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Comparison of absorbable barbed suture devices versus polyglactin 910 sutures in double-layer gastrotomy closure in A canine model

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Abstract

Objectives: To evaluate the safety and efficacy of a commercially available absorbable barbed suture device in double-layer gastrotomy closure in a dog model.

Methods: In this experimental comparative study a gastrostomy was performed in 12 adult healthy mongrel dogs (divided into two groups A and B). The stomach was closed using polyglactin 910 (Vicryle, Ethicon) suture in group A and using absorbable barbed suture (Stratafex, Ethicon) in group B.

Results: Polyglactin 910 suture produced a more inflammatory reaction around the wound which caused a delay in gastric wound healing and gastric motility as well as gastric emptying time. The ultrasonographic examination revealed a significant increase in gastric wall thickness in group A compared to group B and a highly significant decrease of gastric contraction in group A in comparison to group B. Gastric closure time was significantly shorter in group B than in group A. No postoperative complications or deaths were observed in both groups.

Conclusion: Absorbable barbed suture was recommended in gastric surgery as it is minimizing the time of gastric closure and optimizing the healing of the wound with faster returning of the stomach to its normal function.

Keywords: Barbed suture; Gastrotomy; Dog; Polyglactin suture.

1. Introduction

Suturing with knot-type sutures is increasingly more challenging (Thanakumar and John, 2011). Barbed sutures were first discovered in the United States in 1964 (Alcamo, 1964). They were developed to allow safe and efficient knotless suturing during minimally invasive surgery (Moran et al., 2007; Villa et al., 2008; Demyttenaere et al., 2009). Recently, knotless barbed self-anchoring sutures have become presented to the surgical field replacing the ordinary suture materials at which knots are necessitated (Villa et al., 2008; Matarasso and Pfeifer, 2008; Rosen, 2010). The primary gain of barbed sutures is the existence of barbs to anchor the suture to tissues in a knotless fashion, avoiding the need to tie a knot in a confined space (Manigrasso et al., 2019). In minimally invasive surgeries, the supposed advantages of knotless barbed sutures over traditional sutures are short operative time, maximum apposition, less wound dehiscence as the tension is uniformly distributed along the length of the wound, improved wound healing due to decrease of ischemia, and less suture extrusion (Murtha et al., 2006; Matarasso and Pfeifer, 2008; Villa et al., 2008; Paul, 2009; Rosen, 2010; Ruff, 2013). These suture devices are designed with an end loop permitting the suture needle to be passed through the loop after the first tissue bite. This precludes the need for a knot at the beginning of the suture line (Ehrhart et al., 2013). The suture material passes in one direction through the tissue due to the barbs and prevents backward slippage. Also, no end knot is required if the suture line is continued 1–3 three bites beyond the termination of the incision. Barbed suture devices have been evaluated in various kinds of surgery; (Greenberg and Goldman, 2013; Manoucheri and Einarsson, 2013; Einarsson et al., 2011; Shah et al., 2012; de Blacam et al., 2012; Warner and Gutowski, 2009) Nevertheless, less is known about general surgery (Manigrasso et al., 2019). A knotless barbed suture device has been proposed to make the internal sutures easier, but there are only a few studies in the literature that propose its use for intestinal anastomosis (Lee et al., 2011; Facy et al., 2013; Tyner, et.al, 2013).

The safety and efficacy of barbed sutures have been shown in many surgical fields, (Warner and Gutowski, 2009; Einarsson et al., 2011; de Blacam et al., 2012; Shah et al., 2012; Greenberg and Goldman, 2013; Manoucheri and Einarsson, 2013), but less is known in digestive surgery (Milone et al., 2013; Lin et al., 2019; Pennestrì et al., 2019), especially intestinal (Feroci et al., 2018; Bracale et al., 2018) and gastric surgery (Bautista et al., 2016; Lee et al., 2016; Lee et al., 2019).

Peritonitis secondary to intraoperative contamination, incisional dehiscence, and tissue necrosis are the most severe complications but are rare if proper surgical techniques are used. Because of the stomach's rich blood supply and collateral circulation, dehiscence is rarely a problem, particularly if two-layer closures are used (Fossum, 2002). This study aimed to evaluate the safety and efficacy of the barbed device versus conventional polyglactin 910 sutures in double-layer gastrostomy closure.

2. Materials and methods

2.1. Animals

This study was performed at the Surgery, Anesthesiology, and Radiology Department, Faculty of Veterinary Medicine, Kafrelsheikh University. Twelve dogs, weighing 15-20 kg were used. All experimental procedures and protocols involved both animal welfare and surgical techniques of this study were reviewed and approved by the research ethics committee of the Faculty of Veterinary Medicine, Kafrelsheikh University. Dogs were divided into 2 groups (n = 6 each); The stomach was closed using polyglactin 910 suture in group A and using absorbable barbed suture in group B.

