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The Impact of Gastric Sleeve and Bypass on Weight loss in Dogs: A Comparative Study

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Ph.D./ Dissertation

Veterinary Medicine / Veterinary Surgery

Supervised By

Professor

Dr.Muneer S.AL-Badrany

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The Impact of Gastric Sleeve and Bypass on Weight loss in Dogs: A Comparative Study

A Dissertation Submitted

By

Ahmed Saad Mohammed Ali AL-Qadhi

To

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In

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In

Veterinary Medicine / Veterinary Surgery

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بسم الله الرحمن الرحيم

ذَلِكَ فَضْلُ اللَّهِ يُؤْتِيهِ
مَنْ يَشَاءُ وَاللَّهُ ذُو
الْفَضْلِ الْعَظِيمِ

صدق الله العظيم

سورة الجمعة

الآية (4)

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Ahmed saad

Abstract

In the current study, the effectiveness of gastric bypass and gastric sleeve surgeries in reducing excessive weight in dogs was to be compared. The goal was to determine which procedure was better and had fewer adverse effects. The search was restricted to 12 male dogs. Clinically, they were in good health. Their weights varied between 33 and 39 kg, with an average of (33 ± 1.3) kg, while their ages ranged from 20 months to 38 months, with an average of (29 ± 1.5) months.

Two groups of animals were randomly assigned to each other. There were six dogs in each group. The **first group** had a gastric sleeve procedure, while the **second group** had a gastric bypass.

The following criteria were used to evaluate the results: temperature, breathing rate, heart rate, and observation of the animals' urination and defecation. Clinical signs were also measured, and the animals were monitored and observed following the procedure to identify any changes or the appearance of abnormal signs, such as weakness in the animals or infections at the site of the operation. Following surgery, the animals weights are also checked every two weeks for eight weeks. For eight weeks following the surgical procedure, all animals are also examined laparoscopically two and eight weeks after the operation to assess the degree of adhesions at the surgical site and ensure no stomach or intestinal contents leak into the abdominal cavity.

Every animal had a blood sample taken before surgery, as well as after 2, 4, 6, and 8 weeks, to evaluate the level of iron, vitamin B12, vitamin D3,

calcium, sodium, potassium, and chloride levels. The percentages of white blood cells, red blood cells, hemoglobin, and platelets were also measured before the procedure and after two, four, six, and eight weeks of general blood testing.

After the second day of the procedure, the results of the clinical examination for both groups revealed the presence of inflammation at the site of the operation. This was indicated by a slight increase in body temperature, heart rate, and respiration rate, as well as slight redness and edema at the operation site. Gradually, these symptoms begin to disappear on the third- and fourth-day after surgery. After the first week of the procedure, the animals' heart and breathing rate returned to normal.

The clinical picture was also evident in the activity and barking of the animals after the operation, as well as in urination, defecation, and other visual signs, which were almost the same in both groups except that the animals of the second groups were less active than the first group.

The results of the laparoscopic examination showed that there was no leakage of stomach and intestinal contents into the abdominal cavity. However, adhesions with omentum, adjacent organs, or another part of the intestine are observed at the surgical site. These adhesions were lower in the first group than the second group.

The weights of the animals in both groups decreased over two, four, six, and eight weeks. The animals in the second group showed a more pronounced and statistically significant weight loss ($p \leq 0.05$) compared to the animals in the first group. A significant decrease was also observed in the iron level in both groups, but the decrease was more severe in the second group. The same thing was observed in the level of vitamin B12, as the vitamin decrease in both groups, and decrease was more severe in the second group. Regarding vitamin D3, there was no a significant difference between the two groups in the second and eighth weeks after the procedure.

The blood calcium level was lower in the second group than in the first. There was a slight decrease in sodium in the first group compared to the second group. However, potassium did not differ between the two groups. Chloride levels were lower in the first group than in the second group, especially in the fourth, sixth, and eighth weeks after the procedure.

According to the blood test results, both groups had higher levels of white blood cells, although the increase in the second group's was more significant than the first. Both groups, showed a significant decrease in hemoglobin and red blood cells levels during the first few weeks after the procedure. In the sixth and eighth weeks after the procedure, as for the number of platelets, there was a noticeable increase in both groups after the procedure, especially in the second and fourth weeks, and in the sixth and eighth weeks after the procedure.

In conclusion gastric sleeve surgery, and gastric bypass, are among the most common bariatric surgeries that can be performed on dogs. Roux-en-Y-gastric bypass surgery was more invasive than gastric sleeve surgery, but it causes greater weight loss than gastric sleeve surgery. The most common complication recorded for both methods was a clear decrease in the level of iron and vitamin B12, which causes anemia. Therefore, it is recommended to give iron and vitamin B12 to the animals undergoing the operation.

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List of Abbreviations

HCL	Hydrochloric acid
CCK	Cholecystokinin
GIP	Gastric inhibitory polypeptide
MMC	Migrating motor complex
GH	Growth hormone
RYGB	Roux-en-Y gastric bypass
SG	Sleeve gastrectomy
IU	International unit
KG	Kilogram
EDTA	Ethylenediamine tetra acetic acid
WBC	White blood cell
RBC	Red blood cell
HGB	Hemoglobin
PLT	Platelets

Chapter One

Introduction

The stomach is a portion of the digestive system it is located under the diaphragm in the abdomen, the stomach is connected to the duodenum, which is the first section of the small intestine, to the esophagus (Aspinall, 2004; McErlean, 2016; Tortora and Derrickson, 2018).

The stomach is located in the left upper quadrant of the abdominal cavity, left of the liver (Scanlon and Sanders, 2018). The stomach is not a tube; it is a sac that connects the esophagus and small intestine. The stomach stores food so it can continue the process gradually. In the stomach, both chemical and mechanical digestion can occur (Aspinall, 2004; Scanlon and Sanders, 2018).

Overeating leads to obesity in the animals. Animal obesity is regarded as an epidemic, according to some researchers (Speakman *et al*., 2008). They have shown that it could be more severe than what has been seen in humans. In both domestic canine and feline populations, the prevalence of combined overweight and obesity has been observed to range from roughly 25% to approximately 45% (Lund *et al*., 2006).

They have extensively discussed the causes and risk factors that predispose animals to obesity. Similar to humane obesity (German, 2006; Bland *et al*., 2009). Multiple research lines point to a hereditary component of obesity in dogs and cats. It is well known that some dog breeds are more likely than others to become obese. Cavalier King, Cairn Terrier, and Labrador Retriever are a few examples. Scottish terriers, cocker spaniels, and Charles spaniels are examples of cats. Evidence suggests that domestic shorthairs are more susceptible (Degeling *et al*., 2011; Zoran and Buffington, 2011). Food consumption patterns such as feeding schedules, food types, and amounts can all lead to obesity in dogs and cats (Degeling *et al*., 2011; Zoran and Buffington, 2011). Obese dogs are more likely to be fed many meals, and snacks, treats and leftover food from the table, and to be present when their owners cook or dine (Chauvet *et al*., 2011). The only long-term, proven effective treatment for obesity or overweight is surgery. long-term weight loss has been achieved by bariatric procedures such as traditional or laparoscopic Roux-en-Y gastric bypass (Miller, 2004; Braghetto *et al*., 2007; DeMaria, 2007).

Surgeons conduct sleeve gastrectomy to limit how much food animals can eat (Lombardo *et al*., 2021). Sleeve gastrectomy (SG) is a bariatric procedure that has developed from both restrictive and malabsorptive or a combination of the two surgeries for the management of morbid obesity (Patrikakos *et al*., 2009; Katz *et al*., 2011). One surgical operation used to treat morbid obesity is called a sleeve gastrectomy (SG), which involves removing the gastric fundus and narrowing the stomach (Castelan *et al*., 2007; Patrikakos *et al*., 2009). Also, laparoscopic sleeve gastrectomy (Roa *et al*., 2006; Braghetto *et al*., 2007).

Aims of the study:

1-Comparison between the two methods on loss weight.

2-Identify the complications that accompany these two methods.

3-Know the biochemical and hematological alteration between the two methods.

Chapter Two

Literature Review

2-1: Stomach

It is an expansion of the gastrointestinal tract that lies beneath the abdominal diaphragm. The duodenum, the first segment of the small intestine, is connected to the esophagus by the stomach (Aspinall, 2004; McErlean, 2016; Tortora and Derrickson, 2018). To the left of the liver and in front of the spleen, in the upper left quadrant of the abdominal cavity, is where the stomach is situated (Scanlon and Sanders, 2018). The stomach, which is a sac, serves as a food reservoir so digestion can happen gradually and we don't have to keep eating. The stomach is where mechanical and chemical digestion happens (Aspinall, 2004; Scanlon and Sanders, 2018).

2-2: Attachments of The Stomach

1-gastrohepatic ligament: - It is a part of lesser omentum, which joins the lesser curvature and proximal duodenum to the liver, is responsible for gastrohepatic connection (Fielding *et al*., 2005).

2-gastrospleenic ligament: - It is connecting the greater curvature with spleen (Fielding *et al*., 2005; Singh *et al*., 2018).

3-gastrophrenic ligament: - It connects the diaphragm to the larger curvature from the cardia (Fielding *et al*., 2005; Sader *et al*., 2016).

2-3: Structure of The Stomach

The stomach has four fundamental districts: the cardia, fundus, body, and pylorus. The cardia also known as the cardiac area is where the esophagus joins the stomach and is where food enters the stomach. A fundus Dome-shaped structure is above and to the left of the cardia inferior to the diaphragm. Its body the majority of the stomach is located below the fundus. The pylorus, which resembles a funnel joins the duodenum and stomach. This funnel is double-ended. The pyloric canal which is the wider end connects to the duodenum while the pyloric antrum which is the narrower end communicates with the body of the stomach.

There are several muscular layers in the stomach, includes:

1. Longitudinal muscle layer.

2. Circular muscle layer.

3. Oblique muscle layer covers mucosa.

Greater curvature refers to the convex lateral surface of the stomach, while lesser curvature refers to the concave medial border (Figure 2-1). When the stomach is empty the mucosa lies in pronounced folds or rugae that are visible to the unaided eye (Fielding *et al*., 2005; Ellis, 2011; McErlean, 2016; Scanlon and Sanders, 2018; Singh *et al*., 2018; Tortora and Derrickson, 2018;).

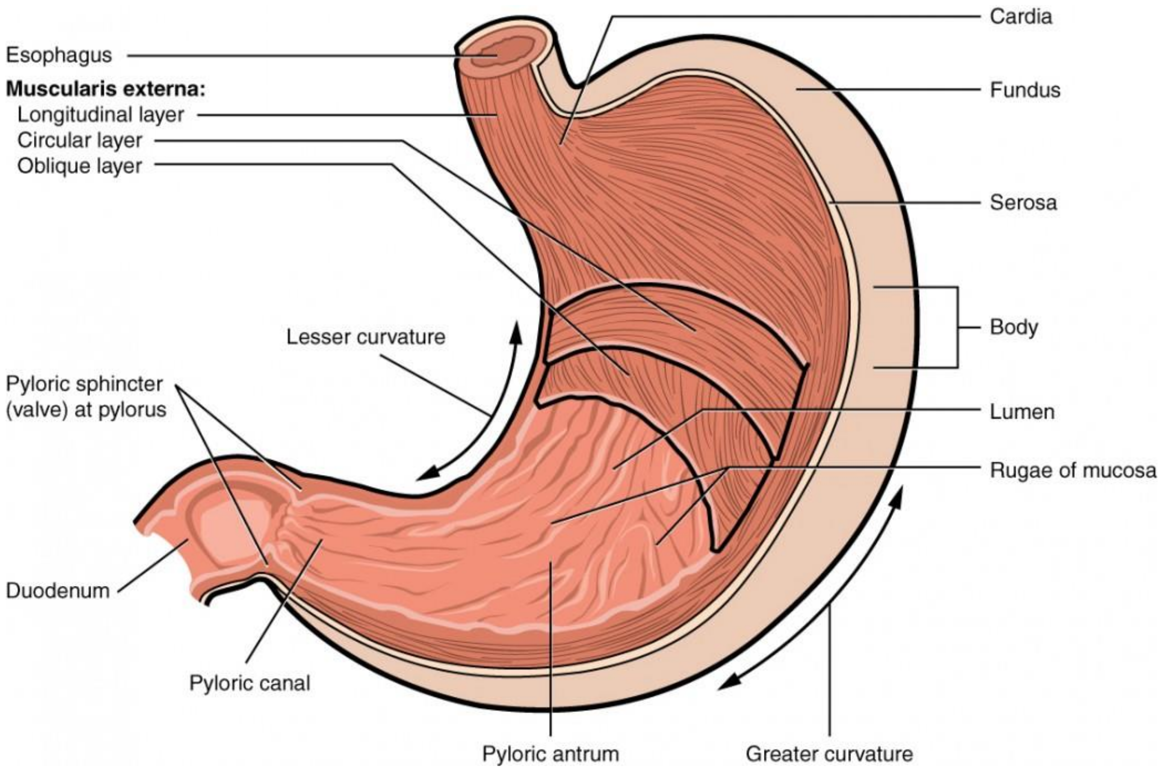


Figure 2-1: The structure and muscles of the stomach (Singh *et al*., 2018)

2-4: Blood Supply and Innervation of The Stomach

The coeliac artery, also known as the artery of the foregut, is the major artery that supplies the stomach with blood. It is divided into three branches and originates from the front of the aorta.

1-The left gastric artery: - the expansive vessel supplies the upper portion of the stomach.

2-The hepatic artery: - the first branch of the hepatic artery is called the right gastric artery supplies the lesser curvature of the stomach before anastomosis with the left gastric artery, and the second branch of the hepatic artery is called the right gastroepiploic artery supplies the greater curvature of the stomach before anastomosis with the left gastroepiploic artery.

3- The splenic artery: - divided into two branches first the left gastroepiploic artery and second the short gastric arteries that supply the greater curvature of the stomach from the middle to the fundus (Fielding *et al*., 2005; Ellis, 2011; McErlean, 2016; Singh *et al*., 2018) (Figure 2-2)

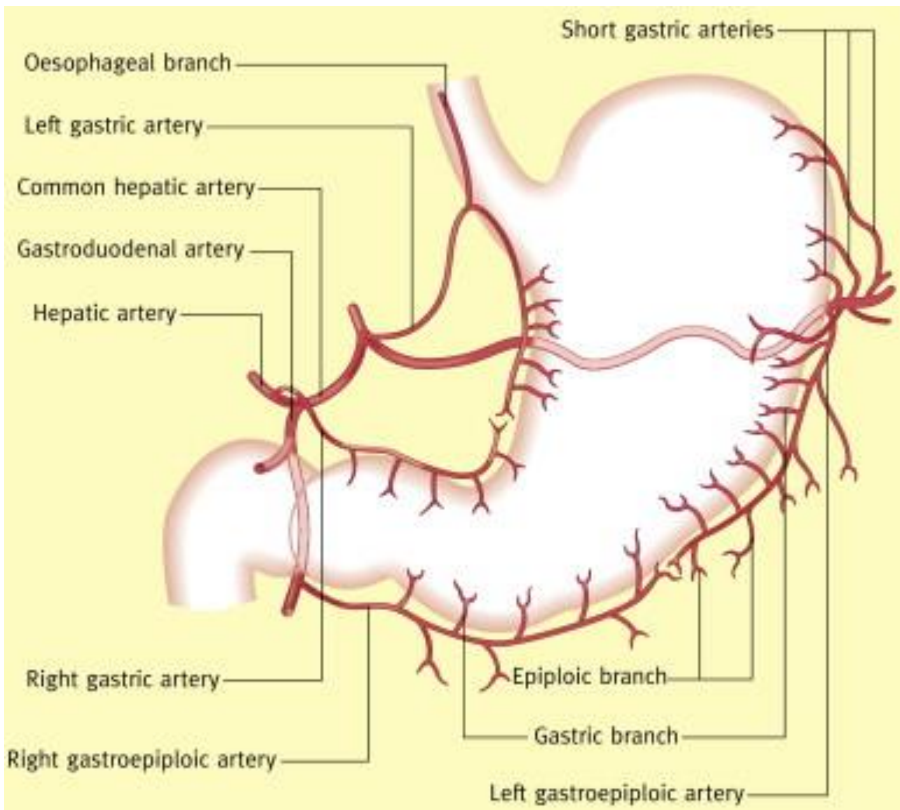


Figure 2-2: Arterial supply of the stomach (Singh *et al*., 2018)

Sympathetic fibers run with the arteries. Parasympathetic fibers from the vagus nerve (Fielding *et al*., 2005; Budras *et al*., 2010; Ellis, 2011; Singh *et al*., 2018;).

