Introduction

Equine colic is considered the major disease state in horses and donkeys causing severe abdominal pain. Colic is a frequent and important cause of death to these species of animals. The aetiological agents to this clinical syndrome are several including disease base on system that classifying the cause of colic as obstructive and strangulating, non strangulating infarctive and inflammatory such as peritonitis, and enteritis (Radostits *et al.*, 2007). Also another classification system based on anatomy of the structure of gastrointestinal tract was suggested by Cohen *et al.*, (1999). In this state, colic can be due to gastric dilatation or volvulus in small intestine or impaction of caecum.

Hewetson (2006) defined the clinical sign syndrome as spasm of digestive system and the major sign is the pain which manifested by pawing, stamping, kicking or rolling (Radostits *et al.*, 2007). The pain of the abdomen can be classified according to Archer *et al.*, (2006) to true colic in the digestive system from false colic outside the as in the liver, urinary system and others. Losses caused by equine colic are due to almost entirely to death of these animals. However the cost of treatment and the emotional trauma to the owners of their animals being afflicted with potentially fatal disease are important consideration.

Objectives are:

1. Investigation of the underlying etiological agents and/or mechanisms of colic.
2. Studying the haematological changes.
3. Studying the biochemical changes that may occur.
4. Response of colicky animals to treatment with Flunixin meglumine and Ketoprofen.

Chapter one

Literature review

1. Equine colic

Equine colic is considered as one of the major disease states in horses and donkeys, causing severe abdominal pain. It is a frequent and important cause of death to these species of animals (Radostitis *et al.,* 2007 and Bryan *et al.,* 2009). Colic originates from gastrointestinal tract is more frequent than that originate from other organs within the abdominal cavity (Bryan *et al.,* 2009). Gastrointestinal tract problems that result in colic include: gastric ulcer, intestinal volvulus, caecal intussception, caecal rupture, colonic impaction, and dorsal displacement of the colon either to the right or to the left, outside gastrointestinal tract peritonitis, uterine torsion also are considered colic causative agents (Nappert and Johnson, 2001). Colic due to gastrointestinal tract problems is more severe and fatal than that originate from other organs (Ihler *et al.,* 2004); small intestinal infections and strangulation have worse outcome than large intestinal infections and non strangulation lesions respectively (Sutton *et al.,* 2009).

1.1 Risk factors associated with equine colic

A risk factor is not important to be the causative agent of equine colic, but it means that horse will be more susceptible to the colic when it exposes to this factor (White and Edward, 1999). Not only knowledge of the risk factor enable clinician to identify specific types of colic, and take care of those horses more

susceptible to them (Archer and Proudman, 2006), but also important for right management, understanding colic pathogenesis, and planning for effective control of equine colic (Cox *et al*., 2007 and Scantlebury *et al*., 2011).

1.1.1 Species

Comparing to ruminants equines are more susceptible to colic, because of both physiological and anatomical properties of their digestive system. In ruminants the fermentation compartment (rumen) is in beginning of the digestive system, but in equines partially digested food has to be pushed from stomach to large intestine through relatively narrow hyperactive small intestine to be fermented there (Blood *et al*., 1989), also junction between the distal oesophagus and cardia works as a valve, allowing the food to be moved from the stomach to the intestine only, but not back, so any disturbance of this normal movement results in colic, or even death which may due to gastric rupture (Dana *et al*, 2005).

1.1.2 Breed, age and sex

They are valuable colic risk factors (Concalves *et al*., 2002). Arabian breed (Cohen *et al*., 1999 and Proudman and Holdstock, 2000) crossbred horses (Mehdi and Mohammad, 2006) and older horses are more susceptible to the colic (Cohen *et al*., 1999 and Rabuffo *et al.,* 2009) and its fatal outcome (Kaneene *et al*., 1997);

Geriatric horses were found more susceptible to death due to colic unless there is surgical intervention (Southwood *et al.*, 2010b), aged horses have more opportunity to be subjected to the colic causative agents and its risk factors comparing to younger ones (Cohen *et al.*, 1999). As in horses old donkeys are more susceptible to colic development (Toit *et al.*, 2008 and Toit *et al.*, 2009) because, dental problems and muscular weakness, which are considered the most important risk factors for colic in donkeys, are more common among old members of this species (Cox *et al.*, 2007). Gender is not considered a risk factor (Mehdi and Mohammad, 2006 and Rabuffo *et al.*, 2009). Unfortunately mentioned animal related factors are not controlled by man, but fortunately not management factors which are considered the most important risk factors for colic (Concalves *et al.*, 2002).

1.1.3 Management factors

Food and water

Equine nutrition has important role in their health, although veterinarians are considered the basic sources of nutritional advices for the equine owners, unfortunately many of them were found do not counselling their clients (Roberts and Murray, 2013).

Type of food (Concalves *et al.*, 2002), sudden change of food (Archer and Proudman, 2006) and way of feeding are important risk factors for colic. When a horse is fed on the ground, or when it is being at a pasture with no grasses, or with short grasses, it will be more susceptible to sand colic (Husted *et al.,* 2005), hay of poor quality is relatively indigestible and it changes intestinal

media (pH, microflora, volatile fatty acids production) ending in impaction colic (Cohen *et al*., 1999). But no change was found in cellulolytic, amylolytic bacteria and volatile fatty acids or lactate in faeces of horses fed starch (Murray *et al*., 2014).

Decrease in water intake is considered a risk factor for equine colic (Scantlebury *et al*., 2011 and Archer and Proudman, 2006), in addition to over drinking of water especially after heavy work (Cohen *et al*., 1999; Hillyer *et al*., 2002 and Archer and Proudman, 2006).

1.1.4 Control of internal parasites

Equine colic risk factors, due to internal parasite control programme include history of this programme (Concalves *et al*., 2002) treatment of worms within seven days preceding colic (Cohen *et al*., 1999) and extensive usage of ivermectin, frequent usage of ivermectin increase the risk of colic due to tapeworm infection, but fortunately this problem can be overcome by administration of anticestodes (Proudman and Holdstock, 2000). In addition to that, history of previous episodes of colic (Cox *et al.,* 2007) and abdominal surgery are also important equine colic risk factors (French *et al*., 2002).

1.1.5 Teeth problems

Teeth problems are risk factor for colic in donkeys (Toit *et al*., 2008) and in their counterparts horses (Hillyer *et al*., 2002 and Scantlebury *et al.,* 2011) especially recurrent type (Hillyer *et al*., 2002 and Scantlebury *et al.,* 2011) and simple colonic obstruction (Hillyer *et al*., 2002) because these problems do not make horses

(Hillyer *et al.*, 2002) and donkeys (Toit *et al.*, 2008) masticate well, allowing long undigested fibres passing down causing colic (Hillyer *et al.*, 2002., Toit *et al.*, 2008 and Toit *et al.*, 2009).

1.1.6 Exercise

Colic risk factors due to exercise include, recent change of stabling (Cohen *et al.,* 1999 and Hillyer *et al.*, 2002) and of exercise schedule, which reduce large intestine peristalsis, resulting in simple obstruction and distension of colon (Hillyer *et al.*, 2002). Large intestinal peristalsis was found reduced in stable confined horses compared to large intestine movement of horses at pasture especially that of left ventral colon, this makes stabled horses more susceptible to colic compared to the pastured ones (Williams *et al.*, 2011).

Exposure to cold (Mott *et al.*, 2004 and Scantlebury *et al.*, 2011) fatigue, exhaustion, wet stormy weather, and overwork, paralyze the digestive system, making equine more susceptible to colic (Mott *et al.*, 2004).

1.2 Causes of equine colic

There are many causes of equine colic, but sometimes it is difficult to recognize them (White and Edwards, 1999). Generally gastrointestinal tract is most important source of colic (Robertson and Sanchez, 2010). Causes of colic can be put into four groups: distension, simple obstruction, complete obstruction, and enteritis (Ferraro, 2008).

1.2.1 Distension

Distension can happen either because of physical obstruction due to accumulation of ingesta, or fluids in gastrointestinal tract, causing physical colic (Blood *et al.*, 1989) or without physical obstruction (Ferraro, 2008) known by ileus that characterized by moderate to severe continuous signs of colic, in mares ileus happens after delivery mostly with unknown causes (Hillyer *et al.*, 2008) but White and Edwards, (1999) stated that ileus happens due to disturbance of serum quantity of calcium and potassium .

Peristalsis hyper motility leads to a type of colic known by functional colic (Blood *et al.*, 1989).

1.2.2 Simple obstruction

Simple obstruction is partial blockage of ingesta pathway in digestive system, by food, enteroliths, parasites, foreign body (Ferraro, 2008), or sand (Hart *et al.*, 2012) resulting in disruption of food movement downwards, this obstruction makes the horse shows clinical signs of colic ranging from mild to moderate (Ferraro, 2008). The most common site of impaction is the large colon, either in horses (White and Edwards, 1999 and Mezerova *et al.*, 2001) or in donkeys (Cox *et al.*, 2007) but when small intestinal impaction happens in donkeys it always very fatal (fatality rate reaches100%). Caecal impaction also happen either because of caecal base muscles enlargement or when whole caecum muscles are enlarged, this type of impaction is characterized by mild colic, that doesn’t respond to medical

treatment, and it is confirmed by rectal palpation findings, caecal impaction or distension with gas thickening of caecal wall (Huskamp and Scheidemann, 2000). Histologically the myenteric ganglia were found low in number in the large intestine compared to the small intestine; within the large intestine their number is higher in the pelvic flexure, left dorsal colon, and descending colon than the other parts of the large intestine (Pavone *et al*., 2012).

Enterolith is a mineral stone, composed especially of magnesium and ammonium phosphate. These minerals accumulate round a nidus (metal, plastic, or gravel which make stone inside the bowl), it is usually formed in large colon, then it passes out with faeces, or retain causing obstruction according to its size, colic because of this retained stone is usually chronic intermittent. There are specific diets predispose the horse to enterolith formation when eaten in large amounts for long time, such as alfalfa. Genetically Arab breed and Arabian-cross horses are more susceptible to enterolith formation than other breeds (Ferraro, 2008).

Strongylus vulgaris, Parascaris equorum, and Anoplocephala perfoliata are the most predominant causes of verminous colic (Reinemeyer and Nielsen, 2009). *Strongylus vulgaris* larvae are found in mesenteric arteries causing either acute or chronic lesions and thickening of the artery wall. Haematological *Strongylus vulgaris* leads to decrease of PCV, RBCs, and albumin/globulin ratio (Pilo *et al.,* 2012). In study for investigation

of an outbreak of colic among horses revealed that *Anoplocephala perfoliata* is responsible of spasmodic and ileocecal impaction colic and increasing of its incidence increase colic cases (Proudman and Holdstock, 2000). The main source for this parasite is the pasture, this fact was proved by ELISA test for identification of anti-12/13KDa IG(T) which is a protein released by *Anoplocephala perfoliata* (Williams *et al.,* 2008).

1.2.3 Complete obstruction

Complete obstruction, happen because of intestinal accidents such as torsion and intussception, causing severe intolerable pain, and shock due to intestinal infarction and bacterial toxins that pass into the blood stream (Ferraro, 2008).

