DIAGNOSIS OF PANCREATITIS IN DOGS

SRINIDHI BHAT

DEPARTMENT OF VETERINARY MEDICINE
VETERINARY COLLEGE, BANGALORE
KARNATAKA VETERINARY, ANIMAL AND FISHERIES SCIENCES UNIVERSITY, BIDAR

NOVEMBER 2015

DIAGNOSIS OF PANCREATITIS IN DOGS

Thesis submitted to the

KARNATAKA VETERINARY, ANIMAL AND FISHERIES

SCIENCES UNIVERSITY, BIDAR

In partial fulfillment of the requirements for the award of the degree of

MASTER OF VETERINARY SCIENCE

in

VETERINARY MEDICINE

By

SRINIDHI BHAT

DEPARTMENT OF VETERINARY MEDICINE
VETERINARY COLLEGE, BANGALORE
KARNATAKA VETERINARY, ANIMAL AND FISHERIES
SCIENCES UNIVERSITY, BIDAR

NOVEMBER 2015

KARNATAKA VETERINARY ANIMAL AND FISHERIES SCIENCES UNIVERSITY, BIDAR

DEPARTMENT OF VETERINARY MEDICINE
VETERINARY COLLEGE, HEBBAL, BANGALORE

CERTIFICATE

This is to certify that the thesis entitled ***"DIAGNOSIS OF PANCREATITIS IN DOGS"*** submitted by **Ms. SRINIDHI BHAT, ID. No. MVHK-1343** in partial fulfilment of the requirements for the award of degree of **MASTER OF VETERINARY SCIENCE** in **VETERINARY MEDICINE** of the Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar is a record of bonafide research work carried out by her during the period of her study in this University under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

Bangalore
November, 2015

Prof. S. YATHIRAJ
Major Advisor

Approved by:

Chairman : _____
(Prof. S. YATHIRAJ)

Members : 1. _____
(Prof. P. T. RAMESH)

2. _____
(Dr. KSHAMA M. A)

3. _____
(Prof. L. RANGANATH)

4. _____
(Prof. H. D. NARAYANSWAMY)

Affectionately Dedicated to,

MY PARENTS

ACKNOWLEDGEMENT

I wish to express my eternal gratitude to ***Dr. S. Yathiraj****, Chairperson of Advisory Committee and Dean, Veterinary College Bangalore and my mentor for the ceaseless support and guidance, which has made this thesis a reality.*

My sincerest thanks goes to ***Dr. P. T. Ramesh****, Advisory Committee Member and, Professor and Head, Department of Veterinary Medicine, Veterinary College Bangalore for his constant assistance and encouragement.*

My everlasting gratitude goes to ***Dr. Kshama M. A.****, Advisory Committee Member and Associate Professor, Department of TVCC, Veterinary College Bangalore, for the moral support and valuable suggestions that helped me complete my research work and thesis. It was an honour to have her as my teacher.*

I am equally grateful to ***Prof. L. Ranganath****, Advisory Committee Member and, Professor and Head, Department of Veterinary Surgery and Radiology, Veterinary College Bangalore for his valuable suggestions and encouragement throughout the period of study.*

I extend my sincere thanks to ***Dr. H. D. Narayanswamy****, Advisory Committee Member and Professor, Department of Veterinary Pathology, Veterinary College Bangalore, for his help and guidance throughout my research.*

I thank ***Drs. Kamran, Suryanarayan and Deepti B. R.*** *for all the support and aid they gave with my research cases.*

I also thank ***Drs. Sayeed, Muralidhar and Santhosh****, Veterinary College, Bangalore, for their kind suggestions throughout this study.*

I would like to take this opportunity to thank all my senior colleagues ***Drs. Bipin, Vinu David, Sunil, Adam and Somesh*** *for their constant support and suggestions at each and every step of my MVSc.*

I am also deeply indebted to my colleagues ***Drs. Mayur, Soumya and Virupaksha*** *who were ever ready with their assisstance and practical suggestions throughout my course work and research.*

My humble thanks to my junior colleagues ***Drs. Pradeep, Shruthi, Rakesh and Mohan*** *for providing good working environment during my stay in the department.*

I also thank all the non-teaching staff members, ***Mr. Srikanth, Ravi, Prabhakar, Rajgopal, Kumar, Somalinga and Chandru*** *for their kind help and cooperation throughout my course work and research.*

This note wouldn't be complete without mentioning my friends ***Swetha, Salisha, Vibha, Vineetha, Zaheer, Byra, Smitha, Shilpa, Estella, Sachin and Amitha*** *for all the good times.*

Above all, I am forever indebted to my parents and sister and my aunt and uncle for their unconditional love and support all through my life and especially through my college years. Words aren't enough to express how indebted and blessed I am, to have you as my family. You have always been my inspiration and a guiding hand in thick and thin.

My heartfelt gratitude goes out to all my well wishers, whose support and aid have helped me in my research. I convey my sincerest apologies, if I have missed out any names, please know that your help has been greatly valued and pardon my abominable memory.

Bangalore

November, 2015 ***Srinidhi Bhat***

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF ABBREVIATIONS

BUN	- Blood Urea Nitrogen
cPLI	- canine Pancreatic Lipase Immunoreactivity
cTLI	- canine Trypsin like Immunoreactivity
CNP-G	- 2-chloro-4-nitrophenol-β-1,4-galactopyranosylmaltotrioside
CTZ	- Chemoreceptor Trigger Zone
CARS	- Compensatory Anti-inflammatory Response Syndrome
CBC	- Complete Blood Count
CT	- Computed Tomography
DKA	- Diabetic Ketoacidosis
EDTA	- Ethylenediaminetetraacetic acid
ELISA	- Enzyme Linked Immunosorbent Assay
EN	- Enteral Nutrition
EPI	- Exocrine Pancreatic Insufficiency
HRPO	- Horse Radish Peroxidase enzyme
MODS	- Multiple Organ Dysfunction Syndrome
ND	- Non-descript
PLI	- Pancreatic Lipase Immunoreactivity
PSTI	- Pancreatic Secretory Trypsin Inhibitor
PO_2	- Partial Pressure of Oxygen
SPINK-1	- Serine Protease Inhibitor Kazal type 1
SGPT	- Serum Glutamic pyruvic Transaminase
SDS	- Simple Descriptive Scale
SIRS	- Systemic Inflammatory Response Syndrome
TLC	- Total Leukocyte Count
TPN	- Total Parenteral Nutrition

Introduction

I. INTRODUCTION

Dogs play a major role in the day to day lives of people. Of late animals are given much more importance than in earlier years. Thus it is important to make a precise diagnosis of disease conditions which put the animal's life at risk. There are many diseases which are a threat to the animal's life either because they aren't diagnosed in early stages or because there are less therapeutic options. Gastrointestinal disorders are one of the major problems, pet practitioners face and many times if not diagnosed and treated properly they can cause fatalities. Pancreatitis is one such condition which if left untreated puts the dog's life in jeopardy.

Pancreatitis is an inflammatory condition of the exocrine pancreatic tissue, with infiltration by inflammatory cells and interstitial damage by pancreatic enzymes. Canine pancreatitis although under diagnosed, is a major problem in small animal practice (Charles, 2007). Although a lot of research has been conducted to determine different diagnostic tests to diagnose canine pancreatitis, most of them have either a low sensitivity or poor specificity.

Pancreatitis occurs when there is inappropriate activation of exocrine pancreatic digestive enzymes within the pancreatic parenchyma (Ruaux, 2003). It may occur in chronic and acute forms and is believed to be multi-factorial in origin. Episodes of pancreatitis can range from mild to severe (Bradley, 1993).

Clinical signs in pancreatitis are variable and non specific (Mansfield, 2011). Although pancreatitis is a relatively common disorder in dogs, the ante-mortem diagnosis

of this disease remains clinically challenging. A CBC, biochemical profile, urinalysis, and abdominal radiographs are indicated for most patients, acting to rule out other differential diagnoses, rather than to provide specific results to support a diagnosis of pancreatitis. Recently, new diagnostic tests, including tests measuring species-specific pancreatic lipase immunoreactivity (PLI) have been validated. Pancreatic lipase immunoreactivity is currently considered to be the most reliable and sensitive blood test for diagnosis of canine pancreatitis. The canine Pancreatic Lipase Immunoreactivity (cPLI) assay has been refined by using monoclonal antibodies in a sandwich ELISA and recombinant antigen for calibration, and is now available commercially as the cage-side SNAP cPL test (Steiner, 2010).

Abdominal ultrasonography is cited as being a useful aid in the diagnosis of canine pancreatitis, and is considered superior to survey radiographs but is operator-dependent (Hess, 1999). Histopathology remains the gold standard in terms of diagnosis (Hess, *loc. cit.*), and is the only modality that may distinguish acute and chronic pancreatitis. In view of the difficulty of using histopathology as a gold standard in a clinical case, amongst the various recent diagnostic techniques SNAP-cPL has been considered as one of the gold standard tests in the diagnosis of pancreatitis.

Initiation of treatment should be immediate barring which, patient's life will be in danger. The accurate and timely treatment of canine pancreatitis is, therefore, reliant upon the practitioner's ability to incorporate historical data, physical examination findings, and nonspecific and specific testing to arrive at a diagnosis and devise an effective and patient-specific treatment plan. Though information on the diagnosis and

treatment is available, from the works of earlier researchers in different parts of the globe, under the Indian scenario, there is paucity of information as regards the occurrence of pancreatitis, the diagnostic methods that can be employed and early initiation of treatment of pancreatitis.

In view of all this, the present research was undertaken with the following objectives:

1. Diagnosis of pancreatitis in dogs based on clinical signs, hematology, biochemistry, radiography, ultrasonography and histopathology.
2. Comparison and evaluation of different diagnostic tests for pancreatitis.
3. To study occurrence of pancreatic disorders in dogs.

Review of Literature

II. REVIEW OF LITERATURE

2.1 Normal Canine Pancreas

2.1.1 Normal Canine Pancreatic Anatomy

Evans and Christensen (1979) in their study reported that the pancreas was composed of a left and right lobe, joined to a small central body. Embryologically, the right lobe was formed from the ventral primordium (bud) and contained a majority of polypeptide-producing cells. The left lobe developed from the dorsal bud and predominantly contained glucagon secreting cells. In dogs there were usually two pancreatic ducts leading to the small intestine. The duct that originated from the ventral bud was the pancreatic, or Wirsung's, duct and opened adjacent to the bile duct on the major duodenal papilla. The accessory duct or Santorini duct originating from the left lobe opened distally at the minor duodenal papilla. They stated that in some dogs only one duct (generally the accessory as it is the largest) was present and so all pancreatic juice entered the intestine through the minor duodenal papilla.

They demonstrated that the pancreas was situated in the cranial part of the abdomen (Plate 1). The body followed along the mesenteric surface of the duodenum, curving at the first duodenal flexure. The right lobe then traveled alongside the duodenum, and reached the caecum. The left lobe was deeper in the mesentery and sat adjacent to the pylorus. This resulted in the pancreas having direct physical contact with the liver, transverse colon, left kidney and spleen, as well as the surrounding omentum and that inflammation of and around the pancreas therefore has the potential to directly affect multiple organs within the abdomen.

Williams (1996) in his research stated that the functional units of the exocrine pancreas were the acinar cells. The bulk of the exocrine function was performed by the central acinar cells, with an extensive duct system allowing complex communication between the exocrine and endocrine cells of the pancreas. The endocrine function was performed by the islets of Langerhans, which were scattered throughout the tissue. He theorized that there was close communication between the exocrine and endocrine cells, ensuring coordination of digestion and the production of endocrine hormones such as insulin.

Williams (*loc. cit.*) also observed that the blood supply to the pancreas originated from the coeliac and cranial mesenteric arteries. They branched off to form the cranial and caudal pancreatico-duodenal arteries respectively, and entered the right limb of the pancreas. The splenic artery, which itself arises from the coeliac artery, supplied to the left limb. The nervous supply to the pancreas originated from the vagus and splanchnic nerves, which travels alongside the coeliac and caudal mesenteric arteries.

2.1.2 Normal pancreatic physiology

Scheele (1980) reported that within the acinar cell the zymogen granules were kept separately from the lysosomal granules enclosed in membrane bound organelles and these two enzyme groups were kept physically apart throughout all stages of their production.

Laskowski and Kato (1980) put forward that the location of pancreatic secretory trypsin inhibitor (PSTI) within the acinar cells allowed for immediate inhibition of

trypsin should it be prematurely activated within the acinar cells. They also stated that the PSTI was produced and stored in the same location as the digestive enzymes.

Rinderknecht (1986) reported that the pancreas had a number of exocrine functions. It was responsible for secreting enzymes into the small intestine to assist in degradation of proteins, fats and carbohydrates. To protect itself from the digestive nature of these enzymes the pancreatic enzymes were stored as zymogens within the pancreatic acinar cells. Zymogens were catalytically inactive precursors of digestive enzymes that were secreted into the lumen of the small intestine in response to food. Enterokinase, a peptide produced by small intestinal mucosal cells, activated trypsin. Trypsin subsequently activated an enzyme cascade, cleaving the activation peptides from other digestive zymogens.

Steer and Meldolesi (1988) indicated that the pancreatic enzymes were stored in the acinar cells as inert zymogens, and theoretically were only activated within the lumen of the duodenum.

Williams (1996) observed that should any activated trypsin reach the circulation, larger anti-proteases were present in the blood, which have the capacity to deactivate some circulating trypsin.

Frossard and Pastor (2002) in their research suggested that lysosomal enzymes were produced in the ribosomes attached to the rough endoplasmic reticulum, in the same manner that zymogens are, but were additionally glycosolated and phosphorylated as they passed through the Golgi complex.

2.2 Canine Pancreatitis

2.2.1 Etiology and Risk Factors of Pancreatitis in Dogs

Haig (1970) provided evidence citing that low-protein, high-fat diets induced pancreatitis and that high-fat diets in dogs can cause severe pancreatitis.

Schaer (1979) stated that the potential of glucocorticoids to cause pancreatitis in cats and dogs is controversial and believed that there was a connection between glucocorticoid administration and pancreatitis.

Moore and Withrow (1982) in their article observed that pancreatitis had been reported in a small percentage (3.1%) of dogs with intervertebral disc disease treated with intravenous corticosteroids, primarily dexamethasone. Only two of these dogs had pancreatitis confirmed at post-mortem, but there may have been other precipitating factors for pancreatitis, such as hypotension associated with severe spinal cord disease, that caused this inflammation, rather than the corticosteroids *per se*.

Corticosteroid treatment in healthy dogs or those with neurological signs, failed to induce clinical pancreatitis but did result in an increase in serum pancreatic enzyme concentrations in a study conducted by Parent in 1982. Another experiment conducted by Fittschon and Bellamy in 1984 also ended up with the same results.

Risk factors for acute pancreatitis in dogs include obesity, diabetes mellitus, hyperadrenocortcisim, hypothyroidism, prior gastrointestinal disease, and epilepsy, and Miniature Schnauzers and Miniature Poodles appear overrepresented as reported by Cook *et al.* (1993).

Drugs that have been reported in the veterinary literature to cause pancreatitis includes azathioprine, chlorthiazide, hydrochlorthiazide, zinc, potassium bromide, vinblastine, sulfanomides, cisplatin, organophosphates, L-asparginase and 5-aminosalicylate according to Williams (1994).

Mithofer *et al.* (1995) in their research stated that acute pancreatitis may also directly result from hypoxia and ductal hypertension, via an effect on pancreatic microcirculation.

Carrasco *et al.* (1997) during their study opined that specific diseases such as Babesiosis and Leishmaniasis are also reported to cause pancreatitis in dogs.

Ruaux and Atwell (1998) identified Terriers as having a higher incidence in their study.

Lucena *et al.* (1999) proposed that corticosteroid administration in dogs increased serum pancreatic enzyme levels. One review of canine pancreatitis put forward by Hess *et al.* (1999) found that Yorkshire terriers were at increased risk, whilst Labrador retrievers and Miniature poodles had a decreased risk of developing pancreatitis.

A retrospective study conducted by Mohr *et al.* (2000) described four cases of Canine Babesiosis with histologically confirmed acute pancreatitis. In addition, 16 dogs with babesiosis were reported as having a serum amylase (>3500 U/l) and/or lipase (>650 U/l) activity elevations of a magnitude that would support a diagnosis of probable acute pancreatitis, although extra-pancreatic sources of the enzymes could not be excluded in these cases.

A report presented by Aste *et al.* (2005) described a case of acute pancreatitis during meglumine therapy in a 12 year old English Setter dog affected by visceral Leishmaniosis.

Cuthbertson and Christophi (2006) showed evidence of pancreatic and systemic microvascular disturbances in the pathogenesis of pancreatitis, including vasoconstriction, shunting, inadequate perfusion, and increased blood viscosity and coagulation. They stated that these processes may be caused or exacerbated by ischaemia–reperfusion injury and the development of oxygen-derived free radicals.

Lem *et al.* (2008) reported that suggested that dietary factors, being neutered any previous surgery other than neutering increased the odds of pancreatitis in dogs. He also stated that overweight dogs were at greater risk of pancreatitis, which could be associated with abnormal dietary intake or a general predisposition to inflammation and demonstrated a higher incidence of pancreatitis in Terriers.

Schwartz *et al.* (2008) suggested that a high incidence of pancreatitis was reported after abdominal surgeries, especially adrenalectomies.

According to Radin *et al.* (2009) adipose tissue and adipokines are associated with a chronic inflammatory state which may be an important factor in canine pancreatitis especially in consideration of the peripancreatic fat involvement, but this has yet to be evaluated.

Shukla (2010) presented a case of pancreatitis in a female mixed breed dog with signs of abdominal discomfort and vomiting of 24 h duration following an episode of

dietary indiscretion and stated that the connection between pancreatitis and indiscretory eating was anecdotal.

Hereditary pancreatitis occurs in people, and although a variation in the *SPINK* gene has been recognized in Miniature Schnauzers, a causal relationship with pancreatitis has yet to be established as reported by Bishop *et al.* (2010).

The list of potential etiologies that can cause pancreatitis in dogs is long and includes dietary factors, hyperlipoproteinemia, drugs, toxins, hypercalcemia, duct obstruction, duodenal/ biliary reflux, pancreatic trauma, ischemia/reperfusion and idiopathic causes according to Mansfield (2011).

Schleis *et al.* (2011) diagnosed a case of hemorrhagic pancreatitis on necropsy two hours after administration of L-asparginase.

2.2.2 Pathophysiology of Pancreatitis

According to Lasson and Ohlsson (1984) pancreatitis develops when there is excessive activation of trypsin and other pancreatic proteases within the pancreas, which overwhelm the safeguards of both PSTI within the acinar cell and anti-proteases in the circulation. The local and distant inflammatory effects of pancreatitis are mediated by a range of inflammatory pathways, and severe disease is perpetuated by splanchnic circulatory failure.

Studies conducted on animal models by Schröder *et al.* (1985) demonstrated that vasoconstriction within the pancreas appears to be an early event in acute pancreatitis.

Rinderknecht (1986), in his study stated that the earliest event in pancreatitis occured when there was activation of trypsinogen to trypsin within the acinar cell. He reported that a secretory (or apical) block developed, where zymogen granules were not secreted into the intestinal lumen and as a result of the apical block, co-localization of zymogen granules took place and trypsinogen was activated to trypsin by lysosomal proteases. He showed that trypsin was activated by Cathepsin B, a lysosomal protease.

Steer and Meldolesi (1988) confirmed the findings of Rinderknecht (*loc. cit.*) that conversion of trypsinogen to trypsin within the acinar cell was the first step in pancreatitis by electron microscopy and ultrastructural studies.

Klar *et al.* (1991) expressed that administration of phenylepinephrine (a potent vasoconstrictor) converted mild, edematous pancreatitis to a severe, necrotizing form.

The findings of Lerch *et al.* (1992) suggested that altered intracellular targeting of endocytosed proteases might be one mechanism by which digestive zymogens reach an intracellular compartment in which premature activation can occur. This phenomenon may be a critical and early event in the pathogenesis of biliary pancreatitis.

Gross *et al.* (1993) believed that inflammatory mediators and cytokines were central to the development of multiple organ failure syndromes in severe acute pancreatitis.

Mithofer *et al.* (1995) demonstrated that hypotension caused trypsin activation prior to the appearance of proteases thus suggesting that there were other cellular mechanisms not fully elucidated which may lead to premature trypsin activation.

Saluja *et al.* (1997) implied that although concurrent administration of a cathepsin B inhibitor significantly reduced the development of pancreatitis in one study, it didn't completely prevent it.