2-5: Histology of The Stomach

The basic layers of the stomach wall are the same as those of the rest of the GI tract but with some modifications. Simple columnar epithelial cells also known as **surface mucous cells** cover the surface of the mucosa. Lamina propria and muscularis mucosae are present in the mucosa. Gastric glands are columns of secretory cells formed by epithelial cells that descend into the lamina propria. opening the various gastric glands beneath tiny channels called gastric pits. Three different exocrine gland cell types are found in the gastric glands, and they discharge their products into the stomach lumen.

1-Parietal cells or oxyntic cells: - concentrated mainly in the middle portion of the gastric glands. These actually large cells release intrinsic factor and hydrochloric acid (HCL). The high level of acidity in the stomach is caused by hydrochloric acid, which is also required to activate the pepsin protein-digesting enzyme. Many of the microorganisms that you consume with meals are also killed by the acidity. A glycoprotein called intrinsic factor is required for the small intestine to absorb vitamin B12, which is used in the process of producing red blood cells.

2-Chief, zygomatic or peptic cells: - concentrated largely in the basal areas of the gastric glands. They produce pepsinogen the proenzyme form of pepsin that is inactive. Pepsinogen must be converted into pepsin in the presence of hydrochloric acid.

3-Mucous neck cells: - concentrated in the upper part of the stomach structure that produce mucus which produces a protective layer that prevents the stomach wall from breaking down. In addition, the gastric glands include a type of enteroendocrine cell **G cell** which is concentrated in the pyloric antrum also secretes the hormone gastrin into the bloodstream stimulates parietal cells to secrete HCL and chief cells to secrete pepsinogen also act on contracts lower esophageal sphincter, increases motility of stomach, and relaxes pyloric sphincter (Figure 2-3)(Fielding *et al*., 2005; Klein and Cunningham, 2013; McErlean, 2016; Tortora and Derrickson, 2018; Scanlon and Sanders, 2018).

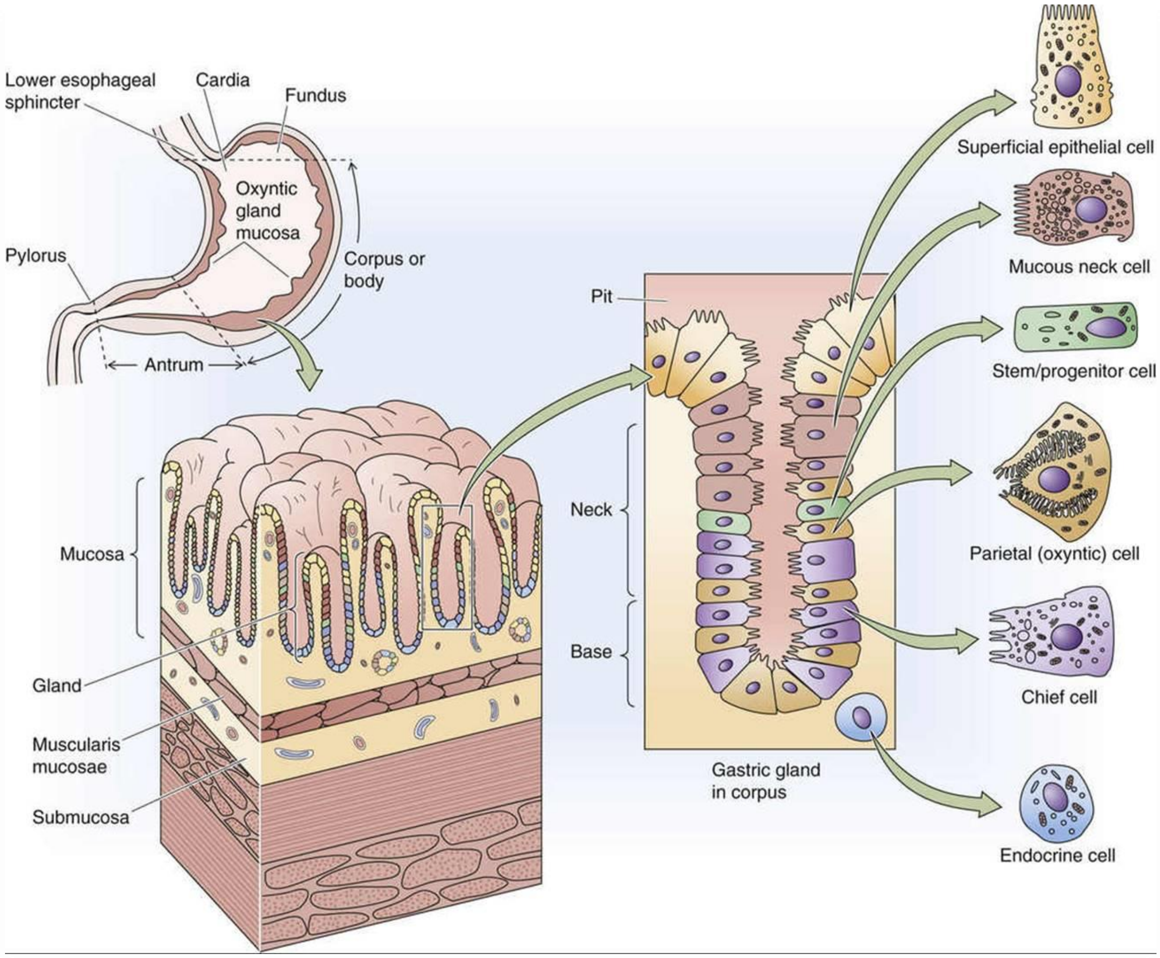


Figure 2-3: layers of stomach, gastric gland and cells (Scanlon and Sanders, 2018).

2-6: Physiology of The Stomach

2-6-1: Gastric Secretions

Neurological and hormonal routes control the highly complex and dynamic process of gastric acid secretion by parietal cells (Schubert, 2010). The gastric glands' cells secrete roughly 2500 ml of gastric juice each day. This has a range of substances and stomach enzymes. Its function is to destroy ingested germs, facilitate protein digestion, enhance the flow of bile and pancreatic secretions, and create a pH sufficient for pepsin to start destroying proteins (Fielding *et al*., 2005). There are three processes involved in controlling gastric juice secretion (McErlean, 2016).

1-Cephalic phase (reflex phase): - Even before food enters the stomach, and particularly while it is being eaten, the cephalic phase of gastric secretion takes place. It occurs as a result of food being seen, smelled, thought of, or tasted, and increases the appetite (McErlean, 2016).

2-Gastric phase: - Starts this phase when food enters the stomach (Fielding *et al*., 2005; McErlean, 2016). The hormone gastrin is released into the bloodstream, stimulating the secretion of gastric juice (McErlean, 2016). Also, when the food enters the stomach this stimulates parasympathetic neurons to release acetylcholine which then provokes increased secretion of gastric juice. Partially digested proteins, caffeine (Fielding *et al*., 2005) and the pH of the gastric contents decreases due to the release of hydrochloric acid, and gastrin secretion decreases when the PH falls below 2 (McErlean, 2016). The reduced PH promotes the release of gastrin from enteroendocrine G cells, which in turn causes parietal cells to produce more HCL, which is necessary to produce an acidic environment for the conversion of pepsinogen to pepsin and protein digestion (Fielding *et al*., 2005).

3-Intestinal phase: - Begins when chyme enters the intestine, the hormones cholecystokinin (CCK) and secretin are released as the stomach's acidic contents pass into the duodenum of the small intestine. Gastric juice secretion and motility are both decreased by these hormones. The size and composition of the meal affect the rate of stomach emptying. A large meal requires more time than a small one. While solids take longer to properly mix with gastric juice than liquids, they move through the stomach more quickly. Four hours after eating, most meals will have passed through the stomach (McErlean, 2016).

2-6-2: Hormones Secreted by The Stomach

1-Gastrin: -Gastrin is produced by cells known as G cells in the duodenum, antrum, and gastric pylorus. When there is a protein present and there is stomach distention, gastrin is released. Its primary effects include increasing gastric acid and pepsin secretion as well as stimulating the growth of the mucosa in the stomach, small intestine, and large intestine. Depending on how many amino acids are present in the peptide chain, Gastrin comes in two different forms, G-17 (also known as little gastrin) and G-34 (commonly known as big gastrin) (Fielding *et al*., 2005; Barrett *et al*., 2010; Schubert, 2010; Klein and Cunningham, 2013).

2-Secretin: -It is the first gastrointestinal hormone identified and is released by the S cells in the mucosa of the duodenum and upper jejunum in response to acidic gastric juice emptying into the duodenum from the pylorus of the stomach. Secretin has little effect on gastrointestinal tract motility and acts to promote pancreatic secretion of bicarbonate, which in turn helps to neutralize the acid in the small intestine. Additionally, secretin reduces the production of gastric acid (Barrett *et al*., 2010; Klein and Cunningham, 2013).

3-Cholecystokinin (CCK): -It is a peptide hormone that was found in the small intestine. In addition to gastrin and secretin, Additionally, the upper small intestine's mucosa contains I cells, endocrine cells that release CCK (Rehfeld, 2004; Barrett *et al*., 2010; Klein and Cunningham, 2013;). There are numerous effects it has on the digestive system, but the two most significant seem to be the stimulation of pancreatic enzyme secretion and gallbladder contraction and relaxation of the Oddi sphincter, allowing bile and pancreatic juice to enter the intestinal lumen (Barrett *et al*., 2010).

4-Gastric inhibitory polypeptide (GIP): -It is created by K cells in the jejunal and duodenal mucosa. It was given the name gastric inhibitory peptide because, in large concentrations, it inhibits stomach secretion and motility. Its secretion is promoted by glucose and fat in the duodenum. GIP is also known as a glucose-dependent insulinotropic peptide since its secretion is induced by the presence of glucose in the duodenum, and one of its functions is to promote insulin secretion from the endocrine pancreas (Barrett *et al*., 2010; Klein and Cunningham, 2013).

5-Motilin: -This peptide is secreted by duodenal M cells and, to a lesser extent, jejunum M cells. Motilin controls the migrating motor complex (MMC) by acting on both muscles and neurons. Motilin promotes gastric emptying and the release of pepsinogen, a protein-digesting enzyme of the stomach (Klein and Cunningham, 2013). Motilin causes smooth muscle contractions in the stomach and intestine between meals (Barrett *et al*., 2010).

6-Ghrelin: - It is a new growth hormone (GH) releaser acylated peptide recently purified from the stomach that binds to the GH secretagogue receptor (Peino *et al*., 2000). It appears to have a significant role in the central control of food intake. It also promotes growth hormone secretion by acting directly on pituitary receptors (Barrett *et al*., 2010).

7-Somatostatin: -The growth hormone-inhibiting hormone, which was discovered in the hypothalamus, is released as a paracrine by D cells in the pancreatic islets and comparable D cells in the gastrointestinal mucosa. Somatostatin suppresses the secretion of gastrin, GIP, secretin, and motilin (Fielding *et al*., 2005; Barrett *et al*., 2010).

2-7: Iron

Iron is required for most life on Earth, including humans, through performing a range of metabolic processes such as oxygen transport, DNA synthesis, and electron transport (Lieu *et al*., 2001; Gupta, 2014). Iron is essential for the creation of red blood cells (a process known as hematopoiesis), but it is also a component of hemoglobin (the pigment of red blood cells), attaching to oxygen and allowing its delivery from the lungs to all cells throughout the body via the arteries (Gupta, 2014).

Iron concentrations in the body's tissues must be strictly controlled because excess iron causes tissue damage due to the generation of free radicals (Gupta, 2014). The duodenum is the site of almost all iron absorption (Lieu *et al*., 2001; Barrett *et al*., 2010). Anemia is usually caused by iron deficiency, which is a typical side effect of bariatric surgery (Love and Billett, 2008; Gowanlock *et al*., 2020). Iron deficiency and anemia are common side effects of obesity. Iron loss and absorption are both increased by bariatric surgery (Salgado *et* *al*., 2014). Because of elevated circulation levels of acute-phase reactant hepcidin and adiposity-associated inflammation, iron insufficiency is more common in obese patients. Iron deficiency is linked to inflammation in obese people.

The reduces iron absorption by inhibiting duodenal ferroportin expression in conjunction with increased hepcidin concentrations (Bjørklund *et al*., 2021). Low iron intake after surgery is not the only factor for the development of iron insufficiency. Changes in the gut anatomical structure have an effect on iron digestion and absorption. First, decreased hydrochloric acid secretion impedes the conversion of ferric iron to absorbable ferrous iron. Second, the Roux-en-Y gastric bypass limits the intestinal absorption area for iron, which is primarily absorbed in the duodenum. Third, the villi of the gastrointestinal tract are damaged, which may contribute to the lowering of the intestinal absorption area for iron following surgery (Steenackers *et al*., 2018). The Roux-en-Y gastric bypass of the principal site of absorption in the duodenum and proximal jejunum may lead to the development of iron deficiency and anemia after surgery (Bloomberg *et al*., 2005).

2-8: Vitamin B12

Vitamin B12 (cobalamin) is a water-soluble vitamin that can be gained by the consumption of fortified cereals and supplements, as well as fish, meat, eggs and dairy products. After being extracted by gastric acid, it is absorbed with intrinsic factor, a product of the stomach's parietal cells, in the terminal ileum. Vitamin B12 is essential for neurological function, red blood cell creation, and DNA synthesis (Bloomberg *et al*., 2005; Tucker *et al*., 2007; Bal *et al*., 2012; Stabler, 2013; Shipton and Thachil, 2015; Langan and Goodbred, 2017).

In the absence of exogenous supplementation, the loss of intrinsic factor producing parietal cell mass in patients having Roux-en-Y gastric bypass leads to decreased intrinsic factor mediated absorption of cobalamin in the distal ileum, leading to vitamin B12 insufficiency (Majumder *et al*., 2013). Vitamin B12 absorption requires an intrinsic factor produced from gastric parietal cells, acidic gastric pH, and ileum absorption, all of which may be affected following bariatric surgery (Becker *et al*., 2012; Kornerup *et al*., 2019).

Because liver stockpiles are sufficient to provide for years after initial dietary insufficiency, deficient vitamin B12 levels may not manifest for several years following bariatric surgery (Becker *et al*., 2012; Langan and Goodbred, 2017). At a mean of 22 months postoperatively, vitamin B12 insufficiency was observed after gastric bypass (Bloomberg *et al*., 2005). Vitamin B12 insufficiency affects various systems, with symptoms ranging from mild fatigue to severe neurologic impairment (Langan and Goodbred, 2017; Serin and Arslan, 2019).

Paresthesias, weakness, diminished reflexes, spasticity, ataxia, position and vibratory sensation loss, incontinence, loss of vision due to optic nerve injury, dementia, psychosis, memory impairment, convulsions and changed mood are frequent neurologic symptoms associated with B12 insufficiency (Becker *et al*., 2012; Serin and Arslan, 2019). Surgical treatments that create restriction through forming a tiny gastric pouch, such as RYGB, can result in serious vitamin B12 deficiency due to decreased acid and pepsin digestion of protein-bound cobalamins in food, inadequate release of R binders, and decreased intrinsic factor production (Tucker *et al*., 2007).

2-9: Calcium and Vitamin D3

It is generally known that people undergoing bariatric surgery can suffer from calcium and vitamin D deficiency. Calcium is absorbed preferentially in the duodenum and proximal jejunum, whereas vitamin D is absorbed primarily in the jejunum and ileum (Bloomberg *et al*., 2005; Tucker *et al*., 2007).

By improving calcium absorption in the intestine, vitamin D, the principal regulator of calcium metabolism, maintains perfect calcium and phosphate levels essential for bone production, allowing parathyroid hormone to function properly (Bal *et al*., 2012). Calcium and vitamin D malabsorption occurs as a result of bypassing certain parts of the gut during bariatric surgery (Bloomberg *et al*., 2005).

Vitamin D deficiency has been linked to subsequent hypocalcemia following gastric bypass and is frequently related to symptoms of chronic nonspecific musculoskeletal discomfort (Becker *et al*., 2012). Secondary hyperparathyroidism can be caused by both hypocalcemia and vitamin D insufficiency (Bloomberg *et al*., 2005).