1.2.4. Enteritis

Enteritis is inflammation of intestinal mucosa, because of microbial infection (Ferraro, 2008) such as *Salmonella*, *Clostridia* (Blood *et al.,*1989, and Ferraro, 2008) *Rickettsia*, and equine viral arteritis, or chemical poisons (Blood *et al*., 1989) Enteritis causes colic of short-lived which is characterized by fever, depression, and diarrhoea (White and Edwards, 1999).

1.2.5 Other causes of colic

Include gastric ulcers (Nappert and Johnson, 2001 and Andrews *et al.,* 2013) which are related to the gastrointestinal diseases (Kasap *et al.,* 2010 and Andrews *et al.,* 2013). Gastric ulcers are less common among neonate foals (less than one year) compared to the older foals (Elfenbein and Sanchez, 2012). Gastric ulcers have fatal outcome due to gastric rupture (Kasap *et*

al., 2010 and Andrews *et al.,* 2013). These ulcers develop because of direct contact between stomach mucosa and gastric acids. Protein and carbohydrate rich-food, leads to lowering of stomach (pH) and growing up of lactobacillus bacterium which ferment carbohydrates, producing lactic acid and volatile fatty acids, both of them cause ulcers, so horses should be fed hay every five to six hours to neutralize gastric pH and to avoid gastric ulcers formation (Andrews *et al.,* 2013). Gastric ulcers are more common in non glandular portion of the stomach than glandular part (Andrews *et al.,* 2013 and Elfenbein and Sanchez, 2012), because the glandular part is well protected from corrosive hydrochloric acid (HCl) by mucoid layer rich in bicarbonate, and from harmful hydrogen ions, by adequate blood flow, that remove this ions from the stomach. When gastric ischemia happens it results in necrosis and ulcers, because of hypoxia –induced acidosis, release of oxygen free radicals, phospholipase, and protease. This protective mechanism is kept well by production of prostaglandin, so that disturbance of this hormone production leads to gastric ulcers (Andrews *et al.,* 2013) this disturbance can happen, either by prolonged use of non-steroidal anti-inflammatory agents such as phenylbutazone (White and Edwards, 1999) or by stress, which reduce the production of this hormone by increasing of endogenous cortisol release (Andrews *et al.,* 2013). Attention should be paid when treating gastric ulcers in foals by histamine- type 2 receptors antagonist and omeprazole

because they may increase the risk of diarrhoea in hospitalized cases (Furr *et al.*, 2012).

Urolithiasis is another cause of colic, because it may obstruct the urethra then colic develops, when obstruction happens urine dribbling and azotemia are noticeable. If cystolithiasis happened, it would be characterized only by haematuria after exercise (Schott, 2002).

Generally colic happen because of: sudden drinking of large quantities of water, eating large amounts of grains, dry rough hay or immature green graces, infection of urinary system, pleurisy, exhaustion, cold weather, laminitis, babesiosis, Monday morning disease, (Alsaad and Nori, 2010) and Sand especially when a horse is fed on the ground (Ferraro, 2008).

1.3 Diagnosis of equine colic

For favourable prognosis, and decrease of fatality rate, an early diagnosis of colic is important (Dukti and White, 2009).

1.3.1 Case history

The most important element in the case history of colicky horse, is the time when the horse shows signs of colic, which can be estimated from the owner, by asking him, what is the first time he noticed that his horse was attacked by the colic, and the last time he saw his horse well, then he/she should be asked about the factors that preceded colic, especially that considered as risk factors for colic, such as stabling, food, usage of anthelmintics for treatment and prevention of internal parasites, treatment with drugs that known as causes of colic, such as

prolonged usage of non-steroidal anti-inflammatory agents (White and Edward, 1999).

1.3.2 Clinical signs and parameters

Evaluation of pained animals depends on the observable clinical signs and their interpretation, so identification of the animal, source of the pain and its duration are important data (Robertson and Sanchez, 2010). Clinical signs are also important for identification and differentiation of medical treatable colic cases than surgical needed others (Ihler *et al*., 2004 and Sutton *et al.,* 2009).

Clinical parameters which include evaluation of the cardiovascular system, such as heart rate, mucous membrane colour (Ihler *et al*., 2004 and Sutton *et al.,* 2009) capillary refill time (Thoefner *et al*., 2001 and Sutton *et al.,* 2009) are negatively affect by fatal endotoxaemia (Thoefner *et al*., 2001 and Skyes and Furr, 2005) so they play an important role in evaluation the outcome of the case. In addition to that degree of pain and deviation of temperature from 38^{o}C are also important factors for prognosis of colicky cases (Thoefner *et al*., 2001). It was noticed that, in old horses after exercise their temperature can reach 40□C faster with increasing heart rate and more sweat loss than young horses (Mckeever, *et al*., 2010).

Important signs of colic include: getting up and lying down, anorexia, pacing, abnormal sounds, polypnea, frequent stretching, inability of defaecation, tympani, rolling eyes (Scantlebury *et al.,* 2011). Rolling on the ground, flank watching, pawing, sweating,

kicking of the abdomen, curling lips (Ferraro, 2008, Alsaad and Nori, 2009, Alsaad and Nori, 2010, and Scantlebury *et al*., 2011), sitting like dog, playing with water, passing small amounts of urine frequently (Blood *et al*., 1989) diarrhoea, weight loss, fever, and reduction of performance as in sand colic (Hart *et al*., 2012) but distension of abdomen is rarely noticed in colicky horses, but symmetrical distension of abdomen refers to accumulation of gas in small colon, and distension of the right flank is indicator of gas accumulation in the caecum (Blood *et al*., 1989).

Existence of skin abrasions around the eyes, and on the skin over tubercoxae are indicators of rolling due to severe abdominal pain (White and Edward, 1999).

Endotoxaemia which can be the causative agent of colic (Skyes and Furr, 2005) or develop in already pained horse (White and Edward, 1999) as in intestinal infarction cases (Ferraro, 2008), endotoxins enter the blood stream and provoke production and release of endogenous inflammatory mediators, which reduce threshold of pain provokers, and clinical signs appearance which occur after they react with specific cell receptors (Moore and Barton, 2003). Endotoxaemic horse appears, indolent, dull with downward head, (White and Edward, 1999) feverish, anorexic with reduced intestinal motility, dehydrated, altered mucous membrane colour, and increased heart and respiratory rates (Moore and Barton, 2003). In addition to that it may be associated with acute laminitis (Kwon *et al*., 2013).

Colic increases capillary refill time and pulse rate (Reeves *et al.,* 1989; Hillyer *et al*., 2008; Sutton *et al.,* 2009 and Alsaad and Nori, 2010) and they are of great value in assessment of prognosis of colicky horse (Blood *et al*., 1989 Southwood *et al*., 2010b) as the most the case gets worse the most they increase (Reeves *et al.,* 989 and Sutton *et al.,* 2009 Southwood *et al*., 2010a) for favourable prognosis pulse rate should be less than 80/minute, but when it reaches 100pulse/minute this is considered bad prognosis indicator (Blood *et al*., 1989).

Examination of mucous membranes is important for assessment of hydration, cardiovascular status, degree of shock and endotoxaemia (Bryan *et al.,* 2009) pale dry clammy mucosa is indicator of coma that; congested dark red to purple colour with long capillary refill time are indicators of severe dehydration and shock (Blood *et al*., 1989).

Respiratory rate is of less importance in estimating the prognosis of colicky horse (Blood *et al*., 1989 and Bryan *et al.,* 2009), but it is said to be increased in colicky horses (Reeves *et al.,* 1989; Ferraro, 2008; Bryan *et al.,* 2009; Sutton *et al.,* 2009 and Scantlebury *et al.,* 2011) due to either pain, or acidosis (Bryan *et al.,* 2009).

Although body temperature is usually in the normal range in colicky horses, sometimes it decreases as in shocked cases (Blood *et al*., 1989 and Hillyer *et al*., 2008), or increase (Blood *et al*., 1989; Alsaad and Nori, 2010 and Hart *et al*., 2012) as in acute (Alsaad and Nori, 2010) and sand colic (Hart *et al*., 2012) due to

either physical effort (Blood *et al*., 1989) or presence of pyrogenic agent (Blood *et al*., 1989 and Bryan *et al.,* 2009).

1.3.3 Physical examination

Physical examination and observation of clinical signs are important for determination of colic cause and degree of severity (Bryan *et al.,* 2009).

1.3.4 Nasogastric intubation

Nasogastric intubation is important for diagnosis of colic, and relief of gastric distension, which will rupture the stomach, if not treated, because of inability of equines to vomit (Ferraro, 2008). Normal stomach contents are thick, mucoid, acidic (Blood *et al*., 1989) and of large quantities of fetid gas and fluids (Hillyer *et al*., 2008). But they become watery, bile stained and alkaline as duodenum contents get into the stomach (Blood *et al*., 1989).

1.3.5 Rectal palpation

Rectal examination is important step in diagnosis of colic, through it clinician can examine reachable organs (Ferraro, 2008 and Hillyer *et al*., 2008), some cases such as impaction of pelvic flexure accurately diagnosable by rectal palpation. Intestinal ileus is characterized by palpable loops of distended small intestine with normal wall thickness (Hillyer *et al*., 2008); distended small intestine appears in accordion–like shape which can be located vertically or horizontally (White and Edward, 1999). Impaction of faeces in the large intestine gives palpable long column like-shape, which indicates impaction colic. Stretching of mesentery is detected when there are heavy contents in the

intestine pulling it down, or when small intestine is twisted or telescoped into itself. If the rectum is empty from faeces, this refer to either partial or complete obstruction, they are distinguishable by administration of oil, in partial obstruction drenched oil will pass out through rectum, but not in complete obstruction (Blood *et al*., 1989). Despite the importance of rectal palpation, it is difficult to be carried out in small sized horses and in horse with severe abdominal pain (Mezerova *et al*., 2001).

Anyhow rectal palpation findings are not dependable alone in final decision making, they should be interpreted with the results of other steps of examination (Bryan *et al.,* 2009).

1.3.6 Ultrasonography

Ultrasonograhpy is used for examination of unreachable organs by rectal examination (Ferraro, 2008). Percutaneous ultrasoungraphy is used in confirming of gastric rupture diagnosis which is characterized by increased volume of peritoneal fluids (Hillyer *et al*., 2008). Abdominal ultrsonograhpy also can be used for definitive diagnosis of small and large intestine diseases such strangulation obstruction (Beccati *et al*., 2011). In addition to that transcutaneous ultrasonography is usable for assessment of intestinal peristalsis (Williams *et al*., 2011).

1.3.7 Abdominal auscultation

Auscultation to the abdomen by stethoscope is carried out parallel to the edge of the last rib on both sides (White and Edward, 1999) but one should pay attention so as not to confuse gas sound which is produced by microbes, with sounds of

intestinal movement (Blood *et al*., 1989). There are two sounds can be heard in normal equine, short mixing sounds 2-4 times/minute, and long propulsive sound which can be heard one/2-4minute. The last one increase directly after eating (White and Edward, 1999), or at the beginning of enteritis or peritonitis (Blood *et al*., 1989) but in colic cases this sound would decrease, or even absent if the case was severe (Reeves *et al.,*1989; White and Edward., 1999; Hillyer *et al*., 2008; Scantlebury *et al*., 2011 and Hart *et al*., 2012) as in paralytic ileus, impaction (Blood *et al*., 1989) and strangulation (White and Edward, 1999) or may not be affected during colic period (Scantlebury *et al*., 2011 and Hart *et al*., 2012).

