) developed a survival prediction index (SPI) that allows objective quantification of the severity of illness in dogs with naturally occurring disease, therefore allowing them to be categorized into groups that can be statistically compared. Unfortunately while the SPI is a useful tool for statistical analysis of groups of patients, the accuracy of this technique is too low for use in individuals.

5. Conclusions and future perspectives

Triage and assessment of the patient with acute abdominal pain and associated clinical signs remain a diagnostic and therapeutic challenge to the clinicians because of the multi-organ effects and the occult nature of the cause. While definitive diagnosis and ultimate treatment are the primary goals, clinical stabilization of the patient's cardiovascular and respiratory status is of extreme importance, often taking priority over invasive and non-invasive diagnostic testing until the patient's condition is more stable.

Sequential examination of the abdomen as described, allows the clinician to accurately assess the patient's clinical status and helps to determine the prioritized order of diagnostic tests that must be performed. Many diagnostic tests are neither specific nor sensitive for one particular problem, so the clinician must use a combination of history, physical examination findings, and results of diagnostic testing to guide specific and definitive therapy. Patients with a diagnosed surgical condition, with evidence of sepsis, with evidence of free abdominal gas, with intractable haemorrhage, or those that fail to stabilize with aggressive medical therapy, are candidates for emergency surgical intervention. Careful attention to anaesthetic and surgical details is important in these patients, and close postoperative anaesthetic monitoring is a necessity. Cautious planning to facilitate invasive and non-invasive monitoring, enteral nutrition and pre-emptive analgesia, combined with regular evaluation of both subjective and objective parameters, optimises the care of postoperative patients. Animals recovering from acute abdominal disease generally require intensive care, which can be extremely challenging and often necessitates high numbers of nursing staff. However, careful and systematic preoperative assessment and stabilization, appropriate surgical intervention and postoperative care will ensure that most patients with acute abdominal disease can be successfully treated. Prognosis and definitive treatment ultimately depend on each individual patient's primary problem and the presence of secondary complicating factors.

New approaches to diagnosis and treatment have also been performed, for example, a new approach to these patients, when trying to assess the presence of abdominal fluid, is the focused abdominal sonogram for trauma (FAST), which is a non-invasive and repeatable technique that can be used to localize fluid for sampling. It has been proved to be a simple and rapid technique that could be performed by clinicians with minimal previous ultrasonographic experience. Hypotensive therapy has been also tried, and the goals in that approach is to avoid removing any possible clot formed in the traumatized areas, reaching sub-normal values of blood pressure when using products as fresh frozen plasma or fresh plasma. The end-point treatment is systolic pressures lower than 90mmHg or mean pressures lower than 60mmHg.

Last but not least, conclusions from clinical trials are often limited by the inability to define a homogeneous patient population. Methods for scoring the severity of disease address this problem by placing a numerical value on the degree of illness in clinical patients. Ideally, such indices should be independent of the diagnosis and, therefore, applicable to any patient and any disease. In addition, the ideal prediction index should use readily available information that can be collected early during the hospitalization period. Numerical scoring of the severity of disease is analogous to risk stratification for prediction of outcome.

Being able to provide additional predictive information, to facilitate decision-making regarding patient management to the owners, is a goal to every clinician. Unfortunately, while useful predictive information is available for some specific disease processes when the diagnosis and stage of disease are known, for example some neoplasms, for most disorders no technique replaces the thoughtful clinical judgement of an experienced clinician.

This study was made in order to try to achieve a fastest and accurate way of providing more information to the owners at the early stages of the acute abdomen. The limitations of the present study are connected with the small number of patients included in the studied cohort because of the reduced amount of time the author had to collect the cases and the lack of data in some parameters considered, which provided only the ALP, creatinine, skin tent and MMC as risk factors and possible predictors of outcome, differently from other studies made in this issue. However, one has to take into account that in some situations the collection of information was hampered by lack of affordability by the owners or death of the animal, whether by natural cause or euthanasia, automatically affecting statistics.

The suggestion to overcome this obstacle involves increasing the number of animals for this clinical trial, paying special attention to the clinical history and making sure that all the information needed is gathered. Also for further investigation and confirmation that the statistically significant parameters found in this study can actually predict the prognosis, each parameter should be recorded in all the diseases that can cause acute abdomen, despite the initial clinical presentation of the animal, for example, in all the neoplasms that can lead to an acute abdomen situation, so that a comparison between the results obtained and the ones from this study can be made. There were at least 2 other parameters that were not included in this study, which shown to be significantly important in previous studies such as C-reactive protein concentrations and serum lactate values, last one especially in GDV cases. This type of data was not collected and the author strongly recommends including this information in the laboratory analysis, when facing cases with acute abdomen as they may help predicting the prognosis.