Inadequate vitamin D status leads to inadequate calcium absorption, hypocalcemia, and compensatory increases leading to parathyroid hormone release (Compher *et al*., 2008; Becker *et al*., 2012; Bal *et al*., 2012). Vitamin D deficiency has been identified as a major cause of calcium metabolism abnormalities and metabolic bone disease following weight loss surgery, which can result in clinically significant long-term morbidity, including bone loss and fractures. After bariatric surgery, patients with calcium or vitamin D insufficiency experience muscle cramping, backache, bone pain, or limb hurting (Bal *et al*., 2012).

2-10: Electrolytes

2-10-1: Sodium (Na^+)

The sodium concentration in the gastrointestinal tract lumen and extracellular fluid is normally higher than inside the enterocyte. The inner of cells is negative when compared to the outside of cells. To maintain electrical equilibrium, sodium cotransporters work with chloride. These Na+/Cl-cotransporters are found in all parts of the small and large intestines (Reece *et al*., 2015). Some complications can happen following bariatric surgery, the most serious of which are electrolyte (sodium, potassium, chloride) and nutritional deficiency. Hyponatremia is characterized by an incorrect antidiuretic hormone syndrome, elevated vasopressin levels, and adrenal insufficiency, as well as edema, diuretic usage, vomiting, and diarrhea (Wang *et al*., 2016).

2-10-2: Potassium (K^+)

Most K+ absorption happens through tight junctions, and K+ passes directly across cells into the extracellular fluid, especially in the lower small intestine. The concentration of K+ in extracellular fluid is small, whereas the concentration of K+ in the lumen can be many orders much larger (Reece *et al*., 2015).

Bariatric surgery candidates frequently have hypokalemia. Hypokalemia in patients can be caused by a lack of potassium intake, renal loss via osmotic diuresis, or gastrointestinal loss from intestinal dysbacteriosis or diarrhea.

Hypokalemia is invariably associated with metabolic alkalosis and unnatural acidic urine (Wang *et al*., 2016). According to one study, the incidence of hypokalemia has increased by 56%. Another research of 150 patients found that 6.3% of the subjects had severe hypokalemia. As a result, diuretics must be used with precaution following bariatric surgery (Bernert *et al*., 2007).

2-10-3: Chloride (Cl^-)

The amount of Cl^- in the lumen varies. Chyme excreting from the stomach includes around 120 mmol/L Cl^-. Cl^- concentrations will be closer to zero in the distal large intestine. Intracellular Cl- concentrations can range from 4 mmol/L in the colon to 30 mmol/L in the upper small intestine (Reece *et al*., 2015). Chinese bariatric surgery candidates typically suffer hypochloremia. Hypochloremic patients are more likely to develop metabolic alkalosis than hyperchloremic and normochromic patients (Wang *et al*., 2016).

2-11: Obesity

Obesity is now so prevalent in the world's population that it is overtaking malnutrition and infectious diseases as the leading cause of illness. Obesity, in particular, is linked to diabetes, coronary heart disease, some cancers, and sleep-breathing difficulties. Obesity is defined by a body mass index (weight divided by height squared). also refers to an illness in which extra body fat has accumulated to the point where health is threatened (Kopelman, 2000).

Obesity is related to an increased incidence of type 2 diabetes mellitus, cardiovascular disease, dyslipidemia, and hypertension, as well as an increased risk of atherosclerotic disease and mortality. Bariatric surgery refers to operations that induce weight loss by reducing stomach capacity or creating nutrient malabsorption (Lopez *et al*., 2009; Gowanlock *et al*., 2020).

According to medical definitions, morbid obesity is a chronic, complex condition that has significant physical and mental side effects that can lower the quality of life and reduce life expectancy (Jauregui, 2013).

Obesity is the reason for the decline in life expectancy and deterioration of quality of life (Salgado *et al*., 2014). Also, the chronic inflammatory condition is linked to obesity (Menzie *et al*., 2008). An imbalance in the amount of energy consumed by food compared to the amount of energy exerted is the etiology or cause of obesity (Bray, 2004). Obesity has a complicated and poorly understood etiology that includes genetic, behavioral, psychological, and other components (DeMaria, 2007). The risk of hypovitaminosis D increases in obese patients (Gemmel *et al*., 2009).

2-12: Bariatric Surgery

For patients with clinically significant obesity, bariatric surgery is increasingly regarded as an accepted treatment (Malinowski, 2006). The current most effective treatment for morbid obesity is regarded to be bariatric surgery (Rao *et al*., 2010; Chen *et al*., 2016; Carniel *et al*., 2020). resulting in long-term weight loss, noticeable improvements in comorbid conditions like diabetes, hypertension, and obstructive sleep apnea, and a decline in mortality (Chang *et al*., 2014; Yu, 2014).

One part of the multimodal approach to treating obesity is bariatric surgery, which also includes multidisciplinary evaluation and diagnosis, non-invasive and surgical therapies, and lifelong follow-up care (Elder and Wolfe, 2007). In patients undergoing bariatric surgery, recent studies have found an increased risk of developing vitamin deficiencies in the following areas:

vitamin A, vitamin D, vitamin B12, vitamin B1, folate, and iron (Majumder *et al*., 2013).

2-13: Types of Bariatric Surgery

2-13-1: Gastric Bypass or Roux-en-Y Gastric Bypass (RYGB)

The most popular and highly efficient method for treating severe obesity is gastric bypass surgery (Chen *et al*., 2016). is a form of weight reduction surgery that causes weight loss by both food restriction and malabsorption, in these bypass surgeries, the duodenum and a piece of the small intestine are excluded from the digestive system, A tiny gastric pouch is made as part of the RYGBP procedure. This pouch is joined to the area of the jejunum where food passes (Bloomberg *et al*., 2005; Ponsky *et al*., 2005; Bernert *et al*., 2007; Love and Billett, 2008; Tarplin *et al*., 2015; Ghanbari *et al*., 2021).

Given its advantageous balance between long-term efficacy and complication rate, the RYGB technique is regarded as the gold standard of all bariatric procedures (Steenackers *et al*., 2018). Although there are a few changes because of anatomical differences, the RYGB procedure used in pigs and humans is remarkably comparable (Rao *et al*., 2010). Studies on humans have demonstrated that operations affecting the gastrointestinal tract, such as bariatric procedures and the complete or partial removal of the stomach, reduce the absorption of vitamin B12 (Ghanbari *et al*., 2021).

The best way to address extreme obesity is through bariatric surgery, the most frequent procedures performed are laparoscopic Roux-en-Y gastric bypasses (Lombardo *et al*., 2021). The most successful treatment for severe obesity is currently gastric bypass surgery, and it is now well known that it has positive benefits on co-morbidities associated with obesity, such as diabetes and hypertension (Bueter *et al*., 2011). The RYGB technique's effectiveness has been demonstrated in terms of weight loss and comorbidity improvement (Sjostrom *et al*., 2004; Bernert *et al*., 2007). This intervention does not come without danger so frequent short- and long-term follow-up is necessary for a number of reasons. First off, surgical problems (leaks, fistula, obstructions, anastomotic stenosis, internal hernias, etc.) are a possibility, especially for patients who have severe digestive complaints. It's also crucial to monitor comorbidities and modify therapies, particularly anti-diabetic ones.

The procedure could also have a significant psychological and social impact on the patient, necessitating multidisciplinary support. In any case, the procedure causes significant alterations in the physiology of the digestive system, such as malabsorption, non-acid reflux, exclusion of the inferior gastric pocket, and asynergy between the various secretions (enzymes, acids, and hormones). As a result, the procedure could cause iatrogenic pathologic symptoms to affect all of the digestive tube organs (Ponsky *et al*., 2005; Bernert *et al*., 2007). Gastric bypass surgery is especially related to iron insufficiency and iron deficiency anemia, which are more common with bypass than with simply restrictive operations (Love and Billett, 2008).

2-13-2: Gastric Sleeve Surgery or Sleeve Gastrectomy (SG)

Surgeons conduct sleeve gastrectomy to limit how much food a person can eat (Lombardo *et al*., 2021). Sleeve gastrectomy (SG) is a bariatric procedure that has developed from both restrictive and malabsorptive or a combination of the two surgeries for the management of morbid obesity (Patrikakos *et al*., 2009; Katz *et al*., 2011). One surgical operation used to treat morbid obesity is called a sleeve gastrectomy (SG), which involves removing the gastric fundus and narrowing the stomach (Castelan *et al*., 2007; Patrikakos *et al*., 2009). Also, laparoscopic sleeve gastrectomy (Roa *et al*., 2006; Braghetto *et al*., 2007). In this procedure, the fundus and a significant portion of the stomach are excised and removed. Secretory cells that create hormones that control hunger are present in this region of the stomach.

Weight loss results from this procedure when the stomach's volume is reduced and its production of appetite hormones (Tarplin *et al*., 2015; Ghanbari *et al*., 2021). However, there are some risks associated with sleeve gastrectomy. The most frequent side effects include gastroesophageal reflux, sleeve stenosis, splenic damage, bleeding, and leaking. Gastric volvulus, is the rotation of the entire or a portion of the stomach around its anatomical axes which can result in necrosis and perforation (Dejardin *et al*., 2013).

Also, there are other complications such as pulmonary embolism, delayed gastric emptying, intraabdominal abscess and wound infection (Akkary *et al*., 2008). With a sleeve gastrectomy, the stomach is left without any fixations along the entire greater curvature, which increases the risk of volvulus (Dejardin *et al*., 2013).

Chapter Three

Materials and Methods

3-1: Experimental Animals

Twelve mature male dogs of the local breed were used in the current study. The average age was 29 months ± 1.5 and the average weight was 33 kg ± 1.3. The animals were provided with free food and water and were kept in the dog house at the University of Mosul's College of Veterinary Medicine. They were in clinically good health. To eliminate any internal or external worms, ivermectin at a dosage of 1% was administered subcutaneously to all animals in a single dose (1 ml / 50 kg).

3-2: Solution, Medications, Surgical Threads, Devices and Instruments Used in The Experiment

3-2-1: Solution

1-Ethyl alcohol 99.8% company production Higeen.

2-Tincture of iodine 10% the record from

Potassium iodine 200g company production chem-lab Belgium.
Crestal iodide 100g company production chem-lab Belgium.
Ethyl alcohol 1 litter.
3-Distilled water.

3-2-2: Medications

1-Ivermectine 1% company production Rheivet Germany.

2-Xylazine 2% company production interchemie Holland.

3-Ketamine 10% company production alfasan Holland.

4-Pencillin-streptomycin company production interchemie Holland.

5-Wound spray (OTC) company production hanvet Vietnam.

3-2-3: Surgical Threads

1-Absorbable suture material type polyglycolic acid NO: 0 company production medipac Greece.

2-Absorbable suture material type chromic catgut NO:1 or 2 company production medipac Greece.

3-Non-absorbable suture material type silk NO:2 company production medipac Greece.

3-2-4: Devices and Instruments

1-Autoclave company production Labtech Korea.

2-Traditional surgical set.

3-Fuji Film corporation for electrolyte measurement company production in Japan.

4-LIASON (Diasorin) for D_3, B_{12} measurement company production in Germany.

5- Mythic 18 for complete blood picture measurement company production in France.

6- Spin 120 for iron measurement company production in British

7- laparoscopic system which was imported from Karl Starz company, Germany.

3-3: Experimental Design

In the current study, twelve mature male dogs of the local breed were used and they were divided into two groups at random, each with six dogs.

Group 1 (6 animals): they were underwent sleeve gastrectomy.

Group 2 (6 animals): they were underwent gastric bypass.

The following tests are performed on each animal both before and after the procedure.

1)Measurement of typical physiological indicators, including activity, temperature, heart rate, and breathing rate second day of surgery to period of disappear of the signs.

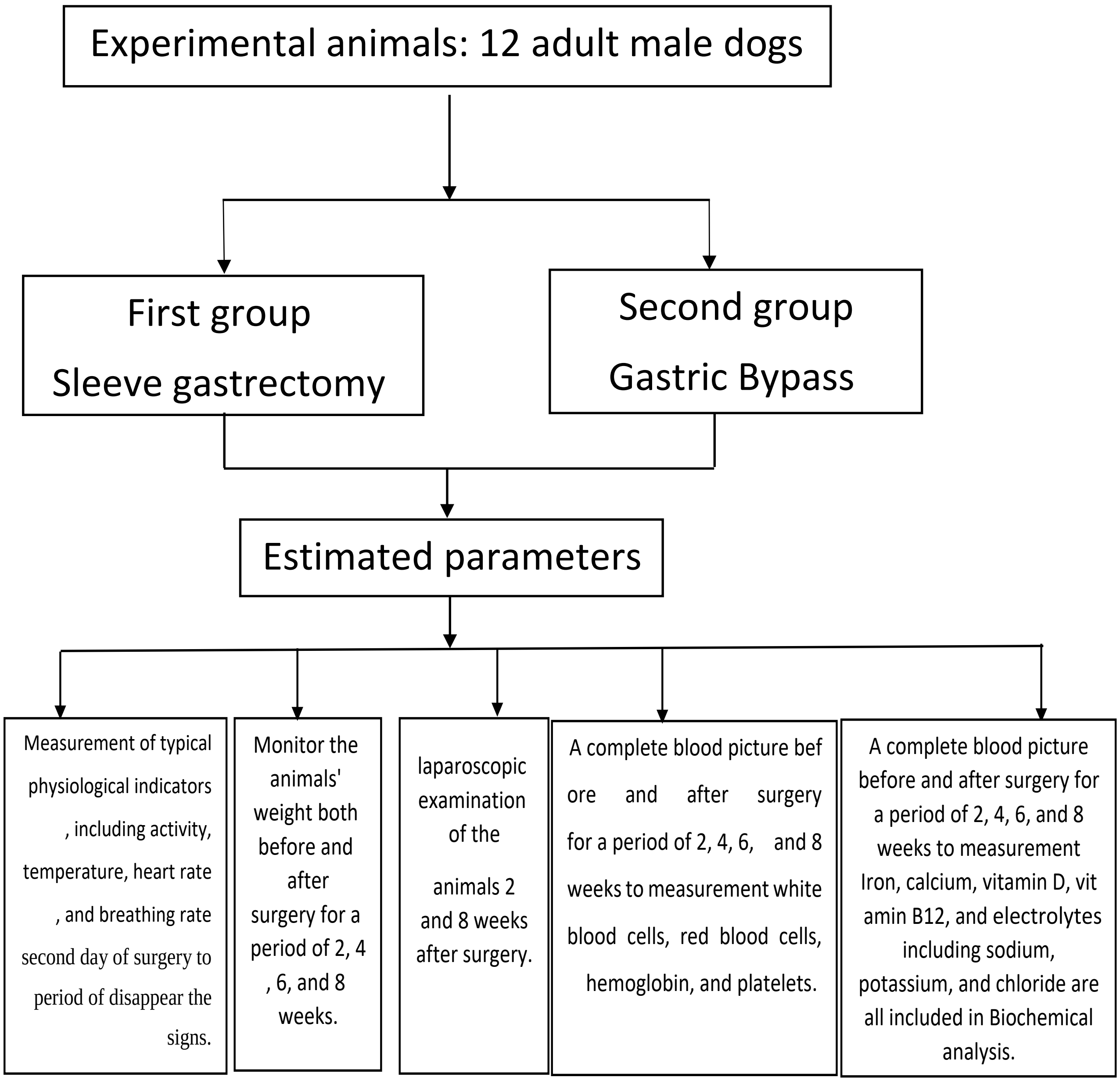
2)Monitor the animals' weight both before and after surgery for a period of 2, 4, 6, and 8 weeks.

3)Weekly laparoscopic examination of the animals (two and eight weeks).

4)A complete blood picture for a period of 2, 4, 6, and 8 weeks to measure white blood cells, red blood cells, hemoglobin, and platelets.

5)A complete blood picture for a period of 2, 4, 6, and 8 weeks to measure Iron, calcium, vitamin D, vitamin B12, and electrolytes including sodium, potassium, and chloride are all included in biochemical analysis.

The experimental design is depicted in the following diagram (Figure 3-4).