Result of abdominal auscultation is important for evaluation of colicky horses, as those with absent gastrointestinal movement are more likely to die, compared to those with decrease or normal gastrointestinal movement respectively (Reeves *et al.,* 1989). Propulsive sound usually increases in spasmodic colic (Blood *et al*., 1989 and White and Edward, 1999). Gas sounds are audible in flatulent colic (White and Edward, 1999).

Abdominal radiography can be used in diagnosis of some causative agents of colic such as sand, metallic foreign bodies, and enteroliths, but the accurate diagnosis depends on the size of the horse, content of the intestine, and used equipments. Existence of gas in intestine, horse size, air of the lungs not allows evaluation of all contents of the abdominal cavity (Ferraro, 2008).

1.3.8 Abdominocentesis

It means collection of peritoneal fluids by blunt canula (Ferraro, 2008) or needle (19-gauge, 3.75) introduced through mid line of the abdomen *linea alba*, then fluids are collected in tubes with or without EDTA according to the needed tests (White and Edward, 1999), although abdominocentesis is important for evaluation of degree of gastro-intestinal damage, wrong application lead perforation of intestine and development of peritonitis (Blood *et al*., 1989). The normal peritoneal fluids are characterized by small amount, with clear pale yellow colour (Ferraro, 2008), parameters that can be evaluated from peritoneal fluids include: white blood cells (WBCs), protein, and specific gravity (Blood *et al*., 1989 and White and Edward, 1999).

1.4 Clinical pathology

In spite of importance of laboratory values in differentiation between colic cases that need surgical treatment, from medical treatable cases, they are also of great value for correction of both dehydration and acid-base imbalance (Ihler *et al*., 2004).

1.4.1. Haematology analysis

Packed cell volume (PCV) is used for estimation of dehydration degree (Blood *et al*., 1989 and Moore and Palmer, 2001) after excluding of anaemia and acute blood loss, every 1% (PCV) increasing above average normal value, means 10ml/kg deficit of water (Moore and Palmer, 2001). As long as PCV increases because of either spleenic contraction or dehydration,

the use of this variable alone as indicator of hydration status is unreliable, so PCV has to be measured with total protein concurrently, for accurate estimation of dehydration (Blood *et al*., 1989 and White and Edward, 1999) and that after excluding of causes result in hypoproteinaemia such peritonitis and intestinal infarction, so as to avoid wrong interpretation of the measured protein value (White and Edward, 1999). PCV is also important for estimation of the outcome of colicky horse (Thoefner *et al*., 2001 and Ihler *et al*., 2004) especially after surgical treatment, (Ihler *et al*., 2004) the cut-off point of PCV (which means, the point where one decides whether the case is survivable or not) is 44% (Detilleux and Serteyn, 2005).

Generally mild, recurrent, and severe colic increases PCV value. Decrease of total red blood cells (TRBCs) and haemoglobin (Hb) concentration was noticed in recurrent colic (Alsaad and Nori, 2009). Leukocytosis and neutrophilia was seen in horses with severe and recurrent colic, and eusinopenia and lymphocytosis in horses with recurrent colic (Alsaad and Nori, 2010). Total and differential WBCs count are of value in estimation cases with peritonitis, leukocytosis is seen in acute local peritonitis and leucopenia in diffused peritonitis (Blood *et al*., 1989).

1.4.2 Biochemical analysis

Monitoring of total protein during colic period is important for evaluation of colic case hydration (Blood *et al*., 1989 and White and Edward, 1999) and for fluid therapy, because large quantity of protein may be lost during colic period into the intestine

resulting in decrease of blood quantity of protein, which will subject the animal to pulmonary oedema if fluids are injected (Blood *et al.*, 1989). Total protein and albumin increase in horses with mild and recurrent colic and they decrease in horses with severe one (Alsaad and Nori, 2009).

Reduction of glucose in colicky horses was recorded by (Alsaad and Nori, 2010) but the opposite was reported in study by (Hassel *et al.*, 2009).

Electrolytes are important for keeping normal intestinal peristalsis and for choice of suitable fluid therapy for rehydration, so they have to be kept within the normal range, the most important minerals to be measured are: sodium, chloride, potassium, and calcium. Sodium provides information about extracellular fluids and water deficit in this space. Although measurement of plasma or serum quantity of potassium does not represent the real amount of intracellular potassium level its measurement is important especially during severe acidosis. Importance of calcium is to maintain normal intestinal motility and cardiac contractility (White and Edward, 1999).

Nappert and Johnson (2001) noticed that colic decrease the blood quantity of sodium and potassium. Alsaad and Nori (2009, 2010) reported that potassium blood level increase during acute and recurrent colic, but calcium and chloride levels decrease during them (Alsaad and Nori, 2009 and 2010).

Acid-base balance in colicky horses is not stable, ranging from severe alkalosis to severe acidosis (White and Edward, 1999)

when there is a problem such as obstruction at the pyloric region, it confines acidic gastric fluids and develop alkalosis, but if the problem is in the intestine it leads to confining of alkaline fluids and acidosis develop (Blood *et al.*, 1989).

Volatile fatty acids concentrations increase in colic cases (Nappert and Johnson, 2001) in addition to lactate dehydrogenase (LDH) and urea nitrogen which increase only during acute and recurrent colic periods (Alsaad and Nori, 2010).

Level of blood lactate usually increase when the source of the colic is the small intestine, but this level is less affected by the large intestinal accidents, such as torsion; its level is important for prognosis of colic case; the most blood lactate increased the most poor prognosis is expected (Blood *et al.*, 1989).

Measurement of serum quantity of urea and creatinine are useful in evaluation of renal work before administration of drugs known as nephrotoxic such as non-steroidal anti-inflammatory drugs and Gentamicin (Bryan *et al.,* 2009). Plasma beta-endorphin, cortisol, ACTH, and lactate concentrations are good indicator of severity of colic and the prognosis of the colicky case (Niinistö *et al.,* 2010).

1.5 Treatment of equine colic

Treatment of equine colic is an art and science in the same time (Sanchez and Robertson, 2014); colic can be treated medically, surgically, or by both medical and surgical treatment according to the case (Hillyer *et al.*, 2008). Mild colic can relieve

even without or with minimal medical care (Bryan *et al*., 2009) medical treatable cases are more favourable in prognosis than surgical ones (Reeves *et al*., 1989 and Sutton *et al.,* 2009) so it is important to differentiate between them, because delay in identification of complicated cases increase the probability of death (Bryan *et al.,* 2009)

Measurement of abdominal fluid protein concentration and evaluation of this fluid colour are helpful in differentiation between medical and surgical treatable cases, also clinical parameters that indicate status of cardiovascular system such as mucous membrane colour, capillary refill time, heart rate, and the severity of clinical signs are of great value in assessment of colic cases outcomes (Sutton *et al.,* 2009) including respiratory rate (Reeves *et al.,* 1989). Laboratorial the more neutrophils count, PCV, glucose, bicarbonate, chloride, and peritoneal fluid total protein increase the more the case near to die (Reeves *et al*., 1989). F2-isoprostane which its production increases by increasing of oxidation reactions as in intestinal ischaemia and inflammation that is characterized by oxidative stress, it is considered good indicator for equine colic prognosis. Isoprostane is measured from urine, and it was found increased in urine of colicky cases, its concentration was found higher in surgical treatable and in un-survivable cases than medical treatable and survivable cases respectively (Noschka *et al.,* 2011)

Treatment of horse with colic should be directed towards killing pain, rehydration, and normalizing intestinal peristalsis

(White and Edward, 1999; Hillyer *et al*., 2008 and Hart *et al*., 2012) but laxatives (such as psyllium, mineral oil, and magnesium sulphate or combination of all the mentioned laxatives at once in are used in treatment of impaction colic cases) anthelmintics, antibiotics, adsorbents, hydrochloric acid suppressant (such as ranitidine or omeprazole) and gastro-protectants are usable when needed according to the case (Hart *et al*., 2012)

Killing pain is the most important step when dealing with pained horse (Robertson and Sanchez, 2010) because it may harm itself, if pain is not killed to do this, when there is distended stomach or intestine it should be decompressed first before administration of analgesics (White, 2006).

1.5.1 Decompression of stomach and large intestine

Nasogastric intubation is applicable for decompression of stomach distended by gas or fluids, intubation should be repeated until no gastric reflux is seen (White and Edward, 1999 and Hillyer *et al*., 2008) sometimes intubation alone is not enough for removing of gastric contents, so they should be siphoned out over and over to avoid gastric rupture, intubation must be repeated every three hours interval (White and Edward, 1999).

Caecum is the most common place for gas accumulation, for removal of this gas, caecum is punctured from outside, in the right flank, in the middle distance between prominence of tuber coxae and last rib, by needle characterized by 5-6 inch long and 14-16gauge. Aseptic technique must be done before puncture, for avoidance of peritonitis; after insertion of the needle, the caecum

should be pressured through rectum for better removal of the gas, then normal saline has to be passed through the inserted needle to forbid peritonitis. Unfortunately when caecum decompression is needed, surely there is lesion need surgical interference (White and Edward, 2001). Generally abdominal distension has to be taken in account when assessing colicky horses (Southwood *et al*., 2010a).

1.5.2 Analgesics

Analgesics make the colicky horse relax and prevent it from injuring itself (White, 2006), the most used pain killers during colic period are: non-steroidal anti-inflammatory agents, alpha2 agonists, opioids (White, 2006 and Robertson and Sanchez, 2010 and Hart *et al*., 2012) and spasmolytics (White, 2006).

1.5.2.1 Non-steroidal anti-inflammatory agents

Non-steroidal anti-inflammatory agents which include flunixin meglumine, ketoprofen, phenylbutazone (White, 2006 and Robertson and Sanchez, 2010) and meloxicam (Mezerova *et al*, 2001) are the most drugs used for killing pain (Sanchez and Robertson, 2014) of either surgical or non-surgical cases (White, 2006) and for manage of endotoxaemia associated with equine colic (Marshall and Blikslager, 2011a), and relief of pain due to lameness also (Foreman and Ruemmler, 2011). Non-steroidal drugs have different effects when they used as pain killers, this may be either due to their mode of action (White, 2006), or to their distribution, non-steroidal anti-inflammatory agents distribute in different levels in the different tissues, clear example

is phenylbutazone which concentrate in muscles more than viscera, so it is more useful in killing somatic pain, than visceral pain (Blood *et al*., 1989) non-steroidal anti-inflammatory agents inhibit cyclo-oxygenase 1and cyclo-oxygenase 2 in different levels also, and these enzymes are distributed in different concentrations in the different tissues (White, 2006). Ketamine and/or butorphanol are being used for controlling severe pain; drugs such as gabapentin which control neuropathic pain are used for controlling pain as that of laminitis (Sanchez and Robertson, 2014).

Flunixin meglumine is spasmolytic and analgesic drug (Huskamp and Scheidemann, 2000) it is the strongest available non steroidal analgesic (Blood *et al*., 1989; White, 2006 and Robertson and Sanchez, 2010) single dose of 1mg/kg of flunixin meglumine given intravenous, intramuscular, or per os can treat many cases of colic completely (Robertson and Sanchez, 2010) Flunixin meglumine also is characterized by relative long duration of action, endotoxins antagonist (Blood *et al.,*1989; Moore and Barton, 2003 and White, 2006) and it keeps blood flow to the obstructed and strangulated organs (White, 2006), without interfering with healing of damaged intestinal mucosa (Morton *et al.,* 2011). But the opposite was said in the small intestine, Flunixin meglumine was found to influence recovery of small intestine mucosa injury because of ischaemia (Marshall *et al.,* 2011a and Marshall and Blikslager, 2011b) due to inhibition of cyclo-oxygenase enzymes (Marshall *et al.,* 2011b). Flunixin

meglumine has no effect on physiological response of horse to the stress (Kallings *et al.,* 2010). Ketoprofen is less in killing pain than flunixin meglumine, but it is as effective as it in counter acting endotoxins, in addition to that it is less ulcerogenic than flunixin meglumine (White, 2006).