In order to resemble as closely as possible to the reality that the veterinarians have to handle everyday, this study included medical and surgical patients with acute abdomen, regardless of the underlying disease process. That obviously influenced the results because it made the study very widespread, which leaded to very general significant parameters. Therefore, further studies are needed considering maybe only medical cases with acute abdomen, as for surgical cases one has already been made. Another possibility would be investigated more deeply real acute *versus* chronic agudization processes causing acute abdomen in order to achieve more possible comparisons to predict outcome.

Consequently the final conclusions that can be drawn are that the acute abdomen syndrome is still a challenge for all the clinicians, because the initial prediction of prognosis in order to help owners to make a decision is very difficult to achieve. Predictors of prognosis have been studied in order to help this type of obstacles and with this study the author hopes to have been able to contribute a little further for the knowledge of the acute abdomen. Nevertheless, the author expects with this investigation to be able to stimulate the interest of further research about this subject, given that it is still a syndrome with many unanswered questions, especially regarding outcome and prognosis.

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Annexes

Annex I

Table 11: Classification of shock (Aldrich, 2007).

Clinical signs	Cardiovascular parameters represented by the clinical signs	Changes in clinical signs due to changes in vasomotor tone	
		Vasoconstriction	Vasodilation
Mental state	Perfusion to the brain	Altered mental state	
Mucous membrane colour	Volume and composition (haemoglobin, oxygen) of capillary blood	Pale to white mucous membranes	Hyperaemic (red, injected) mucous membranes
Capillary refill time	Peripheral vasomotor tone	Slow to absent capillary refill time	Fast capillary refill time
Heart rate	Response to vascular volume	Increased heart rate	Increased heart rate
Pulse quality	Pulse pressure (systolic minus diastolic blood pressure)	Poor pulse quality	Bounding pulse quality
Extremity temperature	Perfusion to the extremities	Cool extremities	Warm extremities

Annex II

Table 12: Guide to the physical examination of the abdomen (Murphy & Warman, 2007).

Physical examination of the abdomen:
Visual evaluation for evidence of abdominal distension or bruising
Abdominal auscultation for increased borborygmi (acute enteritis, acute obstruction) or decreased borborygmi (peritonitis, ileus, chronic obstruction, abdominal effusion)
Four-quadrant approach to abdominal palpation to ensure full evaluation. Elevation of forelegs may aid detection of cranial abdominal abnormalities
Assess for organomegaly, masses, foreign body, intussusception, mesenteric lymphadenopathy
Assess for pain: - Focal – small intestinal obstruction (foreign body, intussusception), mild pancreatitis, gastrointestinal ulceration - Regional – moderate/severe pancreatitis, cholecystitis, pyometra, pyelonephritis - Diffuse – diffuse gastroenteritis, peritonitis, referred spinal pain
Assess for fluid – ballottement, presence of fluid thrill
Rectal examination, assess faecal character
Assess urogenital tract

Annex III

Table 13: Characteristics of common causes of abdominal effusion in the acute abdomen (Beal, 2005).

Diagnosis	Cytologic characteristics	Fluid characteristics	Biochemical analysis	Course of treatment
Septic peritonitis	Septic suppurative inflammation with intracellular infectious agents	Exudate most commonly	Abdominal fluid BG/ serum BG gradient >20 mg/dL	Emergency surgery
Pancreatitis	Nonseptic suppurative inflammation	Modified transudate to exudate		Supportive measures, possible surgery
Bile peritonitis	Nonseptic suppurative inflammation plus phagocytosed bile pigment or mucinous substance	Exudate most commonly	[Total bilirubin] abdominal fluid/ [total bilirubin] serum >2.0 is sensitive indicator	Emergency surgery
Hemoperitoneum	Evidence of hemorrhage, may contain platelets if acute; erythrophagocytosis may be observed	Exudate		Possible surgery depending on cause, most traumatic hemoabdomen cases do not require surgical intervention
Uroperitoneum	Suppurative inflammation with or without evidence of sepsis if animal has concurrent urinary tract infection	Modified transudate	[Creatinine] abdominal fluid/[creatinine] serum >2.0 [K^+] abdominal fluid/[K^+] serum >1.4 (dogs)/1.9 (cats)	Emergency surgery or urinary diversion

Annex IV

Table 14: Drug doses for the emergency patient (Quandt, 2013).