(Figure 3-4) Diagram of the experimental design

3-4: Stage of Surgical Operation

3-4-1: preoperative preparation

The animals should be kept fasting for approximately 48 hours from food before surgery and 24 hours from drinking water. Additionally, the abdominal region which extends from the xiphoid cartilage to the umbilical area should be prepared for the procedure.

3-4-2: Anesthesia

The animals were given an intramuscular injection of a mixture of xylazine at a concentration of 2% and a dose of 5 mg/kg, as well as 10% ketamine hydrochloride and a dose of 15mg/kg.

3-4-3: Disinfecting the Operating Site

A thin layer of cotton saturated with 70% ethyl alcohol was used to sterilize the surgery site, and remained in place while the surgeon prepared to do the procedure. Surgical towels were placed in the operating region after the cotton layer was removed. surgical drapes that are wrapped around the surgery site and fixed with towel clips (Figure 3-5).

Figure 3-5: Disinfected the site of operation and put the surgical drapes that are wrapped around the surgery site and fixed with towel clips.

3-4-4: The Surgical Operation

An abdominal wall incision of 10 to 15 centimeters was made, extending from the xiphoid cartilage to the umbilical region. The central line of the incision passed just above the linea alba. then open the fascia and make a small incision in the linea alba by using a surgical scalpel and by scissor the incision has been completed in the white line and peritoneum to the enter the abdominal cavity (Figure 3-6)

Figure 3-6: Open the skin and by using scissor make complete incision in the linea alba and peritoneum

After this there are two types of operation

1-Sleeve gastrectomy: - the stomach and spleen are completely exteriorized outside the abdominal cavity (Figure 3-7) by, using non- absorbable suture materials like silk, we make a double ligation to occlude the blood supply from the part that needs to be removed. Next, we cut between this ligation to release the portion that needs to be removed (Figure 3-8) Once the blood supply to the area that needs to be removed has been completely severed, a doyen's intestinal clamp is applied along the stomach, make the remaining part tube shape to mark the surgical site and stop the stomach contents from flowing out (Figure 3-9). Once the site has been established, we use surgical blades and scissors to cut the area that needs to be removed. To prevent dryness, we additionally cleanse the stomach and spleen while they are outside of the abdominal cavity with sterile normal saline solution at a concentration of 0.9% (Figure 3-10) Following the removal of the specified stomach portion, the edges of the stomach are sutured using continuous lumbert suture technique, and absorbable suture materials of type polyglycolic acid no: 0 or 1 (Figure 3-11).

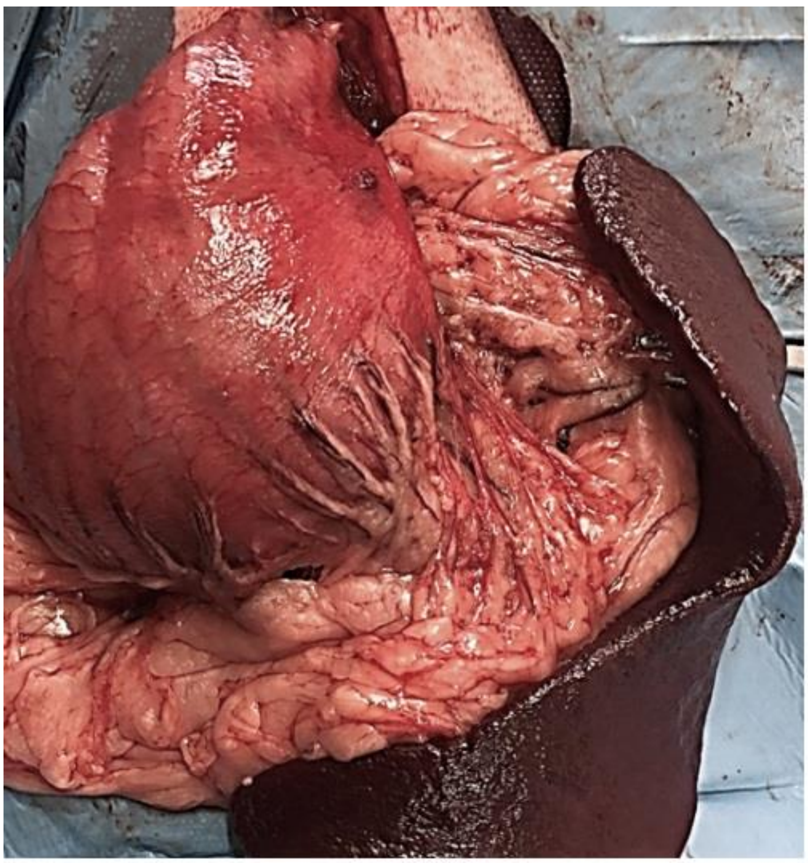


Figure 3-7: The stomach and spleen are completely exteriorized outside the abdominal cavity

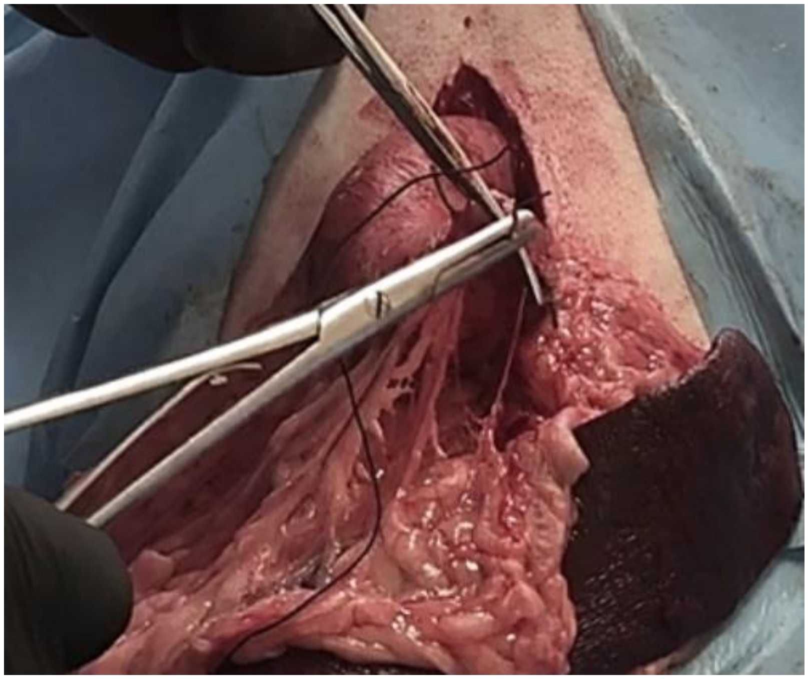


Figure 3-8: Make double ligation in blood supply

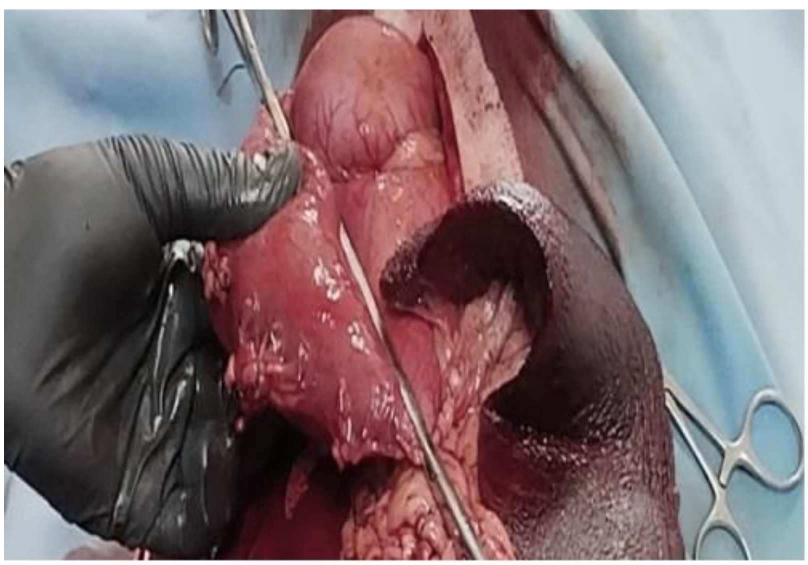


Figure 3-9: Put the
doyen’s intestinal clamp is inserted to mark the surgical site and stop the stomach contents from flowing out

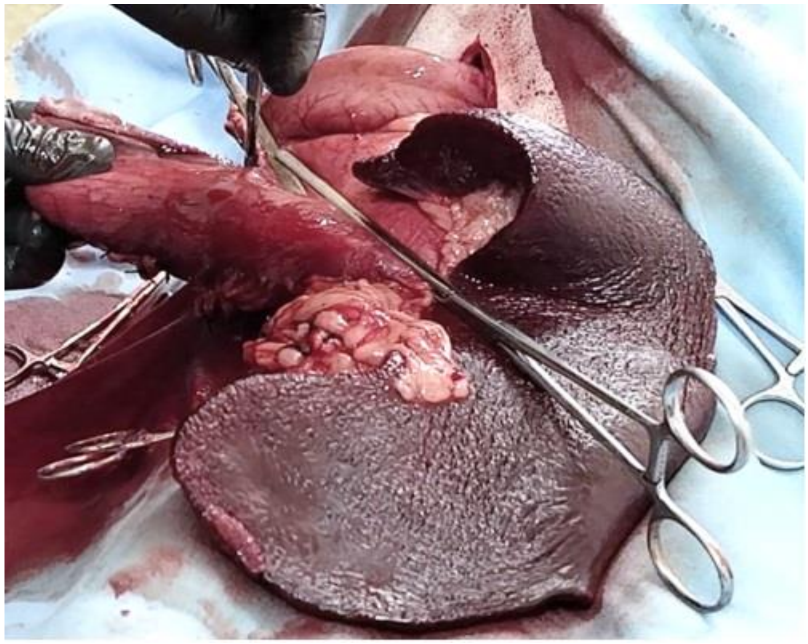


Figure 3-10: Cut the identified area of the stomach by using surgical blades and scissors

Figure 3-11: Sutured the edges of stomach by continuous lumbert suture technique by absorbable suture materials

2-Gastric Bypass: - the first steps are similar to the sleeve gastrectomy. The doyen's intestinal clamps are inserted perpendicular to the stomach to create a small pouch from the side of cardiac orifice. The stomach from the specified part was excised (Figure 3-12).

The proximal part of the stomach is sutured using continuous lumbert suture technique, and absorbable suture materials of type polyglycolic acid no: 0 or 1 and leaving the distal part without suturing to connect it to the intestine (Figure 3-13) but the second part of the stomach near the duodenum are sutured completely with the same technique and materials (Figure 3-14)

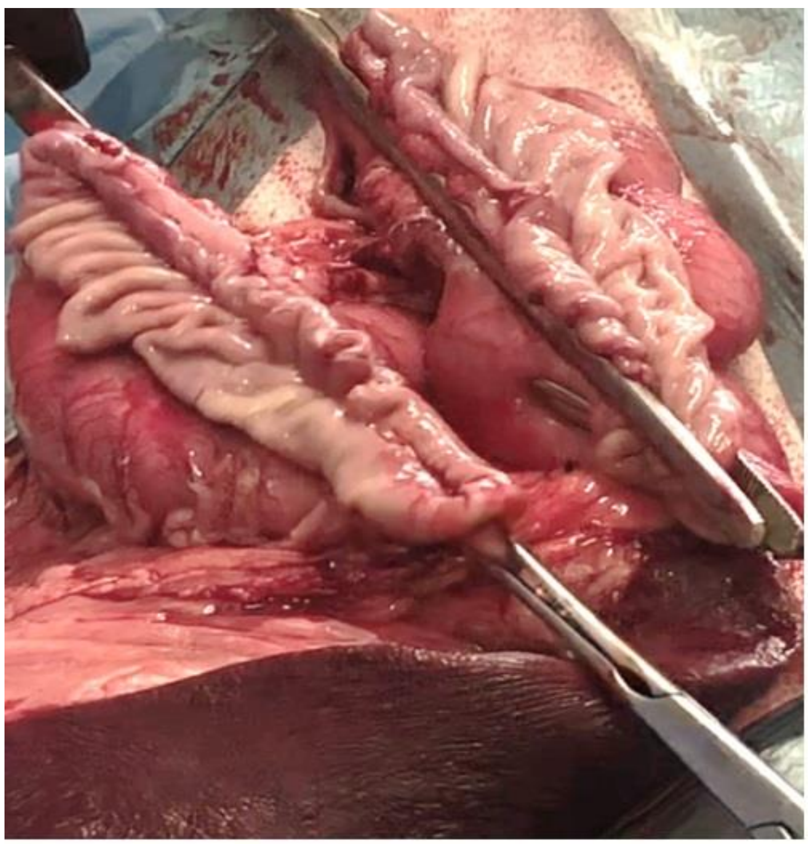


Figure 3-12: Put the doyens intestinal clamps are inserted perpendicular to the stomach

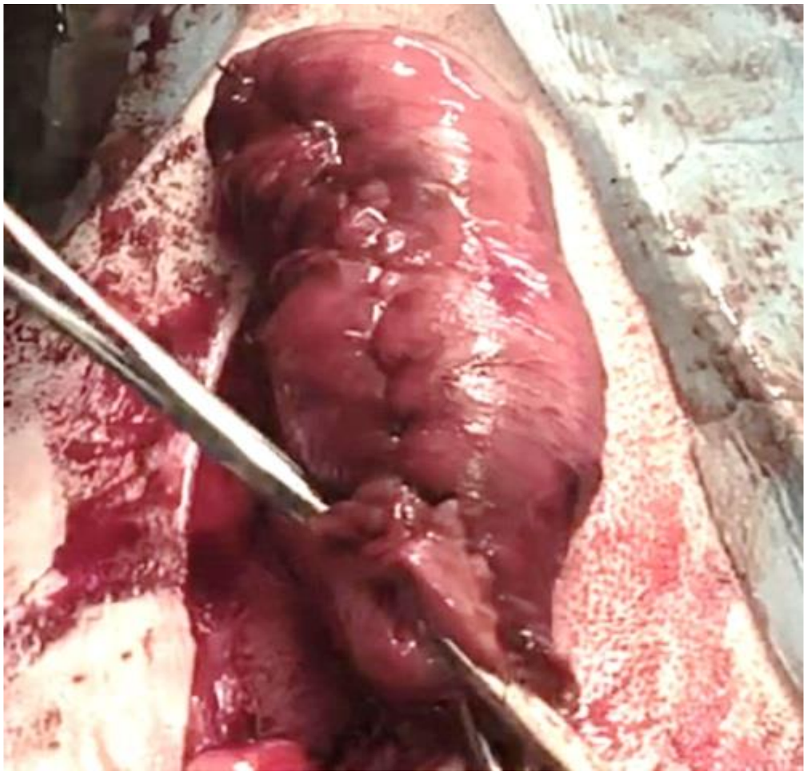


Figure 3-13: The proximal part of the stomach near the cardiac orifice is sutured and leaving the distal part without suturing to connect it to the intestine

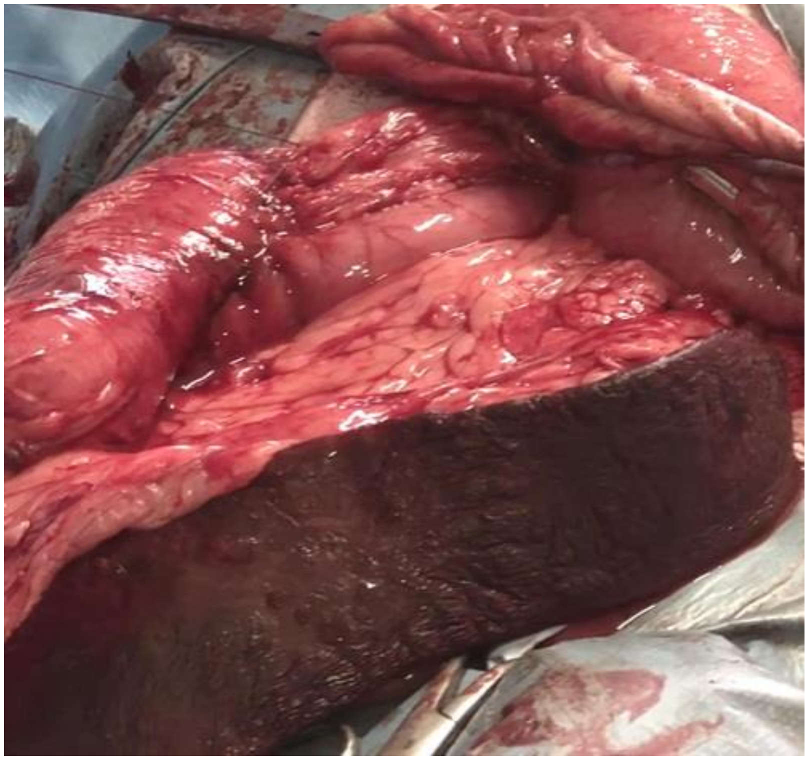


Figure 3-14: Completely suturing the part of the stomach near the duodenum

after that, we exteriorize the intestine outside the abdominal cavity and do to the point where the duodenum connects with the jejunum and cut between them in order to connect the jejunum with the stomach by using the End-to-End anastomosis technique by absorbable suture materials of type polyglycolic acid and simple interrupted suture technique (Figure 3-15).