The disadvantages of non-steroidal anti-inflammatory agents especially phenylbutazone include, gastrointestinal ulcers and renal damage (Moore and Barton, 2003 and White, 2006) especially when they are administrated per os for long time during dehydration or when they given concomitantly with the aminoglycosides (White, 2006).

1.5.2.2 Alpha2 agonists

They include Xylazine, Detomidine which are strong analgesics, with muscle relaxation and sedation properties, but unfortunately their disadvantages reduce their usage in the treatment of colic cases (White, 2006), but they are usable initially during evaluation of colicky cases (Robertson and Sanchez, 2010) their disadvantages include bradycardia, reduction of blood flow to the obstructed large intestine, increasing urine production which complicate dehydration, reduction of intestinal motility which complicate ileus, and the short duration of action (White, 2006). Usage of Romifidine which is also Alpha2 agonist is restricted to horse with heart problems because it reduces heart and respiratory rates the same as other Alpha2 agonists (Figueiredo *et al*, 2005).

1.5.2.3 Opioids

Morphine and oxymorphine are strong analgesics, but they may excite horse when given alone, this is avoidable by administering them concomitantly with xylazine, but unfortunately they also reduce transit of ingesta which discourage their use in colicky horses (White, 2006).

1.5.2.4 Spasmolytics

They include: atropine and hyoscine, they produce their analgesic effect indirectly by reducing intestinal peristalsis, so they are used in spasmodic colic (White, 2006). Atropine is not advisable in treatment of equine colic because intestinal relaxation that it does continue to several days, so that it complicates the cases that already have intestinal ileus (Blood *et al.*, 1989 and White, 2006). Dipyrone also one of spasmolytics and has the same side effect as atropine (Blood *et al.*, 1989). Hyoscine is the most used spasmolytic, because it has short duration of action comparing to atropine (White, 2006).

Gradual response of colicky horse to analgesics, which is identified by gradual disappearance of clinical signs and paying attention to surrounding environment, is good indicator for the response to the treatment. Not responding to analgesics is indicator of surgical intervention (Blood *et al.*, 1989 and Mezerova *et al.*, 2001). When there is sudden relief of pain, accompanied by rapidly deterioration of the physiological parameters, muscle tremor, and sweating are considered bad indicators (Blood *et al.*, 1989).

1.5.3 Rehydration

Colic cases with dehydration, almost have metabolic acidosis, so solutions contain lactic acid must be avoided so as not to deteriorate the case; fluids contain carbohydrate are suitable for such cases (infusion of 50gram in one litter intravenously) (Blood *et al*., 1889) and fluids with potassium and calcium should be administered according to the laboratory investigations (Hillyer *et al*., 2008). In addition to that equine albumin solution also can be used for rehydration of the dehydrated colicky horses; the rehydration is indicated by attraction of fluids into intravascular compartment, the last is known by increasing of arterial pressure and capillary refill time, and decreasing of packed cell volume and serum protein concentration (Belli *et al.,* 2013).

1.5.4 Normalizing intestinal peristalsis

Stasis of gastrointestinal tract that happen without any physical obstruction is known by ileus, the most susceptible site of the digestive system to the ileus is small intestine, ileus due to calcium, potassium, and magnesium disturbance can be treated by correction of this problem (White and Edward, 1999). Large intestine ileus is treatable by zelnorm, but it has no effect on the small intestine ileus (Ferraro, 2008) or by infusion of isotonic electrolyte solutions (ringer lactate) by rate of 40-80 litre every twenty four hour, (White and Edward, 1999). Generally erythromycin and acepromazine normalize intestinal peristalsis, and they are useful in treatment of ileus (Hillyer *et al*., 2008). In post operative ileus that develop after surgical intervention

because of strangulation is related to the dysfunctional muscle layer (Ceulaer *et al.,* 2011a)

1.5.5 Impaction colic treatment

Impaction is treated either by laxatives or anthraquinone purgatives, efficacy of anthraquinones is variable and may cause severe diarrhoea (Blood *et al*., 1989) they lubricate the intestine and prevent toxins absorption the recommended dose is 5-10ml/kg, mineral oil administration is contraindicated in horses with obstruction especially obstruction of small intestine because they worsen the already distended stomach, so they must not be give to horses with severe colic without accurate diagnosis (White and Edward, 1999).

1.5.6 Treatment of endotoxemia

Although most colic cases do not become endotoxic, but when endotoxaemic signs appear it had better to be treated early without waiting for laboratory diagnosis (Moore and Barton, 2003) because it has high fatality rate (Skyes and Furr, 2005). Treatment of endotoxaemia should include suitable anti microbial drug, fluid therapy, heparin (Skyes and Furr, 2005) and neutralization of endotoxins either by non-steroidal anti-inflammatory agents such as Flunixin meglumine, which also reduce the release of inflammatory mediators that responsible for development of endotoxaemia, or by anti-endotoxin serum (Moore and Barton, 2003).

1.5.7 Surgical treatment

Most of death due to colic happens after surgical treatment of colic (Kaneene *et al*., 1997., Hunt *et al.,* 1986; and Ihler *et al*., 2004) due to post operative complications. Death is more common after surgical treatment of small intestine problems comparing to large intestine problems (Hunt *et al*., 1986), most cases of death are noticed during the first ten days post surgical operation (Proudman *et al*., 2002).

Surgical intervention is required in cases of intestinal accidents (Blood *et al*., 1989) such as strangulation (Ceulaer *et al.,* 2011b) and most cases of right dorsal colon impactions (Mezerova *et al*., 2001) and all cases of caecal muscle hypertrophy (Huskamp and Scheidemann, 2000). Surgical intervention should be done only when there is accurate diagnosis and real need for it. Severe abdominal pain (Blood *et al*., 1989 and Mezerova *et al*., 2001) and the mild one because of caecal hypertrophy (Huskamp and Scheidemann, 2000) which do not respond to analgesics need surgical intervention (Blood *et al*., 1989 and Mezerova *et al*., 2001) long duration of the disease, high degree of general health alteration are good indicators of need for surgical treatment especially in right dorsal colon impaction cases (Mezerova *et al*., 2001). Gastric reflux, pain and abdominal distension are strong indicator for surgical intervention when nephrosplenic entrapment of the large colon is diagnosed, but both of surgical intervention and increased tachycardia are indicators of poor prognosis in this case (Lindegaard *et al*., 2011). Heart rate and mucus membrane colour are good indicators for

horse situation after surgical intervention as colicky horse with very changed mucus membrane colour (cyanotic or hyperaemic) and increase heart rate are bad indicators.

1.6.1 Complication of surgical treatment of colic

Patient discomfort, jugular thrombosis, carrying out of laparotomy to the second time, incised hernia and colic (French, 2002 and Proudman *et al.,* 2002) which is considered the most common complication after surgical treatment of colic (Proudman *et al*., 2002) ileus, wound infection (Hunt *et al*., 1986; French, 2002 and Proudman *et al.,* 2002), diarrhoea, infection of the surgical wound and death in some cases (Mezerova *et al*., 2001 and Proudman *et al*., 2002), abortion of pregnant mares (Mezerova *et al*., 2001) laminitis (Hunt *et al*., 1986; Mezerova *et al*., 2001 and Proudman *et al*., 2002), and peristalsis stasis (Hunt *et al*., 1986; Ferraro, 2008 and Proudman *et al*., 2002) which may stay for long time after surgery leading to stomach rupture (especially when colic is originating in small intestine) and death (Ferraro, 2008), salmonellosis (Proudman *et al.,* 2002) and long hospitalization which subject the horse to gastric ulceration due to stress, feeding, or medical treatment (Rabuffo *et al*., 2009). Impaction colic, gastric rupture, and hyposarcoma as in surgical treatment of colic due to caecal hypertrophy (Huskamp and Scheidemann, 2000).

1.7 Feeding of colicky cases

Horse suffering gastrointestinal diseases needs to be fed parentally for provision of energy; used infusion fluids should

contain glucose, amino acids, and lipids. Lipids provide high energy and they are less irritant compared to glucose, but unfortunately horse may be less tolerant to them during endotoxaemic periods (White and Edward, 1999). Food and water forbiddance have to continue even neither gastric reflux, nor intestinal ileus is available so as to avoid gastric distension (White and Edward, 1999 and Hillyer *et al*., 2008). Then water is offered first gradually, four hours after water is tolerated by the horse, it is allowed to eat (Hillyer *et al*., 2008) any type of hay gradually also until it defecates normally, then the horse is left to eat hay freely, return to grain usually after the horse passes out normal faeces for a week, the normal amount of grain preceded colic is reached gradually within 5-7days (White and Edward, 1999).

Chapter Two

Materials and Methods

2.1 Study area

The current study was conducted in Nyala, South Darfur state, western Sudan that is located between Latitude 13-9.30º north and Longitude 27-24.30º east. During the period from the 1st of January 2012 up to the 1st of October 2014.

2.2 Study population:

A total number of 80 draught horses and 11 draught donkeys were examined in Nyala, South Darfur State, Sudan.

2.2.1 Inclusion criteria

Animals showed signs of colic were included in the study.

2.3 Classification of colic cases

2.3.1 According to severity of pain

Surveyed animals were assigned according to the severity of pain into three groups viz: mild, recurrent, and severe.

Mild: Animals showed clinical signs as flank watching, getting up and down, stretching, rolling on the ground, positive rectal palpation, and heart rate 50 -60 beat/minute, and responsive to the pain killer were considered as mild colic cases.

Severe: Whereas animals with sweating, restlessness, severe uncontrollable rolling, muscle tremor, abdominal distension, capillary refill time more than 4 seconds, negative rectal palpation, not responding to pain killers (Flunixin meglumine, or ketoprofen) heart rate more than 60 beat/minute, were considered as severe colic cases.

Recurrent colic: animals with episodes of colic at 20-30 minutes interval are to be considered as having recurrent colic.

2.3.2 According to age

According to age animals were categorized as follows:

1. Less than one year
2. More than one year and Less than five year.
3. More than five years

2.4 Clinical examination

2.41. History

A detailed history of the cases was obtained from the owner and examination of source of feed, environment, and source of water as described by Kelly (1984).

2.4.2 Clinical signs

Clinical signs were documented for each individual case according to Kelly (1984).

2.4.4 Physiological parameters

All animals were examined clinically for estimation of respiratory rate, pulse rates, rectal temperature, eye mucous membrane colour, capillary refill time, percussion auscultation, and rectal palpation, using standard methods according to Kelly (1984).

2. 5 Blood samples collection

Five millilitre of whole blood were collected from Jugular vein of each animal by disposable syringe, after following of aseptic technique procedures, 2.5ml were mixed with EDTA in plastic container for haematological indices. The remaining part (2.5ml) of the blood was mixed with fluoride in plastic container for

plasma separation, for blood biochemical parameters measurement.

