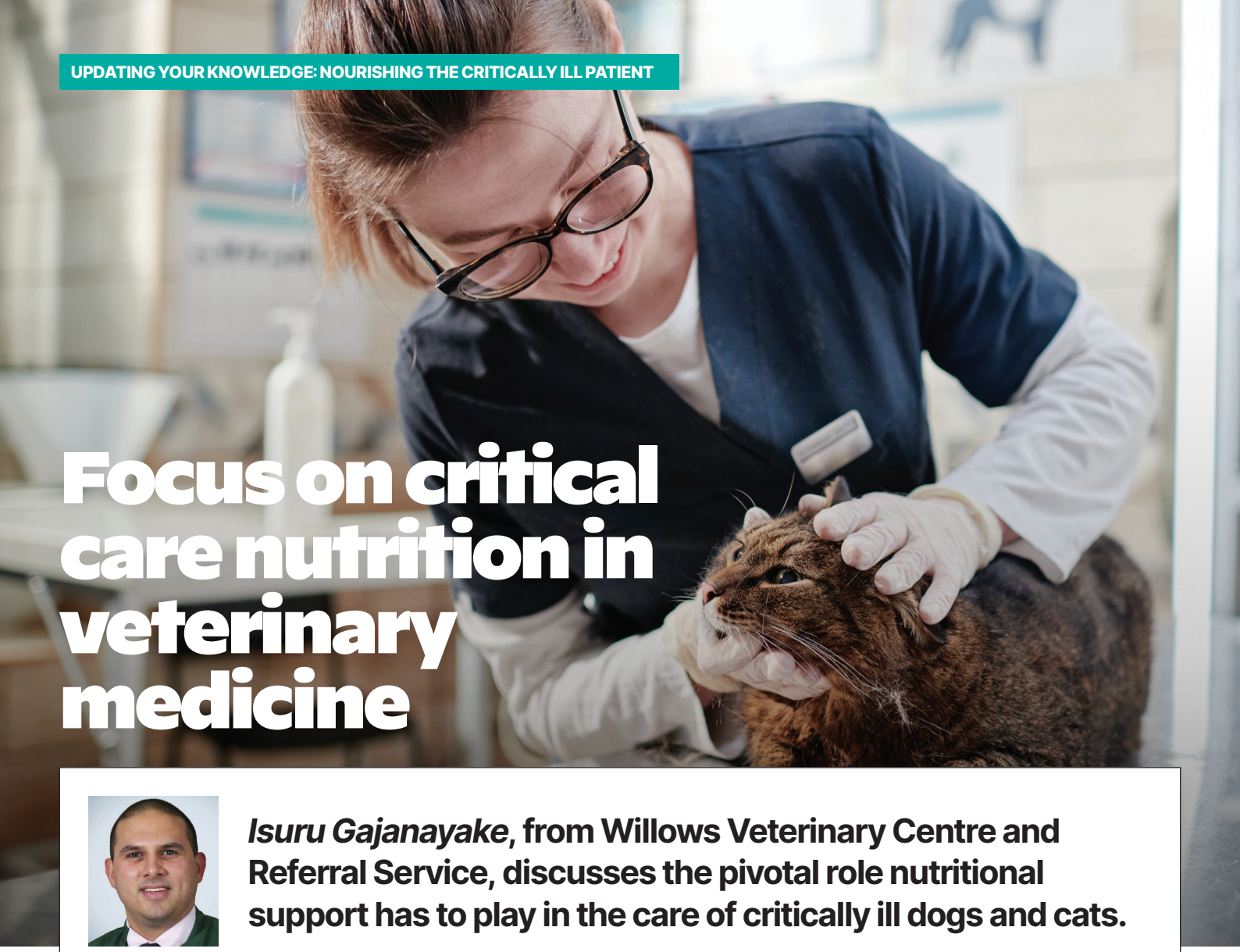

Focus on critical care nutrition in veterinary medicine

***Isuru Gajanayake*, from Willows Veterinary Centre and Referral Service,** discusses the pivotal role nutritional support has to play in the care of critically ill dogs and cats.