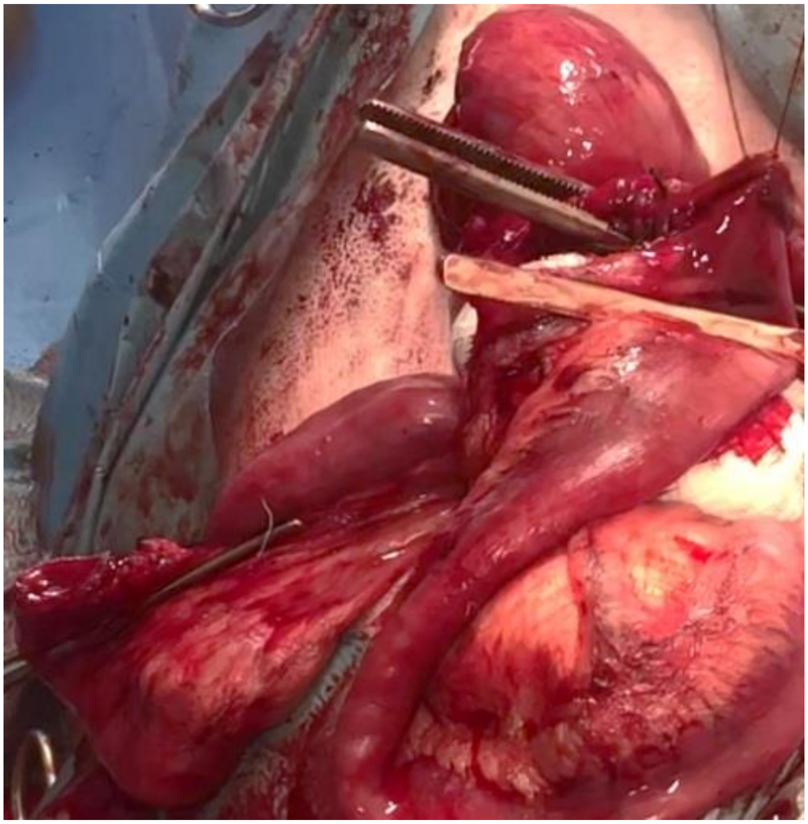


Figure 3-15: End-to-End anastomosis technique between the stomach and jejunum

Finally, we connect the duodenum with jejunum by using the End-to-Side anastomosis technique by absorbable suture materials of type polyglycolic acid and simple interrupted suture technique to obtain a Y-Shape (Figure 3-16).

Figure 3-16: Y-Shape after anastomosis jejunum with stomach by End-to-End and duodenum with jejunum by End-to-Side anastomosis

After completing the gastric bypass, the anastomosis area and the parts close to it are washed with sterile normal saline solution, and then the anastomosis site is examined to ensure that there is no leakage of stomach and intestinal contents from the anastomosis site by applying pressure on the anastomosis area with the finger. After that, the abdominal cavity is closed by suturing the peritoneum with the abdominal muscles together with a simple continuous suture technique using absorbable suture materials such as chromic catgut, then the skin was sutured with a simple interrupted suture technique by using non-absorbable suture materials such as silk, then the wound was sprayed with wound spray to prevent contamination.

3-5: Postoperative Animals Care

After completing the surgical procedure and full recovery from anesthesia, the experimental animals were placed in the animal home. The animals were given fluid therapy a little soft food and water. The dogs continued to be given soft food until the third day after the operation. After that, the animals were returned to the food were accustomed to before the operation, while their weight was monitored. The animals were also given antibiotics for 3-5 days postoperatively, a mixture of penicillin and streptomycin intramuscularly at a dose of 10,000 IU (international units) per Kg body weight. Clinical monitoring of the animal's, such as defecation and urination throughout the experiment.

3-6: Measurement of Normal Physiological Signs and Activity

The animals are monitored daily monitoring their vital signs by observing their movements and barking inside the cage, as well as when taking it outside to monitor their playing and running habits. Additionally, the temperature, heart rate and breathing rate were measured. Monitoring of the animals continues for two weeks after surgery in both groups.

3-7: Monitoring the Animal's Weight Postoperatively

The dogs of both groups that underwent surgery are weighed 2,4,6 and 8 weeks after surgery making sure that they are given the same quantity and type of food, as the weight before the operation is compared with after the operation.

3-8: Postoperative Laparoscopic Examination

To confirm the surgical procedure, the animals are examined using the laparoscopic method. All dogs in both groups are examined within 2 and 8 weeks after surgery. the dogs are given general anesthesia and the umbilical area is prepared for aseptic surgery as described in a surgical procedure. The dogs are then insufflated with carbon dioxide gas and the 10 mm laparoscope is inserted into the abdomen according to the method described by (Alkattan *et al*., 2014) and the area is examined completely to ensure that there is no leakage into the abdominal cavity from the stomach or intestines, or to notice the presence of adhesions, to identify the severity of these adhesion, or to record any complication that were associated with the surgical procedure in both groups.

3-9: Complete Blood Picture

Before the surgical procedure was taken a blood, sample was taken into account time zero, as well as 2, 4, 6, and 8 weeks following the procedure, a blood sample was obtained from each animal, and a comparison was conducted between them. To avoid contaminating the sample, the collection site was prepared before the sample was collected from the jugular vein. 3 ml of blood were collection, put into a glass tube with the anticoagulant ethylenediamine tetraacetic acid (EDTA), and brought to the laboratory to measure white blood cells, red blood cells, hemoglobin, and platelets.

3-10: Biochemical Analysis

Every animal had a blood sample collected prior to surgical operation considering into account time zero, as well as 2, 4, 6, and 8 weeks following the procedure.

To avoid infection, the area where the blood was collected was cleaned and prepared. 5ml of blood was collected from the jugular vein, put in a glass tube empty of anticoagulant to get the serum, and sent to the laboratory to measure Iron, calcium, vitamin D, vitamin B12, and electrolytes including salt, potassium, and chloride.

3-11: Statistical Analysis

Data of all experiments were expressed as mean ±SE. The data were compared by two-way repeated measures ANOVA (Analysis of Variance). Significant differences were determined by Duncan's Multiple Range Test. Data were analyzed using Sigma Stat (Jandel scientific software V3.1), and $P<0.05$ was considered statistically significant.

Chapter four

Results

All bariatric surgery conducted on experimental animals were clinically successful, and no animal deaths occurred in either group of animals. Within 24-48 hours of the surgical procedure, all animals returned to defecation and urination, as well as their full normal activity.

4-1: Clinical Findings

Clinical evaluations for both groups following the second day of surgery revealed evidence of inflammation at the site of the operation, which was indicated by slight redness and edema, as well as a slight increase in body temperature, respiration rate, and heart rate. These inflammatory symptoms began to disappear progressively on the fifth and seventh days following the operation. The improvement of the animal’s health, as indicated by temperature, respiratory rate, and heart rate during the first week of the surgical procedure, and their return to normal rates.

The clinical picture was reflected by the animal’s activity and barking following the surgical procedure, as well as defecation, urination, and other visible signs, which were nearly the same in both groups. However, the dogs in the second group were less active and mobile than the dogs in the first group, all of these dogs returned to full activity and movement a ten days after the surgical procedure.

4-2: Animals Weights

The preoperative weights of group one animals ranged between 27-37 kg, with an average of 33.5 ± 1.5 kg. Two weeks after the surgical procedure, the animal's weights decreased, ranging between 26-36 kg, with an average of 32.5 ± 1.5 kg. After four weeks, a further decrease in the animal's weights was observed. Their weights ranged between 24-33 kg, and a mean of 30.1 ± 1.4 kg. The loss of weight continued after six weeks, when another decrease in the animals' weight was observed, reaching their weights between 21-30 kg, with an average of 27.6 ± 1.4 kg. After eight weeks reached 19-28 kg and a mean of 25.0 ± 1.4 kg (Table 4-1).

Statistical analysis showed that the average weight decreases significantly ($P \leq 0.001$) two weeks after surgery compared to preoperative weights. A significant decrease ($P \leq 0.001$) in average weights was also observed in the fourth, sixth, and eighth weeks (Table 4-2).

In the second group, the weights of the dogs in this group before the surgery ranged between 34-47 kg, with an average of 39.1 ± 1.8 kg. Two weeks after the surgery, a decrease in the animals' weights was observed, as their weights ranged between 32-44 kg, with an average of 36.5 ± 1.7 kg. After four weeks, a further decrease in the animal's weights was observed. Their weights ranged between 29-41 kg, with an average of 33.5 ± 1.7. The animal's weights continued to decrease, reaching 26-39 kg six weeks after the operation, with an average of 30.5 ± 1.8 kg. After eight weeks, a decrease in the animals' weights was also observed, as their weights ranged between 22-35 kg and an average of 27.0 ± 1.8 kg (Table 4-1).

Statistical analysis showed that the average weight decreased significantly ($P \leq 0.001$) two weeks after surgery compared to the preoperative weights. A significant decrease ($P \leq 0.001$) in the average of weights was also observed in the fourth, sixth, and eighth week (Table 4-2)

Table 4-1: - Weight of the animals before and after the surgical operations

Animals No.		Body weight (Kg)				
		Before surgical operation	Two weeks after surgical operation	Four weeks after surgical operation	Six weeks after surgical operation	Eight weeks after surgical operation
Group 1	1	27	26	24	21	19
	2	33	32	30	28	25
	3	35	34	32	30	27
	4	37	36	33	30	28
	5	37	36	33	30	28
	6	32	31	29	27	23
Group 2	7	34	32	29	26	22
	8	38	35	32	29	27
	9	47	44	41	39	35
	10	40	38	35	31	28
	11	36	33	30	27	23
	12	40	37	34	31	27

Table 4-2: - The mean of weight of the animals before and after the surgical operations in two groups

Surgical operation	Body weight (kg)				
	Before surgical operation	Two weeks after surgical operation	Four weeks after surgical operation	Six weeks after surgical operation	Eight weeks after surgical operation
Group 1	33.5 ± 1.5[a]	32.5 ± 1.5[b]	30.1 ± 1.4[c]	27.6 ± 1.4[d]	25.0 ± 1.4[e]
Group 2	39.1 ± 1.8[a]	36.5 ± 1.7[b]	33.5 ± 1.7[c]	30.5 ± 1.8[d]	27.0 ± 1.8[e]

[a-e] the different small letters refer to a significant variation between the columns ($P \leq 0.001$).

The result of the statistical analysis showed a significant ($p \leq 0.05$) difference in the mean weight loss between the two groups of animals. The mean of weight loss in the second group was higher significantly ($p \leq 0.05$) in comparison with the first group at two, fourth and eighth weeks after the operation. At the sixth weeks, there was no significant difference in weight loss between the two groups (Table 4-3).

The results showed that the mean weight loss was 1 ± 0.0 kg two weeks after the surgical procedure in the first group, and the decreases continued until the eighth week, which reached to 2.6 ± 0.3 kg (Table 4-3).

In the second group, the rate of decrease two weeks after the surgical operation was 2.6 ± 0.2 kg, and the decrease was continued until the eighth week. That was recorded at 3.5 ± 0.3 kg (Table 4-3).

The statistical analysis's findings demonstrated that the first group's weight loss rate in the second week was significantly (P≤0.05) lower than it was in the following weeks. For the second group, throughout the experiment there was no significant difference in the rate of weight loss, except in the second week, when there was a significant difference (P≤0.05) in the eighth week (Table 4-3).

The statistical analysis showed a significant (P≤0.05) difference in the mean of weight loss between the two groups of animals. The mean of weight loss in the second group was higher significantly (P≤0.05) in comparison with the first group at two, fourth and eighth weeks after surgery. At the sixth weeks, there was no significant difference in weight loss between the two groups (Table 4-3).

Table 4-3: -The mean of the lost weight of the animals after the surgical operation

Surgical operation	Body weight (kg)			
	Two weeks after surgical operation	Four weeks after surgical operation	Six weeks after surgical operation	Eight weeks after surgical operation
Group 1	1 ± 0.0 A, a	2.3 ± 0.2 A, b	2.5 ± 0.2 A, b	2.6 ± 0.3 A, b
Group 2	2.6 ± 0.21 B, a	3.0 ± 0.0 B, a, b	3.0 ± 0.2 A, a, b	3.5 ± 0.3 B, b

[a,b] The different small letters refer to a significant variations between the columns (P≤0.05).

[A, B] The different capital letters refer to a significant variation between the rows ($P \leq 0.05$).

4-3: Laparoscopic Examination

According to the results of the laparoscopic examination performed on both groups, there were no stomach or intestine contents leaking into the abdominal cavity from the surgical site. However, it was seen that adhesions with the omentum, other organs, and each other existed at the surgical site (Figure 4-17).

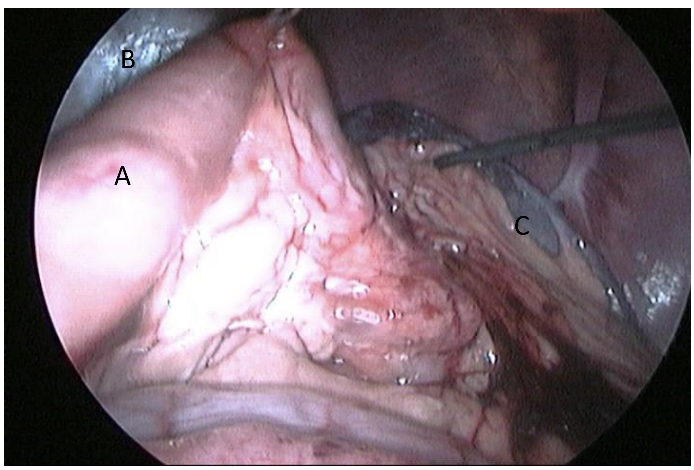


Figure 4-17: - There are very slight adhesions with omentum without leaks in the first group. A(stomach), B (liver), C(spleen).

The degree of adhesions varied from group to group; in the first group, as seen in the picture above, the adhesions were minor, but in the second group the adhesions were very severe (Figure 4-18).

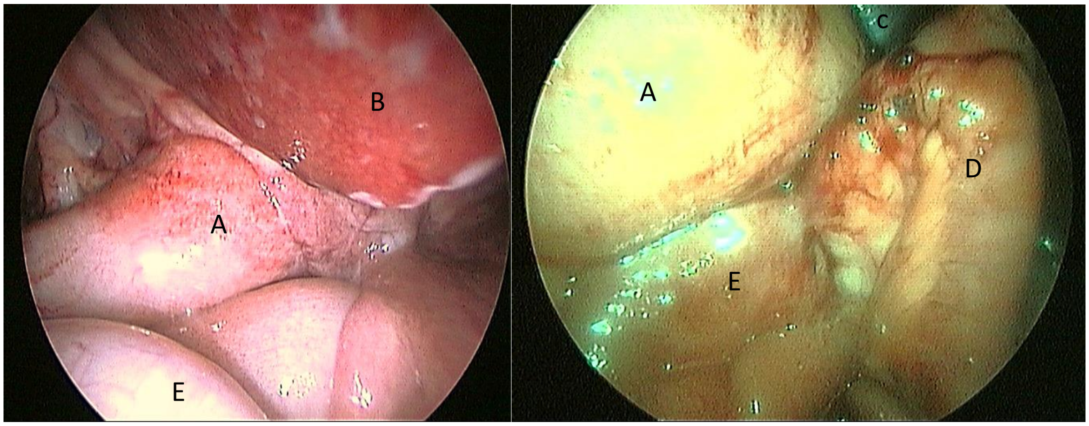


Figure 4-18: - Shows the presence of strong adhesions with the omentum and between adjacent organs in the second group. A(stomach), B(liver), C(spleen), D(jejunum), E(duodenum)

In addition to the presence of adhesion, it was also noted that the shape of the stomach had changed, become tubular in shape in the first group (Figure 4-19).