2.6 Haematological indices

The whole blood was tested for the determination of red blood cell count (RBCs) 10^6 cell/µl, haemoglobin concentration (Hb) g/dl, packed cell volume (PCV) %, Total white blood cells (WBCs) 10^3 cell/µl, and differential count of the white blood cells according to (Jain *et al*., 1986) as follows:

2.6.1 Red blood cells (RBCs)

For counting the red blood cells (RBCS), the whole blood was diluted by Gower's solution (consisting of sodium sulfate12.5g, glacial acetic acid 33.3ml and 200ml distilled water) to 1:200. Haemocytometer was used for counting the RBCS using lens objective 40. The counted number was multiplied by 10000 for obtaining numbers of RBCS in micro litre of the blood sample.

2.6.2 Haemoglobin concentration (Hb)

Haemoglobin composed of protoporphyrin, native globin and iron; measurement of the haemoglobin usually depends either upon determination of its iron content or on its oxygen carrying capacity.

In this study haemoglobin was measured by haematin method, which depends upon separation of globin from haemoglobin by hydrochloric acid for obtaining the brown coloured acid haematin. The quantity of haemoglobin was determined by Sahli apparatus.

2.6.3 Packed cell volume (PCV)

Three-fourth of plain capillary tube was filled by blood using capillary traction, the same end of capillary tube used for blood traction was sealed by sealing material, and then blood in capillary tube was separated by centrifugation at 1500rpm for five minutes. PCV was measured in millimetre, which usually expressed in percentage (%).

Centrifugation separates blood in the capillary tube into three parts:

-The clear upper part is blood plasma which exceeds 50% of the whole blood in the capillary tube.

-In the middle under plasma directly, white to gray coloured thin layer, called buffy coat consisting of white blood cells and thrombocytes.

-The last part under buffy coat is mass of red blood cells, called packed cell volume (PCV).

2.6.4 Total WBCs count

For counting of the white blood cells, the blood was diluted by turkey solution to 1:20. Haemocytometer was used for counting the WBCS using objective 10 the counted number in one was multiplied by 50 for obtaining numbers of WBCS in micro litre of the blood.

2.6.5 Differential count of White blood cells count

One layer blood film was made on glass slide, after drying the film it was fixed by absolute methyl alcohol and stained by Giemsa stain, then 100 of white blood cells was counted using

objective 100, percentage of each neutrophils, basophils, acidophils, monocytes, and lymphocytes were counted.

2.7 Blood biochemical parameters

The following blood biochemical parameters: glucose, Total protein, albumin, urea, sodium, potassium, calcium, were measured using spectrophotometer (*Biosystem* –BTS-302) in the Physiology Laboratory, Faculty of Veterinary Science University of Nyala.

2.7.1 Total protein

Total proteins were measured according to the method described by (King and Wooton, 1956), in alkaline media protein form intensive violate blue complex with copper salt. This intensity is directly related to the concentration of protein in the sample, Sample concentration of protein was calculated by the equation:

Sample concentration of protein = $\frac{sample}{standard} \times 7(standard\,concentration)$.

2.7.2 Albumin

At PH 4.2 bromocresol green binds to the albumin. The intensity of the formed colour is proportional to the concentration of the albumin in the sample; the concentration of the albumin in the sample was calculated by the equation according to the method described by (Bartholomew and Delany (1966) as follows:

Albumin concentration in sample = $\frac{sample}{standard} \times 5(standard\,concentration)$

2.7.3 Glucose

The procedure of measuring glucose was according to (spinreact, Girona Spain) instructions

Glucose is converted to Quinone as follow:

B-D-glucose + o_2 +H_2o –glucose oxidase → Gluconic acid+H_2o_2

H_2o_2 + phenol + aminophenazone −peroxidase→ quinine + H_2o

Produced colour intensity refers to the concentration of the glucose in sample. Concentration of glucose in mg/dl in the collected samples was calculated as following Sample glucose

concentration (mg/dl) = $\frac{sample}{standard} \times 100 (standard\ concentration)$

2.7.4 Urea

Urea is converted to indophenol as following equation

Urea + H_2o −urease→ $(NH^+_4)_2$ +co_2

NH^+_4 + salicilate + NaClO −Nitroprusside→ indophenols

The produced colour intensity is directly related to the concentration of urea in the sample, and it was calculated according to the method described by (Fawcett and Scott, 1960) by the equation:

Urea concentration in sample (mg/dl) = $\frac{sample}{standard} X\ 50$

2.7.5 Calcium

Calcium was measured according to (spinreact, Girona Spain) instructions. Colour produced following the reaction between calcium and o-Cresolphtalein in alkaline medium, is directly related to the concentration of calcium in the sample. The final result was calculated as following:

Concentration of calcium in the sample (mg/dl) =

$$\frac{sample}{standard} \times 10(standard\ conc)$$

2.7.6 Sodium

Sodium was measured according to (spinreact, Girona Spain) instructions, it reacts with chromogen to produce chromophore which its colour absorption refers to the sodium concentration in the sample. The final result was calculated as following:

Concentration of sodium in the sample (mEq/L) =

$$\frac{sample}{standard} \times 5(standard\ conc)$$

2.7.7 Potassium

Potassium was measured according to (spinreact, Girona Spain) instructions, its concentration was measured by using tetraphenylboron which produce turbid colloid suspension. Resulted turbidity directly refers to the concentration of the potassium in the sample this concentration was calculated by equation

Sample concentration of potassium (mEq/L) =

$$\frac{sample}{standard} \times 5(standard\ conc) \quad .$$

2.8 Faecal sampling and analysis.

Fresh faecal sample was taken directly from the rectum of each colic case suspected by verminous colic for egg count and culture. Modified McMaster technique was used for egg count

according to (Anonymous, 1986). Positive faecal sample for egg of internal parasites was cultured and infected larvae were harvested by Baermann technique, as described by Zajac and Conboy (2006) for more accurate diagnosis. Percentage of the infestation was also determined.

2.9 **Treatment**

Animals proved to be with colic were treated using two different drugs as follows:

Ketoprofen,Montajat Pharmaceuticals-Saudi Arabia

Flunixin meglumine, Pharma Swede-Egypt

According to severity of colic animals either treated with one of the following two doses:

Light cases were injected 1.1mg/kg of Ketoprofen or Flunixin meglumine by intravenous route.

Severe cases were injected 2.2mg/kg of Ketoprofen or Flunixin meglumine by intravenous route.

Response to the drug was evaluated by gradual disappearance of the clinical signs 10 minutes after injection of the drug. Response of animals to treatment was categorized as follows:

Responded cases, means responded to single dose of the injected drug

Responded but colic returns means, colic return in less than six hours and needed more doses (recommended dose interval by producing company is 24 hour for both drugs).

Not responded cases, means no changes in clinical signs were noticed after injection.

2.10 Control animals

For the purpose of normal standard values, six donkeys and six horses were included in this study; they were examined for normal parameters included in this study.

2.11 Statistical analysis

Analysis of variance (ANOVA) was used for analysis of data obtained from horses, whereas Descriptive statistics was used for description of data that obtained from donkeys.

Chapter Three

Results

3.1 Aetiology of colic in horses and donkeys

The main encountered causes of colic in horses were unknown causes (25%), feeding large amount of rough dry fodder (23.75%) and feeding large amounts of grains (16.25%). While in donkeys feeding large amount of green fodder (27.3%) and urinary infection (18.2%), were the main causes encountered. Other causes were enlisted in Tables (1 and 2).

3.2 Clinical signs

According to the severity of the clinical signs colic group was divided into subgroups light and severe. Noticed clinical signs (Tables 3 and 4) included flank watching (Figure1), stretching (Figure 2), pawing at the ground, restlessness curling of lips were observed in light colicky cases. Rolling (Figure 3), running, muscle tremor, still lying down, and sweating were observed in severe colic cases. Three types of eye mucous membrane colour (congestion, petechial haemorrhage, and cyanosis) (Figures 4) were also noticed in this study. Dilatation of anal sphincter was observed in horses and coffee like (Figure 5) urine in Monday morning disease cases.

3.3 severity of colic pain in relation to age

Horses more than five years old were the most susceptible to colic attack than other ages (Table 5). But all colic cases in donkeys were found in more than five years old donkeys.

3.4 Classification of colic according to severity of pain

From Table (6) it is clear that the most cases of colic in horses were light and only one case of recurrent colic was found; in donkeys 8 cases were light and 3 severe.

3.5 Response of treated colicky horses to treatment with Ketoprohen and Flunixin meglumine

As demonstrated in Tables (7 and 8) Flunixin meglumine appears to be better than Ketoprofen in the treatment of equine colic in general. All cases of colic in donkeys were treated by Flunixin meglumine; 3 out of 11cases of colic in donkeys were severe and not responded to the treatment and the rest were light and all of them responded to single dose of Flunixin meglumine.

3.6 Changes in physiological parameters in colicky horses

From Table (9) Respiratory rate was increased in all light and severe colic cases, while there was no differences in pulse rate, temperature and capillary refill time were found between light colic cases and normal control group; all of the three increased in severe colic cases.

In Table (10) the range of respiratory rate in colic group is wider than in control group, because some cases had deep respiration and low rate, in the pulse rate and capillary refill time the range is also wider in colic group, because three severe colic cases with higher readings were included in the mentioned group.

3.7 Haematological changes in colicky equine

From the Table No (11), no differences in PCV and Hb were found between control and light colic cases but both of them increased in the severe colic cases, total white blood cell count

increased in both light and severe colic cases, but no differences were notice in the differential count of colic group except the basophils which decreased in both of light and severe colic cases. In table (12) the range of white blood cell count is wider than in normal control group because total number in higher in severe colic cases than in light colic cases.

3.8 Biochemical changes in colicky equines

From Tables (13 and 14) no differences were found in total protein, albumin, urea and sodium between control group and light and severe colic cases, but increase of globulin and glucose and decrease of calcium and potassium were registered in light and severe colic cases.

3.3

Table 1: The most encountered causes of colic in horses

Cause	Frequency	%
Feeding large amount of grains	13	16.25
Feeding large amount of green fodder	9	11.25
Feeding large amount of rough dry fodder	19	23.75
Sand	1	1.25
Helminths infestation	5	6.25
Urinary origin (urine retention)	11	13.75
Unknown causes	20	25
Protein overload	2	2.5

Table 2: The most encountered causes of colic in donkeys

Cause	Frequency	%
Feeding large amount of grains	1	9.1
Feeding large amount of green fodder	3	27.3
Plastic	1	9.1
Feeding large amount of rough dry fodder	1	9.1
Helminthes infestation	1	9.1
Monday morning disease	1	9.1
Urinary infection	2	18.2
Unknown causes	1	9.1

Table 3: Frequency of clinical signs noticed in colicky horses

Clinical signs		No. of cases	%
Pain		80	100
Diarrhoea		4	5
Constipation (Dry offensive faeces)		8	10
Urine colour (oil –like urine)		10	12.5
Mucous membrane colour	Congested	50	62.5
	Petechial haemorrhage	29	36.25
	Cyanosis	1	1.25
Normal heart sounds		79	98.75
Abnormal heart sounds		1	1.25
Tight rectal sphincter		75	93.75
Dilated rectal sphincter		4	5
Rectal prolapsed		1	1.25
Rectal palpation *	Faeces detected	51	63.75
	Faeces not detected	28	35

***** One case the animal was very tough so I could not either check it rectally or listen to its' GIT sounds.

Table 4: Frequency of clinical signs noticed colic in colicky donkeys

Clinical signs		No. of animals	%
Pain		11	100
Urine colour (coffee –like urine)		1	9.1
Mucous membrane colour	Congested	5	45.5
	Pink colour	6	54.5
Normal heart sounds		11	100
Abnormal heart sounds		0	0
Tight rectal sphincter		11	100
Dilated rectal sphincter		0	0

*All cases were small in size so rectal palpation was not done.