Gloor *et al.* (1998) stated that the activated neutrophils and other leucocytes such as macrophages, may contribute to the development of inflammation in distant organs as they were produced by the bone marrow and were present in the circulation.

Saluja and Steer (1999) confirmed in an *in vitro* model that the cathepsin B inhibitor used in the experiment conducted by Saluja *et al.* (*loc. cit.*) was only a partial antagonist.

Halangk *et al.* (2000) reported that cathepsin-B deficient mice also developed pancreatitis albeit to a lesser severity than mice without that deficiency which suggests that other mechanisms are also involved in the development of pancreatitis.

Leucocyte accumulation occurs initially in the perivascular areas of the pancreas, and then following oedema and the resultant change in permeability, the leucocytes egress to the pancreatic body (Pezzilli, 2009).

2.2.3 Pancreatic microcirculation

Bassi *et al.* (1994) and Knoefel *et al.* (1994) in separate studies came to the conclusion that disturbed pancreatic microcirculation played a very important role in pancreatic inflammation and permeability.

Foitzik *et al.* (1995) reported that impaired lymphatic drainage could also contribute to poor circulation to the pancreas, as red blood cells can enter the lymph and enhance leucocyte adhesion. They conducted experimental studies in rats and identified that lower pancreatic perfusion was associated with more severe pancreatitis.

Takeda *et al.* (2005) stated that in people, early onset spasm of large pancreatic vessels has been shown to correlate with poorly perfused areas of the pancreas, and subsequent high mortality rates.

Keck *et al.* (2005) in their study evinced that the vascular disturbance in pancreatitis was likely to be multi-factorial in origin and occurred as a result of increased vascular permeability resulting from inflammatory cytokines, the direct effects of pancreatic proteases, and/or microthrombi formation resulting from hypercoaguability.

2.2.4 Perpetuation of disease

Kampp *et al.* (1968) reported that in people and cats it had been shown that the oxygen counter-current exchange system and the anatomical position of the villi circulation predispose the pancreas to hypoperfusion during times of decreased splanchnic circulation.

Rowell *et al.* (1984) thought that prolonged oxygen extraction of > 70% can lead to regional ischaemia. Additionally, the theory that increased bowel permeability leads to cytokine release and skeletal muscle lysis was put forward by Wilmore *et al.* (1988).

Fink (1991) reported that ischaemia of the intestine increases permeability and mucosal acidosis, which, as it progresses increases the rate of apoptosis of enterocytes and decreases nutrient transport of intestinal epithelial cells.

Takala (1996) stated that pancreatic and peritoneal inflammation may cause vomiting due to stimulation of peripheral chemoreceptors in the mesentery and that circulating emetic agents may also reach the chemoreceptor trigger zone (CTZ) adjacent to the vomiting centre in the medulla in pancreatitis. He concluded that vomiting resulted in significant third space loss and splanchnic circulation subsequently decreased as part of circulatory shock. The body adjusts for this by increasing the oxygen extraction from systemic circulation up to 90%. He further stated that in intestinal villi the artery and vein run parallel, but in opposite directions and this resulted in a decreasing tissue PO_2 gradient from the base up to the tip of the villi. The change in PO_2 may also be due to the higher metabolic activity of cells located in the tip. Regardless of the mechanism, this low PO_2 tension makes the villi tips susceptible to tissue hypoxia if vasoconstriction occurs.

Strombeck (1996) hypothesized that dogs were exquisitely sensitive to villus hypoxia as the drainage from the capillary network to the veins occurred closer to the tip of the villus than in other species.

Flint and Windsor (2003) while explaining about the role of the intestine in severe acute pancreatitis stated that the epithelial layer was the most important part of the intestinal barrier, as it is a single cell layer that is very prone to disturbances in microcirculation.

2.2.5 Classification of pancreatitis

Mergener and Baillie (1998) defined acute interstitial pancreatitis as a swollen organ due to diffuse interlobular edema and occasionally haemorrhage or necrosis. They stated that chronic interstitial pancreatitis arose by an extension of an inflammatory process that commenced in the ducts and was usually of minor clinical consequence.

Windsor and Hammodat (2000) described severe acute pancreatitis in people as being associated with organ failure, local complications (such as local fluid collections, infected necrosis, pseudocysts) or both.

Blum *et al.* (2001) sub-classified acute pancreatitis into necrotising or non-necrotising, with the consensus being that there was a worse outcome with the former.

Watson (2004) demonstrated that mild acute pancreatitis caused no multi-system failure and had an uncomplicated recovery, whilst severe acute pancreatitis caused multi-system failure or development of complications.

Charles (2007) observed that there was a lot of confusion about the nomenclature surrounding pancreatitis and its various definitions in the veterinary literature. He suggested that this was probably because pathological classifications were dependent on histological descriptions. As the different types of pancreatitis overlapped in their clinical presentation, and biopsy specimens were rarely obtained ante-mortem in acute pancreatitis, a clinical bias in terminology currently existed in the veterinary literature. He described acute pancreatic necrosis as having perilobular necrosis and reactive

inflammation at the periphery of affected lobes, with a variable degree of involvement of adjacent adipose and other tissues.

Al Mofleh (2008) in his research stated that necrosis was generally diagnosed by Computed Tomographic (CT) evaluation in people. The presence of infected necrosis and the extent of the necrosis were the two most important determinants of the outcome of pancreatitis in people and that such a determinant had not been made in dogs, partly due to the difficulty in assessing the amount of necrosis.

2.2.6 Prevalence and mortality rates in dogs

The reported mortality rate in dogs according to a study conducted by Schaer (1979) ranged from 27% to 58%.

Strombeck (1990) stated that the prevalence of pancreatitis is very difficult to determine and quoted it to be 3.2%. But he concludes that this was likely to be grossly inaccurate due to both under diagnosis of chronic pancreatitis and over diagnosis of acute pancreatitis.

Severe pancreatitis is associated with both local and systemic complications and can lead to significant morbidity and mortality according to Bradley (1993).

Cook *et al.* (1993) and Ruaux and Atwell (1998) in their studies questioned the findings of Schaer (1979) about the occurrence of pancreatitis as the reports were from referral centres and therefore predisposed to more severe cases, or there was a lack of definitive gold standard diagnosis.

Studies have identified between 75 and 92% of dogs in a referral institution to have pancreatic inflammation on post-mortem examination (Newman *et al.*, 2005; Newman *et al.*, 2006). This is likely to be an over-estimation, as most of the reported inflammation is likely to have been incidental, and also reflects a referral bias.

Prevalence of chronic pancreatic inflammation in one post-mortem study was 34%, but there was no determination of how clinically important these changes were according to Watson *et al.* (2007).

Al Mofleh (2008) reported that euthanasia for non-medical reasons may also influence the true mortality of pancreatitis. Even taking those factors into account, it was a higher mortality rate than the 5-15% reported in human studies.

2.2.7 Differential Diagnosis

The clinical signs of acute pancreatitis in dogs are not pathognomonic. The differential diagnoses for acute pancreatitis that need to be eliminated as a priority are the life threatening conditions such as intestinal obstruction, closed pyometra or septic peritonitis, which all require surgical intervention and have very similar presentations. Other differentials include non-specific gastroenteritis, dietary indiscretion, diabetic ketoacidosis, liver disease, uraemia and other metabolic causes of vomiting (Ruaux, 1998; Kenneth, 2000; Ruaux, 2003; Kalli *et al.*, 2009).

2.3 Diagnosis of Pancreatitis in Dogs

2.3.1 Clinical Signs

Studies conducted by Akuzawa *et al.* (1994) on 53 dogs with experimentally induced pancreatitis reported that anorexia, depression, diarrhoea and vomiting were consistent signs in all the dogs.

Diagnosis of acute pancreatitis is difficult because clinical signs, physical examination findings and clinicopathologic abnormalities are often nonspecific according to Hess *et al.* (1999). He states that 91% of the dogs had a history of anorexia, 90% vomiting, 79% weakness and 33% diarrhea. Other clinical abnormalities included polyuria and polydypsia (50%), neurologic abnormalities (20%) melena (11%), weight loss (8%), hematemesis (7%) and passage of frank blood in the feces.

Mildly affected dogs may have less dramatic signs. Complications such as icterus due to extra-hepatic bile duct obstruction develop 2-3 days after the onset of vomiting (Watson, 2004).

The findings on clinical examination vary considerably with the severity and stage of the disease, and the associated degree of dehydration and shock. Severely affected dogs will have signs of dehydration and shock such as tachycardia, tachypnea, prolonged capillary refill time, hypothermia and dry mucous membranes (Williams and Steiner, 2005).

In a study conducted on 22 dogs, clinical signs compatible with pancreatitis was seen in 20 of the 22 dogs, vomiting in 18 dogs (81%), abdominal pain in 10 dogs

(45.5%), anorexia in 13 (59.1%) and diarrhea in 8 (36.4%). Abdominal ultrasonography was performed in 9 of the 22 dogs and evidence of pancreatitis was considered to be present in 6 of these dogs (Steiner *et al.*, 2008).

2.3.2 Pain Assessment

Studies conducted by Akuzawa *et al.* (1994) on 53 dogs with experimentally induced pancreatitis reported that the dogs stood with their backs arched suggesting abdominal pain and showed a reluctance to move.

Hess *et al.* (1999) concluded that 59% of dogs with pancreatitis had abdominal pain while Steiner *et al.* (2008) claimed that 45.5% of the dogs had abdominal pain.

2.3.3 Hematological Findings

Leukocytosis was reported as being present in dogs with pancreatitis by Akuzawa (1994).

The various haematologic abnormalities reflected in patients with acute pancreatitis were reticulocytosis, hemolytic anemia, coagulation abnormalities, thrombocytopenia, and leukocytosis by Olhovich *et al.* (2013).

2.3.4 Pancreatic Enzymes

2.3.4.1 Amylase and Lipase

According to Hudson *et al.* (1978) renal failure as well as acute pancreatitis show a high serum amylase level, supposed to occur on account of renal azotemia.

Serum amylase and lipase activities have traditionally been used for the diagnosis of canine pancreatitis but are neither very specific nor very sensitive for the diagnosis of this disease in dogs theorized Strombeck *et al.* (1981).

Jacobs *et al.* (1985) showed that serum lipase and amylase concentrations increase in experimental and naturally occurring canine pancreatitis.

Walter *et al.* (1992) in their research demonstrated that diseases associated with a greater than twofold elevation in serum lipase activity as determined by kinetic method of estimation included pancreatitis, gastritis with liver disease, and oliguric renal failure with metabolic acidosis. In some cases, pancreatitis was seen with other clinical problems, such as gastroenteritis, diabetic ketoacidosis, duodenal mass, disseminated intravascular coagulation, and septic peritonitis. Diseases associated with serum lipase activity within the reference range or elevated less than twofold included gastritis, gastric ulcer, cholestasis, phenobarbital-induced hepatopathy, colitis, copper hepatopathy, abdominal hematoma, apocrine gland adenocarcinoma, and thrombocytopenia with pneumonia.

A study conducted by Akuzawa *et al.* (1994) revealed that amylase specific activities in pancreatic tissue extracts were more than 2,300 times higher than that in serum, and were also higher than those in other tissues; parotid and mandibular salivary glands, lung, heart, liver, spleen, duodenum, jejunum, ileum and kidney. Serum lipase and amylase concentrations can also be normal in dogs that do have pancreatitis.

Akuzawa *et al.* (*loc. cit.*) also indicated that serum amylase increased owing to the induction of acute pancreatitis unrelated with renal failure or azotemia.

Rallis *et al.* (1996) concluded that serum lipase activity had been shown to be markedly increased in dogs with acute enteritis, gastroenteritis, liver disease and in renal failure. Lipase concentration could also be elevated up to five-fold by the administration of dexamethasone in dogs with no pancreatic inflammation reported Williams (1996).

In one retrospective review by Hess *et al.* (1999) less than 50% of dogs with acute fatal pancreatitis had increased lipase concentrations, whilst only 30.8% had increased amylase concentrations (Hess *et al.*, *loc. cit.*). Serum lipase has the lowest sensitivity for macroscopic pancreatitis (13.6%), followed by serum amylase activity (18.2%), serum T-α1-PI concentration (31.8%) and serum c-TLI (36.4%).

Quigley *et al.* (2001) observed a marked increase in serum pancreatic lipase activity with minimal concurrent increase in serum α-amylase activity in 6 dogs with pancreatic or hepatic neoplasia.

Steiner and Williams (2002) in their study on classical pancreatic lipase stated that it was a digestive enzyme with a molecular weight of approximately 50,000 that had been isolated in many species, including pigs (*Sus scrofa*), sheep (*Ovies aries*), cattle (*Bos taurus*), horses (*Equus caballus*), rats (*Rattus rattus*), dromedars (*Camelus dromedaries*), chickens (*Gallus gallus*), and human beings (*Homo sapiens*).

Dogs with acute renal failure, intestinal foreign bodies, acute enteritis, and liver disease have all been shown to have increased total serum lipase concentration according

to Mansfield *et al.* (2003). They also implied that serum amylase was reasonably sensitive but not very specific for the differentiation of severe from mild pancreatitis. The calculated cut-off value was less than the upper limit of the reference range, making it an inaccurate tool for assessing severity.

Rallis *et al.* (1996) researched serum lipase activities in 48 young dogs with acute enteritis or gastroenteritis due to canine parvovirus (16 Cases) and presumably to other infectious agents (32 cases) and revealed that elevated serum lipase activity (> 500 U/L) was found in 13 dogs (27.1 %) with values ranging from 800 to 2,780 U/L. They deduced that hyperlipasemia in these cases may be attributed to acute pancreatitis secondary to acute gastroenteritis or to gastrointestinal upset.

Studies conducted by Giuseppe *et al.* (2008) showed no statistical influence of feeding schedule on lipase and α-amylase and a robust daily rhythmicity of lipase and α-amylase in fed and fasted dogs. Serum c-PLI concentration, as measured by in-house ELISA or Spec-cPL, had the highest sensitivity at 63.6% each in a study conducted by Steiner *et al.* (2008).

Assays for measuring pancreatic lipase immunoreactivity (PLI) determine the serum concentration of lipase that originates from acinar cells of the exocrine pancreas. When the pancreas is inflamed, acinar cells leak pancreatic lipase into the vascular space and serum pancreatic lipase immunoreactivity increases. The half-life of PLI is estimated to be approximately 90 minutes in dogs. Therefore, if leakage of pancreatic lipase is stopped, serum pancreatic lipase immunoreactivity quickly returns to the reference range.

Leakage must be ongoing in order to maintain an increased serum concentration of PLI (Steiner, 2010).

Serum amylase and lipase activities have been shown to increase in experimental and naturally occurring canine pancreatitis. However, neither enzyme activity is specific to the pancreas because they also originate from the gastrointestinal mucosa and are excreted by the kidneys (Mansfield *et al.*, 2011).

Olhovich *et al.* (2013) stated that the half-life of serum amylase in healthy dogs was one to five hours, but in dogs with pancreatitis serum amylase may last for one to three days. Hence, when diagnosing acute pancreatitis by serum amylase, levels should be determined after the first signs of abdominal pain, and its increase should be four to five times above the reference value to allow an accurate diagnosis of pancreatitis.

2.3.4.2 Canine Pancreatic Lipase

Canine pancreatic lipase is one of the most recently established laboratory tests in veterinary medicine, and its use is now widespread. This test measures lipase that originates solely in the pancreas, and so it will only be increased in pancreatic inflammation (Steiner and Williams, 2002). Immunohistochemical studies have determined that the Canine pancreatic-specific lipase is localized in the exocrine pancreas (Steiner and Williams, 2002).

Ruaux (2003) stated that lipase produced in the pancreas is antigenically and structurally different from the other lipases in circulation while sharing the same substrate specificity. This means that although activity assays are relatively non-specific for

pancreatic disease, immunoassays for pancreatic lipase show promise for a much higher specificity.

Canine pancreatic lipase was first developed as a radioimmunoassay, and then as an enzyme immunoassay that has been well validated and is now widely used. The current commercially available test for specific canine pancreatic lipase (Spec-cPL) is a sandwich enzyme linked immunosorbent assay, using a recombinant peptide as the antigen and monoclonal antibody for measurement (Steiner and Williams, 2003).

Canine pancreatic-specific lipase has been shown to be virtually undetectable in dogs with exocrine pancreatic insufficiency according to Steiner *et al.* (2006).

Xenolius *et al.* (2008) stated that the best marker identified so far is immunoreactive lipase which besides being species-specific is also specifically pancreatic in origin and therefore indicative of pancreatitis; moreover, its concentration does not change with renal impairment or administration of steroids, which makes it a highly specific and sensitive marker.

Steiner (2010) reported that the advantage of the SNAP-cPL is that it helps to rule out pancreatitis in dogs with acute gastrointestinal signs and also to strengthen a suspicion of pancreatitis within minutes. Many dogs with acute gastritis, hypoadrenocorticism, renal failure, or other diseases may present with similar clinical signs. A negative SNAP-cPL helps the clinician quickly shift the focus of the clinical investigation to other conditions. Measurement of Spec cPL often allows diagnosis even in animals with mild or chronic disease. The disadvantage of SNAP cPL is that while a

positive SNAP-cPL test helps strengthen a suspicion of pancreatitis, it does not definitively diagnose it. Other diagnostic tests, including abdominal ultrasound and measurement of Spec cPL, are necessary.

An in-clinic rapid semi quantitative assay (SNAP-cPL, Idexx, Maine, USA) has also been developed and shows good alignment and reproducibility with Spec-cPL. A negative or low test had a good correlation to dogs having a disease other than acute pancreatitis (Beall *et al.*, 2011).

A study from a different group assessed 70 dogs consecutively presented for post-mortem at a tertiary referral centre (Trivedi *et al.*, 2011). Sixty-three of those were found to have pancreatic inflammation on histology (56 mild, 7 moderate), whilst 7 had no histological evidence of pancreatic inflammation. The estimated sensitivity of canine pancreatic lipase was 21% for mild disease, and 71% for moderate disease. This was a lower sensitivity than total lipase (54 and 71% respectively) in the same cohort. Although only 7 dogs were classified as having normal pancreatic histology, they published a specificity of 86% for cPL as compared to 43% for total lipase. Again, this study had limitations due to the small number of dogs classified as true negatives, and the lack of correlation between clinically significant disease and the histological grading.

Dogs with a Spec-cPL of less than 200µg/l or a negative SNAP-cPL were unlikely to have clinical acute pancreatitis (McCord *et al.*, 2012).

2.3.5 Diagnostic Imaging

2.3.5.1 Ultrasonography

Changes in pancreatic echogenicity and development of focal lesions can be detected on ultrasonography according to Nyland *et al.* (1983) and Murtaugh *et al.* (1985).

Abdominal ultrasonography is a valuable tool for the diagnosis of pancreatitis, and a variety of ultrasonographic changes have been reported, including enlargement of the pancreas, fluid accumulation around the pancreas, echogenicity changes within and around the pancreas, a pancreatic mass effect, and a dilated major duodenal papilla (Saunders, 1991).

Chronic pancreatitis may result in decreased pancreatic size, variable mixed echogenicity of pancreatic parenchyma, nodular echotexture, acoustic shadowing due to mineralization and scarring, irregular widening of the pancreatic duct (Saunders, *loc. cit.*).

Lamb and Simpson (1995) in their research demonstrated that ultrasonography had a sensitivity of 75% for detection of pancreatic neoplasms and 55% to detect metastasis.

The highest reported sensitivity of abdominal ultrasonography for canine pancreatitis is 68% as stated by Hess *et al.* (1999).

Nyland *et al.* (2002) states that on ultrasonographic examination, acute pancreatitis is characterized by enlarged, irregular, hypoechoic, and, on occasion, mass-like pancreas. Surrounding mesentery appears hyperechoic, indicating peripancreatic steatitis, fat necrosis, and focal abdominal effusion is commonly seen.

Use of abdominal ultrasound in veterinary practice is increasing in importance and aids substantially in the diagnosis of acute pancreatitis in dogs. The normal pancreas is an ultrasonographically inconspicuous organ, which can usually be visualized in cats and small dogs but may be difficult or impossible to identify in large dogs (Hecht and Henry, 2007).

Acute necrotizing pancreatitis is frequently associated with an enlarged, hypoechoic pancreas and peri-pancreatic necrosis (manifested as hyperechogenicity surrounding the pancreas), and is relatively easy to identify, although gas and ingesta in the gastrointestinal tract may hamper visibility (Hecht and Henry, 2007).