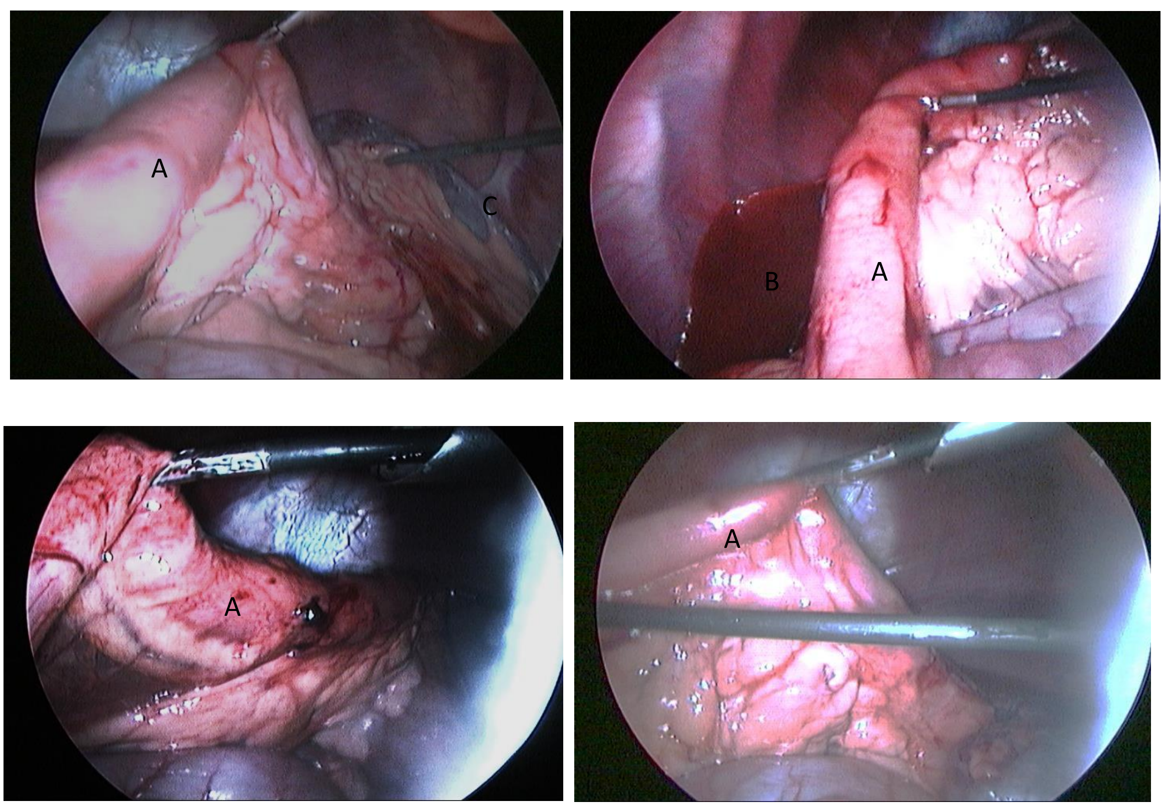


Figure 4-19: - These forms show the stomach's tubular form following the gastric sleeve technique. A(stomach), B(liver), C(spleen).

The stomach's Y-shape was also noticeable following the bypass operation (Figure 4-20).

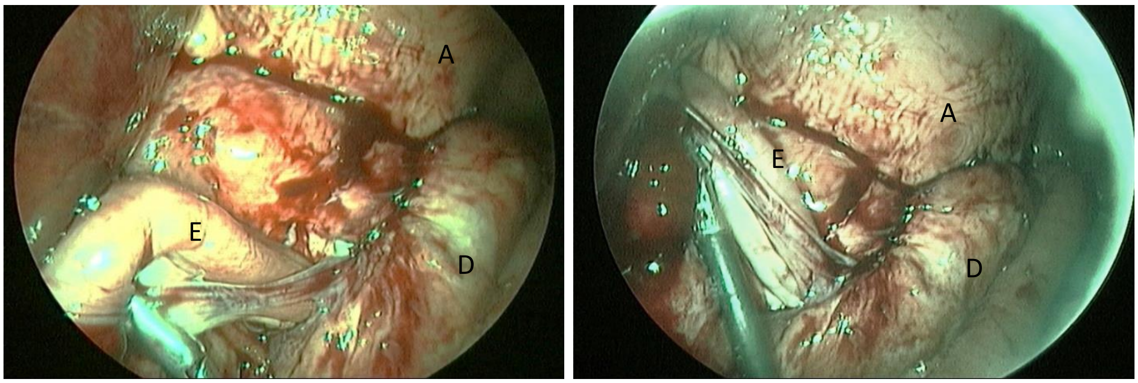


Figure 4-20: - Y-shape stomach after bypass operation. A(stomach), D(jejunum), E(duodenum).

4-4: Biochemical Analysis

4-4-1: Iron

The results showed the first group's pre-surgery iron level was 134.3±5.3µg/dl, whereas the second group's iron level was 113.5±3.8µg/dl. Two weeks following the surgery, it was seen that the iron level in the first group started to decrease significantly ($P \leq 0.05$), it reached 105.8±7.2 µg/dl, and in the second iron level reached to 99.1±2.7 µg/dl. Following four weeks, the iron level in both groups decreased more, with the first group's iron level reaching 100.3±6.6 µg/dl and the second group's reaching 86.6±1.8 µg/dl. Six weeks following surgery, the iron level in both groups started to decline further; in the first group, it was 95.1±7.4 µg/dl, and in the second, it was 76.6±2.0 µg/dl. Eight weeks following surgery, the iron level in both groups decreased more, reaching 87.6±6.3 µg/dl in the first group and 65.0±1.7 µg/dl in the second. Total body iron level decreased more after the Roux-en-Y technique than after sleeve gastrectomy (Table 4-4).

The statistical analysis of the results indicated that, prior to the procedure and for only six and eight weeks following it, there was a significant ($P \leq 0.05$) difference in the average iron levels between the two groups; however, no significant difference was observed after two and four weeks following the procedure (Table 4-4).

The statistical analysis of the results also demonstrated a significant difference ($P \leq 0.05$) between the first group's average iron level before and after the procedure. Before the procedure and after two, four, six, and eight weeks, there was an obvious and significant difference ($P \leq 0.05$) in the first group. Additionally, we did not find any significant difference in iron level of sixth and fourth weeks after the surgery, but significant variation ($P \leq 0.05$) was noted in the second week in comparison with the eighth week. The eighth week following the procedure was observed to change significantly ($P \leq 0.05$) from the fourth week, but no significant difference was found between the sixth and eighth weeks following the procedure (Table 4-4).

Further, it was observed that the second group differed significantly ($P \leq 0.05$) before and after the surgical procedure, as well as during the second, fourth, sixth, and eighth weeks following the procedure. Additionally, a significant variation ($P \leq 0.05$) was noted between the eighth and sixth weeks following surgery in the second week, but not with the fourth week. There was no significant difference found between the fourth and sixth weeks after the surgical surgery, however there was a significant difference ($P \leq 0.05$) between the fourth and eighth weeks. Lastly, in the second group, there was no significant difference between the sixth and eighth weeks of surgery (Table 4-4).

Table 4-4: - The mean of iron measurement of the animals before and after surgical operation in two groups

Surgical operation	Iron (µg/dl)				
	Before surgical operation	Two weeks after surgical operation	Four weeks after surgical operation	Six weeks after surgical operation	Eight weeks after surgical operation
Group 1	134.3± 5.3 a, A	105.8± 7.2 a, B	100.3±6.6 a, B, D	95.1± 7.4 a, B, D	87.6±6.3 a, C, D
Group 2	113.5±3.8 b, A	99.1±2.7 a, B	86.6±1.8 a, B, D,	76.6±2.0 b, C, D	65.0±1.7 b, C

[a, b] the different small letters refer to a significant variation between the rows (P≤0.05).

[A-D] the different capital letters refer to a significant variation between the columns (P≤0.05).

4-4-2: Vitamin D3

The study's findings demonstrated that the animals in the first group had an average level of vitamin D3 of 40±1.5ng/ml before surgery, and in the second group had an average level of 37.6±0.7 ng/ml. The vitamin D3 level was found to have slightly decreased in both groups two weeks following the surgical operation, it was 34.5±1.5 and 33.3±0.8 ng/ml respectively. Four weeks following the procedure, the D3 level continued decreasing, but very slightly, reaching 30.3±1.5 ng/ml in the first and 29±1.0 ng/ml in the second group. At six weeks following the procedure the vitamin D3 level in the first group reached 27±1.3 ng/ml and in the second group reached 25.8±0.6 ng/ml. Finally, at eight weeks following the procedure, the first group's D3 level was 24±1.0 ng/ml and the second group was 22.6±0.6 ng/ml (Table 4-5).

The statistical analysis revealed that there was no significant variation in the average vitamin D3 levels between the two groups' before and after the surgical procedure at 2, 4, 6, and 8 weeks. However, in both groups. the vitamin D3 level was decreased significantly (P≤0.05) over the length of the study, with the exception, it’s level at 6 and 8 weeks in the first group, and its level at 4 and 6 weeks and at 6 and 8 weeks in the second group (Table 4-5).

Table 4-5: - The mean of D3 measurement of the animals before and after surgical operation in two groups

Surgical operation	D3 (ng/ml)				
	Before surgical operation	Two weeks after surgical operation	Four weeks after surgical operation	Six weeks after surgical operation	Eight weeks after surgical operation
Group 1	40± 1.5 a, A	34.5± 1.5 a, B	30.3±1.5 a, C	27± 1.3 a, D	24±1.0 a, D
Group 2	37.6±0.7 a, A	33.3±0.8 a, B	29±1.0 a, C	25.8±0.6 a, C, D	22.6±0.6 a, D

[a] the similar small letters refer to no significant variation between the rows ($P \leq 0.05$).

[A-D] the different capital letters refer to a significant variation between the columns ($P \leq 0.05$).

4-4-3: Vitamin B12

According to the study's findings, the animals in the first group had a vitamin B12 level of 280.0±13.4 pg/ml prior to surgery, whereas the animals in the second group had a level of 297.5±2.5 pg/ml. Two weeks following the procedure, it appeared to decrease, it became 251.3±8.6 pg/ml in the first group and 253.3±4.9 pg/ml in the second group. After four weeks following the surgery, the levels of vitamin B12 in the first group and the second group decreased more, 227±2.9 pg/ml and 216.6±2.4 pg/ml, respectively. Six weeks following the procedure, the first group's level of vitamin B12 was 214.5±1.3 pg/ml, while the second group's level was 196.6±3.3 pg/ml. Eight weeks following the surgery, the levels of vitamin B12 decreased more, reaching 204.8±1.6 pg/ml in the first group and 183.3±3.8 pg/ml in the second (Table 4-6).

The statistical analysis's findings demonstrated that there is a significant variation ($P \leq 0.05$) between the first and second groups. Specifically, there was significant variation ($P \leq 0.05$) in the average level of vitamin B12 after two and eight weeks, but there was no significant variation at fourth- and sixth-week following surgery (Table 4-6).

However, a notable variation in the first group's average vitamin B12 level was observed both before and after the surgery. a significant variation ($P \leq 0.05$) was recorded between all measurement times, with an exception in comparison of its level between the fourth and sixth and its level between the sixth and eight weeks following the operation in the first group and only between the sixth and eighth weeks following the procedure in the second group (Table 4-6).

Table 4-6: - The mean of B12 measurement of the animals before and after surgical operation in two groups

Surgical operation	B12 (pg/ml)				
	Before surgical operation	Two weeks after surgical operation	Four weeks after surgical operation	Six weeks after surgical operation	Eight weeks after surgical operation
Group 1	280.6± 13.4 a, A	251.3± 8.6 a, B	227±2.9 a,C	214.5± 1.3 a, C, D	204.8±1.6 a, D
Group 2	297.5±2.5 a, A	253.3±4.9 b, B	216.6±2.4 a, C	196.6±3.3 a, D	183.3±3.8 b, D

[a, b] the different small letters refer to significant variation between the rows (P≤0.05).

[A-D] the different capital letters refer to a significant variation between the columns (P≤0.05).

4-4-4: Calcium

The results showed that the calcium levels in the first group of the animals before surgery were 9.6±0.09 mg/dl, while in the second group, the calcium levels was 9.4±0.04 mg/dl. Two weeks after surgery, it decreased a 9.3±0.06

mg/dl level in the first group and a 9±0.04 mg/dl in the second. Four weeks post-surgery, the levels were 9.3±0.06 mg/dl and 8.8±0.04 mg/dl, respectively. The first group's calcium level was 9±0.05 mg/dl six weeks following the operation, whereas the second group's level was 8.5±0.05 mg/dl. After eight weeks following surgery, its level finally reached 8.8±0.08 mg/dl in the first group and 8.4±0.06 mg/dl in the second (Table 4-7).

The average calcium levels in the two groups and at all periods before and after the surgical treatment were significantly ($P \leq 0.05$) variation. according to the statistical analysis's findings in both groups (Table 4-7). The calcium level decreased significantly ($P \leq 0.05$) over the length of the study, with the exception, of its level at 4 and 6 weeks and at 6 and 8 weeks in the first group. and its level at 6 and 8 weeks in the second group (Table 4-7).

Table 4-7: - The mean of calcium measurement of the animals before and after surgical operation in two groups

Surgical operation	Calcium (mg/dl)				
	Before surgical operation	Two weeks after surgical operation	Four weeks after surgical operation	Six weeks after surgical operation	Eight weeks after surgical operation
Group 1	9.6± 0.09 a, A	9.3± 0.06 a, B	9.3±0.06 a, B	9± 0.05 a, C	8.8±0.08 a, C
Group 2	9.4±0.04 b, A	9±0.04 b, B	8.8±0.04 b, C	8.5±0.05 b, D	8.4±0.06 b, D

[a, b] the different small letters refer to significant variation between the rows ($P \leq 0.05$).

[A-D] the different capital letters refer to a significant variation between the columns ($P \leq 0.05$).

4-4-5: Sodium

The study's findings demonstrated that the animals in the first group had a sodium level of 148.5±0.2 mmol/L prior to surgery, while the animals in the second group had a level of 148.8±0.3 mmol/L. The concentration of sodium levels in the both groups decreased to 9.3±0.06 mmol/L and 9±0.04 mmol/L respectively after two weeks of the surgery. After four weeks of surgery, the first group's sodium level was 145.6±0.5 mmol/L, whereas the second groups was 147.5±0.4 mmol/L. Its level in the first group was 143.8±0.4 mmol/L, and in the second group it was 146.6±0.3 mmol/L, six weeks following the operation. Eight weeks following the procedure, the level of sodium reached to 143.3±0.6 mmol/L in the first group and 146.5±0.5 mmol/L in the second group (Table 4-8).

The statistical analysis's findings demonstrated that, while no significant difference between the two groups prior to surgery, there was a significant difference ($P \leq 0.05$) between the two groups average sodium levels after surgery along the experience (Table 4-8).

Additionally, a significant difference ($P \leq 0.05$) in the first group's average sodium level was observed before and after the operation; this difference was observed between all times, with an exception between second and fourth weeks, as well as the sixth and eighth weeks, when there was no significant difference observed (Table 4-8).

The average sodium level in the second group was also found to differ significantly ($P \leq 0.05$) before and after the surgical procedure; this difference was observed at all times with the exception of the second and fourth week, fourth and eighth and sixth weeks, sixth and eighth weeks, when there was no significant difference observed (Table 4-48).

Table 4-8: - The mean of sodium measurement of the animals before and after surgical operation in two groups

Surgical operation	Sodium (mmol/L)				
	Before surgical operation	Two weeks after surgical operation	Four weeks after surgical operation	Six weeks after surgical operation	Eight weeks after surgical operation
Group 1	148.5± 0.2 a, A	146.6± 0.3 a, B	145.6±0.5 a, B	143.8± 0.4 a, C	143.3±0.6 a, C
Group 2	148.8±0.3 a, A	148±0.4 b, B	147.5±0.4 b, B	146.6±0.3 b, B, C	146.5±0.5 b, B, C

[a, b] the different small letters refer to significant variation between the rows ($P \leq 0.05$).