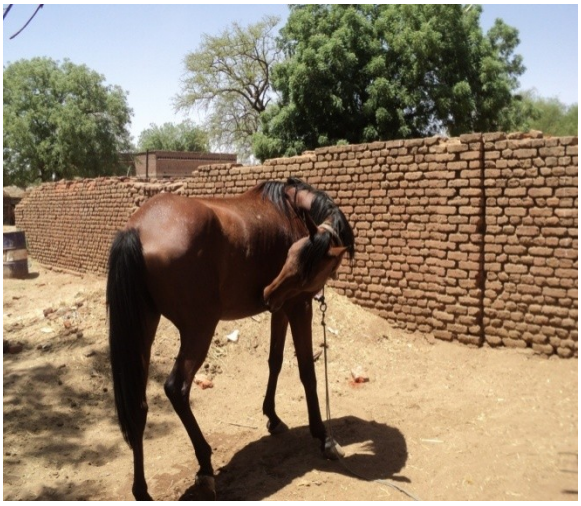

Figure 1: watching flank region

Figure 2:Stretching

Figure 3:Rolling in the ground

Figure 4: Cyanosis

Figure 5: Coffee- like urine

Table 5: Distribution of colicky horses according to severity of colic pain in relation to age

Age	Severity	No. of cases	%
Less than one year	Light	2	2
	Severe	2	4
More than one year and less than five years	Light	4	4
	Severe	1	0
More than five years	Light	45	58
	Severe	25	29
	Recurrent	1	2
Total		80	100

Table 6: Classification of colic in horses according to severity of pain

Severity of clinical signs	No. of cases	%
Light	48	60
Severe	31	38.75
Recurrent	1	1.25
Total	80	100

Table 7: Response of treated colicky horses to Ketoprofen

Type of colic	Total No.	Responded No. (%)	Responded but colic return No. (%)	Not responded No. (%)
Light	25	18 (72)	4 (16)	3 (12)
Severe	16	0 (0)	0 (0)	16 (100)
Recurrent	1	0 (0)	1 (0)	0 (100)

Table 8: Response of treated colicky horses to Flunixin meglumine

Type of colic	Total No.	Responded	Responded but colic return	Not responded
Light	23	20 (87)	1 (4.3)	2 (8.7)
Severe	15	3 (20)	2 (13.3)	10 (66.7)
Recurrent	0	0 (0)	0 (0)	0 (0)

Table 9: Physiological parameters of colicky horse compared to control group

Parameter	Control	Mild	Severe
Respiration rate	26 ± 8.29^{c}	37.2 ± 14.49^{b}	46.62 ±
Pulse rate	43.3 ±	51.63 ± 13.20^{b}	20.72^{a}
(beat/min.)	4.67^{b}	37.86 ± 1.14^{b}	92.76 ±
Temperature (□C)	37.2 ±	2.27 ± 0.73^{b}	31.72^{a}
Capillary refill time	0.25^{b}		38.22 ± 0.94^{a}
	2 ± 0.00^{b}		4 ±1.87^{a}

*Values with different letters in the same row are significantly different ($p < 0.05$)

Table 10: Physiological parameters of colicky donkeys (n=11) and control group of donkeys (No=6)

Parameter	Colicky donkeys			Control group		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Respiratory rate	36	20	52	32	24	48
Pulse rate	55.7	32	112	47.3	40	60
Temperature	36.2	35.1	37.7	37.7	37.1	38.2
Capillary refill time	2.4	1	5	1.3	1	2

Table 11: Haematological indices of control group and colicky horses

Parameter	Control	Mild	Severe
PCV (%)	34.5±3.39[b]	35.92±8.73[b]	44.69±8.99[a]
Hb	13.67±1.37[b]	12.29±2.61[b]	15.07±3.33[a]
RBCS	851.17±139.5	1229.54±447.32[a]	1303.5±545.9
WBCS	9[b]	12675.64±8514.	4[a]
Neutrophils	4650±742.29[b]	10[a]	13673±5236.
Basophils	59.50±10.04[a]	59.78±19.26[a]	77[a]
Acidophil	1.67±1.63[a]	0.27±0.67[b]	71±13.86[a]
Lymphocyte	1.67±1.03[a]	1.93±1.51[a]	0.16±0.45[b]
s	35.17±10.53[a]	34.07±17.24[a]	2.84±2.93[a]
Monocytes	2±1.27[a]	1.8±2.85[a]	23.97±13.33[a]
			1.32±1.51[a]

*Values are mean ± standard deviation

*Values with different letters in the same row are significantly different ($p < 0.05$)

Table 12: Haematological parameters of colicky donkeys (n=11) and the control group (n=6)

Haematological parameter s	Colicky donkey			Control group		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum
PCV (%)	35.9	30	42	32	30	35
Hb	11.5	8	15	11	9	13
RBCs	$971X10^4$	$500X10^4$	$1750X10^4$	$615.7X10^4$	$300X10^4$	$942X10^4$
WBCs	12452	9700	15800	8633	7200	11000

Table 13: Biochemical parameters of control group and colicky horses

Parameter	Control	Mild	Severe
Total protein	7.10±0.81[a]	7.29±2.38[a]	7.53±1.68[a]
Albumin	3.52±0.44[a]	2.89±1.04[a]	3.46±1.39[a]
Globulin	2.1±0.00[c]	4.45±1.87[a]	4.34±1.72[b]
Glucose	85.80±14.79[c]	149.89±80.59[b]	187.21±98.23[a]
Urea	48.73±5.25[a]	61.59±42.13[a]	71.67±47.90[a]
Calcium	7.83±1.72[c]	3.69±2.09[b]	2.89±1.53[c]
Potassium	17.50±8.95[a]	1.45±1.99[c]	1.99±3.81[b]
Sodium	326.97±22.99[a]	281.72±465.73[a]	196.66±90.03[a]

*Values with different letters in the same row are significantly different ($p < 0.05$)

Table 14: Biochemical parameters of colicky donkeys (n=11) and control group (no=6)

Parameter	Colicky donkeys			Control group		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Total protein	7.8	6.5	8.8	6.2	4.3	8
Albumin	3.3	3	3.6	3.4	1.6	4.2
Globulin	4.4	3.3	5.8	2.7	0.7	5.8
Glucose	67.4	56.5	82.6	250.3	46.2	350.7
Urea	26	17	38	95.1	58.3	154.2
Calcium	4.2	3	6	4.3	0.3	10.8
Potassium	24.3	18.3	29.2	8.7	0.00	25.3
Sodium	274.3	290.6	326	274.3	170.7	350.8

Chapter Four

Discussion

Identified causes of colic in this study included, eating large amount of grains, green fodders, and rough dry fodder, in addition to protein over load and urine retention, these causes were in agreement with those reported in a previous study by Alsaad and Nori (2010), *Strongylus vulgaris* as a cause of colic was also previously reported by Reinemeyer and Nielsen (2009).

Animals with colic were divided into two subgroups light and severe according to the severity of pain. Different clinical signs were observed in colicky cases included: flank watching, stretching, pawing at the ground, curling of lips, rolling, running, muscle tremor, still lying down, sweating, and abnormal eye mucus membrane colour. These signs came in agreement with that reported by Ayaz *et al., (*1999), Alsaad and Nori (2009), and Scantlebury *et al.,* (2011). The more serious signs were in severe colic cases, and this may be attributed to the physiological changes and severity of pain (Blood *et al.,* 1989), these signs included: rolling, running, muscle tremor, still lying down, and sweating.Flank watching, stretching, pawing at the ground, restlessness curling of lips in light colicky cases.

Horses and donkeys more than five years of age were found to be more susceptible to colic than younger animals this result in harmony with observations of Cohen *et al.,* (1999) and Rabuffo *et al.,* (2009) in horses and Toit *et al.,* (2008) and Toit *et al.,* (2009) in donkeys. Old horses have more opportunity to be subjected to

the colic causative agents and its risk factors comparing to younger ones (Cohen *et al*., 1999), dental problems and muscular weakness, which are considered the most important risk factors for colic in donkeys, are more common among old members of this species (Cox *et al*., 2007).

Following treatment we could consider Flunixin meglumine better than Ketoprofen in the control of equine colic in general, this result is supported by observations of Huskamp and Scheidemann (2000) who reported that Flunixin meglumine is the strongest available non-steroidal anti-inflammatory agent. This study revealed that single dose of Flunixin meglumine and to some extent of Ketoprofen was enough for the control of light colic cases, as result that was consistent with previous reports of Robertson and Sanchez (2010). Severe cases did not respond to either Flunixin or Ketoprofen that necessities surgical intervention a recommendation that was confirmed by post-mortem findings of some cases which died following severe colic attack, the same observation was reported by Blood *et al.,* (1989) and Mezerova *et al.,* (2001).

Here also it is worthy to mention that attention should be paid because urine retention also does not respond to Ketoprofen or Flunixin meglumine administration; and do not require to surgical intervention as long there is no urethral stones, just evacuation of the bladder by urine catheter is enough for relieving of this type of pain.

Documented elevation of capillary refill time and pulse rate in severe colic cases in this study is in agreement with observations in previous studies (Reeves *et al.,* 1989, Hillyer *et al.*, 2008, Sutton *et al.,* 2009; Alsaad and Nori, 2010). The increase in respiratory rate in both light and severe colic cases was similar with that observed by Ayaz *et al.,* (1999) and Alsaad and Nori (2010) who attributed the increase of respiratory rate to pain (Bryan *et al.,* 2009). No differences in capillary refill time, and pulse rate between mild colicky animals and the control group were detected, this could be justified as that pain relatively has minor effect on the heart rate as long there were no haemoconcentration, reducing venous return which affect capillary refill time, and endotoxaemia, all of that made pulse rate important indicator of severity of the colic and its effect on the cardiovascular system (White and Edward, 1999). Blood *et al.,* (1989) added remarkable physiological changes that happen due to pain are determined by severity of the pain, so that these physiological parameters increase according to degree of pain. Rectal temperature was elevated in severe colic cases this result in the same line with that reported by Ayaz *et al.,* (1999) and Alsaad and Nori (2009), while no change was observed in light colic cases. Body temperature is usually in the normal range in colicky horses, sometimes it decreases as in shocked cases (Blood *et al*., 1989 and Hillyer *et al*., 2008), or increase (Blood *et al*., 1989; Alsaad and Nori, 2010 and Hart *et al*., 2012) as in severe

pain due to either physical effort (Blood *et al*., 1989) or presence of pyrogenic agent (Blood *et al*., 1989 and Bryan *et al.,* 2009).