In acute pancreatitis, the pancreas may appear hypoechoic surrounded by hyperechoic fat seen medial to the duodenum while in chronic cases pancreas becomes hyperechoic (Kumar *et al.*, 2010).

According to Watson *et al.* (2010) ultrasound examination of the pancreas had a sensitivity of 56% for detection of pancreatitis.

In a case study of two dogs with pancreatitis, the pancreas was identified using duodenal loop as landmark and ultrasonography revealed area of mixed echogenicity in

pancreatic stroma along with thickened duodenal wall suggestive of chronic pancreatitis (Kumar *et al.*, 2010).

Mansfield (2011) stated that despite the common use of ultrasound for the diagnosis of acute pancreatitis, it is extremely difficult to elucidate a sensitivity of specificity for this diagnostic modality based on published reports. The diagnostic utility of ultrasound is highly operator dependant and also requires equipment that is of high standard. Ultrasound cannot distinguish between inflammation, necrosis and neoplasms. Specificity of this modality is virtually impossible to determine, as histology would need to be performed in order to establish this. It certainly remains an important component of a diagnostic work-up to evaluate for other abdominal disease.

2.3.5.2 Radiography

In a retrospective survey of 70 fatal cases of acute pancreatitis in dogs, radiographic findings were consistent with acute pancreatitis in 10 of 41 cases (24%) for which radiographs were available (Hess *et al.,* 1999).

Plain radiographic findings are nonspecific and at best, only supportive of a clinical diagnosis of acute pancreatitis (Ruaux, 2003).

Radiological changes that may be apparent include decreased contrast and lack of detail in the cranial abdomen due to the surrounding peritonitis, a widened pyloric-duodenal angle and a shift of the descending duodenum to the abdominal wall (Herman *et al.*, 2005).

These changes are often difficult to detect and is also not specific for pancreatitis, as it may occur in a number of conditions such as septic peritonitis. Despite these limitations, abdominal radiography is still a very important part of the diagnostic work-up for a dog with acute onset of vomiting or abdominal pain. This is mainly due to the ability to evaluate for differential diagnoses, such as intestinal obstruction or other changes such as free gas within the abdomen or a distended uterus (Mansfield, 2011).

2.3.5 Post mortem and Histopathology

In a single postmortem study of 9,342 dogs, the prevalence of pancreatitis was 1.0%, but it has been speculated that this number underestimates the true prevalence of pancreatitis in dogs (Hanichen *et al.*, 1990).

Histologically acute pancreatitis is characterized by findings that range from pancreatic edema to necrosis, variable infiltrates of mononuclear and polymorphonuclear cells, and local changes such as peripancreatic fat necrosis and thrombosis (Kenneth, 2000).

Histological grading schemes have been developed for diagnosing pancreatitis in dogs, and to assist in assessing the sensitivity and specificity of diagnostic tests. The failing of these schemes is a lack of correlation with clinical severity, and therefore an understanding of the clinical significance of those grading systems. It has been established that pancreatic histological changes can be unevenly distributed throughout the pancreas, necessitating frequent sectioning along the organ in order to be able to rule out pancreatic inflammation (Newman *et al.*, 2004).

The finding of hyperplastic nodules in the pancreatic parenchyma is thought to be incidental and increases with age (Newman *et al.*, 2005). These nodules can be both grossly and microscopically evident, and are very common.

One of the most common grossly apparent manifestations of macroscopic pancreatitis in a study conducted by Steiner *et al.* (2008) was peripancreatic fat necrosis revealed by presence of saponified fat.

In a study conducted by Trivedi *et al.* (2011) twelve of 70 dogs had macroscopic evidence of pancreatitis at necropsy, including hemorrhage (8), edema (5), pancreatic nodules/plaques (6), a firm pancreas (4), hyperemia (2), pancreatic necrosis (1) and peripancreatic fat necrosis (3).

2.4 Complications of Pancreatitis in Dogs

2.4.1 Systemic Complications

Potential complications that can occur early in the course of pancreatitis are diabetes mellitus, diabetic ketoacidosis, pancreatic abscess/pseudocyst formation, cardiac arrhythmias, abdominal distension, ileus, disseminated intravascular coagulation, septicemia, bile duct obstruction, respiratory distress and renal failure (Schaer, 1991).

Renal failure does not cause histologically apparent lesions in the pancreas of rats according to a study conducted by Lerch *et al.* (1994).

Hess *et al.* (1999) reported that it was possible that chronic pancreatitis caused a predisposition to renal disease and this was more likely as it was already known that a

significant proportion of dogs with acute pancreatitis had evidence of intrinsic renal damage in addition to pre-renal failure and also 78 per cent of dogs had proteinuria. They also state that it was possible that the association was age related or purely coincidental.

The development of systemic complications in acute pancreatitis is due to an imbalance between the development of SIRS and the compensatory anti-inflammatory response syndrome (CARS) (Windsor and Hammodat, 2000). This is likely to be mediated by the cytokine storm, nitrous oxide and other inflammatory mediators.

Watson (2003) described late onset complications such as chronic relapsing pancreatitis and the subsequent development of EPI of diabetes mellitus in dogs.

Barton (2005) stated that systemic inflammatory response syndrome (SIRS) is a generalised systemic reaction, with resultant organ dysfunction that is characterised by peripheral vasodilation and increased capillary permeability. The clinical criteria for SIRS in dogs is tachycardia (heart rate > 120 beats per minute), tachypnoea (respiratory rate > 40 breaths per minute), pyrexia (>39°C) or leucocyte abnormalities (> 18,000 or < 5000 WBC/μL) (Barton, 2005).

A relatively high proportion of the dogs with chronic pancreatitis in a study conducted by Watson *et al.* (2007) had renal disease. This may suggest that renal disease causes chronic pancreatitis.

Multiple organ dysfunction (MODS) is an extension of SIRS, and is defined as altered organ function such that homeostasis cannot be maintained without intervention. It is unknown how many dogs with pancreatitis have SIRS, but approximately 60% of

people with acute pancreatitis have been reported to have SIRS, and it is considered a sign of severity (Singh *et al.*, 2009). Another known complication of acute pancreatitis in humans is the development of acute renal failure (Wang *et al.*, 2009).

Systemic complications seen in acute pancreatitis include disseminated intravascular coagulation and cardiac arrhythmias, all mediated by the many systemic inflammatory cascades initiated by acute pancreatitis. Diabetic ketoacidosis (DKA) is a commonly reported comorbidity in canine acute pancreatitis. It is suspected that the acidosis present in DKA may cause trypsin activation and then acinar cell necrosis (Mansfield, 2011).

The occurrence of renal failure is influenced by factors such as hypovolaemia and renal endothelial damage caused by a severe systemic inflammatory response. Furthermore, dehydration in a patient with acute pancreatitis is a predisposing factor for the development of hypovolaemia, primarily by vomiting that leads to a significant loss of chloride and thus to hypochloraemic metabolic alkalosis. When hypovolaemia is exacerbated, a decrease in the glomerular filtration rate occurs; subsequently, ischaemia leads to acute kidney injury (Olhovich *et al.*, 2013).

2.4.2 Local Complications

Williams (1994) reported that one of the local complications that occur in acute pancreatitis is the development of extrahepatic bile duct obstruction. This may occur due to physical obstruction of the bile duct, or be functional secondary to localised peritonitis. This condition typically manifests as jaundice 3-7 days after the onset of acute

pancreatitis. Dogs may be systemically well despite the jaundice, or at times this is associated with a deterioration in clinical status.

In most dogs, the jaundice and bile duct obstruction resolves with time (Herman *et al.*, 2005). This may be due to reduction in the size of the pancreas. However, as the pancreas does take weeks to return to normal size, it is more likely to be due to resumption of oral intake, and subsequent gall bladder contraction.

A pancreatic pseudocyst develops at least 6 weeks after an episode of pancreatitis and does not contain an epithelial lining. Its contents are composed of amylase-rich pancreatic secretion, generally occurring in milder cases of acute pancreatitis (Wu and Conwell, 2010). Another late development local complication is a walled off area containing necrotic tissue. In people, this may become a nidus for infection, but in dogs this late onset change is rarely diagnosed.

2.5 Treatment of Pancreatitis in Dogs

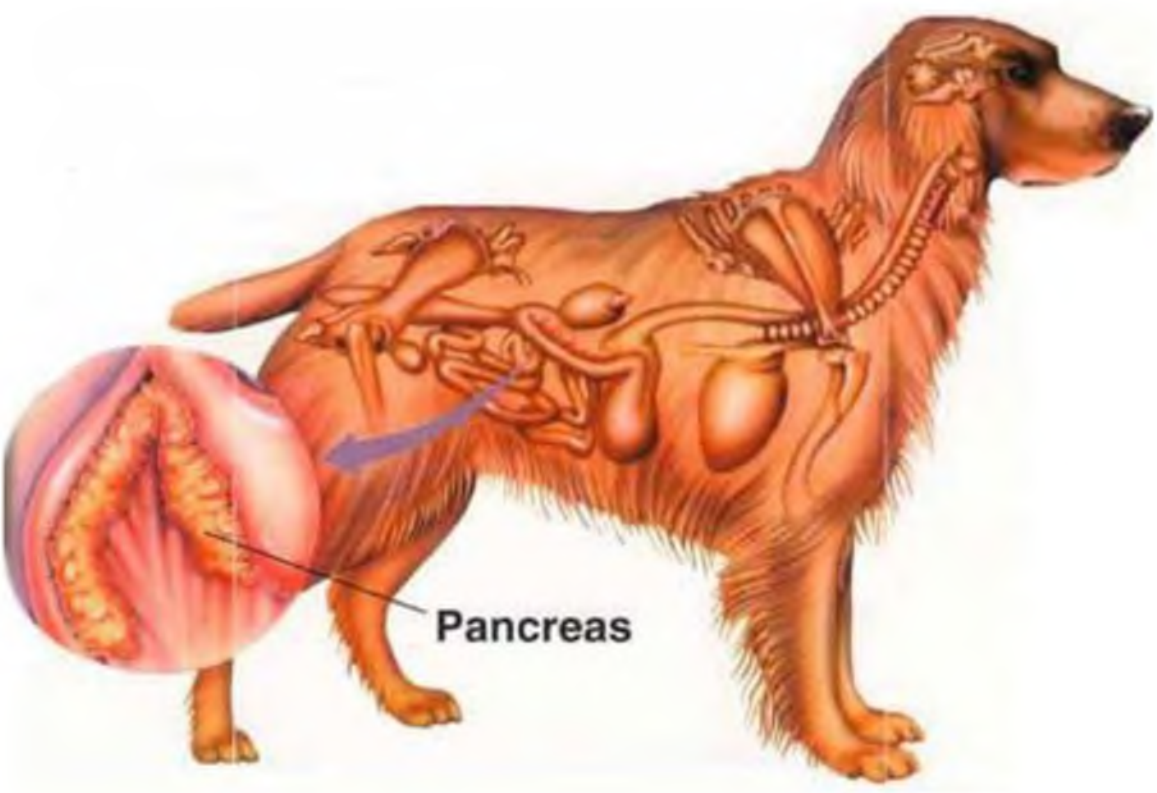
Intravenous fluids are the mainstay of therapy for pancreatitis. Initially fluids should correct dehydration over the first 12–24 hours, while also meeting maintenance needs. The fluid rate should be adjusted frequently to account for ongoing losses (e.g., vomiting, diarrhea and ascites) and to correct fluid, electrolyte and acid-base imbalances. If needed, colloidal support can be given in the form of fresh frozen plasma, hetastarch or dextrans (10–20 mL/kg/day) reports Strombeck (1990).

Analgesic therapy should be considered for abdominal pain in every animal with suspected or confirmed pancreatitis. Although nutritional support for pancreatitis has

been debated in veterinary medicine, human literature recommends nutritional support. In uncomplicated pancreatitis, the vomiting patient can be held on fasting for 24–48 hours with subsequent gradual reintroduction of a low-fat diet when vomiting subsided states Stewart (1994).

According to Carsten (2007), nutritional support can be provided by total parenteral nutrition (TPN) or enteral nutrition (EN). Other potential therapies for pancreatitis include antiemetics, antacids, antibiotics and dopamine. Antiemetics will help control vomiting and allow for earlier EN. Antacids can either be an H2-receptor antagonist (ranitidine or famotidine IV) or a proton-pump inhibitor (pantoprazole IV). Pancreatitis is usually a sterile process in dogs and antibiotics are not indicated. Rarely, antibiotics may be used if a pancreatic abscess is present or there is evidence of bacterial translocation from the gastrointestinal tract. Patient prognosis is guarded in many cases of pancreatitis. However, rapid diagnosis and implementation of appropriate therapy early in the course of disease will reduce patient morbidity and mortality.

Plate 1: Anatomical position of the pancreas in dogs



Materials and Methods

III. MATERIALS AND METHODS

3.1 Materials

3.1.1 Clinical Materials

- Blood: Whole blood from dogs with EDTA for hematology and without EDTA for serum separation was collected by cephalic or saphenous venipuncture.
- Pancreatic tissue sample collected during post mortem examination for histopathology.

3.1.2 Laboratory Materials:

1. Dispovan syringes (2 ml) manufactured by Hindustan Syringes and Medical devices Ltd.
2. Scalp vein sets manufactured by Hindustan Syringes and Medical devices Ltd.
3. K3 EDTA Tube manufactured by J. K. Diagnostics
4. Plain clot Activator tube manufactured by J. K. Diagnostics.
5. Cotton swabs
6. Electric fur clipper
7. Ultrasound machine manufactured by General Electronics.
8. Semi biochemical analyser manufactured by Trivitron Health Care.
9. Fully Automatic Blood Cell Counter, PCE 210, manufactured by Erma INC, Tokyo; marketed by Hospimed Diagnostics, Bengaluru.

10. Centrifuge machine manufactured by Remi.

11. Hot water bath manufactured by Scientek Services, Bangalore.

12. X-ray machine manufactured by Allengers.

13. Micropipette (10-100 µl)

14. Micropipette (100-1000 µl)

15. Micropipette tips (10-100 µl)

16. Micropipette tips (100-1000 µl)

17. Ultrasound paper

18. Tissue roll

19. X-ray film

20. X-ray processing solutions

21. Ultrasound gel

22. 10% Formalin

3.1.3 Diagnostic Materials

1. Creatinine kit from ERBA diagnostics, Germany; marketed by TRANSASIA Biomedicals Ltd., Bengaluru (Plate 2).
2. SGPT kit from ERBA diagnostics, Germany; marketed by TRANSASIA Biomedicals Ltd., Bengaluru (Plate 2).
3. BUN kit from ERBA diagnostics, Germany; marketed by TRANSASIA Biomedicals Ltd., Bengaluru (Plate 2).

4. α-amylase kit from ERBA diagnostics, Germany; marketed by TRANSASIA Biomedicals Ltd., Bengaluru (Plate 2).

5. Snap cPL kits from Idexx Laboratories Inc., Maine (Plate 3).

3.2 Method/s

3.2.1 Selection of cases

A total of 31 dogs presented to the Veterinary College Hospital, Hebbal, between October 2014 and May 2015 were selected for the study.

3.2.1.2 Age

The dogs were divided into four categories based on their age: Puppies (0-1 year), Young adults (2-3 years), Adults (4-7 years) and old dogs (>7 years).

3.2.1.1 Clinical Signs

Dogs were included if they had two or more of the following clinical signs: anorexia, vomiting, acute onset of abdominal pain (< 2 days), diarrhoea and dehydration.

3.2.1.1 Pain Assessment

The Simple Descriptive Scale method of assessing pain was used. Based on abdominal palpation the dogs were categorized into four groups as mentioned below.

Category	Description	Pain Score
No Pain	Dog showed no signs of pain	1
Mild Pain	Abdomen slightly tense on palpation	2
Moderate Pain	Arched back, obvious signs of pain on palpation, reduced appetite	3
Severe Pain	Change in body posture, vocalization and altered reaction to touch.	4

3.2.2 Blood collection

Blood was collected in tubes with and without EDTA by cephalic or saphenous venipuncture within 24 hours of admission as part of the diagnostic investigation. Two ml of blood was collected into plain serum tubes and EDTA tubes from each dog.

The blood in the serum tubes were kept in slanting position for half an hour and then centrifuged at 3000 rpm for 10 minutes. It was transferred to the laboratory and the serum that had separated was pipetted into Eppendorf tubes using a micropipette and stored at 4°C until further use.

3.2.2.1 Hematological Analysis

Blood collected in EDTA vacutainers were analyzed for Total Leukocyte Count, Hemoglobin and Platelet Count using the automated blood cell analyzer within 30 minutes of collection and the values were recorded.

3.2.2.2 Biochemical Analysis

Serum was analyzed for biochemical parameters namely serum Creatinine, SGPT, Blood Urea Nitrogen and α- amylase within 24-48 hours. Serum Creatinine was

estimated using Modified Jaffe's Kinetic Method. SGPT was estimated using the method proposed by the International Federation of Clinical Chemistry. BUN was estimated using the method described by Talke and Schubert. For the measurement of α- amylase 2-Chloro-4-nitrophenol-β-1-4 galactopyranosylmaltotrioside (CNP-G) was used. It is a direct substrate for determination of α-amylase activity, which does not require the presence of ancillary enzymes. The rate of 2-chloro-4-nitrophenol formation can be monitored at (400-420) nm and is proportional to the α-amylase activity

3.2.2.3 SNAP cPL detection

Serum was used for canine pancreatic lipase detection using the SNAP-cPL test kits. The storage of the SNAP cPL (SNAP cPL Test Kit, Idexx Laboratories Inc., Westbrook, ME) kits, sample handling and testing procedure was followed according to manufacturer's instructions (Packet Insert, Idexx Laboratories Inc., Westbrook, ME). The test kit uses anti-chicken: HRPO/anti-cPL: HRPO conjugate to detect the cPL levels in the serum sample.

Test Procedure of SNAP-cPL:

- All the components were allowed to equilibrate at room temperature (18-25°C) for at least 30 min.
- 3 drops of sample was dispensed into a sample tube.
- To this 4 drops of conjugate was added.
- The tube was capped and mixed thoroughly by inverting 4-5 times.
- The entire tube contents are added to the sample well.

- When the colour first appears in the activation circle the activator is firmly pushed.
- Test results are read after 10 min from the time of activation.
- The result is positive when the colour intensity of the sample spot is equal to or more than the reference spot.
- The result is negative if the colour intensity of the sample spot is less than the reference spot.

3.2.3 Ultrasonography

- Patient was placed on the scanning table on dorsal recumbency.
- Scanning area was prepared by clipping the fur from the last intercostal space caudally till the groin region.
- Ultrasound gel was applied on the cranial mid-abdominal region.
- Pancreas was located by first identifying the stomach and duodenum and then scanned using high frequency transducers (7-10 MHz) which provides good penetration.
- Size and echogenicity of the pancreas was examined and the images stored.

3.2.4 Radiography

- X-ray film of size 8x10 was prepared and labeled accordingly.
- Patient was placed on the radiography table over the x-ray film on ventro-dorsal or lateral recumbency.
- Radiograph was taken and processed.

3.2.5 Histopathology

- Patients who succumbed were subjected to post mortem examination.
- A 2x3cm section of the pancreas was collected in 10% Formalin and subjected to histopathology.
- The tissue samples were fixed in 10% neutral buffered formalin, routinely processed, and embedded in paraffin.
- Four-micrometer sections were stained with hematoxylin and eosin stain and examined under oil immersion microscope.

3.2.6 Statistical Analysis

Results were analyzed by prism pad 5 software. Different diagnostic tests were compared for their efficacy in diagnosing pancreatitis in dogs.

Plate 2: Reagents used for Serum biochemical analysis- From left to right: SGPT, Creatinine, α-amylase and BUN reagents from ERBA Diagnostics

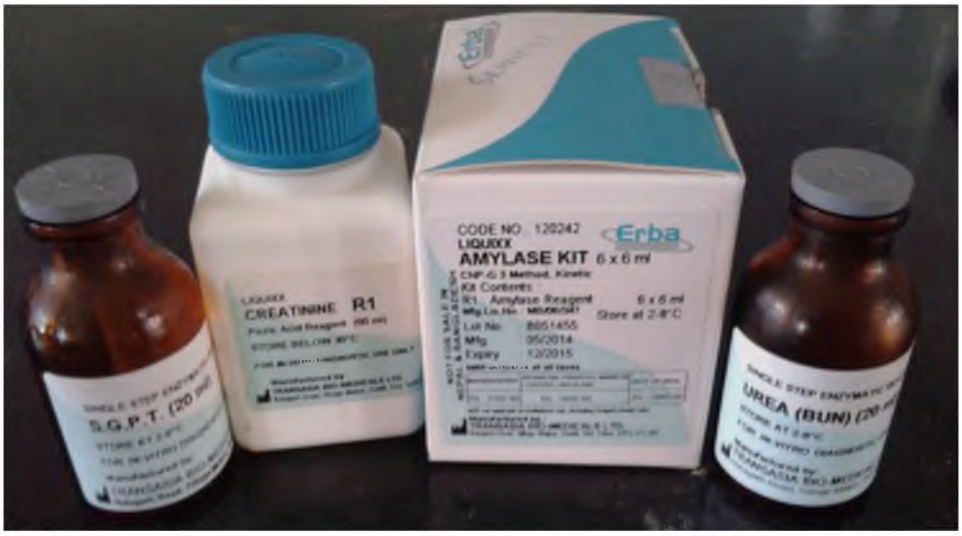


Plate 3: SNAP-cPL kits from Idexx Laboratories, Maine

Results

IV. RESULTS

The results of the current study have been outlined below.