Critically ill dogs and cats can be seen in general veterinary practice due to a number of processes including:

- Trauma (e.g., road traffic accidents, dog bite injuries)
- Sepsis (e.g., septic peritonitis, aspiration pneumonia)
- Severe inflammatory diseases (e.g., pancreatitis, gastroenteritis)
- Neoplasia (e.g., haemoabdomen from ruptured splenic mass)
- Neurological disease (e.g., status epilepticus)
- Toxicities (e.g., acute kidney injury).

The management of critically ill patients often requires a holistic approach including surgery, medical therapy and supportive measures. Nutritional support is a vital component of the care afforded yet is often ignored to the detriment of the patient. Numerous studies in human medicine have demonstrated the benefit of nutrition in critical illness including by reducing complications (such as nosocomial infections), the duration of hospitalization, and even mortality.

Based on robust clinical studies in humans, strict guidelines have been developed for the type of nutrition to be provided (e.g., oral, enteral, parenteral), the timing of its introduction (e.g., early versus delayed) and the composition of the diet (e.g., calorie provision, macronutrient provision and use of supplements such as fish oils and glutamine).

Energy and nutrient needs in critical illness

Energy requirements during critical illness

The energy requirements of critically ill animals are usually increased due to the effect of inflammatory mediators, catecholamines and the sympathetic nervous system. This contrasts the process of 'simple starvation' where food intake is limited in the absence of illness (e.g., due to a lack of food) whereby the energy requirements of the animal is decreased. Despite the increased energy needs seen during illness, over-feeding of critically ill patients, especially in the early stages, can have multiple detrimental effects. For this reason, a relatively conservative energy provision is usually recommended in critical illness. In dogs and cats, this is usually estimated by the Resting Energy Requirement (RER) calculation, whereas in humans the energy requirement can be measured using indirect calorimetry.

The resting energy requirement is most accurately calculated using the logarithmic formula:

RER in kilocalories per day
= 70 x (bodyweight in kg)$^{0.75}$

It is important to **use the actual bodyweight** for this calculation, rather than an ideal or target bodyweight (for an overweight or underweight animal). The full calculated RER energy provision is usually provided in 3–5 days to prevent overfeeding in the initial stages. For example, on the first day 33% of the calculated RER is provided, on the second day 66% is provided, and from the third day 100% is provided.

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Macronutrient requirements in critical illness

Protein and amino acids – In simple starvation, the catabolism of muscle tissue is minimized, and adipose stores are preferentially used for energy. However, during illness there is continued muscle breakdown via the process of gluconeogenesis to produce glucose. This accelerated muscle wasting can be especially detrimental to the animal, as it can affect cardiac, respiratory and oropharyngeal muscles, as well as the appendicular muscles. The muscle wasting associated with illness, termed cachexia, can ultimately lead to many devastating effects including reduced cardiovascular function, compromised respiration, poor wound healing (including surgical wounds), reduced immunity and increased complications.

Dietary protein is vital to provide essential amino acids (required for a number of vital metabolic and other functions) and as a source of energy. Although a high provision of protein is generally recommended in critical illness, some caution should be exercised where there is protein intolerance due to disease (such as chronic kidney disease). A high protein diet may mitigate the effects of certain conditions that cause excessive protein loss (e.g., a protein-losing enteropathy, protein-rich abdominal effusions due to peritonitis) and help prevent and/or manage cachexia. Due to their status as obligate carnivores, cats require a higher proportion of their calories from protein compared to dogs.

Apart from the 10 essential amino acids which are required in the diet by dogs (11 in cats), glutamine can be considered a conditionally essential amino acid (i.e., not required in the diet in healthy dogs but essential in illness). Glutamine serves a number of vital functions including as the preferred energy source for enterocytes and in nitrogen metabolism. Glutamine supplementation has been widely investigated in human intensive care units and is currently recommended for a number of specific conditions such as to manage severe burns and for people with extensive trauma. Based on the current research, there is no clear proven benefit for glutamine supplementation in dogs.