Packed cell volume (PCV) was significantly increased in severe colic cases this finding is in agreement with Ayaz *et al.,* (1999) and Alsaad and Nori, (2010), while no effect on PCV and Hb level was observed in light colic cases. An increase of haemoglobin was observed in severe colic cases this result that was not consistent with that observed by Alsaad and Nori (2010).This may be as in human, in whom visceral pain may not lead to recognizable either organic or biochemical changes as happen in functional gastrointestinal disorders (Farmer and Aziz, 2013). Alsaad and Nori (2010) showed that, total white blood cells were significantly increased in colic cases. While, no significant variation was seen in differential white blood cells percentages in this study except a decrease in basophils in both light and severe colic cases, increasing of white blood cells was justified by saying that colic is considered as stress factor (Blood *et al*., 1989) it increases corticosteroid levels in the blood, that forbid migration of white blood cells out of the blood vessels to the tissues, in addition to that neutrophils migrate from the marginal pool to the blood stream during pain, both of them increase the total count of the white blood cells in the blood, this increase in total white blood cells may not be accompanied with effects on differential count (Kerr, 2002).

No differences in total protein, albumin and urea between normal control horses and colic group were observed, but globulin

significantly increased in colic group in this study. Plasma protein is affected by blood water which can decrease in case of over hydration and increase in case of dehydration in which all fractions of protein (albumin and globulin) increase by the same percentage, but when there is increase of total protein because of inflammation only globulin increase and albumin either remain unchanged or decreased (Kerr, 2002).

Plasma glucose was increased in light and severe colic cases compared to the normal control group, this result is in agreement with reported by Hassel *et al.*, (2009) and not in line with the observations of Alsaad and Nori, (2010). Increasing of plasma glucose during colic was justified by increasing of both glucocorticoids and adrenaline during pain (Kerr, 2002).

Decreasing of potassium level in both light and severe colic horses in this study matched the previous result of Nappert and Johnson (2001) and differed from the result of Ayaz *et al.,* (1999) who reported that potassium level dose not influence by colic, and from Alsaad and Nori (2010) who indicated that potassium increase in acute and recurrent colic cases. Kerr (2002) explained that, plasma potassium level in horse is fluctuating even in healthy horses; it can decrease in them either due to its losing in their saliva during eating hay or in sweat during prolonged exercise because they have high concentration of potassium in their sweat, oppositely plasma potassium level in horses increase during active exercises.

Decreasing of plasma calcium level which was reported in this study is in agreement with the result reported by Alsaad and Nori (2010) who agreed with Corley (2002), that both of intestinal disturbance and clots that happen during acute colic reduce calcium level in their blood.

Sodium is related to the body water balance, so its disturbance depends on the body water problems. No change in sodium plasma level happened in light and severe colic cases in this study, there may be some physiological factors not included in this study, because when the loss of electrolytes is isotonic to the extracellular fluids the plasma electrolytes do not influence, and sodium is the main extracellular electrolyte in extracellular fluids. A different result reported by Ayaz *et al* (1999) and Alsaad and Nori (2010) indicated that sodium plasma level decrease in colic cases.

Chapter Five

Conclusion and Recommendations

5.1 Conclusion

As horses and donkeys over five years old are the most susceptible age to colic they should be give especial attention so as to avoid risk factors and causes of colic. Pulse rate, mucus membrane colour and capillary refill time are the most important clinical parameters, when evaluating colicky equine. Calcium and potassium should be corrected during treatment of equine colic, but glucose should not be given to colicky horses and donkeys as it was found high in them.

Flunixin meglumine is advised to be used for controlling pain of all types of equine colic by 1.1mg/kg, body weight through intravenous injection in light colic cases and by 2.2mg/kg, body weight through intravenous injection in severe colic cases.

5.2 Recommendations

1. Investigation of equine colic causative agents and their nature must be identified for specific treatment of the disease.
2. Enough water should be given to the horses when they are being fed rough dry fodders and grains.
3. More studies are needed for identification of equine colic causes and for evaluation of the cases especially by measurement of glucocorticoids, as long colic is considered stress factor.
4. Equine colic should be studied during the year so as to identify the season it become more common in it.

References

Alsaad, K.M. and Nori, A.A. (2009). Equine colic and coagulation disorders. *Journal of Animal and Veterinary Advances,* **8**(12): 2675-2679.

Alsaad, K.M. and Nori, A.A. (2010). Clinical, haematological and biochemical studies of colic syndrome in draught horses in Mosul. *Proceedings of the 14th Scientific Conference Faculty of Veterinary Medicine Assiut University, Egypt,* 169-189.

Andrews, F.M., Buchanan, B.R., Elliot, S.B., Clariday, N.A. and Edwards, L.H. (2013). Gastric ulcers in horses*. Journal of Animal Science,* **83**(E. suppl): 18–21.

Anonymous (1986). *Manual of Veterinary Parasitological Techniques*, Ministry of Agriculture, Fisheries and Food. Reference book 418, (3rd Ed) HMSO, London, p.160.

Archer, D.C. and Proudman, C.J. (2006). Epidemiological clues to preventing colic. *Veterinary Journal,* **172**:29–39.

Ayaz, M.M., Pervaz, K., Khan, S.M., Khan, S.A., and Ashraf, M. (1999). Clinical and biochemical studies in equine colic. *Pakistan Veterinary Journal.* 19 (2):91-93

Bartholomew, R.J., and Delany, A.M. (1966). Blood albumin determination. Proceeding of Australian Association of Clinical Biochemists.1-214.

Beccati, F., Pepe, M., Gialletti, R., Cercone, M., Bazzica, C. and Nannarone, S. (2011). Is there a statistical correlation between ultrasonographic findings and definitive diagnosis in horses with acute abdominal pain? *Equine Veterinary Journal,* **43**(39): 98-105.

Belli, C.B., Tavora, J.P.F., Ferreira, R.A., Fernandes, W.R. (2013). Evaluation of equine albumin solution in fluid therapy in horses with colic. *Research in Veterinary Science,* **33**:509-514.

Blood, D.C., Radostits, O.M., Arundel, J.H. and Gay, C.C. (1989). *Veterinary Medicine*. *A Text Book of the Diseases of Cattle, Sheep, Pigs, Goats, and Horses*. 7thed, W.B. Saunders. London.

Bryan, J., David, F. and Duggan, V. (2009). Investigation of acute colic in the adulthorse. *Irish Veterinary Journal,* **62**(8): 541-547.

Ceulaer, K., Delesalle, C., Elzen, R.V., Brantegem, L.V., Weyns, A. and Ginneken, C.V. (2011b). Morphological changes in the

small intestine smooth muscle layers of horses suffering from small intestine strangulation. Is there a basis for predisposition for reduced contractility?. *Equine Veterinary Journal,* **43** (4):439-445.

Ceulaer, K.D., Delesalle, C., Elzen, R.V., Brantegem, L.V., Weyns, A. and Ginneken, C.V. (2011a). Morphological data indicate a stress response at the oral border of strangulation small intestine in horses. *Research in Veterinary Science,* **91**:294-300.

Cohen, N., Gibbs, P. and Woods, A. (1999). Dietary and Other Management Factors Associated with Equine Colic. *AAEP Proceedings* **45**: 96-98.

Concalves, S., Julliand, V. and Leblond, A. (2002). Risk factors associated with colic in horse. *Veterinary Research,* **33**: 641-652.

Corley, K. (2002). Fluid therapy for horse with gastrointestinal disease. In: *Large Animal Internal Medicine*.3rd edition.USA 682-693.

Cox, R., Proudman, C.J., Trawford, A.F., Burden, F. and Pinchbeck, G.L. (2007). Epidemiology of impaction colic in donkeys in the United Kingdom. *BMC. Veterinary Research*. **3**(1): abstract.

Dana, G.A., Dave, P.A., Leo, B.J., Katherine, E.Q., Otto, M.R., Philip, T.R. and Alice, M.W. (2005). *The Merck Veterinary Manual*. 9thed. Merck& CO; INC. U.S.A. ISBN: 0-911910-50-6.

Detilleux, J.C. and Serteyn, D. (2005). Cost-Effectiveness Analysis in Veterinary Medicine: Illustration with Packed cell value in the Prognosis of Horse Surgical colic in Belgium. *Internal journal of Applied Research, Veterinary Medicine* **3**(4): 309-318.

Dukti, S. and White, N.A. (2009). Prognosticating equine colic. *Veterinary Clincs of Equine*. **25**:217–231.

Elfenbein, J.R. and Sanchez, L.C. (2012). Prevalence of gastric and duodenal ulceration in 691 non surviving foals (1995-2006). *Equine Veterinary Journal,* **44***(*41): 76-79.

Fawcett, J.K., and Scott, J.E.(1960). A rapid and precise method ofr the determination of urea. *Journal of clinical pathology*.**13**:156-159

Ferraro, G.L. (2008). Colic: An Age-Old Problem. *CEH Horse report,* **26**(1): 3-16.

Figueiredo, J.P., Muir, W.W., Smith, J. and Wolfram, G.W. (2005). Sedative and Analgesic Effects of Romifidine in Horses. *Internal Journal of Applied Research, Veterinary Medicine* **3**(3): 249-258.

Foreman, J.H. and Ruemmler, R. (2011). Phenylbutazone and Flunixin meglumine used singly or in combination in experimental lameness in horses. *Equine Veterinary Journal,* **43** (40): 12-17.

French, N.P. (2002). Case control study to identify risk factors for simple colonic obstruction and distension colic in horses. *Equine Veterinary Journal,* **34** (5): 455-463.

French, N.P., Smith, J., Edward, G.B. and Proudman, C.J. (2002). Equine surgical colic: risk factors for postoperative complications. *Equine Veterinary Journal,* **34**(5): 444-449.

Furr, M., Cohen, N.D., Axon, J.E., Sanchez, L.C., Pantaleon, L., Haggett, E., Campbell, R. and Brown, B.T. (2012). Treatment with histamine- type 2 receptor antagonist and omeprazole increase the risk of diarrhoea in neonatal foals treated in intensive care units. *Equine Veterinary Journal,* **41**:80-86.

Hart, K.A., Linnenkohl, W., Mayer, J.R., House, A.M., Gold, J.R. and Giguère, S. (2012). Medical management of sand enteropathy in 62 horses. *Equine Veterinary Journal,* **45**(4): 465-469.

Hassel, D.M., Hill, A.E. and Rorabeck, R.A. (2009). Association between hyperglycemia and survival in 228 horses with acute gastrointestinal disease. *Journal of Veterinary Internal Medicine,* **23**(6): 1261-1265 (abstract).

Hewetson,M.(2006). Investigation of false colic in the horse. *Practice* **28**:326-338.

Hillyer, M.H., Smith, M.R.W. and Milligan, P.J.P. (2008). Gastric and small intestinal ileus as a cause of acute colic in post parturient mare the. *Equine Veterinary Journal,* **40** (4): 368-372.

Hillyer, M.H., Taylor, F.G., Proudman, C.J., Edwards, G.B., Smith, J.E. and French, N.P. (2002). Case control study to identify risk factors for simple colonic obstruction and distension colic in horses. *Equine Veterinary Journal*, **34** (5): 455-463.

Hunt, J.M., Edwards, G.B., and Clarke, K.W. (1986). Incidence, diagnosis and treatment of postoperative complications in colic cases. *Equine Veterinary Journal,* **18** (4): 264-270.

Huskamp, B. and Scheidemann, W. (2000). Diagnosis and Treatment of Chronic Recurrent Caecal Impaction. *Equine Veterinary Journal Suppl.,* **32**: 65-68.