[A-C] the different capital letters refer to a significant variation between the columns ($P \leq 0.05$).

4-4-6: Potassium

According to the study's findings, the potassium levels of the animals in the first group were 4.9±0.01 mmol/L before surgery, whereas its levels in the animals of the second group were 4.9±0.04 mmol/L. Two weeks following surgery, the concentration in the first group dropped to 4.8±0.04 mmol/L, whereas in the second group it reached 4.8±0.04mmol/L. The first group's potassium level was 4.7±0.05 mmol/L after four weeks of surgery, while the second groups was 4.7±0.06 mmol/L. Six weeks after the operation, its level was 4.5±0.08 mmol/L in the first group and 4.6±0.06 mmol/L in the second. After eight weeks of the operation, the first group's potassium level was 4.5±0.08 mmol/L, whereas the second group's level was 4.4±0.2 mmol/L (Table 4-9).

The average potassium level in both groups was not significantly different before and after the surgical procedure at all times, according to the statistical analysis's data.

Additionally, it was observed that, when comparing the average potassium level two weeks following the surgical procedure to its pre-operative level, there was no significant difference, however, when comparing the average potassium level at four, six, and eight weeks following the surgical procedure to its pre-operative level, there was a significant difference ($P \leq 0.05$). Additionally, there is a significant ($P \leq 0.05$) variation between the second week with the eighth and sixth weeks alone. Regarding the remaining times, there is no significant variation. This applies especially for the first group of animals (Table 4-9).

Regarding the animals in the second group, there was no significant variation in the average potassium levels before and after the surgical procedure, with the exception of a significant change ($P \leq 0.05$) that appeared in the eighth week as compared to all other times (Table 4-9).

Table 4-9: - The mean of potassium measurement of the animals before and after surgical operation in two groups

Surgical operation	Potassium (mmol/L)				
	Before surgical operation	Two weeks after surgical operation	Four weeks after surgical operation	Six weeks after surgical operation	Eight weeks after surgical operation
Group 1	4.9± 0.01 a, A	4.8± 0.04 a, A, B	4.7±0.05 a, B, C	4.5± 0.08 a, C	4.5±0.08 a, C
Group 2	4.9±0.04 a, A	4.8±0.04 a, A	4.7±0.06 a, A	4.6±0.06 a, A	4.4±0.2 a, B

[a] the simillar small letters refer to no significant variation between the rows ($P \leq 0.05$).

[A-C] the different capital letters refer to a significant variation between the columns ($P \leq 0.05$).

4-4-7: Chlorides

The results of the study showed that prior to surgery, the animals in the first group had chloride levels of 106.8±0.7 mmol/L, whereas the animals in the second group had levels of 107.1±0.6 mmol/L. The concentration in both groups decreased to 105±0.8 mmol/L in the first group and 106.5±0.7 mmol/L in the second group two weeks after surgery. After four weeks of surgery, the chloride level in the first group was 103.5±0.7 mmol/L, but in the second group was 105.6±0.6 mmol/L. Its level was 102.1±0.4 mmol/L in the first group and 104.5±0.3 mmol/L in the second six weeks following the operation. At eight week surgery, the chloride level of the first group was 101.3±0.3 mmol/L, whereas the second group's level was 104.3±0.4 mmol/L (Table 4-410).

The average level of chloride in the two groups differed significantly ($P \leq 0.05$), according to the statistical analysis's findings. During the study, an important alteration was noted following the surgical procedure; however, no significant difference was observed for any of the two groups in the second week following the procedure.

The statistical analysis's findings also demonstrated that there was a significant ($P \leq 0.05$) difference in the first group's average chlorine level, which was noted at all points following surgery, with the exception of the second with fourth, fourth with sixth and sixth with eight weeks. There was no significant variation (Table 4-10).

Regarding the animals in the second group, the average chlorine level showed a slight significant difference ($P \leq 0.05$). However, a significant ($P \leq 0.05$) difference was only observed between the sixth and eighth week following the surgical procedure and before the procedure, as well as between the second week and the eighth, sixth week following the procedure. There was no significant difference for the other times (Table 4-10).

Table 4-10: - The mean of chlorides measurement of the animals before and after surgical operation in two groups

Surgical operation	Chlorides (mmol/L)				
	Before surgical operation	Two weeks after surgical operation	Four weeks after surgical operation	Six weeks after surgical operation	Eight weeks after surgical operation
Group 1	106.8± 0.7 a, A	105± 0.8 a, B	103.5±0.7 a, C, B	102.1± 0.4 a, D, C	101.3±0.3 a, D
Group 2	107.1±0.6 a, A	106.5±0.7 a, A	105.6±0.6 b, A, B	104.5±0.3 b, B	104.3±0.4 b, B

[a, b] the different small letters refer to significant variation between the rows ($P \leq 0.05$).

[A-c] the different capital letters refer to a significant variation between the columns ($P \leq 0.05$).

4-5: Complete Blood Picture

4-5-1: White Blood Cell Count (WBC)

According to the study's findings, the first group's average of WBC before the surgery was $6.8 \pm 0.5 \times 10^3/\mu l$, whereas the second group's average count was $11.1\pm0.4\times10^3$/µl. WBC were increased significantly two weeks following the surgery, increasing to $18.4\pm1.2\times10^3$/µl in the first group and 17.4±0.1 $\times10^3$/µl in the second. four weeks After the surgery, the average WBC was increased but not as much as it during the second week, it was $14.2\pm0.8\times10^3$/µl in the first group and $16.5\pm0.1\times10^3$/µl in the second. WBC started to decline six weeks following surgery; the average count was $11.4\pm0.5\times10^3$/µl in the first group and $12.8\pm0.1\times10^3$/µl in the second. At eighth week following the surgery, the WBC were decreased reaching $8.4\pm0.2\times10^3$/µl in the first group and $11.1\pm0.2\times10^3$/µl in the second group (Table 4-11).

The statistical analysis's findings demonstrated that the average WBC in the two groups was differed significantly ($P\leq0.05$). Four and eight weeks following the surgery, there was a significant ($P\leq0.05$) difference in the average of WBC, however, no significant difference was seen at two and six weeks following the operation.

In the first group, the WBC was differed significantly ($P\leq0.05$) at all time of measurement except that record between eighth week and before the surgical operation.

A significant ($P\leq0.05$) variation was observed in the second group in WBC before and after the procedure, with the exception of its value between two and fourth weeks following the procedure. Similarly, there was no significant difference between its value the eighth and sixth weeks. also, no significant differences in WBC were recorded between its value before the operation in comparison with their values at the sixth and eighth weeks (Table 4-11).

Table 4-11: - The mean of WBC measurement of the animals before and after surgical operation in two groups

Surgical operation	WBC (10^3/µl)				
	Before surgical operation	Two weeks after surgical operation	Four weeks after surgical operation	Six weeks after surgical operation	Eight weeks after surgical operation
Group 1	6.8± 0.5 a, A	18.4± 1.2 a, B	14.2±0.8 a, C	11.4± 0.5 a, D	8.4±0.2 a, A
Group 2	11.1±0.4 b, A	17.4±0.1 a, B	16.5±0.1 b, B	12.8±0.1 a, A	11.1±0.2 b, A

$^{a,\ b}$ the different small letters refer to significant variation between the rows (P≤0.05).

$^{A\text{-}D}$ the different capital letters refer to a significant variation between the columns (P≤0.05).

4-5-2: Red Blood Cell Count (RBC)

The study's findings demonstrated that the first group's average of RBC before the surgery was 5.2±0.08×10^6/µl, while the second group's count was 5.5±0.1×10^6/µl. There was an obvious decrease in the group's RBC two weeks following the surgery, which was 4.2±0.1×10^6/µ in the first group and 3.8±0.08×10^6/µl in the second group. After four weeks of operation, RBC was observed to be nearly identical to pre-surgery levels (5.1±0.1×10^6/µl in the first group and 4.6±0.08×10^6/µl in the second group). The RBC levels returned to pre-surgery levels at six and eight weeks following the procedure, reaching 5.1±0.1×10^6/µl and 5.2±0.1×10^6/µl in the first group and 5.3±0.05×10^6/µl and 5.4±0.07×10^6/µl in the second group, respectively (Table 4-12).

The average of RBC in the two groups differed significantly ($P \leq 0.05$), according to the statistical analysis's findings. Two and four weeks following the surgery, a significant difference ($P \leq 0.05$) in the mean concentration of red blood cells was noted. For the remaining periods, no significant variation was seen (Table 4-12).

It was also observed that in the first group there was a significant difference in RBC ($P \leq 0.05$) before and after the surgery, with a substantial difference observed only in the second week following the procedure in comparison to the remaining periods. Regarding the remaining weeks, there was no significant variation between them (Table 4-12).

In addition, it was observed that the second group experienced a significant ($P \leq 0.05$) difference in RBC both before and after the operation. This difference was noted to be present at all times prior to and following the operation, with the following exceptions: between the sixth week and prior to the operation, at the eighth week and prior to the operation, and between six and eight weeks (Table 4-12).

Table 4-12: - The mean of RBC measurement of the animals before and after surgical operation in two groups

Surgical operation	RBC ($10^3/\mu l$)				
	Before surgical operation	Two weeks after surgical operation	Four weeks after surgical operation	Six weeks after surgical operation	Eight weeks after surgical operation
Group 1	5.2± 0.08 a, A	4.2± 0.1 a, B	5.1±0.1 a, A	5.1± 0.1 a, A	5.2±0.1 a, A
Group 2	5.5±0.1 a, A	3.8±0.08 b, B	4.6±0.08 b, C	5.3±0.05 a, A	5.4±0.07 a, A

$^{a, b}$ the different small letters refer to significant variation between the rows (P≤0.05).

$^{A\text{-}C}$ the different capital letters refer to a significant variation between the columns (P≤0.05).

4-5-3: Hemoglobin (Hgb)

According to the study's findings, the average of Hgb level in the first group was 13±0.2 g/dl before the surgery, and it was 13.7±0.4 g/dl in the second group. Two weeks following the procedure, the levels of Hgb began to decrease, 9.9±0.4 g/dl in the first group's and 11.4±0.1 g/dl in the second groups. At four weeks, the level of hemoglobin continued decreased, reaching to 9.2±0.2 g/dl in the first group and 10.1±0.1 g/dl in the second. After six weeks, the first group's Hgb level was 12.9±0.2 g/dl, while in the second group was 13.2±0.2 g/dl. Following eight weeks, the average of Hgb level in the first group was 13.2±0.2 g/dl, and in the second group was 13.9±0.4 g/dl, indicating a return to pre-surgery levels (Table 4-13).

The average of Hgb level was differed significantly ($P \leq 0.05$) between the first and second groups, with significant ($P \leq 0.05$) variations being shown two and four weeks following the surgical operation. Regarding the remaining periods, no significant variation was noted (Table 4-13).

It was also noted that there was a significant difference ($P \leq 0.05$) in the first group before and after the operation, as it was noted that there was a significant difference ($P \leq 0.05$) before and at all times after the operation, with the exception between sixth and the eighth week after the operation in comparison with its level before the operation, as well as there was no significant variation between the second and fourth week after the operation (Table 4-13).

It was also noted that there was a significant difference ($P \leq 0.05$) in the second group of Hgb before and after the operation, a significant difference ($P \leq 0.05$) was observed at all times before and after the operation, except its level at eighth and sixth week after the operation when compared with before the operation. Likewise, there was no significant between the sixth and eighth week after the operation (Table 4-13).

Table 4-13: - The mean of Hgb measurement of the animals before and after surgical operation in two groups

Surgical operation	Hgb (g/dl)				
	Before surgical operation	Two weeks after surgical operation	Four weeks after surgical operation	Six weeks after surgical operation	Eight weeks after surgical operation
Group 1	13.0± 0.2 a, A	9.9± 0.4 a, B	9.2±0.2 a, B	12.9± 0.2 a, A	13.2±0.2 a, A
Group 2	13.7±0.4 a, A	11.4±0.1 b, B	10.1±0.1 b, C	13.2±0.1 a, A	13.9±0.4 a, A

$^{a, b}$ the different small letters refer to significant variation between the rows (P≤0.05).

$^{A\text{-}C}$ the different capital letters refer to a significant variation between the columns (P≤0.05).

4-5-4: Platelets (PLT)

The study's findings demonstrated that the first group's average PLT count was 180±2.7×10^3/µl before surgery, while the second group's level was 186.5±3.5×10^3/µl. Two weeks following the procedure, the first group's PLT count to increase and reached to 329±26.6×10^3/µl, and the second group's total reached to 303.3±4.4×10^3/µl. At four weeks the PLT counts continued to increase reached to 375.5±29×10^3/µl in the first group and 320.1±6×10^3/µl in the second group. PLT counts in the first group were 261.6±23.9×10^3/µl and in the second group 273.6±5.8×10^3/µl after six weeks (they started to return to pre-surgery levels). At eight weeks, the PLT counts in the first group was 235.8±16.5×10^3/µl and the second group was 212.1±4.2×10^3/µl, it was returned to their pre-surgery levels (Table 4-14).

The statistical analysis's findings demonstrated that there was a significant difference ($P \leq 0.05$) only at fourth week following the procedure between the PLT in both groups (Table 4-14).

It was also noted that there was a significant difference ($P \leq 0.05$) in the first group before and after the surgery, as it was noted that there was a significant difference ($P \leq 0.05$) in the average level of PLT at all times before and after the surgery except its level at eighth week when compared with its level at sixth week (Table 4-14).

In the second group the PLT level at second, fourth, and sixth weeks was higher significantly ($P \leq 0.05$) in comparison with its level at eighth week and before the operation, but there was no significant variation between these three times. Also, there was no significant variation between the level of PLT before the operation and at the eighth week post operation (Table 4-14).

Table 4-14: - The mean of PLT measurement of the animals before and after surgical operation in two groups

Surgical operation	PLT (10^3/µl)				
	Before surgical operation	Two weeks after surgical operation	Four weeks after surgical operation	Six weeks after surgical operation	Eight weeks after surgical operation
Group 1	180± 2.7 a, A	329± 26.6 a, B	375.5±29 a, C	261.6± 23.9 a, D	235.8±16.5 a, D
Group 2	186.5±3.5 a, A	303.3±4.4 a, B	320.1±6 b, B	273.6±5.8 a, B	212.1±4.2 a, A

[a, b] the different small letters refer to significant variation between the rows ($P \leq 0.05$).

[A-D] the different capital letters refer to a significant variation between the columns ($P \leq 0.05$).

Chapter five

Discussion

5-1: Clinical Findings

Clinical assessments performed on both groups after the second surgical day showed signs of inflammation at the incision site, including mild edema and redness as well as a small rise in body temperature, heart rate, and breathing rate. this observation agreed with (Al-Maseeh and Eesa, 2009; Eesa *et al*., 2012; Farman and Eesa, 2015).

These symptoms indicate the start of the inflammatory phase of the wound healing process, which is characterized by vascular changes that enlarge blood vessels and increase capillary permeability to the wound area. These changes are also accompanied by a cellular response manifested in the migration of monocytes and multinucleated white blood cells to the wound site. Visually, the operation site is swollen and red, which is similar to the results of other researchers (Spotnitz *et al*., 1997), who also noted the changes that take place in the wound.

These inflammatory symptoms began to disappear progressively on the fifth and seventh days following the operation. With the improvement of the animals' health, as indicated by temperature, respiratory rate, and heart rate during the first week of the surgical procedure, and their return to normal rates agreed with (Eesa *et al*., 2012). Following surgery, animals return to normal urination and defecation which is in agreement with the results of other researchers (Hamza, 2009). the animals in the second group were less active and mobile than the animals in the first group, while all of these animals returned to full activity and movement a tenth days after the surgical procedure Because we do three surgeries immediately on the animals in the second group, the surgical procedure itself is more complex.

5-2: Animals weights

During this experimental a major segment of the stomach including the fundus is excised and removed, this part of the stomach includes secretory cells which produce appetite hormones, through this experimental following the reduction in stomach volume and appetite hormones, weight loss occurs this agree with (Ghanbari *et al*., 2021).