Drugs dosages
Anticholinergics
Atropine, 0.04 mg/kg IM, 0.02 mg/kg IV
Glycopyrrolate, 0.01 mg/kg IM, IV
May make secretions more viscous
Increase heart rate and can increase myocardial work and oxygen consumption
Glycopyrrolate does not cross the blood brain barrier or the placenta
Opioids, mu-agonists
Morphine, 0.2 to 2.0 mg/kg IM, subcutaneous (SC)
CRI, 0.1 to 0.3 mg/kg loading dose, then 0.1 to 0.3 mg/kg/h
Oxymorphone, 0.05 to 0.20 mg/kg IM, IV, SC
Meperidine, 2 to 11 mg/kg IM, SC
Hydromorphone, 0.1 to 0.2 mg/kg IV, IM, SC
CRI, 0.025 to 0.050 mg/kg IV loading dose, then 0.01 to 0.04 mg/kg/h
Fentanyl, 0.005 to 0.08 mg/kg IM, IV, SC
CRI loading dose for dog, 5 to 10 μg/kg, then 0.7 to 1.0 μg/kg/min
CRI loading dose for cat, 5 μg/kg, then 0.3 to 0.4 μg/kg/min. May need to give anticholinergic before CRI if bradycardic
Remifentanil, 3 μg/kg IV, then CRI, 0.1 to 0.3 μg/kg/min
Complete reversal with naloxone
Analgesic
Respiratory depression
Bradycardia
Minimal effect on cardiovascular performance

Abbreviations: CRI – constant rate infusion, IM – intramuscular, IV – intravenous, SQ – subcutaneous.

Table 14: (continuation).

Partial mu-agonist
Buprenorphine, 0.005 to 0.020 mg/kg IM, IV
Slow onset, difficult to reverse
Good for moderate pain
Kappa-agonist/mu-antagonist
Butorphanol, 0.1 to 0.8 mg/kg intramuscularly, IV, SC
CRI, 0.1 to 0.2 mg/kg IV loading dose, then 0.1 to 0.2 mg/kg/h
Minimal cardiovascular effects, not good for severe pain
Can be used for partial reversal of mu-agonist opioids
Antagonist
Naloxone, 0.002 to 0.02 mg/kg IM, IV
Used for reversal of opioids
Dissociatives
Ketamine, 4 to 11 mg/kg IV, IM
CRI, 0. 5 mg/kg IV loading dose, then 0.1 to 1.2 mg/kg/h
Telazol, 2 to 4 mg/kg IM, 2 mg/kg IV (tiletamine and zolazepam)
Salivation
Increases heart rate
Increases intracranial and intraocular pressure
Analgesic effects

Abbreviations: CRI – constant rate infusion, IM – intramuscular, IV – intravenous, SQ – subcutaneous.

Table 14: (continuation).

Benzodiazepines
Diazepam, 0.2 to 0.5 mg/kg IM, IV
Midazolam, 0.07 to 0.4 mg/kg IM, IV
CRI, 0.1 to 0.5 mg/kg/h
Can decrease other drug doses
Mild sedation and muscle relaxation
Treat seizures
Not analgesic
Diazepam has propylene glycol
Antagonist
Flumazenil, 0.08 to 0.2 mg/kg IV
Phenothiazines
Acepromazine, 0.01 to 0.2 mg/kg intramuscularly, intravenously
No more than 3 mg total dose
Vasodilation
Long duration
Not analgesic
Barbiturates
Thiopental, 4 to 20 mg/kg IV
Cardiovascular and respiratory depression
Rapid induction

Abbreviations: CRI – constant rate infusion, IM – intramuscular, IV – intravenous.

Table 14: (continuation).

Decreases intracranial and intraocular pressure
Effects may be potentiated by concurrent acidosis or hypoproteinemia
Propofol
Propofol, 2 to 8 mg/kg intravenously
CRI, 0.1 to 0.4 mg/kg/min
Rapid-acting with short duration
Respiratory depression
Decreases intracranial and intraocular pressure
Peripheral vasodilation
Myocardial depressant
Etomidate
Etomidate, 0.5 to 4 mg/kg IV
Maintains cardiovascular stability
Not used as a single agent; commonly combined with a benzodiazepine
Suppresses adrenocortical function
Alpha-2 agonists
Dexmedetomidine, 3 to 40 μg/kg IM, IV
CRI, 1 μg/kg intravenous loading dose, then 1 to 3 μg/kg/h
Cardiovascular depression
Vomiting
Good sedation and analgesia
Can combine with opioid or dissociative
Antagonist
Atipamazole, 0.04 to 0.5 mg/kg IM, IV

Abbreviations: CRI – constant rate infusion, IM – intramuscular, IV – intravenous.

Table 14: (continuation).

Lidocaine
Loading dose, 1 to 2 mg/kg IV, then CRI, 1–3 mg/kg/h
CRI not recommended for use in cat
Alfaxalone
Alfaxalone, 2 to 5 mg/kg intravenously.
May need sedation to improve recovery
Neuroleptanalgesics
Combination of an opioid with a tranquilizer or sedative
Analgesic
Noise-sensitive
Maintain cardiovascular stability
Inhalants
Isoflurane, sevoflurane
All inhalants will produce a dose-dependent cardiovascular depression
Cause peripheral vasodilation
Anesthetic depth is rapidly adjusted
Rapid uptake and recovery

Abbreviations: CRI – constant rate infusion, IV – intravenous.