A total of 31 dogs with a history suspected of pancreatitis were included in the study. The age, breed, gender, clinical signs, hematological and biochemical values of these dogs have been recorded in Appendix 1. Based on the clinical signs, hematology, biochemistry, ultrasonography, radiology and Snap cPL test kits fourteen cases were found to be positive for pancreatitis. In the present study, the overall occurrence of pancreatitis among the 31 cases was 45.16%.

4.1 Occurrence of Pancreatitis

The age, breed and gender of these fourteen positive cases of pancreatitis have been depicted in Table 1.

4.1.1 Age-wise occurrence of pancreatitis

Of the fourteen cases diagnosed with pancreatitis, the age of the dogs ranged from one to fourteen years. From Table 2 it can be observed that eight of the dogs (57.15%) were of more than seven years of age, five were adults in the age group of three to seven years (35.71%) and one dog was between one to two years (7.14%).

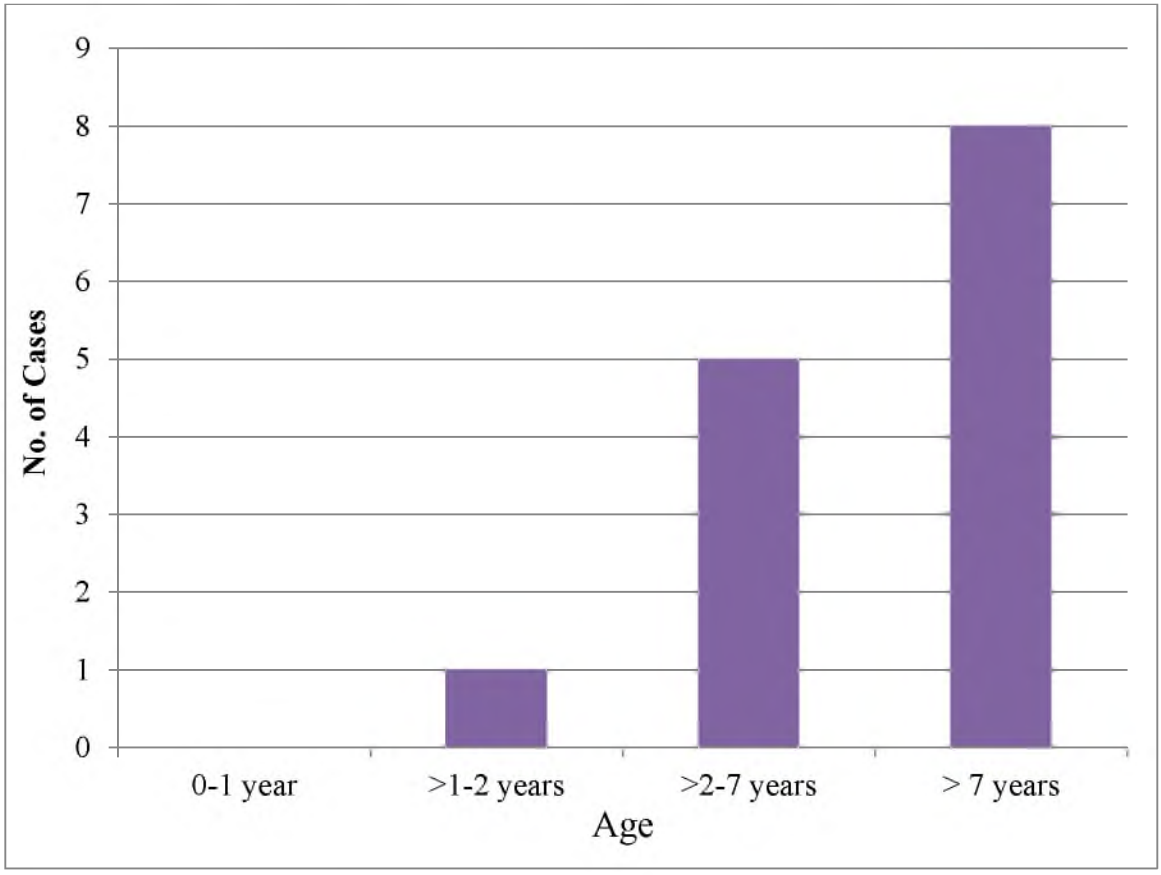
Table 1: Age, Breed and Gender of dogs with pancreatitis (n=14)

Sl. No.	Age	Breed	Gender
1	8 yrs	Irish Setter	M
2	4 1/2 yrs	Boxer	M
3	8 yrs	German Shepherd	M
4	5 yrs	Rottweiler	M
5	3 yrs	German Shepherd	F
6	1 yr	Non descript	M
7	4 yrs	Pomeranian	M
8	6 yrs	Pomeranian	M
9	9 yrs	Dalmatian	F
10	9 yrs	Golden Retriever	M
11	14 yrs	Pomeranian	M
12	9 yrs	Basset Hound	F
13	8 yrs	Labrador Retriever	M
14	12 yrs	Non descript	M

Table 2: Age-wise occurrence of pancreatitis in dogs (n=14)

Category	Age	No. of Dogs	Percentage
Puppy	0-1 year	0	0
Young Adult	>1-2 years	1	7.14%
Adult	>2-7 years	5	35.71%
Old dog	> 7 years	8	57.15%

Figure 1: Age-wise occurrence of pancreatitis in dogs (n=14)



4.1.2 Breed-wise occurrence of pancreatitis

It can be seen from Table 3 and Fig. 2 that clinical cases of the dogs diagnosed as pancreatitis belonged to the following breeds- Pomeranians (3), German Shepherds (2), Non-descript breeds (2) and one each of Irish Setter, Boxer, Rottweiler, Dalmatian, Golden Retriever, Labrador Retriever and Basset Hound.

4.1.3 Gender-wise occurrence of pancreatitis

From Table 1 and Fig. 3 it is evident that among the fourteen dogs which tested positive for pancreatitis based on the Snap cPL tests, eleven dogs (78.57%) were males and three were females (21.43%).

4.2 Clinical Signs exhibited by dogs with Pancreatitis

Prominent clinical signs observed in the fourteen positive cases were anorexia in fourteen dogs (100%), vomiting in eleven (78.54%), weight loss in eight (57.14%), diarrhoea in five (35.71%), ascites in two (14.28%) and dehydration in one (7.14%) as seen in Table 4 and Fig. 4.

4.2.1 Pain Score of dogs with Pancreatitis

Pain score (Table 5 and Fig. 5) as assessed by the SDS method was as follows- Six of the dogs showed no signs of pain (42.85%), while four dogs showed signs of mild pain (28.57%), two dogs had moderate pain (14.28%) and two dogs had severe pain (14.28%).

Table 3: Breed-wise occurrence of pancreatitis in dogs (n=14)

Sl. No.	Breed	No. of Dogs	Percentage
1	Pomeranian	3	21.42%
2	Non-descript	2	14.29%
3	German Shepherd	2	14.29%
4	Rottweiler	1	7.14%
5	Irish Setter	1	7.14%
6	Boxer	1	7.14%
7	Dalmatian	1	7.14%
8	Golden Retriever	1	7.14%
9	Basset Hound	1	7.14%
10	Labrador Retriever	1	7.14%

Figure 2: Breed-wise occurrence of pancreatitis in dogs (n=14)

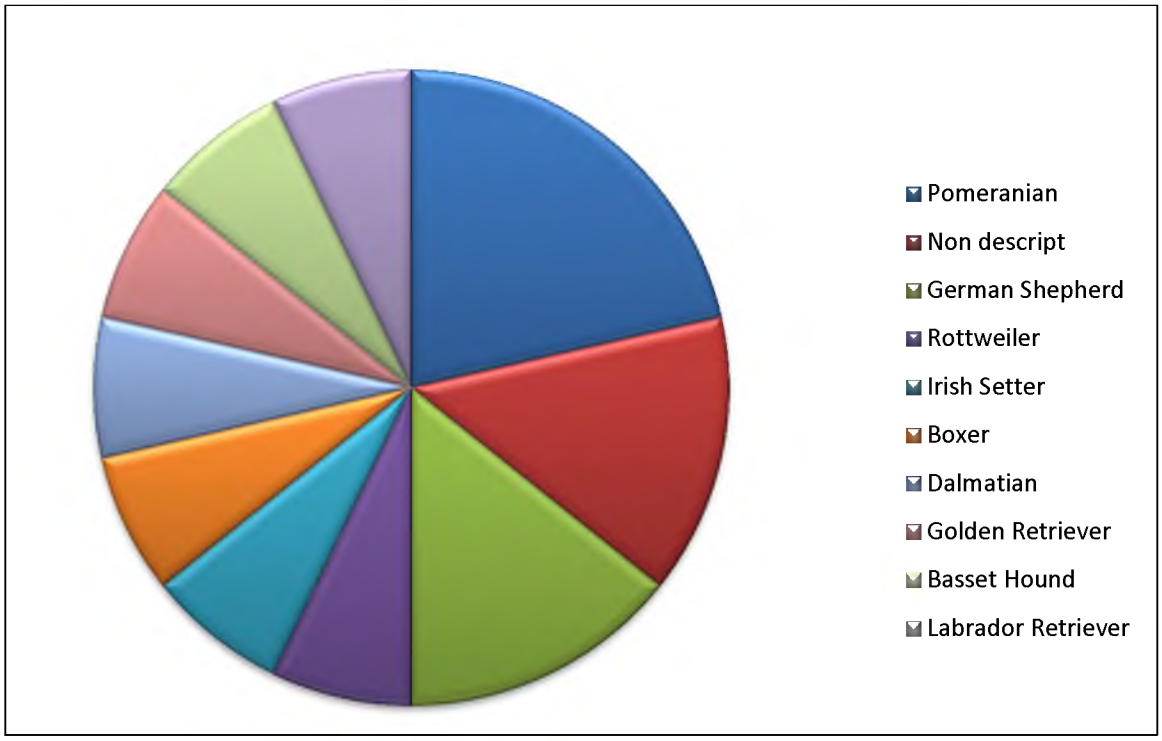


Figure 3: Gender-wise occurrence of pancreatitis in dogs (n=14)

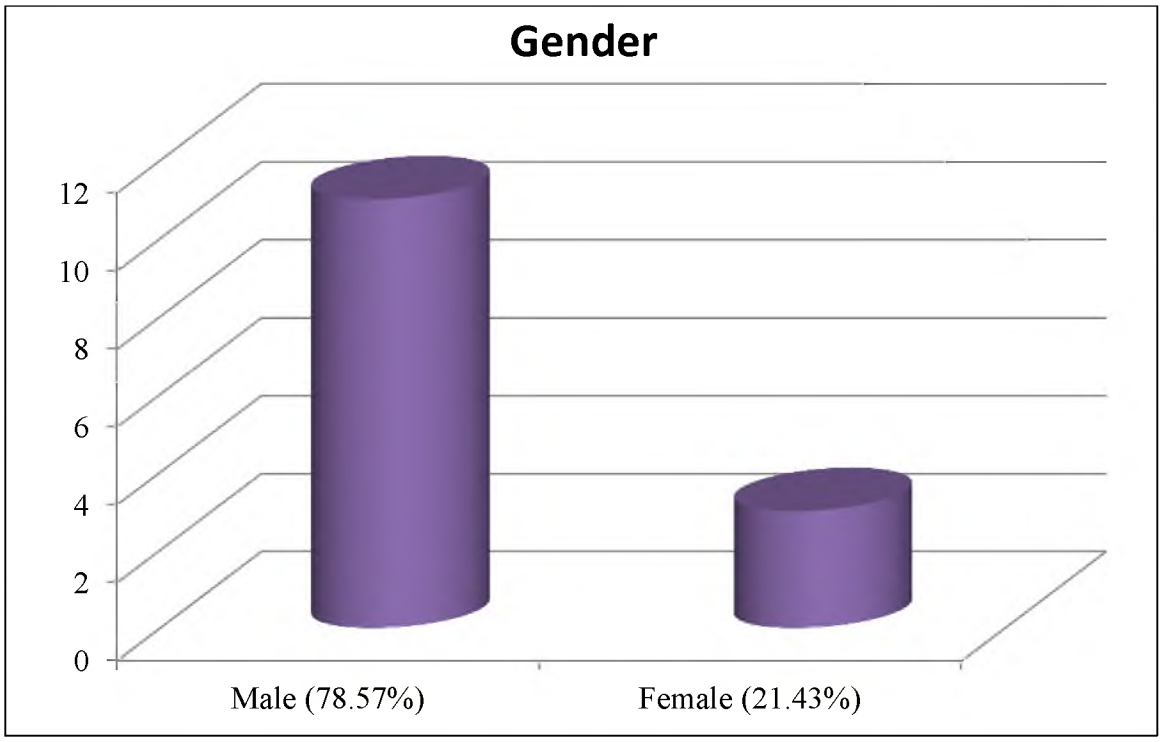


Table 4: Clinical signs exhibited by dogs with pancreatitis (n=14)

Clinical Signs	No. of Dogs	Percentage
Anorexia	14	100%
Vomiting	11	78.54%
Weight loss	8	57.14%
Diarrhoea	5	35.71%
Ascites	2	14.28%
Dehydration	1	7.14%

Figure 4: Clinical signs exhibited by dogs with pancreatitis (n=14)

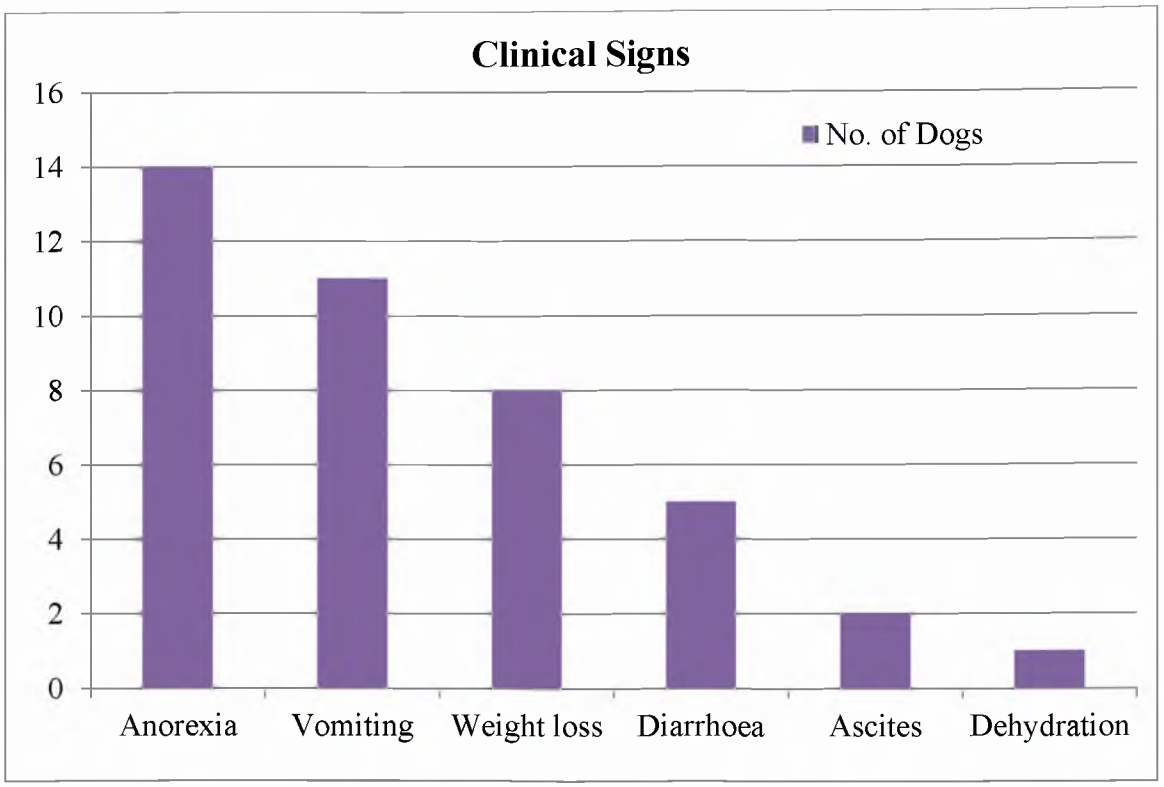
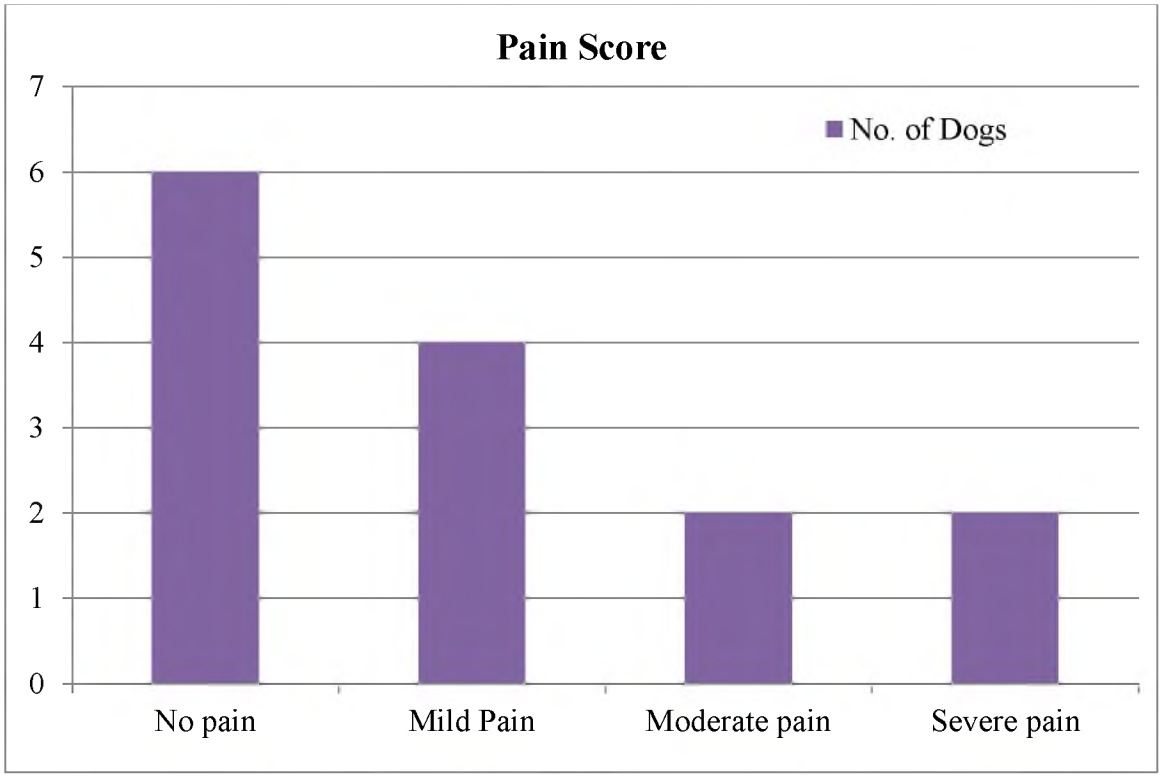


Table 5: Pain score of the dogs with pancreatitis (n=14)

Category	Pain Score	No. of Dogs	Percentage
No pain	1	6	42.85%
Mild Pain	2	4	28.75%
Moderate pain	3	2	14.28%
Severe pain	4	2	14.28%

Figure 5: Pain score of dogs with pancreatitis (n=14)



4.3 Hematological values of dogs with Pancreatitis

The hematological values of all the 31 cases have been depicted in Appendix 2, while the values of the dogs with pancreatitis have been tabulated in Table 6.