Fat and fatty acids – Dietary fat provides more than twice the energy per gram, compared to carbohydrate and protein. Apart from this importance as the most energy dense nutrient, dietary fat also provides essential fatty acids (vital for cell membrane integrity and for inflammation) and is a source of the fat-soluble vitamins (A, D, E and K). Restriction of dietary fat may be indicated when there is decreased gastric emptying due to disease (see complications section).

Fish oil supplementation is used extensively in human medicine to manage many different conditions including those related to critical illness such as sepsis. These supplements have also been shown to be beneficial in veterinary medicine in conditions such as proteinuria, cardiac arrhythmias and osteoarthritis. The principal mechanism of action of fish oil supplementation is to modulate the inflammatory cascade by producing inflammation-resolving mediators (rather than those which perpetuate inflammation). The benefit of fish oil supplementation in canine and feline critical illness has not been investigated.

Carbohydrate and fibre – During critical illness there is accelerated glucose production (via gluconeogenesis), but concurrent insulin resistance ultimately leads to hyperglycaemia. The presence of hyperglycaemia in critically ill humans and dogs has been shown to be a negative prognostic indicator. Although dietary carbohydrate is an excellent source of energy, some care may need to be exercised in patients with hyperglycaemia as a high carbohydrate diet may exacerbate hyperglycaemia.

Dietary carbohydrate does not provide any essential nutrients, such as the amino acids or fatty acids provided by the dietary protein and fat respectively. However, fibre can be considered an important component of a complete diet. Dietary fibre serves many functions including those related to digestion and absorption as well as an energy source (prebiotic) for the microbiome. Microbiome modulation has become a key focus in veterinary medicine in recent years due to the widespread metabolic effects of the gut bacteria. Critically ill patients are potentially at risk of dysbiosis due to their underlying diseases and medical (e.g., antibiotic) treatment. For this reason, mitigation of this risk by feeding a fibre and prebiotic enhanced diet may be beneficial.

Micronutrient requirements in critical illness

Micronutrients including vitamins (water soluble and fat soluble), and minerals (macro-minerals and trace minerals) are an essential part of a balanced diet. Some of these nutrients are particularly important during critical illness.

The water-soluble B vitamins serve several vital functions in energy metabolism and organ function. Compared to the fat-soluble vitamins, the water-soluble vitamins are more likely to be depleted in an anorexic critically ill patient. For this reason, it is vital that any diet for a critically ill patient is adequately supplemented with B vitamins. Vitamin C however is not an essential nutrient in dogs and cats, even during illness. Some of the fat-soluble vitamins can play vital roles in critical illness including vitamin K for coagulation, vitamin E as an antioxidant, and vitamin D for immune function.

The macro-minerals include sodium, potassium, phosphate, chloride, magnesium and calcium. These serve vital functions including for osmoregulation, acid-base balance and neuromuscular function. Aberrations in these minerals can lead to the devastating complication of refeeding syndrome (see later section). For this reason, providing adequate levels of these minerals is essential in critical illness. Trace minerals are needed in much smaller amounts but can still play a vital role. Of particular note are chromium for glucose homeostasis, and zinc which has been noted to be a predictor of poor outcome in humans with sepsis.

Nutritional interventions in the intensive care unit

Nutritional assessment of the critically ill patient

Every critically ill dog and cat should have a nutritional assessment performed to optimize its outcome. This includes consideration of the previous diet history (including any dietary intolerances), the current illness, as well as the animal's body and muscle condition scores.[1]

Many critically ill dogs and cats require a form of nutritional intervention to provide its energy and nutrient requirements. The possible feeding interventions include enteral techniques (i.e., feeding tubes) and parenteral (i.e., intravenous) nutrition. The suitability of an individual patient for a particular feeding intervention will depend on a number of factors including:

- The calorie and nutrient requirements of the patient/disease
- The prognosis of the disease and expected duration of recovery
- Suitability for general anaesthesia
- Presence of coagulopathy or other factors which prevent surgery
- Requirement for specialized equipment or training or aftercare
- Complications
- Cost.