Husted, L., Andersen, M.S., Borggaard, O.K., Houe, H. and Olsen, S.N. (2005). Risk factors for faecal sand excretion in Icelandic horses. *Equine Veterinary Journal,* **37** (4): 351-355.

Ihler, C.F., Venger, J.L. and Skjerve, E. (2004). Evaluation of Clinical and Laboratory Variables as Prognostic Indicators in Hospitalised Gastrointestinal Colic Horses. *Acta Veterinaria Scandavia.* **45**(41): 109-118.

Jain, N. A. (1986). Shallm's veterinary haematology. 4th ed. Lea and Fibiger. Philadelphia. P. A.

Kallings, P., Persson, S.G.B. and Gustavsson, B.E. (2010). Effect of Flunixin on cardio-respiratory, plasma lactate and stride length responses to intense treadmill exercise in standard bred trotters. *Equine Veterinary Journal,* **42**(38): 618-623.

Kaneene, J.B., RoseAnnMiller, W.A., Gallagher, R.K., Marteniuk, J. and Rook, J. (1997). Risk factors for colic in the Michigan (USA) equine population. *Preventive Veterinary Medicine,* **30**: 23-36.

Kasap, S., Salci, H., Kennerman, E., Alasonyalilar, A. and Yilmaz, R. (2010). Gastric Rupture in a Horse. *Kafkas University, Veterinary Fak. Derg*, **16** (4): 707-708.

Kelly, W.R. (1984). *Veterinary Clinical Diagnosis*. 3rd edition. Baillier Tindal. London.

Kerr, M.G. (2002). *Veterinary laboratory medicine*.2ed Blackwell Science limited. United kingdom.

King, E.S., and Wooton, J.G.P. (1956).Microanalysis in: *Medical Biochemistry*. 3rdedition. Church hil, J.A. 57-60.

Kwon, S., Moore, J.N., Robertson, T.P., Hurley, D.J., Wagner, B. and Vandenplas, M.L. (2013). Disparate effects of LPS infusion and carbohydrate overload on inflammatory gene expression in equine laminae. *Veterinary immunology and Immunopathology,* **155**:1-8.

Lindegaard, C., Ekstrom, C. T., Wulf, S. B., Vendelbo, J. M. B. and Andersen, P .H .(2011). Nephrosplenic entrapment of the large colon in 142 horses (2000–2009): Analysis of factors associated with decision of treatment and short-term survival. *Equine Veterinary Journal* **43** (39): 63-68.

Marshall, J.F. and Blikslager, A.T. (2011b).The effect of nonsteroidal anti-inflammatory drugs on the equine intestine. *Equine Veterinary journal,* **43**(39): 140-144.

Marshall, J.F., Bhatnagar, A.S., Bowman, S.G., Morris, N.N., Skorich, D.A., Redding, C.D. and Blikslager, A.T. (2011a). The effects of a novel anti-inflammatory compound (AHI-805) on cyclooxygenase enzymes and the recovery of ischaemia injured equine jejunum *ex vivo*. *Equine Veterinary Journal,* **43**(39).106-111.

Mathews, S., Dart, A. J., Reid, S. W. J., Dawling, B. A. and Hodgson, D. R. (2002). Predictive values, sensitivity and specificity of abdominal fluid variables in determining the need for surgery in horses with an acute abdominal crisis. *Australian. Veterinary Journal,* **80** (3):132-136.

Mckeever, K.H., Eaton, T.L., Geiser, S., Kearns, C.F. and Lehnhard, R.A. (2010). Age related decrease in thermoregulation and cardiovascular function in horses. *Equine Veterinary Journal,* **42** (38): 220-227.

Mehdi, S. and Mohammad, V. (2006). A farm-Based Prospective Study of Equine Colic Incidence and Associated Risk Factors. *Journal of Equine Veterinary Science,* **26** (4):171-

Mezerova, J., Kabes, R., Zert, Z., Jahn, P. and Hanak, J. (2001). Impaction of right dorsal colon in the horse: report of 32 cases. *Journal of Veterinary Medicine – Czech,* **46** (11–12): 293–300.

Moore, J.N. and Barton, M.H. (2003). Treatment of endotoxemia. *Veterinary Clinics of North America : Equine Practice.* **19**: 681–695.

Moore, M.C. and Palmer, N.G. (2001). *Calculations for Veterinary Nurses*. First ed. Blackwell Science. London.

Morton, A. J., Grosche, A., Matyjaszek, S. A., Polyak, M. M. R. and Freeman, D. E. (2011). Effect of Flunixin meglumine on the recovery of ischaemic equine colonic mucosa *in vitro. Equine Veterinary Journal,* **43** (39): 112-116.

Mott, L.O., Shahan, M.S., Giltner, L.T. and Frank, A.H. (2004). *Diseases and Parasites of Horse and Mules*. 2nd edition. Delhi, India PP 188.

Murray, J.A., Longland, A., Colyer, M.M., Dunnett, C. and Longland, A. (2014). The effect of feeding a low- or high- starch diet on equine faecal parameters. *Livestock Science,* **159**: 67-70.

Nappert, G. and Johnson, P. J. (2001). Determination of the acid-base status in 50 horses admitted with colic between December 1998 and May 1999. *Canadian Journal of Veterinary Research,* **42**: 703-707.

Niinistö, K.E., Korolainen, R.V., Raekallio, M.R., Mykkä, A.K., Koho, N.M., Ruohoniemi, M.O., Leppäluoto, J. and Pösö, A.R. (2010). Plasma level of heat shock protein 72(HSP72) and β-endorphin as indicators of stress, pain and prognosis in horses with colic. *Veterinary Journal,* **184**:100-104.

Noschka, E., Werre, S.R., Crisman, M.V., Thatcher, C.D., Milne, G.L. and Dahlgren, L.A. (2011). Implications of urine F2-isoprostane metabolite concentration in horses with colic and its potential use as predictor for surgical intervention. *Equine Veterinary Journal,* **43**(39): 34-41.

Pavone, S., Gialletti, R., Pep, M., Onofri, A. and Mandara, M.T. (2012). Histological and immunohistochemical studies of changes in myenteric plexuses and in interstitial cells of Cajal associated with equine colic. *Research in Veterinary Science,* **93**: 350-359.

Pilo, C., Altea, A., Pirino, S., Nicolussi, P.,Varcasia, V., Genchi, M. and Scala, A. (2012). *Strongylus vulgaris* (Looss, 1900) in horses in Italy: Is it still a problem? *Veterinary Parasitology,* **184**:161-167.

Proudman, C.J., Smith, J.E., Edwards. G.B., and French, N.P. (2002). Long-term survival of equine surgical colic cases. Part 1: Patterns of mortality and morbidity. *Equine Veterinary Journal,* **34**(5): 432-437.

Proudman, C.J. and Holdstock, N.B. (2000). Investigation of outbreak of tape worm-associated colic in a training yard. *Equine Veterinary Journal Suppl.*, **32**:37-41.

Rabuffo, T.S., Hackett, E.S., Grenager, N., Boston, R. and Orsini, J.A. (2009). Prevalence of Gastric Ulcerations in Horses with Colic. *Journal of Equine Veterinary Science,* **29**(6): 540-546.

Radostits, O.M., Gay, C.C., Blood, D.C. and Hinchcliff, K.W. (2007). *Veterinary Medicine: A Text Book of the Diseases of Cattle, Sheep, Pigs, Goats, and Horses*. 10th ed. W.B. Saunders Co. pp. 215-229.

Reeves, M.J., Curtis, C.R., Salman, M.D. and Hilbert, B.J. (1989). Prognosis in Equine Colic Patients Using Multivariable Analysis. *Canadian Journal of Veterinary Research,* **53**: 87-94.

Reinemeyer, C.R. and Nielsen, M.K. (2009). Parasitism and Colic. *Veterinary Clinics of North America: Equine Practice.* **25**: 233–245.

Roberts, J.L. and Murray, J. (2013). Survey of Equine Nutrition: Perception and Practice of Veterinarians in Georgia, USA. *Journal of Equine Veterinary Science,* **33**: 454-459.

Robertson, S. A. and Sanchez, L.C. (2010). Treatment of Visceral Pain in Horses. *Veterinary Clinics of North America* **26**: 603–617.

Sanchez, L. C. and Robertson, S. A. (2014). Pain control in horses: What do we really know? *Equine Veterinary Journal,* **46**: 517-523.

Scantlebury, C.E., Archer, D.C., Proudman, C.J. and Pinchbeck, G.L. (2011). Recurrent colic in the horse: incidence and risk factors for recurrence in the general practice population. *Equine Veterinary Journal,* **43**(39): 81-88.

Schott, H.C. (2002). Recurrent Urolithiasis Associated with Unilateral Pyelonephritis in Five Equids. *AAEP proceedings,* **48**:136-137.

Skyes, B.W. and Furr, M.O. (2005). Equine endotoxaemia-A state-of-the-art review of therapy. *Australian Veterinary Journal,* **83**(1*&2*): 45-50.

Southwood, L.L., Gassert, T. and Lindborg, S. (2010a).Colic in geriatric compared to mature nongeriatric and short-term survival. *Equine Veterinary Journal,* **42**(7):628-635

Southwood, L.L., Gassert,T. and Lindborg, S. (2010b). Colic in geriatric compared to mature nongeriatric horse. Part 1: Retrospective review of clinical and laboratory data. *Equine Veterinary Journal,* **42** (7): 621-627.

Sutton, G.A., Ertzman-Ginsbrg, R., Steiman, A. and Milgram, J. (2009). Initial investigation of mortality rates and prognostic indicators in horses with colic in Israel: A retrospective study. *Equine Veterinary Journal,* **41**(5): 482-486.

Thoefner, M.B., Ersbøllb, A.K., Jensenc, A.L. and Hesselholt, M. (2001). Factor analysis of the interrelationships between clinical variables in horses with colic. *Preventive Veterinary Medicine,* **48**: 201-214.

Toit, N.D., Burden, F.A. and Dixon, P.M. (2009). Clinical dental examination of 357 donkeys in the UK. Part 2: Epidemiological studies on the potential relationships between different dental disorders, and between dental disease and systemic disorders. *Equine Veterinary Journal,* **41**(4): 395-400

Toit, N.D., Gallagher, J., Burden, F.A. and Dixon, P.M. (2008). Post mortem survey of dental disorders in 349 donkeys from an aged population (2005-2006). Part 2: Epidemiological studies. *Equine Veterinary Journal*, **40**(3): 209-213.

White, N. A. (2006). Current use of analgesics for Equine Colic, *Proc. AAEP. Annual Conversation*. **52**: 109-174.

White, N. A. and Edwards, G. B. (2001). *Hand Book of Equine Colic*. First ed. New Delhi.

Williams, L.T., Sheard, P.P., McFarlane, F., Pearl, D.L., Martin, S.W. and Peregrine, A.S. (2008). Occurrence of *Anoplocephala perfoliata* infection in horses in Ontario, Canada and

associations with colic and management practices. *Veterinary Parasitology,* **153**: 73–84.

Williams, S., Tucker, C.A., Green, M.J. and Freeman, S.L. (2011). Investigation of the effect of pasture and stable management on large intestinal motility in the horse, measured using transcutaneous ultrasonography. *Equine Veterinary Journal,* **43**(39): 93-97.

Zajac, A.M. and Conboy, G.A. (2006). *Veterinary Clinical Parasitology*. 7th ed. Blackwell. U.S.A. ISBN-10: 0-8138-1734-x.