4.3.1 TLC of the dogs with pancreatitis

The Mean ± SE for leukocyte values of the pancreatitis cases was 15,300 ± 2620/µl. The values ranged from 5,500/µl to 42,200/µl. Five of the dogs showed leucocytosis (35.71%). Among these two dogs had mild leucocytosis, two dogs had moderate leucocytosis and one dog had severe leucocytosis.

4.3.2 Hemoglobin values of the dogs with pancreatitis

The Mean ± SE of the pancreatitis cases was 12.3 ± 1.07. The Hemoglobin values ranged from 2.3 g/dl to 17.6 g/dl as seen in Table 6. Anemia was seen in six of the dogs (42.85%).

4.3.3 Platelet counts in the dogs with pancreatitis

The Mean ± SE of the pancreatitis cases was 288 ± 31.2. The values ranged from $142x10^3$/µl to $515x10^3$/µl. Thrombocytopenia was seen in three of the dogs (21.43%).

4.4 Clinical Biochemistry in dogs with pancreatitis

The Serum Creatinine, SGPT, α-amylase and BUN of the 31 dogs suspected for pancreatitis are listed in Appendix 3, while those of the dogs with pancreatitis has been shown in Table 7.

Table 6: Hematological values of dogs with pancreatitis (n=14)

Sl. No.	Hematology		
	TLC (/µl)	Hb (g %)	PLT ($x10^3$/µl)
1	25,400	10.6	379
2	12,500	17.6	271
3	7,200	10.6	326
4	7,000	13	227
5	12,300	17.2	273
6	42,200	14.1	353
7	15,500	10.1	274
8	18,800	13.7	479
9	7,700	17.3	312
10	5,500	12.7	157
11	20,800	12.7	179
12	19,300	11.5	142
13	9,800	2.3	148
14	9,900	8.6	515
Mean ± SE	15,300 ± 2620	12.29±1.07	288.20±31.18

Table 7: Serum biochemical values of dogs with pancreatitis (n=14)

Sl. No.	Serum Biochemistry			
	Creatinine (mg/dl)	**SGPT (U/l)**	**α-amylase (U/L)**	**BUN (mg/dl)**
1	9.59	35	8076	149
2	1.4	39	8557	38.9
3	18.5	28	8853	23.5
4	1.7	20	5631	25
5	1.4	21	5299	24.1
6	2.6	69	5367	73.8
7	1.2	31	5010	23.7
8	0.6	201	7437	38.9
9	13.4	42	2924	77.5
10	1.5	48	6148	42.9
11	7.3	110	6528	80
12	0.8	50	6611	34
13	9.9	21	8123	71.2
14	20.5	146	9000	74.5
Mean ± SE	6.46±1.85	61.50±14.44	6683±469.80	55.50±9.35

4.4.1 Creatinine levels in the dogs with pancreatitis

Mean ± SE of Creatinine in the cases of pancreatitis was 6.46 ± 1.85. The values ranged from 0.6mg/dl to 20.5 mg/dl. Creatinine levels were increased in eight of the dogs (57.14%) as seen in Table 7.

4.4.2 SGPT levels in the dogs with pancreatitis

Mean ± SE of SGPT in the cases of pancreatitis was 61.5 ± 14.4. The values ranged from 20 to 201 U/L as seen in Table 7. SGPT was increased in three of these dogs (21.42%).

4.4.3 α–amylase levels in the dogs with pancreatitis

α-amylase levels were increased in all the dogs presented. However most authors believe that α-amylase is indicative of pancreatitis only if the levels are more than 3-5 times the upper limit i.e., >3000 U/l. Mean ± SE of α-amylase in the pancreatitis cases was found to be 6680 ± 470. The highest value was 9000U/L and the lowest was 2924 U/L (Table 7). Thirteen out of the fourteen cases of pancreatitis had high amylase values (92.85%).

4.4.4 BUN levels in the dogs suspected of pancreatitis

Mean ± SE of BUN of the pancreatitis cases was found to be 50.4 ± 9.72. The BUN values of the dogs with pancreatitis ranged from 23.25 to 149 mg/dl. The BUN was increased in ten dogs (71.42%). Of these nine dogs had pre renal azotemia and one dog had renal azotemia.

4.4.5 Snap cPL Test of the dogs suspected for pancreatitis

Serum samples from thirty one dogs were used to conduct the Snap cPL test. Fourteen (45.16%) of the cases were positive as indicated by the increase in the colour intensity of the sample spot (Plates 4, 5 and 6) and seventeen (54.84%) were negative as indicated by the reduced colour intensity of the sample spot (Plates 7 and 8).

4.5 Ultrasonographic Findings in dogs with Pancreatitis

Abdominal ultrasonography was conducted on 29 of the 31 dogs and evidence of pancreatitis was seen in four of the cases (12.90%). Among the fourteen confirmed cases of pancreatitis three of the cases showed ultrasonographic changes suggestive of pancreatitis (21.42%).

Of the four dogs which showed signs of acute pancreatitis, three of the dogs had hypoechoic pancreas surrounded by hyperechoic mesentry (Plates 6, 7 and 8), while one dog had enlarged irregular pancreas (Plate 9).

The other ultrasonographic changes observed were hepatomegaly in three of the dogs, hepatic fibrosis in one dog, ascites in two dogs, splenomegaly in one dog, cystoliths in one dog and pyometra in one dog. The remaining dogs showed no ultrasonographic abnormalities.

4.6 Radiographic Findings in dogs with Pancreatitis

Abdominal radiographs were taken for five of fourteen confirmed cases of pancreatitis. Of these, three dogs had radiographic abnormalities suggestive of

pancreatitis. Two of the dogs had gas filled intestinal loops (Plates 10 and 11); while one dog had a cranial mass effect along with displaced gas filled duodenal loops (Plate 12).

4.7 Histopathologic Findings in dogs with Pancreatitis

Post mortem was conducted on one of the dogs. Grossly the pancreas showed white necrotic foci with congestion (Plate 13). Histopathology revealed pancreatic acini of normal histology amidst which was shown pancreatic adenoma composed of benign tumor cells arranged in glandular pattern. The tumor cells were round to uniform in shape with mild pleomorphism and scanty cytoplasm. Interspersed areas showed fibrosis and focal congestion.

4.8 Comparison of Snap cPL and α-amylase:

Of the 23 cases where α-amylase levels were increased, thirteen were positive and ten were negative (Table 8). One dog had normal α-amylase level but was positive for Snap cPL. Seven of the cases were true negative. Sensitivity of α-amylase was found to be 92.85% while the specificity was 58.82%.

4.9 Comparison of Snap cPL and Creatinine:

Of the 31 cases, Creatinine level was increased in twelve of the cases and normal in nineteen dogs. Among the twelve cases eight were positive for Snap cPL. Thirteen of the cases were negative for Snap cPL and had normal Creatinine levels (Table 9). Sensitivity of Creatinine for pancreatitis was found to be 57.14% and specificity was 23.52%.

Figure 6: Results of the Snap cPL test in all the suspected cases of pancreatitis (n=31)

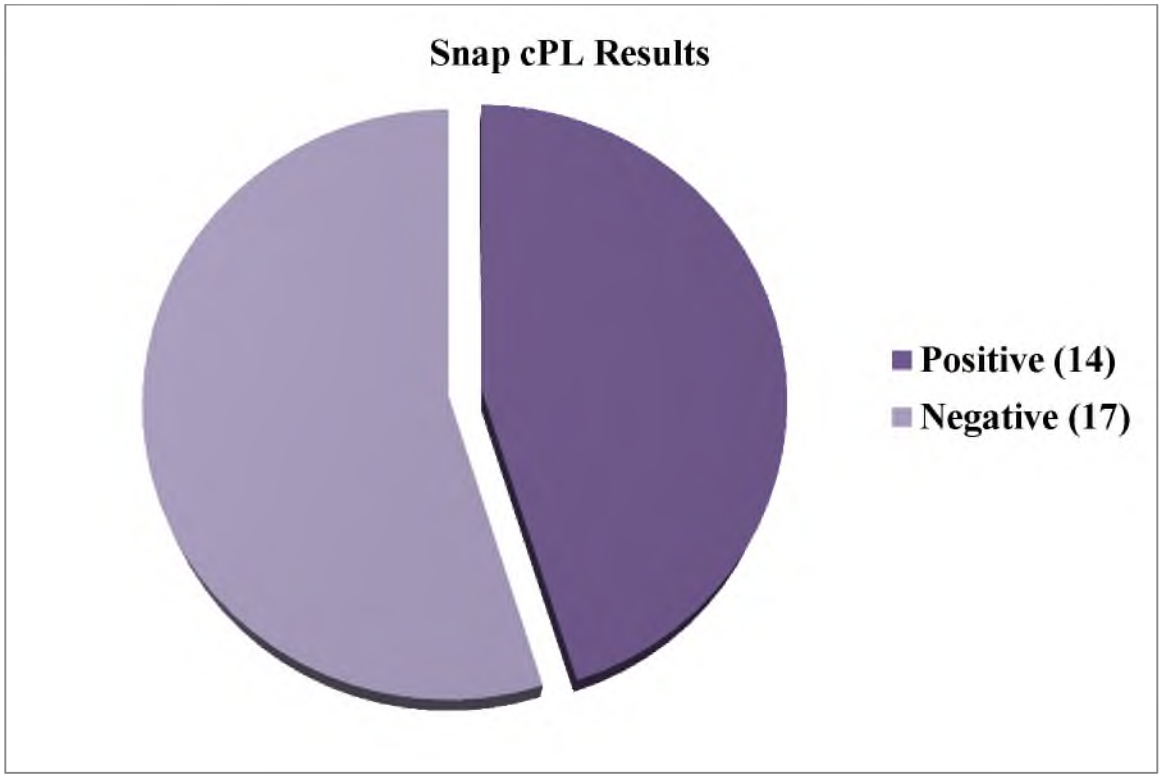


Table 8: Comparison of Snap cPL and α-amylase in dogs suspected for pancreatitis (n-=31)

SNAP cPL / α-amylase	Positive	Negative
Increased	13	10
Normal	1	7

Table 9: Comparison of Snap cPL and Creatinine in dogs suspected for pancreatitis (n-=31)

Snap cPL Test / Creatinine Test	Positive	Negative
Increased	8	4
Normal	6	13

Plate 4: Positive SNAP-cPL test

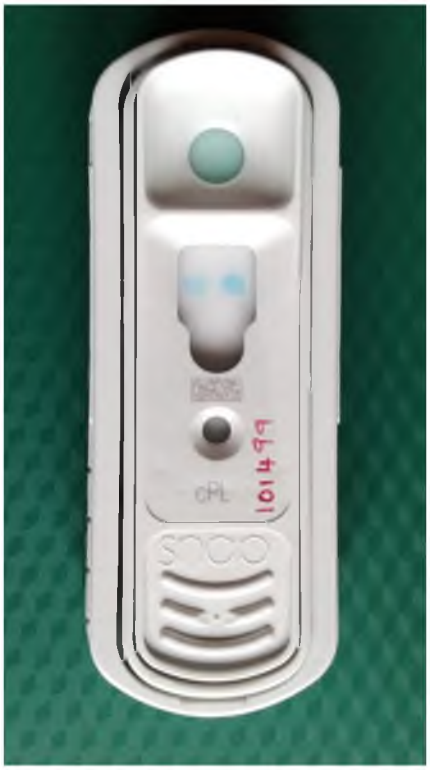


Plate 5: Negative SNAP-cPL Test

Plate 6: Enlarged hypoechoic left limb of the pancreas in a 3 year old male Terrier with a history of vomiting and anorexia

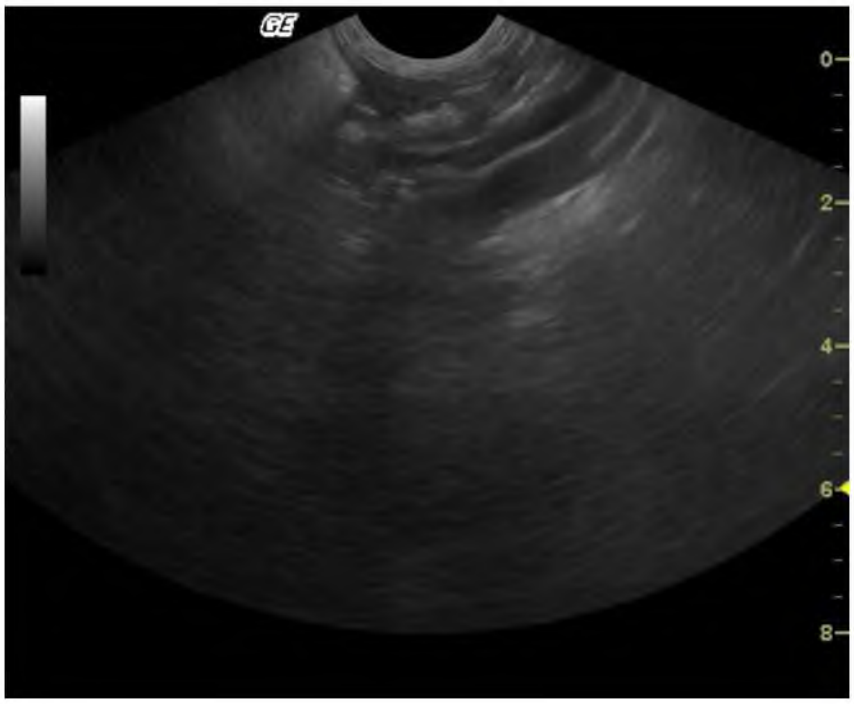


Plate 7: Hypoechoic left limb of the pancreas seen just caudal to the duodenum and surrounded by hyperechoic mesentry in a 6 year old Pomeranian with anorexia and very severe abdominal pain

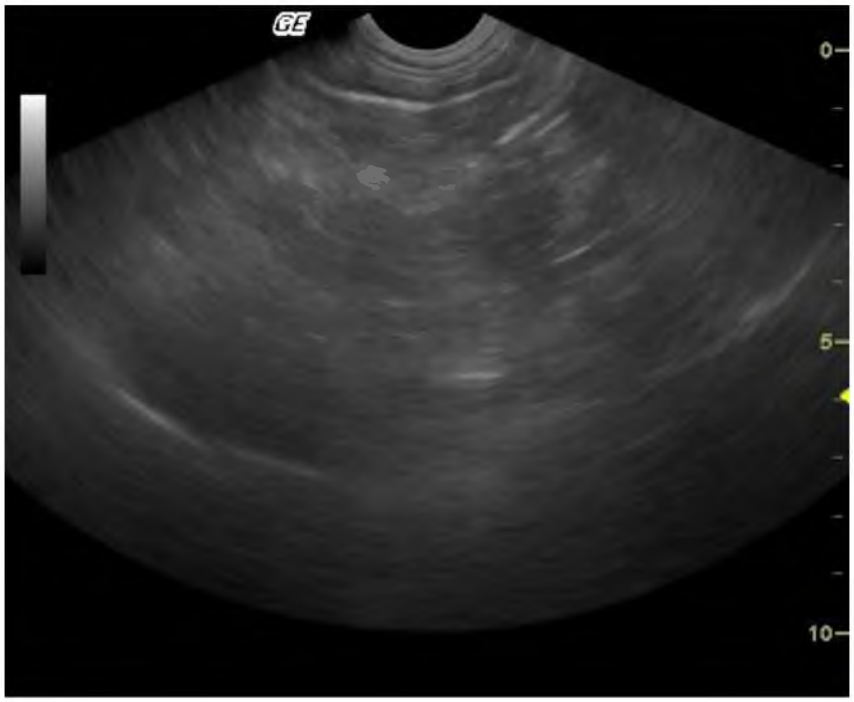


Plate 8: Hypoechoic pancreas seen just caudal to the duodenum and surrounded by hyperechoic mesentry in a 9 year old ND dog with continuous vomiting and diarrhoea for 2 weeks

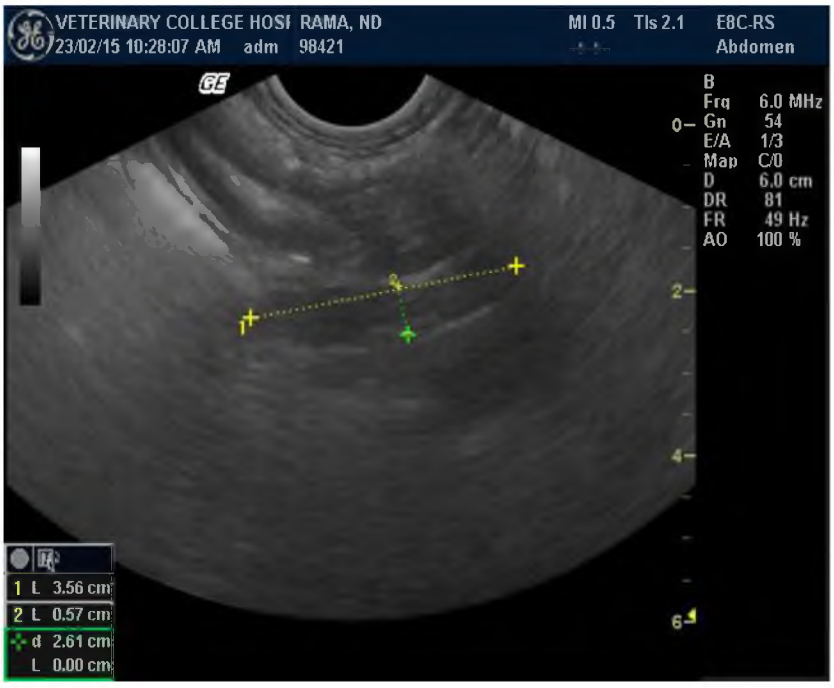


Plate 9: Hyperechoic enlarged pancreas with an irregular border seen within the duodenal loop in a 9 year old Basset Hound with lethargy, anorexia and weight loss for 3 weeks

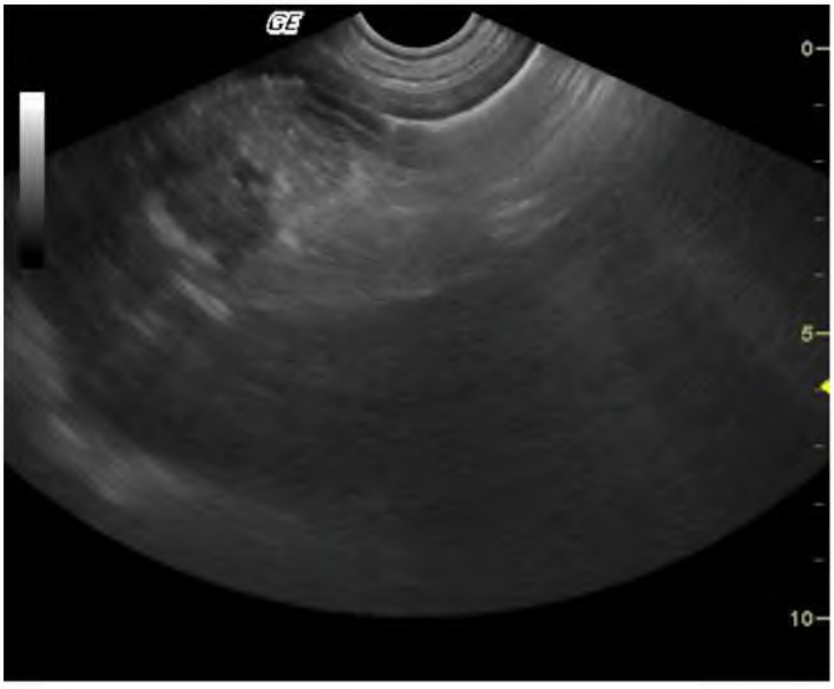


Plate 10: Lateral abdominal radiograph of a 5 year old male Rottweiler with vomiting and diarrhoea. Radiograph reveals gas filled intestines