Appetite stimulants and supportive measures

Nutritional support of any form should not be started until the critically ill patient is cardiovascularly stable and has had any fluid, electrolyte and acid-base disturbances corrected. The provision of these supportive measures, including potassium-supplemented fluid therapy, can also help with recovery of appetite and reducing any feeding-related complications. The provision of medical supportive therapies such as anti-emetics (e.g., maropitant, ondansetron) and analgesia (e.g., paracetamol, opioids) can also help from a nutritional perspective.

There are limited options for appetite stimulants in veterinary medicine. Mirtazapine is often used in feline medicine for chronic disorders such as chronic kidney disease. Capromorelin is also available for both dogs and cats but requires a special import certificate from the Veterinary Medicines Directorate.[2] Appetite stimulants are rarely effective in critical illness and can be associated with complications (e.g., excitement and tachycardia with mirtazapine). For these reasons, this class of medications is generally not useful for the management of critically ill cats or dogs.

Timing of nutritional support

Once haemodynamic stability has been established in a critically ill patient, the provision of oral or enteral nutrition should be considered. Historically, feeding has been delayed in conditions such as acute pancreatitis; however, studies in veterinary medicine (in acute pancreatitis,[3] parvoviral enteritis[4] and septic peritonitis[5]) have demonstrated positive effects such as reduced complications and a faster return of normal appetite when early nutrition was provided.

In patients that are unable to tolerate their complete calorie and nutrient requirements, the provision of trophic feeding can be utilized. With this form of enteral feeding, only a fraction of the animal's total energy requirement (e.g., 25% of RER) is administered but it aims to provide luminal nutrition to the enterocytes. This practice is thought to help maintain the viability of the enterocytes and prevent complications associated with bacterial translocation (such as sepsis).

Feeding tubes

Nasal tubes – Nasal tubes can be placed into the oesophagus (naso-oesophageal) or stomach (naso-gastric). These can be an excellent option for the critically ill patient (Figure 1). Nasal tubes are usually placed with only local (topical) anaesthesia so are ideal for patients in which general anaesthesia is not safe. These tubes are usually well tolerated (unless there is notable nasal disease) but are generally considered a short-term (i.e., 3–5 day) intervention. Due to their narrow diameter, nasal tubes require liquid diets.

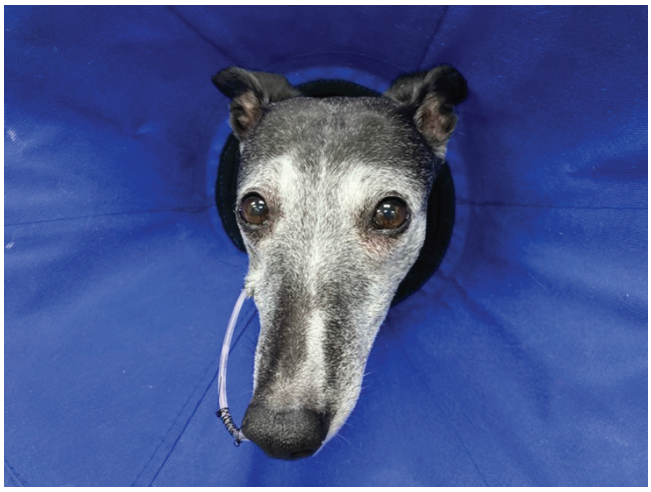

FIGURE 1: A 5-year-old crossbreed dog with a nasogastric tube to manage anorexia following acute haemorrhagic diarrhoea syndrome.