Bariatric surgery has many benefits, including promoting weight loss and other comorbidities of obesity. In addition, bariatric surgery appears to be a more viable option for treating severe obesity compared with conventional therapy (Climent *et al*., 2017; Shoar and saber, 2017). The weight loss in sleeve gastrectomy before and after surgical operation is supported by many researches, including this study (Elder and Wolfe, 2005; Tucker *et al*., 2008) that weight loss not only from the restriction of oral intake but also because of significantly reduced ghrelin levels after resection of the gastric fundus which is the predominant area of ghrelin production (Langer *et al*., 2005; Cohen *et al*., 2005).

Also, weight loss in Roux-en-Y gastric bypass before and after surgical operation is supported by many researchers, including me (Bloomberg *et al*., 2005; Ponsky *et al*., 2005; Bernert *et al*., 2007; Love and Billett, 2008; Tarplin *et al*., 2015; Ghanbari *et al*., 2021) that weight loss by both food restriction and malabsorption, in these bypass surgeries, the duodenum and a piece of the small intestine are excluding from the digestive system, A tiny gastric pouch is made as part of the RYGB procedure, This pouch is joined to the area of the jejunum where food passes.

The weight loss in Roux-en-Y gastric bypass was better than the sleeve gastrectomy and this result was the opposite of what the researchers found (Zhao and Jiao, 2019; han *et al*., 2020) The above researchers proved that the two experiments have the same effect on weight loss.

5-3: Laparoscopic Examination

The results of the laparoscopic examination of the dogs of the first group showed that there was no leakage of contents into the abdominal cavity, and this is due to the use of sutures that lead to the edges turning inward, and this agree with the words of the researcher (Ralphs *et al*., 2003).

Regarding the second group, which used the opposite edges approach, there was a high rate of leakage. The aforementioned researchers discovered this. But in this experiment, the results were the opposite of what the aforementioned researchers discovered, and the reason for this is the surgeon's skill, as the surgeon's skill According to studies, it is one of the most important causes for the incidence of leaks following stomach and intestine surgery and this agrees with researchers (Tang *et al*., 2001).

Adhesions were found in both the sleeve and bypass groups, but they were found to be less severe in the sleeve group. This apparent variation in adhesion degree may have resulted from the type of suture technique employed, since the inverted suture technique produced much less severe adhesions than the apposition suture technique This agrees with the researchers (Kachiwal and Kalhoro, 2000; Kachiwal and Kalhoro, 2003).

They reported that when apposition sutures, such as simple interrupted sutures, simple continuous sutures, and modified Cambee sutures, are used, a tiny amount of inflammation happens because the epithelial layer protrudes, which causes adhesions to form This agrees with the researchers (Eggleston *et al*., 2004).

When using an inverted suture technique, such as lumbert, connell, or cushing, adhesions are restricted to keep the inner epithelial layer from penetrating the outside. This prevents the chance for bacterial propagation and, as a result, lessens the chance of adhesion formation at the anastomosis site this agrees with the researchers (Jardel *et al*., 2011).

5-4: Biochemical Analysis

5-4-1: Iron

The percentage of iron begins to decrease gradually after the surgical operation for both groups, and the decrease is greater in the second group, and this is what the researchers confirmed By (Ruz *et al*., 2012; Jauregui, 2013; kwon *et al*., 2014), In my opinion, the Roux-en-Y gastric bypass surgery was more invasive than the sleeve gastrectomy, which further contributes to the cause. Anemia and iron deficiency are common adverse effects following Roux-en-Y gastric bypass surgery because the blood loss from the procedure is more than that from sleeve gastrectomy, the researchers' findings confirm this theory (Salgado *et al*.,2014).

Changes in the gut anatomical structure have an effect on iron digestion and absorption, also decreased hydrochloric acid secretion impedes the conversion of ferric iron to absorbable ferrous iron this agrees with the researchers (Bernert *et al*., 2007; Steenackers *et al*.,2018), also the Roux-en-Y gastric bypass of the principal site of absorption in the duodenum and proximal jejunum may lead to the development of iron deficiency and anemia after surgery this agrees with the researchers (Bloomberg *et al*.,2005).

5-4-2: Vitamin D3

There is no difference in vitamin D3 deficiency between the two groups, and this was confirmed by the researchers (moore and sherman, 2014). However, there was a decrease in D3 over the course of the experiment in each group because the absorption of vitamin D3 in the jejunum and ileum there was confirmed by the researchers (Bloomberg *et al*., 2005; Tucker *et al*., 2007) this area of absorption will be affected after bariatric surgery this the main causes of vitamin D3 decreased. Also, vitamin D3 malabsorption occurs as a result of bypassing certain parts of the gut during bariatric surgery this agrees with the researchers (Bloomberg *et al*., 2005). Vitamin D deficiency has been linked to subsequent hypocalcemia following bariatric surgery This is what occurred during this experiment, which was supported by the researchers (Becker *et al*., 2012).

5-4-3: Vitamin B12

In both groups, there was a deficiency in vitamin B12, but not at all times, and this is the opposite of what the researchers found (Ghanbari *et al*., 2021). as they proved that there is no difference in the level of B12 between the two groups, the reason for this is that during the bariatric surgery, there is a loss of intrinsic factor producing parietal cell mass and this loss of internal factors is responsible for vitamin B12 deficiency this agrees with (Majumder *et al*., 2013). Over the course of the study, there was also an increasing incidence of vitamin B12 deficiency in each group, particularly in the Roux-en-Y gastric bypass this agree with (kwon *et al.*, 2014). the reason is due to insufficiency 0f food metabolism which lead to of vitamin B12 malabsorption and this agree with (Majumder *et al*., 2013).

5-4-4: Calcium

There was a decrease in calcium levels significantly throughout the experiment in both groups unless there is no significant different at ($p \leq 0.005$) of vitamin D3 and this agreed with many researchers (compher *et al*., 2008; Gemmel *et al*., 2009). Calcium malabsorption occurs as a result of bypassing certain parts of the gut during bariatric surgery this agrees with the researchers (Bloomberg *et al*., 2005). The decrease in calcium levels was greater in the bypass group that changed course, and this agrees with the researchers (Bernert *et al*., 2007). that said calcium deficits are explained by dietary intake and reduction in absorption which usually takes place in the duodenum and the proximal jejunum this agree with (Goode *et al*., 2004).

5-4-5: Electrolytes (Sodium, Potassium and Chlorides)

The variation in electrolyte levels between the two groups or within each group during the experiment was restricted to the normal ranges of (144 – 160 mmol/L) for sodium and (3.6 - 5.5 mmol/L) for potassium (102 – 120 mmol/L) for chlorine. Such variations did not affect the normal level of electrolytes has these proportions according to results from research (latimer, 2011). This is the opposite of what researchers found (wang *et al*., 2016) that there is a deficiency in electrolytes after gastric sleeve operations.

5-5: Complete Blood Picture

White blood cell count (WBC)(×10^3/µl): Prior to surgery, the animals' WBC count was within normal limits (6.8) in group one and (11.1) in group two, indicating their suitability for the procedure. Two weeks following the procedure, the WBC counts are excessively high (18.4) in group one and (17.4) in group two. Although elevated white blood cell counts don't necessarily signify a particular illness, they can be a sign of a problem, such as an infection, stress, inflammation, or trauma, given that the animals have just undergone surgery, where an elevated level of WBCs was expected. Fortunately, the white blood cell count returned to normal once these problems were resolved. For this reason, four, six, eight weeks following surgery, there was a minor decrease in the white blood cell count which simply indicates that the WBC count was returning to normal. this agree with (Estopa, 2019; Bilen, 2019; Rubio *et al*., 2022)

Red blood cell count (RBC)(×10^6/µl): Prior to surgery, the animals' RBC count was within normal limits (5.2) in group one and (5.5) in group two, but it fell below the normal level two weeks after the procedure, then the RBC return to normal level after four, six, eight weeks post-operatively this agree with (Estopa, 2019; Bilen, 2019; Rubio *et al*., 2022) It is evident that the surgical procedure's unavoidable bleeding or blood loss caused the RBC count to decrease this agree with (Estopa, 2019).

Hemoglobin (Hgb)(g/dl): Prior to surgery, the animals' Hgb was within normal limits (13) in group one and (13.7) in group two, but it fell below the normal level two four weeks after the procedure, then the Hg return to normal level after six, eight weeks post-operatively this agree with (Estopa, 2019; Bilen, 2019; Rubio *et al*., 2022). It is evident that the surgical procedure's unavoidable bleeding or blood loss caused the RBC count to decrease this lead to decrease in Hgb level this agree with (Estopa, 2019).

Platelets (PLT)(×10^3/µl): Prior to surgery, the animals' PLT was within normal limits (180) in group one and (186) in group two, but it increased after two, four weeks post-operatively but is still within normal range this agree with (Estopa, 2019; Bilen, 2019; Rubio *et al*., 2022). The animals are having a large cut and the operation very invasive due to hemorrhage so a high or elevated platelet count was expected this agree with (Estopa, 2019; Rubio *et al*., 2022).

Chapter six

Conclusion and Recommendation

6-1: Conclusion

1- Roux-en-Y gastric bypass procedure has more complications than sleeve gastrectomy.
2- Roux-en-Y gastric bypass procedure is better than sleeve gastrectomy in terms of weight reduction.
3- Roux-en-Y gastric bypass procedure leads to iron and vitamin B12 deficiency more than sleeve gastrectomy.
4- In both techniques, there are no significant changes in the level of the electrolyte and vitamin D3.

6-2: Recommendation

1- Use the sleeve gastrectomy procedure to reduce weight in animals suffering from obesity because it has fewer complications.
2- Use the Roux-en-Y bypass procedure to reduce weight in animals suffering from severe obesity, provided the surgeon is extremely trained and qualified to undertake the procedure, even with its associated risks.
3- We recommend using the same study, but for longer periods of up to 6 months.
4- Comparative study between gastric sleeve and invagination to reduce weight loss.

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الخلاصة

هدفت الدراسة الحالية للمقارنة بين عملية المجازة المعدية وعملية التكميم في الكلاب وذلك لمعرفة ايهما أفضل من ناحية السيطرة على الوزن المفرط لدى الكلاب وايهما ذات مضاعفات جانبية اقل. اجريت الدراسة على ١٢ كلبا محليا من الذكور فقط كانت سليمة سريريا تراوحت اعمارها ما بين ٢٠ شهر الى ٣٨ شهر بمعدل (٢٩ ± ١,٥) شهرا وتراوحت اوزانهم ما بين ٣٣ - ٣٩ كغم بمعدل (٢٧ ± ١,٣) كغم. قسمت الحيوانات عشوائيا الى مجموعتين اذ ضمت كل مجموعة ٦ كلاب اجريت عليها عملية تكميم المعدة على المجموعة الاولى اما المجموعة الثانية اجريت عليها عملية المجازة المعدية. تم تقيم النتائج اعتمادا على المعاير التالية منها العلامات السريرية من خلال متابعة ومشاهدة الحيوانات بعد العملية للكشف عن اي تغيرات او ظهور علامات غير طبيعية مثل خمول الحيوانات او وجود التهابات في مكان العملية كذلك قياس درجة الحرارة ومعدل التنفس وضربات القلب كذلك مراقبة التبول والتغوط لدى الحيوانات. كذلك مراقبة اوزان الحيوانات بعد العملية الجراحية كل اسبوعين ولمدة ثمانية أسابيع. يتم ايضا فحص جميع الحيوانات بالجراحة المنظارية بعد أسبوعين وثمانية أسابيع من العملية الجراحية لمعرفة شدة الالتصاقات الحاصلة في مكان العملية وللتأكد من عدم وجود اي تسرب لمحتويات المعدة والامعاء الى داخل التجويف البطني. كذلك نقوم بأخذ عينة من الدم لجميع الحيوانات قبل العملية الجراحية وبعدها بأسبوعين وأربعة وستة وثمانية اسابيع لقياس مستوى الحديد وفيتامين دي ٣ وفيتامين بي ١٢ والكالسيوم وكذلك الصوديوم والبوتاسيوم والكلور. كذلك عمل فحوصات عامة للدم لمعرفة نسبة كريات الدم البيضاء وكريات الدم الحمراء والهيموغلوبين والصفائح الدموية قبل العملية وبعدها باثنين واربعة وستة وثمانية أسابيع. اظهرت نتائج الفحص السريري للمجموعتين عن وجود التهاب في مكان العملية بعد اليوم الثاني من العملية الجراحية والذي اشير اليه من خلال الاحمرار الطفيف والوذمة في مكان العملية بالإضافة الى ارتفاع طفيف في درجة حرارة الجسم ومعدل التنفس وضربات القلب وتبدأ هذه الاعراض بالاختفاء تدريجيا في اليومين الثالث والرابع بعد العملية الجراحية. اما معدل التنفس وضربات القلب تصبح طبيعية بعد الاسبوع الاول من العملية وانعكست الصورة السريرية من خلال نشاط الحيوانات ونباحها بعد العملية وكذلك التغوط والتبول وغيرها من العلامات المرئية والتي كانت متماثلة تقريبا في كلا المجموعتين الا ان حيوانات المجموعة الثانية كانت اقل نشاطا من حيوانات المجموعة الأولى. اما بالنسبة لنتائج الفحص بالناظور كانت متماثلة بعدم وجود تسريب لمحتويات المعدة والامعاء داخل التجويف البطني ولكن لوحظ وجود التصاقات في مكان العملية

مع الثرب او مع الاعضاء القريبة من مكان العملية او مع جزء اخر من الأمعاء وكانت هذه الالتصاقات اقل في المجموعة الاولى عما كانت عليه في المجموعة الثانية. اظهرت نتائج مراقبة اوزان الحيوانات بعد اثنين واربعة وستة وثمانية اسابيع عن وجود انخفاض في اوزان الحيوانات في كلا المجموعتين ولكن كان الانخفاض في حيوانات المجموعة الثانية أفضل عند مقارنتها مع حيوانات المجموعة الأولى. اظهرت نتائج فحص الحديد عن انخفاض مستواه في المجموعة الثانية كان أكثر من انخفاضه في المجموعة الاولى. اما فحص فيتامين دي ٣ فلم يلاحظ عليه اي اختلاف بين المجموعتين. اما فيتامين بي ١٢ كان منخفضا في المجموعة الثانية عما هو عليه في المجموعة الاولى ولكن في الاسبوع الثاني والثامن بعد العملية. اما الكالسيوم كان أكثر انخفاضا في المجموعة الثانية عما هو عليه في المجموعة الاولى وفي جميع الاوقات. ولكن الصوديوم كان انخفاضه بسيط جدا في المجموعة الاولى عما هو عليه في المجموعة الثانية. ولكن البوتاسيوم كان متعادلا في كلا المجموعتين. اما الكلور فكان منخفضا في المجموعة الاولى وخصوصا في الاسبوع الرابع والسادس والثامن بعد العملية عما هو عليه في المجموعة الثانية. اظهرت نتائج الفحص الدموي ان مستوى كريات الدم البيضاء يزداد في كلا المجموعتين ولكن كان أكثر زيادة في المجموعة الثانية عما هو عيه في المجموعة الاولى. اما بالنسبة لكريات الدم الحمراء والهيموغلوبين فلوحظ انخفاض واضح وفي كلا المجموعتين وخصوصا في الاسابيع الاولى بعد العملية ورجوعه الى المستوى الذي كان عليه قبل العملية في الاسبوع السادس والثامن بعد العملية. اما بالنسبة للصفائح الدموية فلوحظ زيادة واضحة بعد العملية وفي كلا المجموعتين وبالأخص في الاسبوع الثاني والرابع بعد العملية وعودتها الى المستوى الذي كانت عليه قبل العملية وذلك في الاسبوع السادس الثامن بعد العملية. نستنتج من هذه الدراسة ان عملية التكميم كانت أفضل من عملية تحويل المسار في هذه التجربة.

تأثير تكميم المعدة وتحويل المسار على فقدان الوزن في الكلاب: دراسة مقارنة

أطروحة تقدم بها

احمد سعد محمد علي القاضي

إلى

مجلس كلية الطب البيطري في جامعة الموصل

وهي جزء من متطلبات نيل شهادة الدكتوراه فلسفة

في اختصاص الطب البيطري / الجراحة البيطرية

بإشراف

الاستاذ الدكتور

منير سالم طه البدراني

١٤٤٦هـ ٢٠٢٤م

جامعة الموصل
كلية الطب البيطري

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