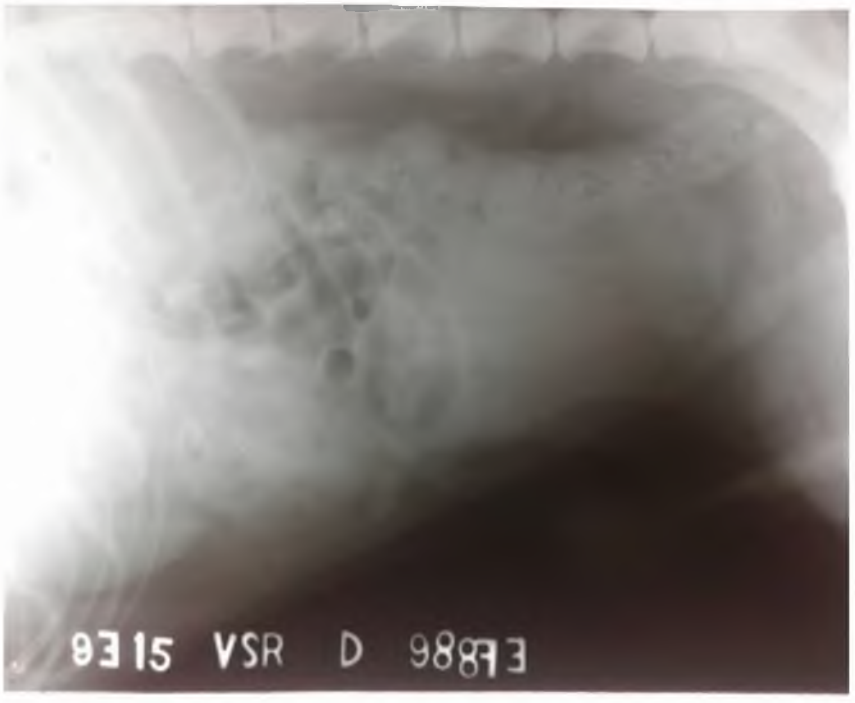


Plate 11: Lateral abdominal radiograph of a 9 year old ND dog with continuous vomiting and diarrhoea for 2 weeks. Radiograph reveals gas filled intestinal loops

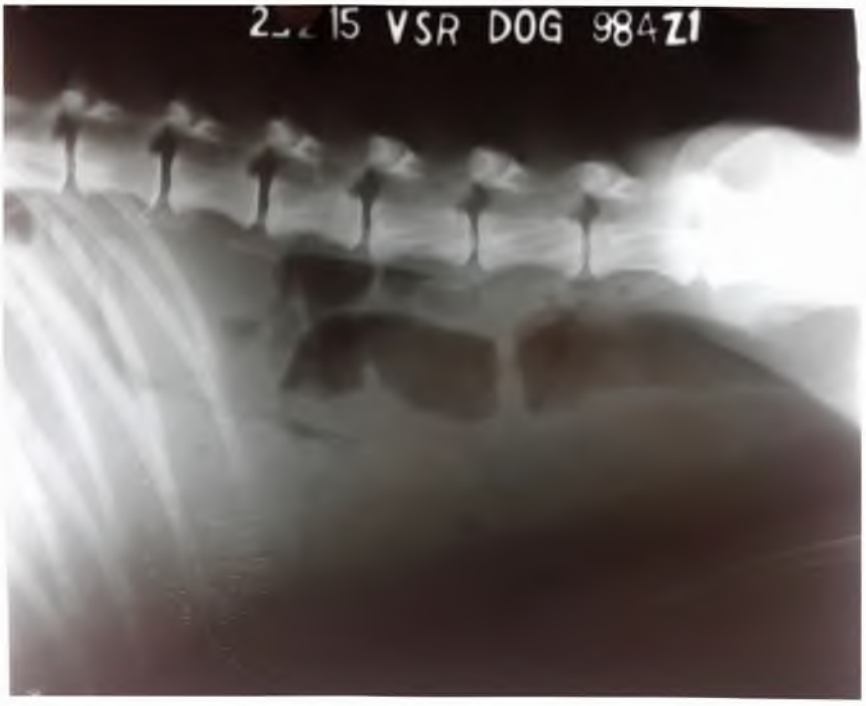


Plate 12: Displaced gas filled duodenal loop with a cranial mass effect seen in a 9 year old Basset Hound.

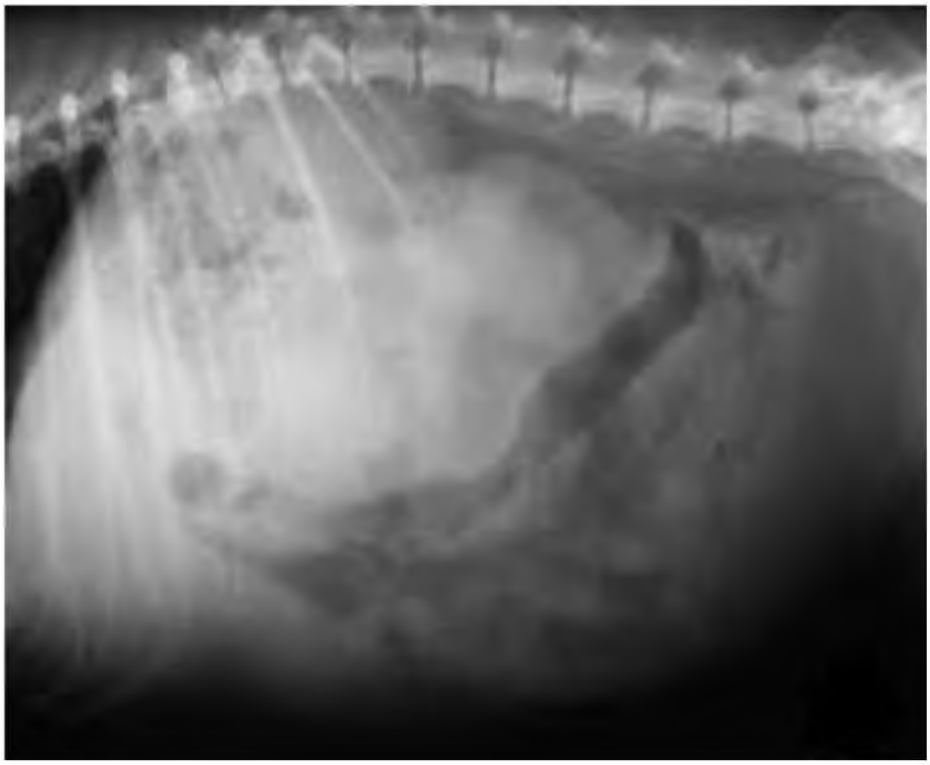
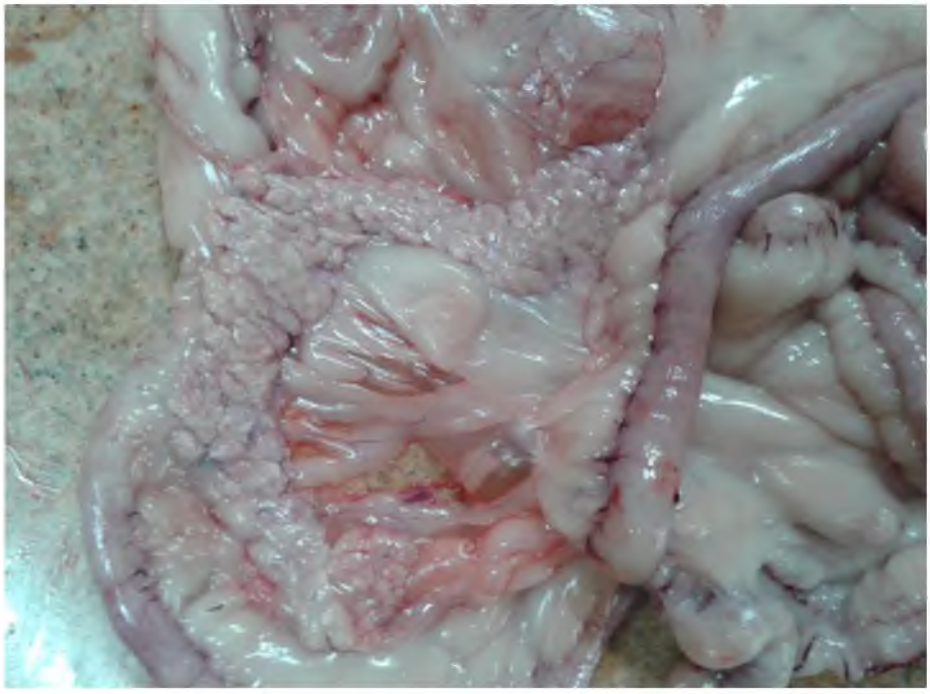


Plate 13: Areas of necrotic foci and congestion in a dog with pancreatitis



Discussion

V. DISCUSSION

A total of 31 dogs brought to the Veterinary College Hospital, Bangalore with a history of vomiting, anorexia, diarrhoea and dehydration suspected of pancreatitis were included in the present study. The dogs were subjected to a CBC, serum biochemistry, ultrasonography, radiography and SNAP cPL tests. Based on the results of these tests fourteen of the dogs were diagnosed with pancreatitis.

5.1 Occurrence of Pancreatitis

In the present study, the overall occurrence of pancreatitis among the 31 suspected cases was 45.16%. This is in accordance with the findings of Hess *et al.* (1999) who indicated that 47% of the dogs had pancreatitis in their study. Further earlier reports by Hess *et al.* (*loc. cit.*) indicated that pancreatitis was seen in dogs of the age group between five to nine years and the occurrence was 47.16%. In the current study, the classification of age was puppy category (0-1 year), young adult (>1-3 years), adults (>3-7 years) and old dogs (>7 years). The age of the dogs ranged from one to 14 years. Majority of the cases (8) consisted of dogs more than seven years (57.15%) of age. Five of the dogs were adults (35.71%) and one dog was between one to two years (7.14%) as outlined in Table 2.

In the current study, pancreatitis was recorded in the following breeds- Pomeranians (3), German Shepherds (2), Non-descript breeds (2) and one each of Irish Setter, Boxer, Rottweiler, Dalmatian, Golden Retriever, Labrador Retriever and Basset Hound (Fig. 2); which indicated that Pomeranians were more commonly affected, followed by German Shepherds and Non-descript breeds. However Hess *et al.* (*loc. cit.*)

reported that Yorkshire Terriers were at increased risk, whilst Labrador Retrievers and Miniature Poodles were at decreased risk of developing pancreatitis. Similarly Cook *et al.* (1993) reported that Miniature Schnauzers, Miniature Poodles and Terriers were at higher risk. Lem *et al.* (2008) and Ruaux and Atwell (1998a) reported that Terriers were at higher risk.

In the present study there were no cases of Miniature Schnauzers, Miniature Poodles and Terriers. The results indicate that there is variation in the occurrence of pancreatitis amongst different breeds and the probable reason for the same could be the preponderance of a particular breed depending on the geographical area/country. These breeds are not popular in this part of the country as indicated by the kind of breeds presented to the Veterinary College Hospital based on the records.

As evident in Fig. 3, the present study indicated the occurrence of pancreatitis to be more in males (78.57%) than in females (21.43%). This corroborates with the findings of Hess *et al.* (1999) who indicated that males had an increased risk of developing pancreatitis than sexually intact females. The current study does not agree with the findings of Akuzawa *et al.* (1993) who stated that gender plays no significant role in canine pancreatitis.

5.2 Clinical signs exhibited by dogs with Pancreatitis

The current study showed anorexia (100%) as the most common clinical sign and was present in all the dogs which were diagnosed with pancreatitis (Table 4). This was followed by vomiting (78.54%) which was present in eleven dogs, weight loss (57.14%) in eight the dogs, diarrhoea (35.71%) in five dogs, ascites (14.28%) in two dogs and

dehydration (7.14%) in one dog. This is in agreement with the findings of Hess *et al.* (1999) who stated that 91% of the dogs had a history of anorexia, 90% had a history of vomiting, 79% had a history of weakness, 59% had abdominal pain and 33% had a history of diarrhea. These findings also coincide with the findings of Yasuda (1998) and Akuzawa *et al.* (1994). However, Steiner *et al.* (2008) stated vomiting as the most common clinical sign (81%), followed by anorexia (59.1%), abdominal pain (45.5%), and diarrhea (36.4%).

These findings indicate that the percentage of occurrence of clinical signs is highly variable in pancreatitis and the signs are not pathognomonic and can only be used as indicators to suspect pancreatitis in dogs. Similar observations have been made by workers like Yasuda (1998) and Akuzawa *et al.* (1994).

5.2.1 Assessment of Abdominal Pain in dogs with Pancreatitis

Based on the SDS method, in the current study, eight dogs (57.15%) showed signs of pain on abdominal palpation (Table 5, Fig. 5). Among these eight dogs, four dogs (28.57%) showed signs of mild pain, two dogs (14.28%) moderate pain and two dogs severe pain (14.28%). These findings are similar to observations made by Hess *et al.* (1999) who reported the pain as 59% in dogs. However Steiner *et al.* (2008) reported that 45.5% of the dogs had abdominal pain. The variation in the observations on pain could be due to the fact that assessing pain is dependent on the observer and vary from person to person.

5.3 Hematological findings in dogs with Pancreatitis

A complete blood count was performed on all the dogs selected for the study (Appendix 2).

The Leukocyte count of the pancreatitis dogs ranged from $5.5x10^3/\mu l$ to 42 $x10^3/\mu l$ as evident from Table 6. The Mean ± SE of the positive cases was 15,300 ± 2,620. There was no statistically significant difference in the TLC values in the cases of pancreatitis as compared to the standard values (6-17 $x10^3/\mu l$, Bentick, 1983). However five (35.71%) of the pancreatitis dogs showed leucocytosis and of these two dogs had mild leucocytosis, two had moderate and one dog had severe leucocytosis.

Of the total 31 cases, 17 being negative, the TLC ranged between $5.5x10^3/\mu l$ to 42 $x10^3/\mu l$ and 10 dogs had Leucocytosis (Appendix 2). Among these two dogs had mild leucocytosis, seven had moderate and one dog had severe leucocytosis. The Leucocytosis observed in the present study appears like an associative finding rather than a primary change in pancreatitis. There is paucity of information as regards the TLC in pancreatitis.

The Mean ± SE of Hemoglobin in pancreatitis cases was 12.3 ± 1.07 and it ranged from 2.3 to 17.6 g/dl (Table 6). There was no statistically significant difference in the Hemoglobin values in the pancreatitis cases as compared to the standard value (12-18 g/dl, Bentick, *loc. cit.*). Among the positive cases, the Hemoglobin values ranged from 2.3 g/dl to 17.6 g/dl. However six dogs (42.85%) showed anemia and the values ranged from 2.3 to 11.5 g/dl. Of the total 31 cases, 14 dogs showed signs of anemia and their values ranged from 2.3 g/dl to 11.5 g/dl.

The non-significant difference observed in the Hemoglobin values in the cases of pancreatitis, though there have been severe cases of anemia, may probably be because of severe dehydration which could have compromised the Hemoglobin value.

The Mean of the Platelet counts of the pancreatitis cases was 288 $x10^3 \pm$ 31.2 $x10^3$ and the values ranged from 142$x10^3$/µl to 515$x10^3$/µl (Table 6). There was no statistically significant difference in the Platelet count in the pancreatitis cases as compared to the standard value (175-500 $x10^3$/µl, Bentick, 1983). However three cases (21.43%) showed thrombocytopenia and the values ranged from 142 $x10^3$/µl to 157 $x10^3$/µl. Of the total 31 cases, six of the dogs showed thrombocytopenia and their values ranged from 65 $x10^3$/µl to 157 $x10^3$/µl.

In the current study based on these findings, it can be construed that Leucocytosis was observed in 35.71% of the cases, anemia in 42.85% and thrombocytopenia in 21.43%. These findings coincide with the findings of Olhovich *et al.* (2013) and Akuzawa *et al.* (1994) who indicated Leucocytosis, anemia and thrombocytopenia in their study. However these findings are non specific and therefore are of non-diagnostic significance for pancreatitis as indicated by Xenolius (2015) and Watson *et al.* (2010).

5.4 Clinical Biochemistry in dogs with pancreatitis

It can be observed from Table 7 that the Creatinine values ranged from 0.6mg/dl to 20.5 mg/dl with a Mean of 6.46 ± 1.85 as compared to the normal (0.5-1.4 mg/dl, Kaneko *et al.,* 2008) thus indicating that these pancreatitis cases were associated with renal failure. Though there was an overall increase in the Mean Creatinine value in the

present study, eight dogs (57.14%) had higher values and six (42.86%) were within the normal range.

Of the total 31 cases, 12 of the dogs showed increased Creatinine levels and their values ranged from 1.5 to 20.5 mg/dl.

Mean of BUN in the pancreatitis dogs was found to be 50.4 ± 9.72 and the values ranged from 23.25 to 149 mg/dl. This indicates that increased BUN may be associated with renal failure, hepatic failure or pancreatitis. The BUN was increased in ten dogs (71.42%) when compared to the standard values (10-28 mg/dl, Kaneko *et al.*, 2008). Of these nine dogs had pre renal azotemia and one dog had renal azotemia.

Of the total 31 cases, 20 of the dogs showed increased BUN levels and their values ranged from 31 to 149 mg/dl. Of these 19 dogs had pre renal azotemia and one dog had renal azotemia.

Azotemia in dogs suffering from pancreatitis frequently results from dehydration and hypovolemia (prerenal) or occasionally from renal damage due to acute renal failure. Sherding *et al.* (2005) noted that around 50-60% of the cases of pancreatitis had increased urea and Creatinine levels. These findings correlate with the findings in the present study.

Mean of SGPT in the pancreatitis cases was 61.5 ± 14.4 and the ranged from 20 to 201 U/L. There was no statistically significant difference between the SGPT values the of pancreatitis dogs with that of the standard (21-102 U/L, Kaneko *loc. cit.*). SGPT was increased in three of these dogs (21.42%).

Of the total 31 cases, SGPT was increased in five of the dogs and the values ranged from 110-313 U/L.

Hepatocellular enzymes were said to increase in 61% of pancreatitis cases (Sherding *et al.*, 2005). Elevated liver enzymes can result from hepatocellular damage due to ischemia, sepsis or toxins from the pancreas and biliary obstruction. However in the present study the sensitivity of SGPT as an indicator for pancreatitis was only 21.42%.

α-amylase levels were increased in all the dogs presented. However most authors (Olhovich *et al.*, 2013; Hudson *et al.*, 1978; Akuzawa *et al.*, 1994) believe that α-amylase is indicative of pancreatitis only if the levels are more than 3-5 times the upper limit i.e., >3000 U/l. Mean of α-amylase in pancreatitis cases was 6680 ± 470. The values ranged from 2924-9000 U/L. There was significant difference between the α-amylase levels in the pancreatic cases when compared to that of the standard (185-700 U/L; Kaneko, *loc. cit.*). Thirteen out of the fourteen cases of pancreatitis had high α-amylase values (92.85%).

According to a study conducted by Hess *et al.* (1999) only 38% of dogs with pancreatitis had elevated α-amylase levels. Other estimates state that only 15-20% of cases with pancreatitis have normal α-amylase activities (Mansfield and Jones, 2000; Stewart, 1994). The findings in the present study are in contrast with earlier studies and shows a high correlation between pancreatitis and increased α-amylase. This could be due to the fact that several of the cases diagnosed with pancreatitis had concurrent renal failure. As α-amylase is also secreted by the kidneys, presence of a pre-existing kidney

problem may result in a two to threefold increase in α-amylase concentration in blood. This could be the cause of the high sensitivity (92.85%) of α-amylase found in this study.

Of the total 31 cases, 23 (74.19%) had increased α-amylase. Ten of these cases had increased α-amylase but were negative for SNAP-cPL, while 13 cases had increased α-amylase and were positive for SNAP-cPL.

5.4.1 SNAP cPL Tests

Fourteen (45.16%) of the 31 cases (Fig. 13) were positive as indicated by the increase in the colour intensity of the sample spot (Plate 4) and seventeen (54.84%) cases were negative as indicated by the reduced or absence of colour intensity of the sample spot (Plate 7). The use of canine pancreatic lipase in the detection of canine pancreatitis is slowly gaining importance and its use is becoming widespread. Studies have shown that it is one of the best markers identified as it identifies pancreatic lipase originating specifically from the pancreas (Xenolius *et al.*, 2008).

The SNAP cPL kits detect pancreatic lipase of levels more than 200 µg/l. According to a study conducted by McCord *et al.* (2012) dogs with Pancreatic Lipase levels of less than 200µg/l or a negative SNAP-cPL were unlikely to have clinical acute pancreatitis. Furthermore canine pancreatic-specific lipase has been shown to be virtually undetectable in dogs with exocrine pancreatic insufficiency (Steiner *et al.*, 2008). The SNAP-cPL helps to rule out pancreatitis in dogs with acute gastrointestinal signs. Many dogs with acute gastritis, hypoadrenocorticism, renal failure, or other diseases may be present with similar clinical signs.

The advantages of SNAP cPL tests are that it is a patient side semi-quantitative assay which can be conducted in 10 minutes. The kits can be used for individual patients and requires only three drops of serum sample from the patient. Each kit costs around Rs. 1000 to 1300. A negative SNAP-cPL helps the clinician quickly shift the focus of the clinical investigation to other conditions. With the acute nature of the disease and the absence of a correct diagnostic technique acute pancreatitis can put the dog's life in jeopardy. Considering this, SNAP-cPL can be used as a bed side diagnostic test to rule out pancreatitis and to diagnose pancreatitis when cases with GI disturbances are presented with abdominal pain.