Oesophagostomy tubes – In patients where nutritional support is needed for a short to medium term (e.g., 1 to 4 weeks), an oesophagostomy feeding tube is ideal. These tubes require general anaesthesia to place so would be contraindicated in dogs and cats unfit for general anaesthesia (e.g., due to cardiorespiratory disease) or surgery (e.g., due to a coagulopathy). Oesophagostomy feeding tubes are quick and easy to place, do not require any specialized equipment or training, and can be added at the end of another procedure. These tubes are also ideal for use at home, once the patient has recovered from its acute critical illness.

Gastrostomy tubes – Gastrostomy feeding tubes can be placed by surgery or endoscopy (i.e., percutaneous endoscopic gastrostomy or PEG tube). For critically ill patients, these tubes are ideal where there is severe oesophageal disease (e.g., megaoesophagus, oesophagitis) or with severe neurological diseases (e.g., tetanus) where there is a high risk of aspiration. And in very large to giant-breed dogs, PEG tubes can be easier to place compared to oesophagostomy tubes.

Jejunal tubes – In humans, post-pyloric feeding into the small intestine is used for several conditions including intolerance of gastric feeding (e.g., due to delayed gastric emptying). Although jejunal feeding tubes can be placed in dogs using surgical and minimally invasive techniques (such as endoscopy and fluoroscopy), true indications for these tubes are rare in veterinary medicine.

Diets to use with feeding tubes – The most convenient diets to use with feeding tubes are specifically designed liquid diets. Current liquid formulations available include diets with formulations with fat restriction for dogs, renal formulation for dogs and cats, increased protein provision for dogs, and for convalescence in dogs and cats (all produced by Royal Canin). With larger diameter feeding tubes (such as oesophagostomy or gastrostomy tubes), canned diets can be liquidized with water and made into a gruel to use with feeding tubes. This approach can be more economical compared to using liquid diets, and also enables use of alternative feeding strategies otherwise not available with liquid diets (e.g., feeding puppies/kittens, use of hydrolysed diets).

Parenteral nutrition

The administration of intravenous nutrition (parenteral nutrition) is commonplace in most human intensive care units and is also available at some referral and tertiary veterinary hospitals. These parenteral nutrition solutions usually contain combinations of carbohydrate (glucose), protein (amino acids) and fat (lipid). Parenteral nutrition can be vital in certain clinical scenarios such as severe vomiting or diarrhoea (e.g., due to parvoviral enteritis, acute pancreatitis), massive protein deficits (e.g., due to protein-losing enteropathies) and with reduced mentation (due to neurological disease or mechanical ventilation) (Figure 2).

Parenteral nutrition is often stigmatized as being associated with a high risk of complications; however, these complications may at least be partly due to the clinical status of the patient receiving this form of nutrition. Broadly, complications associated with parenteral nutrition are categorized as metabolic (e.g., hyperglycaemia), mechanical (e.g., thrombophlebitis) and septic (e.g., catheter infection). The administration of parenteral nutrition thus requires an intensive care unit or high dependency unit to monitor for these complications.