5.5 Ultrasonographic Findings in dogs with Pancreatitis

Abdominal ultrasonography was conducted on 29 of the 31 dogs and evidence of pancreatitis was seen in four of the cases (12.90%). Among the fourteen confirmed cases of pancreatitis three of the cases showed ultrasonographic changes similar to that seen in pancreatitis suggesting a sensitivity of 21.42%.

This does not coincide with the findings of Watson *et al.* (2010) who stated that ultrasound examinations have a sensitivity of 56% and Hess *et al.* (1999) who reported a sensitivity of 68% for canine pancreatitis. This is probably due to the fact that the sensitivity of ultrasonographic examinations is operator dependant and the sensitivity increases with the clinical experience of the operator. Specificity of this modality is virtually impossible to determine, as histology would need to be performed in order to establish this. It certainly remains an important component of a diagnostic work-up to evaluate for other abdominal diseases.

Among the four dogs with pancreatic changes, three of the dogs had hypoechoic pancreas surrounded by hyperechoic mesentry (Plates 6, 7 and 8), while one dog had enlarged, irregular pancreas (Plate 9). The ultrasonographic changes seen in these cases correspond to those reported by Hess *et al.* (1999); Hecht and Henry (2007); Kumar *et al.* (2010) and Nyland *et al.* (2002).

The other ultrasonographic changes observed in the 31 cases were hepatomegaly in three, hepatic fibrosis in one, ascites in two, splenomegaly in one, cystoliths in one and pyometra in one dog. The remaining dogs showed no ultrasonographic abnormalities. These findings suggest that when cases are presented with GI disturbances along with abdominal pain, the other diseases that have to be suspected are hepatitis, splenomegaly, cystoliths and pyometra.

5.6 Radiographic Findings in dogs with Pancreatitis

Among the 14 confirmed cases of pancreatitis by SNAP-cPL, five dogs were subjected to radiography and the findings were gas filled intestinal loops (Plates 10 and 11) in two of the dogs, a cranial mass effect along with displaced gas filled duodenal loops (Plate 12) in another dog. The other two dogs did not show any changes in the abdominal radiograph.

These findings indicate that the changes observed on radiography for pancreatitis are non-specific. This corresponds to the findings of Ruaux (2003), Herman *et al.* (2005) and Mansfield (2011) who stated that in most cases of pancreatitis, a subtle loss of contrast in the right cranial quadrant is the only radiographic finding visible and in some cases the radiographs will be normal.

5.7 Histopathologic Findings in dogs with Pancreatitis

Post mortem was conducted on one of the dogs. Grossly the pancreas showed white necrotic foci with congestion (Plate 13) which is similar to the findings of Trivedi *et al.* (2011). Histopathology of the pancreas revealed pancreatic acini of normal histology amidst which was shown pancreatic adenoma composed of benign tumor cells arranged in glandular pattern. The tumor cells were round to uniform in shape with mild pleomorphism and scanty cytoplasm. Interspersed areas showed fibrosis and focal congestion. The dog also had shrunken, fibrosed, firm kidneys suggestive of Chronic Renal Failure.

5.8 Comparison of different diagnostic tests:

Of the 31 suspected cases; α-amylase was increased in 23 (74.19%) dogs, SNAP cPL was positive for 14 (45.16%) dogs and ultrasonographic changes were seen in three dogs (21.42%). Based on literature, SNAP-cPL being a gold standard for pancreatitis, it can be construed that 45.16% of the dogs had pancreatitis whereas based on α-amylase it indicated the occurrence to be 74.19% in the current study.

Of the 23 cases where α-amylase levels were increased, thirteen were positive for SNAP-cPL and ten were negative for pancreatitis. One dog which had normal α-amylase level was positive for SNAP cPL. Sensitivity of α-amylase was found to be 74.19%.

Of the 31 cases, Creatinine level was increased in twelve of the cases and were normal in nineteen dogs. Among the twelve cases eight were positive for SNAP cPL. Thirteen of the cases were negative for SNAP cPL and had normal Creatinine levels.

Sensitivity of Creatinine for pancreatitis was found to be 57.14% and specificity was 23.52%.

There is a relationship between pancreatitis and renal insufficiency. Acute renal failure is a well known complication of acute pancreatitis in humans and many studies have shown this to be true in dogs as stated by (Wang *et al.* 2009). The complications of renal failure may be because of either hypovolemia which could be due to dehydration and anorexia or renal endothelial damage which is due to a severe systemic inflammatory response as supported by earlier observations by Olhovich *et al.* (2013).

In view of this, many cases of pancreatitis are misdiagnosed as renal failure. In a study conducted by Steiner *et al.* (2010) it has been shown that dogs with experimentally-induced chronic renal failure did not show any increase in serum lipase activity.

Both amylase and lipase (SNAP-cPL) are eliminated by the kidneys, and thus renal insufficiency may result in a two-fold to three-fold increase in these parameters. Whether prerenal azotemia can result in increased amylase and lipase values is controversial. Clinicians should be careful about interpreting increased α-amylase and lipase values in a severely dehydrated animal. One should arrive at a diagnosis of pancreatitis, if the α-amylase level increases are more than four to five times above the upper reference limit and in consistence with clinical signs.

The present study indicates that neither α-amylase nor ultrasonography is specific or sensitive to properly detect pancreatitis in dogs. Many studies by earlier authors (Hess *et al.,* 1999; Steiner *et al.*, 2008; Strombeck *et al.,* 1981; Mansfield, 2011) have reached

the same conclusion. Once radiography, hematology and serum biochemical profile have ruled out causes of anorexia and vomiting such as renal failure, hepatitis, splenomegaly, cystoliths and pyometra a tentative diagnosis of pancreatitis may be made based on ultrasonographic examinations, Snap cPL tests and α-amylase estimations.

Summary

VI. SUMMARY

Gastrointestinal diseases are a major problem faced by veterinarians and one of causes of this is pancreatitis which if left untreated poses a danger to the animal's life. Even with the awareness of pancreatitis, a definite ante-mortem diagnosis is still very difficult at present. A total of 31 dogs were selected for the study and were subjected to a complete physical examination. Blood was collected and hematology and biochemistry was performed. SNAP-cPL kits were used on all the cases. An ultrasonography was performed on most of the dogs. Radiography and post mortem were conducted wherever indicated.

In the current study pancreatitis was observed in 45.16% of the cases. Almost 57% of the dogs were found to be more than seven years of age. About 78.57% of the affected dogs were males and 21.43% were females. Pomeranians were found to be the most affected breed (21.42%) followed by German Shepherds, Non-descript breeds, Irish Setter, Boxer, Rottweiler, Dalmatian, Golden Retriever, Labrador Retriever and Basset Hound.

Anorexia (100%) was the most common clinical sign which was present in all the dogs presented. This was followed by vomiting in 78.54%, weight loss in 57.14%, diarrhoea in 35.71%, ascites in 14.28% and dehydration in 7.14%. The current study revealed that 58% of the dogs had abdominal pain on palpation. Among these, 28.57% showed signs of mild pain, 14.28% moderate pain and 14.28% severe pain.

The hematological reports indicated leucocytosis in 35.71% of the cases, anemia in 42.85% and thrombocytopenia in 21.43%. None of these findings are pathognomonic of pancreatitis. Among the serum biochemical estimations, Creatinine, BUN and α-amylase showed a significant increase in cases with pancreatitis but not SGPT. Creatinine was increased in 57.14% of the cases, BUN in 71.42% and α-amylase in 92.85. From previous studies it is evident that a high relationship is present between pancreatitis and renal failure and the current research supports the same. Azotemia in dogs suffering from pancreatitis frequently results from dehydration and hypovolemia (prerenal) or occasionally from renal damage.

Using the SNAP-cPL kits, 14 cases were diagnosed with pancreatitis. The SNAP cPL kits detect pancreatic lipase of levels more than 200 µg/l. This is one of the best tests available to detect pancreatitis as it identifies canine lipase secreted only from the pancreas. With the acute nature of the disease and the absence of a correct diagnostic technique acute pancreatitis can put the dog's life in jeopardy. Considering this, SNAP-cPL can be used as a bed side diagnostic test to rule out pancreatitis and to diagnose pancreatitis when cases with GI disturbances are presented with abdominal pain.

Ultrasonographic changes were seen in 21.42% of the cases. Among the four dogs with pancreatic changes, three of the dogs had hypoechoic pancreas surrounded by hyperechoic mesentery, while one dog had enlarged, irregular pancreas surrounded by hyperechoic mesentery. Of the five dogs which underwent radiographic examination, three dogs showed changes consistent with pancreatitis on the radiographs such as gas

filled intestinal loops in two of the dogs and cranial mass effect along with displaced gas filled duodenal loops in the third dog.

The results and observations of the present study brings us to the conclusion that among all the available diagnostic tests, SNAP-cPL appears to be one of the best, followed by α-amylase estimation. A combination of diagnostic tests is needed for the proper diagnosis of pancreatitis.

Bibliography

VII. BIBLIOGRAPHY

AKUZAWA, M., MORIZONO, M., NAGATA, K., HAYANO, S., SAKAMOTO, H., YASUDA, N., OKAMOTO, K., KAWASAKI, Y. and DEGUCHI, E., 1994. Changes of serum amylase, its isoenzyme fractions and amylase-creatinine clearance ratio in dogs with experimentally induced acute pancreatitis. *J. Vet. Med. Sci.*, **56**: 269-273

AL MOFLEH, I., 2008. Severe acute pancreatitis: pathogenic aspects and prognostic factors. *World J. Gastroenterol.*, **14(5):** 675-684

ASTE, G., DI TOMMASO, M., STEINER, J. M., WILLIAMS, D. A. and BOARI, A., 2005. Pancreatitis associated with N-methyl-glucamine therapy in a dog with leishmaniasis. *Vet. Res. Commun.* 29 *(Suppl.)* **2:** 269-272

BARTON, L., 2005. Sepsis and the Systemic Inflammatory Response Syndrome, In: Ettinger, S. J., Feldman, E. C. (Eds.) Textbook of Veterinary Internal Medicine. Elsevier Saunders, St Louis, pp. 452-454

BASSI, D., KOLLIAS, N., FERNANDEZ-DEL CASTILLO, C., FOITZIK, T., WARSHAW, A. L. and RATTNER, D. W., 1994. Impairment of pancreatic microcirculation correlates with the severity of acute experimental pancreatitis. *J. Am. Coll. Surg.*, **179:** 257-263

BEALL, M. J., CAHILL, R., PIGEON, K., 2011. Performance validation and method comparison of an in-clinic enzyme-linked immunosorbent assay for the detection of canine pancreatic lipase. *J. Vet. Diagn. Invest.*, **23**: 115-119

BENTINCK-SMITH J, 1983. A roster of normal values for dogs and cats. In: Kirk RW (ed): Current Veterinary Therapy VIII: Small Animal Practice. WB Saunders, Philadelphia, p. 1206

BISHOP, M. A., XENOULIS, P. G. and LEVINSKI, M. D., 2010. Identification of variants in the SPINK 1 gene and their association with pancreatitis in Miniature Schnauzers. *Am. J. Vet. Res.*, **71**: 527-523

BLUM, T., MAISONNEUVE, P., LOWENFALS, A. B. and LANKISCH, P. G., 2001. Fatal Outcome in Acute Pancreatitis: Its occurrence and early prediction. *Pancreatology.*, **1**: 237-241

BRADLEY, E. L., 1993. A clinically based classification system for acute pancreatitis. *Arch. Surg.*, **128**: 586-590

CARRASCO, L., DE LARA, F. C., MARTIN, E., HERVAS, J., MOLLEDA, J. M., GOMEZ-VILLAMANDOS, J. C. and LOPEZ, R., 1997. Acute haemorrhagic pancreatitis associated with canine visceral leishmaniasis. *Vet. Rec.*, **141**: 519-521

CARSTEN ELIZABETH, 2007. Treatment options for Canine Pancreatitis. IDEXX Reference Laboratories, Inc. All rights reserved. • 09-65706-00 (4)

CHARLES, J., 2007. Pancreas, *In:* Maxie, Kennedy and Palmers's Pathology of Domestic Animals 5th Edition. Saunders Elsiever. PP: 389-423

COOK, A. K., BREITSCHWERDT, E. B. and LEVINE, J. F., 1993. Risk factors associated with acute pancreatitis in dogs: 101 cases (1985-1990). *J. Am. Vet. Med. Assoc.* **203**: 673-679

CUTHBERTSON, C. M. and CHRISTOPHI, C., 2006. Disturbances of the microcirculation in acute pancreatitis. *Br. J. Surg.*, **93**: 518-530

EVANS, H. E. and CHRISTENSEN, G. C., 1979. The digestive apparatus and abdomen, *In:* Evans, H. E., Christensen, G. C. (Eds.) Millers Anatomy of the Dog. WB Saunders, Philadelphia, pp. 411-506

FINK, M., 1991. Gastrointestinal mucosal injury in experimental models of shock, trauma and sepsis. *Crit. Care Med.*, **19**: 627-641

FITTSCHON, C. and BELLAMY, J. E. C., 1984. Prednisone treatment alters the serum amylase and lipase activities in normal dogs and cats without causing pancreatitis. *Can. J. Comp. Med.*, **48**: 136-140

FLINT, R. S. and WINDSOR, J. A., 2003. The role of the intestine in the pathophysiology and management of severe acute pancreatitis. *World J. Gastroenterol.*, **5**: 69-85

FOITZIK, T., HOTZ, H. G., SCHMIDT, J., KLAR, E., WARSHAW, A. L. and BUHR, H. J., 1995. Effect of Microcirculatory Perfusion on Distribution of Trypsinogen Activation Peptides in Acute Experimental Pancreatitis. *Dig. Dis. Sci.*, **40**: 2184-2188

FROSSARD, J. L., PASTOR, C. M., 2002. Experimental Acute Pancreatitis: New Insights into the Pathophyisology. *Front. Biosci.*, 7: 275-287

GIUSEPPE PICCIONE, CLAUDIA GIANNETTO, FRANCESCO FAZIO and ELISABETTA GIUDICE., 2008. *J. Vet. Diagn. Invest.*, **20**: 795-799

GLOOR, B., TODD, K., LANE, J. A., LEWIS, M., REBER, H. A., 1998. Hepatic kupffer cell blockade reduces mortality of acute hemorrhagic pancreatitis in mice. *J. Gastrointest. Surg.*, **2**: 430-455

GROSS, V., LESER, H. G., HEINISCH, A., SCHOÈLMERICH, J., 1993. Inflammatory mediators and cytokines - new aspects of the pathophysiology and assessment of severity of acute pancreatitis. *Hepato-Gastroenterol.*, **40**: 522

HAIG, M. D., 1970. Pancreatic digestive enzymes: influence of a diet that augments pancreatitis. *J. Surg. Res.*, **10**: 601-607

HALANGK, W., LERCH, M. M., BRANDT-NEDELEV, B., ROTH, W., RUTHENBUERGER, M. and REINHECKEL, T., 2000. Role of cathepsin B in intracellular trypsinogen activation and the onset of acute pancreatitis. *J. Clin. Invest.*, **106**: 773-781

HANICHEN, T. and MINKUS, G., 1990. Retrospective study of Exocrine pancreas in dogs. *Terarztliche Umschau.*, **45**: 363-368

HECHT, S., HENRY, G., 2007. Sonographic Evaluation of the Normal and Abnormal Pancreas. *Clin. Tech. Small. Anim. Pract.*, **22**: 115-121

HERMAN, B. A., BRAWER, R. S. and MURTAUGH, R. J., 2005. Therapeutic percutaneous ultrasound guided cholecystocentesis in three dogs with extrahepatic biliary obstruction and pancreatitis. *J. Am. Vet. Med. Assoc.*, **227**: 1782-1786

HESS, R. S., SAUNDERS, H. M., VAN WINKLE, T. J., SHOFER, F. S. and WASHABAU, R. J., 1999. Clinical, clinicopathological, radiographic and ultrasonographic abnormalities in dogs with fatal acute pancreatitis: 70 cases (1986-1995). *J. Am. Vet. Med. Ass.*, **213**(5): 665-669

HUDSON, E. B. and STROMBECK, D. R., 1978. Effects of functional nephrotomy on the disappearance rates of canine serum amylase and lipase. *Am. J. Vet. Res.*, **39**: 1316-1321

JACOBS, R. M., MURTAUGH, R. J. and DEHOFF, W. D., 1985. Review of the clinicopathological findings of acute pancreatitis in the dog: use of an experimental model. *J. Am. Anim. Hosp. Assoc.* **21**: 795-800

KALLI, I., ADAMAMA-MORAITOU, K. and RALLIS, T. S., 2009. Acute pancreatitis in dogs: a review article. *Eur. J. Comp. Anim. Pract.* **19**: 147–155

KAMPP, M., LUNDGREN, O. and NILSSON, N. J., 1968. Extravascular Shunting of Oxygen in the Small Intestine of the Cat. *Acta. Physiol. Scand.* **72**: 396-403

KANEKO, J., HARVEY, J. W. and BRUSS, M. L., 2008. Clinical Biochemistry of Domestic Animals, 6th edition. 889-895

KECK, T., FRIEBE, V., WARSHAW, A. L., ANTONIU, B. A., WANECK, G., BENZ, S., HOPT, U. T. and FERNANDEZ-DEL-CASTILLO, C., 2005. Pancreatic proteases in serum induce leukocyte-endothelial adhesion and pancreatic microcirculatory failure. *Pancreatol.*, **5**: 241-250

KENNETH, W. S., 2000. Diagnosis and Management of Acute Pancreatitis in the Dog and Cat. The district of Columbia Academy of Veterinary Medicine

KLAR, E., RATTNER, D. W., COMPTON, C. C., STANFORD, G., CHERNOW, B. and WARSHAW, A. L., 1991. Adverse effect of therapeutic vasoconstrictors in experimental acute pancreatitis. *Ann. Surg.*, **214**: 168-174

KNOEFEL, W. T., KOLLIAS, N., WARSHAW, A. L., WALDNER, H., NISHIOKA, N. S. and RATTNER, D. W., 1994. Pancreatic microcirculatory changes in experimental pancreatitis of graded severity in the rat. *Surg.*, **116**: 904-913

KUMAR, A., DEY, S., SWARUP, D., JASMEET SINGH and HOQUE, M., 2010. Ultrasonographic diagnosis of chronic pancreatitis in two dogs. *Indian J. Vet. Surg.*, **31**(1): 67-68

LAMB, C. R. and SIMPSON, K. W., 1995. Ultrasonographic findings in cholecystokinin-induced pancreatitis in dogs. *Vet. Radiol.*, **36**: 27-32

LAMB, C. R., SIMPSON, K. W., BOSWOOD, A. and MATTHEWMAN, L. A., 1995. Ultrasonography of pancreatic neoplasia in the dog: a retrospective review of 16 cases. *Vet. Rec.* **37**(3): 65-8

LASKOWSKI, M. and KATO, I., 1980. Protein inhibitors of proteinases. *Ann. Rev. Biochem.*, **49**: 593-626

LASSON, A. and OHLSSON, K., 1984. Protease inhibitors in acute human pancreatitis. *Scand. J. Gastroenterol.*, **19**: 779-786

LEM, K. Y., FOSGATE, G. T., NORBY, B. and STEINER, J. M., 2008. Associations between dietary factors and pancreatitis in dogs. *J. Am. Vet. Med. Assoc.*, **233**: 1425-1431

LERCH, M. M., HOPPE-SEYLER, P. and GEROK, W., 1994. Origin and development of exocrine pancreatic insufficiency in experimental renal failure. *Gut.*, **35**(3): 401-407

LERCH, M. M., SALUJA, A. K., DAWRA, R., RAMARAO, P., SALUJA, M. and STEER, M. L., 1992. Acute necrotizing pancreatitis in the opossum: earliest morphological changes involve acinar cells. *Gastoenterol.*, **103**: 205-213

LUCENA, R., GINEL, P. J., NOVALES, M. and MOLLEDA, J. M., 1999. Effects of dexamethasone administration on serum trypsin-like immunoreactivity in healthy dogs. *Am. J. Vet. Res.*, **60**: 1357-1359

MANSFIELD, C., 2011. Acute pancreatitis in dogs: advances in understanding, diagnostics and treatment. *Top. Companion Anim. Med.*, **27**: 123-132

MANSFIELD, C. S. and JONES, B. R., 2000. Plasma and urinary trypsinogen activation peptide in healthy dogs, dogs with pancreatitis and dogs with other systemic disease. *Aust. Vet. J.*, 78: 416-422

MANSFIELD, C. S., JONES, B. R. and SPILLMAN, T., 2003. Assessing the Severity of Canine Pancreatitis. *Res. Vet. Sci.*, **74**: 137-144

MCCORD, K., MORLEY, P. S., ARMSTRONG, J. and SIMPSON, K., 2012. A multi-institutional study evaluating the diagnostic utility of the spec cPL™ and SNAP® cPL™ in clinical acute pancreatitis in 84 dogs. *J. Vet. Intern. Med.*, **26**(4): 888-896

MERGENER, K. and BAILLIE, J., 1998. Acute pancreatitis. *Br. Med. J.*, **316**: 44-48

MITHOFER, K., WARSHAW, A. L., FRICK, T., LEWANDROWSKI, K., KOSKI, G., RATTNER, D. W. and FERNANDEZ-DEL-CASTILLO, C., 1995. Calcium administration augments pancreatic injury and ectopic trypsinogen activation after temporary systemic hypotension in rats. *Anesthesiology.* **83**

MOHR, A. J., LOBETTI, R. G. and VAN DER LUGT, J. J., 2000. Acute pancreatitis: a newly recognized potential complication of canine babesiosis. *J. S. Afr. Vet. Assoc.,* **71**: 232-239

MOORE, R. W. and WITHROW, S. J., 1982. Gastrointestinal hemorrhage and pancreatitis associated with IV disc disease in the dog. *J. Am. Vet. Med. Assoc.* **180**(12):1443-1446.

MURTAUGH, R. J., HERRING, D. S., JACOBS, R. M. and DEHOFF, W. D., 1985. Pancreatic ultrasonography in dogs with experimentally induced acute pancreatitis. *Vet. Radiol.,* **26**: 27-32

NEWMAN, S. J., STEINER, J. M., WOOSLEY, K., BARTON, L. and WILLIAMS, D. A., 2005. Correlation of Age and Incidence of Pancreatic Exocrine Nodular Hyperplasia in the Dog. *Vet. Path.* **42**: 510-513

NEWMAN, S., STEINER, J., WOOSLEY, K., BARTON, L., RUAUX, C., and WILLIAMS, D. 2004. Localization of pancreatic inflammation and necrosis in dogs. *J.Vet.Int.Med.* **18**(4), 488-493.

NEWMAN, S. J., STEINER, J. M., WOOSLEY, K., WILLIAMS, D. A. and BARTON, L., 2006. Histologic assessment and grading of the exocrine pancreas in the dog. *J. Vet. Diagn. Invest.*,**18**: 115-118

NYLAND, T. G., MULVANY, M. H. and STROMBECK, D. R., 1983. Ultrasonic features of experimentally induced, acute pancreatitis in the dog. *Vet. Radiol.,* **24**: 260-266

NYLAND, T. G., MATTOON, J. S., HERRGESELL, E. J. and WISNER, E. R., 2002. Ultrasound-guided biopsy. *Small animal diagnostic ultrasound. 2nd edition. Philadelphia: WB Saunders Co*, 30-48.

OLHOVICH, G. M., ORTUNO, L. G., REMOLINA, J. R., BUITRAGO, C. L., LEZAMA, J. R. and BOUDA, J., 2013. Acute pancreatitis, azotaemia, cholestasis and haemolytic anaemia in a dog: a case report. *Vet. Med.*, **58**(1): 44-49

PARENT, J., 1982. Effects of dexamethasone on pancreatic tissue and on serum amylase and lipase activities in dogs. *J. Am. Vet. Med. Assoc.*, **180**: 743-746

PEZZILLI, R., 2009. Pharmacotherapy for acute pancreatitis. *Expert Opinion Pharmacotherapy,* **10:** 2999-3014

QUIGLEY, K. A., JACKSON, M. L. and HAINES, D. M., 2001. Hyperlipasemia in 6 dogs with pancreatic or hepatic neoplasia: evidence for tumor lipase production. *Vet. Clin. Pathol.*, **30**: 114–120

RALLIS, T. S., KOUTINAS, A. F., KRITSEPI, M. and MORAITOU, K. T., 1996. Serum lipase activity in young dogs with acute enteritis or gastroenteritis. *Vet. Clin. Pathol.*, **25**: 65-68

RADIN, M. J., SHARKEY, L. C., HOLYCROSS, B. J., 2009. Adipokines: a review of biological and analytical principles and an update in dogs, cats, and horses. *Vet. Clin. Pathol.* 38(2):136-56

RINDERKNECHT, H., 1986. Activation of pancreatic zymogens: normal activation, premature intrapancreatic activation, protective mechansims against inappropriate activation. *Dig. Dis. Sci.*, **31**: 314-321

ROWELL, L. B., BLACKMON, J. R., KENNY, M. A. and ESCOURROU, P., 1984. Splanchnic vasomotor and metabolic adjustments to hypoxia and exercise in humans. *Am. J. Physiol.*, **247**: 251-258

RUAUX, C., 1998. General practice attitudes to the treatment of spontaneous canine acute pancreatitis. *Aust. Vet. Prac.*, **28**: 67-74

RUAUX, C. and ATWELL, R.B., 1998a. General practice attitudes to the treatment of spontaneous canine acute pancreatitis. *Aust. Vet. Pract.*, **28**: 67-74

RUAUX, C. G., 2003. Diagnostic Approaches to Acute Pancreatitis. *Clin. Tech. Small. Anim. Pract.*, **18**(4): 245-249

RUAUX, C. G., PENNINGTON, H. L., WORRAL, S. and ATWELL, R. B., 1999. Tumor necrosis factor-a at presentation in 60 cases of spontaneous canine acute pancreatitis. *Vet. Immunology Immunopathol.*, **72**: 369-376

SALUJA, A. K., DONOVAN, E., YAMANAKA, K., YAMAGUCHI, Y., HOFBAUER, B. and STEER, M. L. 1997. Cerulein-induced in vitro activation of trypsinogen in rat pancreatic acini is mediated by cathepsin B. *Gastroenterol.*, **113**: 304-310

SALUJA, A. K. and STEER, M. L., 1999. Pathophysiology of Pancreatitis. Role of cytokines and other mediators of inflammation. *Dig.*, **60**: 27-33

SAUNDERS, H. M., 1991. Ultrasonography of the pancreas. *Probl. Vet. Med.*, **3**: 583-603

SCHAER, M., 1979. A clinicopathologic survey of acute pancreatitis in 30 dogs and 5 cats. *J. Am. Anim. Hosp. Assoc.*, **15**: 681-687

SCHAER, M., 1991. Acute pancreatitis in dogs. *Compendium of Continuing Education for the Practising Vetrinarian.* **13**: 1769-1779

SCHEELE, G. A., 1980. Biosynthesis, segregation and secretion of exportable proteins by the exocrine pancreas. *Am. J. Physiol.*, **238**: 467-477

SCHLEIS, S. E., SCOTT, A. R., JEFFERY, C. P. and AMY, K. L., 2011. Asparginase-associated pancreatitis in a dog. *Can. Vet. J.*, **52**: 1009-1012

SCHRÖDER, T., KIVISAARI, L., STANDERTSKJOLD-NORDENSTAM, C. G., SOMER, K., LEHTOLA, A., PUOLAKKAINEN, P., KARONEN, S. L., KIVILAAKSO, E. and LEMPINEN, M., 1985. Pancreatic blood flow and contrast enhancement in computed tomography during experimental pancreatitis. *Eur. Surg. Res.*, **17**: 286-291

SCHWARTZ, P., KOVAK, J. R., KOPROWSKI, A., LUDWIG, L. L., MONETTE, S. and BERGMAN, P. J., 2008. Evaluation of prognostic factors in the surgical treatment of adrenal gland tumors in dogs**:** 41 cases (1999-2005). *J. Am. Vet. Med. Assoc.* **232**(1):77-84.

SINGH, V. K., WU, B. U., BOLLEN, T. L., REPAS, K., MAURER, R., MORTELE, K. J. and BANKS, P. A., 2009. Early Systemic Inflammatory Response Syndrome Is Associated With Severe Acute Pancreatitis. *Clin. Gastroenterol. Hepatol.*, **7**: 1247-1251

SHERDING, R. G. and BIRCHARD, S. J., 2005. Pancreatitis In: Saunders manual of small animal practice. 3rd Edition. Elsevier Health Sciences.

SHUKLA ANGELIE, 2010. Acute pancreatitis attributed to dietary indiscretion in a female mixed breed canine. *Can. Vet. J.* **51**(2): 201–203

STEER, M. L. and MELDOLESI, J., 1988. Pathogenesis of acute pancreatitis. *Annu. Rev. Med.*, **39**: 95-105

STEINER JORG, 2010. New Tests for Pancreatitis. North American Veterinary Council, Clinician's Brief. Pp: 76-78

STEINER, J. M., NEWMAN, S. J., XENOULIS, P. G., WOOSLEY, K., SUCHODOLSKI, J. S., WILLIAMS, D. A. and BARTON, L., 2008. Sensitivity of serum markers for pancreatitis in dogs with macroscopic evidence of pancreatitis. *Vet. Therapeutics.*, **9**(4): 263-273

STEINER, J. M. and WILLIAMS, D. A., 2002. Purification of classical pancreatic lipase from dog pancreas. *Biochimie*. **84**: 1243-1251

STEINER, J. M. and WILLIAMS, D. A., 2003. Development and validation of a radioimmunosassay for the measurement of canine pancreatic lipase immunoreactivity in serum of dogs. *Am. J. Vet. Res.*, **64**: 1237-1241

STEINER, J. M., RUTZ, G. M. and WILLIAMS, D. A., 2006. Serum lipase activities and pancreatic lipase immunoreactivity concentrations in dogs with exocrine pancreatic insufficiency. Am. J. Vet. Res. **67**:84–87.

STEINER, J. M., FINCO, D. R. and WILLIAMS, D. A., 2010. Serum lipase activity and canine pancreatic lipase immunoreactivity concentration in dogs with experimentally induced chronic renal failure. *Vet. Res.*, **3**(3): 58-63

STEWART, A. F., 1994. Pancreatitis in dogs and cats: causes, pathogenesis, diagnosis and treatment. *Compend. Contin. Educ. Vet.* **16**: 1423-1430

STROMBECK, D. R., 1990. The Exocrine Pancreas, *In*: Strombeck, D. R., Guilford, W. G. (Eds.) Small Animal Gastroenterology. Stonegate Publishing, Davis, p. 429

STROMBECK, D. R., 1996. Small and Large Intestine: Normal Structure and Function, *In:* Guilford, W.G., Center, S.A., Strombeck, D.R., Williams, D.A., Meyer, D.J., (Eds.) Strombeck's Small Animal Gastroenterology. WB Saunders, Philadelphia, pp. 318-350

STROMBECK, D. R., FARVER, T., KANEKO, J. J., 1981. Serum amylase and lipase activities in the diagnosis of pancreatitis in dogs. *Am. J. Vet. Res.*, **192**: 195-201

TAKALA, J., 1996. Determinants of splanchnic blood flow. *Br. J. Anaes.* **77**: 50-59

TAKEDA, K., MIKAMI, Y., FUKUYAMA, S., EGAWA, S., SUNAMURA, M., ISHIBASHI, T., SATO, A., MASAMUNE, A. and MATSUNO, S., 2005. Pancreatic ischemia associated with vasospasm in the early phase of human acute necrotizing pancreatitis. *Pancreas.*, **30**: 40-49

TRIVEDI, S., MARKS, S. L., KASS, P. H., LUFF, J. A., KELLER, D. M., JOHNSON, E. G. and MURPHY, B., 2011. Sensitivity and Specificity of Canine Pancreas-Specific Lipase (cPL) and Other Markers for Pancreatitis in 70 Dogs with and without Histopathologic Evidence of Pancreatitis. *J. Vet. Intern. Med.*, **25**: 1241–1247

WALTER, G. L., MCGRAW, P. and TVEDTEN, H. W., 1992. Serum lipase determination in the dog: a comparison of a titrimetric method with an automated kinetic method. *Vet. Clin. Pathol.*, **21**: 23-27

WANG, G. J., GAO, C. F., WEI, D., CUN, W. and DING, S. Q., 2009. Acute pancreatitis: Etiology and common pathogenesis. *World J. Gastroenterol.*, **15**: 1427–1430

WATSON, P., 2004. Pancreatitis in the dog: dealing with a spectrum of disease. *In Pract.*, **26**: 64-77

WATSON, P. J., 2003. EPI as an end stage of pancreatitis in four dogs. *J. Small. Anim. Pract.*, **44**: 306-312

WATSON, P. J., ARCHER, J., ROULOIS, A. J., SCASE, T. J. and HERRTAGE, M. E., 2010. Observational study of 14 cases of chronic pancreatitis in dogs. *Vet. Rec.*, **167**(25): 968

WATSON, P. J., ROULOIS, A. J. A., SCASE, T., JOHNSTON, P. E. J., THOMPSON, H. and HERRTAGE, M. E., 2007. Prevalence and breed distribution of chronic pancreatitis at post- mortem examination in first- opinion dogs. *J. Small. Anim. Pract.*, **48**(11): 609-618

WHITNEY, M. S., 1993. The laboratory assessment of canine and feline pancreatitis. *Veterinary Medicine*. **85**: 1045-1052

WILLIAMS, D. A., 1994. Diagnosis and management of pancreatitis. *J. Small. Anim. Pract.*, **35**: 445-454

WILLIAMS, D. A., 1996. The Pancreas, *In:* Guilford, W.G., Center, S.A., Strombeck, D.R., Williams, D.A., Meyer, D.J., (Eds.) Strombeck's Small Animal Gastroenterology. WB Saunders, Philadelphia, pp. 381-410

WILLIAMS, D. A. and STEINER, J. M., 2005. Canine Exocrine Pancreatic Disease, *In:* Ettinger, S.J., Feldman, E.C. (Eds.) Textbook of Veterinary Internal Medicine. Elsevier Saunders, St Louis MO, USA, pp. 1482-1488

WILMORE, D. W., SMITH, R. J., O'DWYER, S. T., JACOBS, D. O., ZIEGLER, T. R. and WANG, X. D., 1988. The gut: A central organ after surgical stress. *Surg.*, **104**: 917-923

WINDSOR, J. A. and HAMMODAT, H., 2000. Metabolic Management of Severe Acute Pancreatitis. *World J. Surg.*, **24**: 644-672

WU, B. U. and CONWELL, D. L., 2010. Acute Pancreatitis Part II: Approach to Follow-up. *Clin. Gastroenterol. Hepatol.* **8**: 417-422

XENOLIUS, P. G., SUCHODOLSKI, J. S. and STEINER, J. M., 2008. Chronic pancreatitis in dogs and cats. Compendium on Continuing Education for the Practicing Veterinarian. **30:** 166–180.

XENOULIS, P. G., 2015. Diagnosis of pancreatitis in dogs and cats. *Journal of Small Animal Practice*. **56**: 13–26.

YASUDA, K. 1998. Acute Pancreatitis. In: A Manual of Veterinary Medicine. 199-200.

Abstract

VIII. ABSTRACT

Pancreatitis is an inflammatory condition of the exocrine pancreatic tissue, with infiltration by inflammatory cells and interstitial damage by pancreatic enzymes. Canine pancreatitis although underdiagnosed is one of the major problems in small animal practice which causes mortality more particularly when it is acute. A total of 31 dogs were selected for the study. The different diagnostic tests carried out were CBC, Serum Biochemistry, ultrasonography and a SNAP cPL test. Based on these tests 14 dogs (45.16%) were diagnosed with pancreatitis. 57% of the dogs were more than seven years of age, 78% of the affected dogs were males and Pomeranians were found to be the most affected breed. In the present study 58% of the dogs evinced abdominal pain on palpation. The CBC revealed leucocytosis (35.71%), anemia (42.85%) and thrombocytopenia (21.43%) in the pancreatitis dogs. Mean Creatinine values of the dogs with pancreatitis was 6.46 ± 1.85 indicating a strong relationship between pancreatitis and renal insufficiency as 57.14% of the dogs had increased Creatinine values. There was no statistically significant increase in the SGPT levels (21.42%), while BUN was increased in 71.42% of the dogs. α-amylase was found to have a sensitivity of 92.85%, and was increased in 13 of the dogs. Only 21% of the cases showed ultrasonographic changes which is much lower than that reported by other authors. 45.16% of the cases showed positive for the SNAP-cPL test. From the present study it can be concluded that a tentative diagnosis of pancreatitis may be made using a combination of ultrasonography, Snap cPL and α-amylase estimation.

Appendices

IX. APPENDICES

APPENDIX 1: Age, Breed and Gender of the dogs suspected of pancreatitis

Sl. No.	Breed	Gender	Age (yrs)
1	Irish Setter	M	8
2	German Shepherd	F	2 1/2
3	Boxer	M	4 1/2
4	Non descript	M	7
5	Non descript	M	9
6	Labrador Retriever	M	6 1/2
7	German Shepherd	M	8
8	Rottweiler	M	5
9	German Shepherd	F	1
10	German Shepherd	F	3
11	Non descript	M	1
12	Pomeranian	M	4
13	Doberman Pinscher	F	2 1/2
14	Pomeranian	M	6
15	Labrador Retriever	M	3
16	Mastiff	F	1
17	Non descript	F	8
18	Dalmatian	F	9
19	German Shepherd	M	1 1
20	Golden Retriever	M	9
21	Labrador Retriever	F	1 ½
22	Labrador Retriever	F	3 ½
23	Terrier	M	3
24	Labrador Retriever	M	2
25	Cocker Spaniel	F	2
26	German Shepherd	F	2 ½
27	Pomeranian	M	14
28	Labrador Retriever	M	1 ½
29	Basset Hound	F	9
30	Labrador Retriever	M	8
31	Non descript	M	12

APPENDIX 2: Hematological values of the dogs suspected for pancreatitis

Sl. No.	Hematology		
	TLC (/µl)	Hemoglobin (g/dl)	Platelet (/µl)
1	25,400	10.6	3,79,000
2	22,100	9.8	1,73,000
3	12,500	17.6	2,71,000
4	15,300	15.7	2,35,000
5	32,300	12	2,17,000
6	11,600	10	1,98,000
7	7,200	10.6	3,26,000
8	7,000	13	2,27,000
9	29,600	10.7	2,78,000
10	12,300	17.2	2,73,000
11	42,200	14.1	3,53,000
12	15,500	10.1	2,74,000
13	21,300	11.5	2,02,000
14	18,800	13.7	4,79,000
15	15,300	10.8	1,86,000
16	9,000	16.7	2,89,000
17	8,100	10.8	4,23,000
18	7,700	17.3	3,12,000
19	32,500	12.6	2,41,000
20	5,500	12.7	1,57,000
21	11,200	15	2,78,000
22	6,900	12.7	2,14,000
23	11,900	11.1	3,43,000
24	7,900	15.6	1,11,000
25	13,500	5.1	65,000
26	14,300	13.4	2,84,000
27	20,800	12.7	1,79,000
28	15,000	13.2	2,14,000
29	19,300	11.5	1,42,000
30	9,800	2.3	1,48,000
31	9,900	8.6	5,15,000

APPENDIX 3: Serum biochemical values of the dogs suspected for pancreatitis

Sl. No.	Serum Biochemistry			
	Creatinine (mg/dl)	SGPT (U/l)	α-amylase (U/L)	BUN (mg/dl)
1	9.59	35	8076	149
2	1.1	12	5106	19.3
3	1.4	39	8557	38.9
4	18.4	22	2711	68
5	1	313	3906	24.7
6	0.8	19	5611	24
7	18.5	28	8853	23.5
8	1.7	20	5631	25
9	1.1	30	4399	29
10	1.4	21	5299	24.1
11	2.6	69	5367	73.8
12	1.2	31	5010	23.7
13	1	29	4725	23.1
14	0.6	201	7437	38.9
15	1.3	20	2093	40.4
16	1.1	42	1877	37.5
17	0.8	16	2959	38.6
18	13.4	42	2924	77.5
19	0.8	72	3411	31
20	1.5	48	6148	42.9
21	0.8	46	3847	21
22	1.1	36	2923	21.2
23	1.7	139	2602	76.6
24	1.5	38	4513	54.3
25	1.8	15	2535	75
26	0.9	15	3119	39.5
27	7.3	110	6528	80
28	5.6	95	4847	75.7
29	0.8	50	6611	34
30	9.9	21	8123	71.2
31	20.5	146	9000	74.5