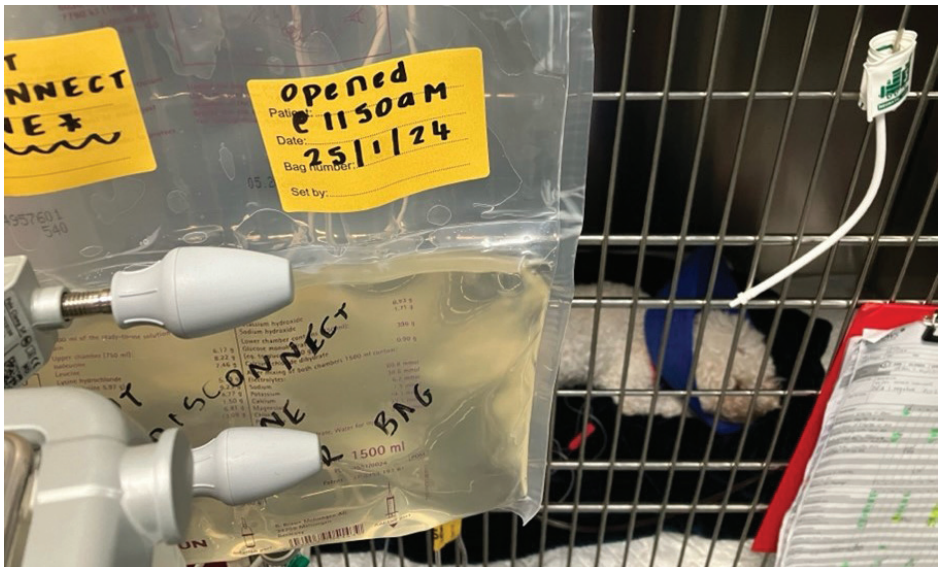

FIGURE 2: A 2-year-old Bichon Friese administered parenteral nutrition to manage a severe protein-losing enteropathy.

Nutrition related complications in critically ill patients

Delayed gastric emptying

Delayed gastric emptying or ileus may be seen due to a number of conditions including gastroenteritis, pancreatitis and after abdominal surgery. This phenomenon may also be exacerbated by electrolyte disturbances (e.g., hypokalaemia) and medications (e.g., opioids). Delayed gastric emptying can manifest as regurgitation, anorexia and abdominal discomfort. To address this, medical prokinetic therapy with a metoclopramide constant rate infusion (rather than bolus injections due to improved efficacy) may be indicated. Nutritional strategies such as dietary fat restriction and feeding multiple small meals can also help manage ileus.

Refeeding syndrome

Refeeding syndrome is a rare but devastating metabolic complication which occurs after rapid reintroduction of food following a prolonged period of starvation, leading to marked and sudden electrolyte deficiencies. It can lead to disorders affecting multiple systems including cardiac (e.g., arrhythmias), neurological (e.g., seizures), haematological (e.g., haemolysis) and vascular (e.g., oedema). Refeeding syndrome can be seen in feline patients and usually leads to haemolytic anaemia secondary to hypophosphataemia.[6]

Nutritional support after recovery from critical illness

Once a dog or cat has recovered from its critical illness, a prolonged period of recuperation is needed, often with continued supportive care. This can include the use of feeding tubes such as oesophagostomy and gastrostomy tubes at home. Specialized diets may also be required (e.g., renal formulated diet to manage chronic kidney disease following recovery from acute kidney injury).

Reflect on your reading

1. The target energy provision for critically ill dogs and cats should be estimated based on:

   A: The illness energy requirement
   B: The maintenance energy requirement
   C: The ideal bodyweight resting energy requirement
   D: The actual bodyweight resting energy requirement

2. The most important blood parameters to monitor for re-feeding syndrome in cats are:

   A: Calcium and magnesium
   B: Phosphate and PCV
   C: Albumin and globulin
   D: Sodium and chloride

3. The provision of early nutrition to critically ill dogs has been shown to be beneficial in:

   A: Acute pancreatitis
   B: Septic peritonitis
   C: Parvoviral enteritis
   D: All of the above

4. Nasal feeding tubes should be avoided when:

   A: General anaesthesia is unsafe
   B: Orofacial injuries are present
   C: Severe diarrhoea is noted
   D: The total energy provision cannot be given

5. Delayed gastric emptying is best addressed by:

   A: A protein restricted diet with erythromycin tablets
   B: A potassium restricted diet with maropitant injections
   C: A fat restricted diet with a metoclopramide infusion
   D: A carbohydrate restricted diet with omeprazole injections

Answers available online in the BSAVA Library.

About the author

Isuru Gajanayake graduated with a Bachelor of Veterinary Science from the University of Sydney in 1998. After several years working in general practice in Australia and England, he completed a combined residency in Small Animal Internal Medicine and Small Animal Nutrition at the Royal Veterinary College (London). Isuru now works at Willows Veterinary Centre and Referral Service as an American, European and RCVS recognized specialist in Small Animal Medicine and as an American Board-Certified Veterinary Nutritionist.

References and further reading are available at **www.bsavalibrary.com**.

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