2.2. Anesthetic protocol

The cephalic vein was cannulated for the intravenous (IV) administration of fluids and drugs. All dogs were initially premedicated with IV administration of 1mg/kg xylazine HCl (Xylaject 2%, ADWIA, Egypt), and after 10 minutes general anesthesia was obtained by IV injection of a10mg/kg ketamine HCl (Ketamax-50, Troikaa Pharmaceuticals Ltd., India).

2.3. Surgical procedure

The surgeries were performed in dorsal recumbency. After routine surgical preparation and draping, a ventral midline laparotomy incision was performed, and the stomach was exposed and elevated with full-thickness stay sutures at either end of the proposed incision site [midway between the lesser and greater curvatures (Fossum, 2002)] to improve visualization of the surgery site and reduce gastric content spillage. A moistened laparotomy pad was placed around the stomach to limit peritoneal contamination. A seven cm long incision was made on the ventral surface of the stomach spaced halfway between the lower esophageal sphincter and pylorus. All liquid gastric contents were suctioned to decrease contamination risk. The gastric incision is usually closed in two layers. The first suture layer should appose mucosa and submucosa with a continuous running suture pattern, the second suture layer includes serosa, muscularis, and submucosa in an inverting Cushing suture pattern. The size of suture materials used in both groups was 2/0. Tissue bites were placed 2–3 mm from the incision edge with an inter-bite spacing of 2 mm.

The time to complete each gastrotomy closure was recorded. At the end of the procedure each gastrotomy was assessed for a satisfactory outcome (even spacing of suture bites and no leakage of intestinal contents using manual pressure) and the site was lavaged with warm sterile saline (0.9% NaCl) solution. The celiotomy was closed routinely in 3 layers. Each animal received a single I.M injection of 500 mg of Ceftriaxone (Mesporine, Sigma, Egypt) and a single I.V injection 1 mg/kg of Flunixin meglumine (Flunix, Bayer) daily for 3 successive days to prevent infection and decrease inflammation.

2.4. Aftercare and follow-up

Dogs were observed until fully conscious and able to ambulate freely. Limited access to freshwater was allowed 6–12 hours after surgery. Small amounts of solid food were offered 12 hours after surgery at 6-hour intervals and increased gradually to normal ration amounts over the next 24– 36 hours. abdominal ultrasonography was performed for each dog in the study on the 21st day after surgery.

2.4.1. Clinical evaluation

The dogs were clinically evaluated before surgery and daily after surgery. Fever, vomiting, anorexia, lethargy, diarrhea, wound-healing complications, or episodes of gastric dilatation were recorded.

2.4.2. Ultrasound examination

Ultrasonographic examinations were performed in all dogs using an ultrasonographic system (Vinno 5, China) with a curved array transducer (6-8 MHz). All abdominal ultrasonographic examinations were performed by the same veterinarian. Ultrasonographic examinations were performed on the 21st day post-operation. Each dog was positioned in dorsal recumbency. Hair was clipped on the ventral portion of the abdomen, and an acoustic coupling gel was applied. The stomach was examined and imaged in longitudinal and transverse sections. The gastric adhesion between the site of gastric surgery and the abdominal wall was considered present if there was a unit motion between the stomach and body wall at the site of the gastric wound. The gastric adhesion was not considered to present if there was a sliding motion between the body wall and the stomach as the dog breathed, as previously described (Rawlings, 2002). Any evidence of a suture reaction, focal peritonitis, or generalized peritonitis was noted in the ultrasound report. Measurements of gastric wall thickness from serosa to mucosa were obtained from transverse images in fasting and feeding conditions using electronic calipers in an ultrasonographic system. Transverse images were obtained by placing the transducer in a transverse plane of the cranial abdomen parallel to the right costal arch. The average number of peristaltic contractions and degree of gastric filling were also evaluated. The number of gastric contractions per minute was counted after 30 minutes of water drinking.

2.4.3. Gastric emptying time

Using positive contrast radiography, 10 ml of 70% barium sulfate (The Egyptian Company for Zinc & Its Products - Zinc Misr) solution /1kg body weight were orally administered to each dog. A radiograph was taken every 30 min until complete emptying of the stomach. Gastric emptying time was evaluated 5 times (before surgery and weekly after surgery).

2.5. Specimen collection

Dogs were euthanatized on day 30 after surgery using IV injection of a high dose (150mg /kg) of thiopental sodium (Thiopental sodium 500 mg, Epico, Egypt). Immediately after euthanasia, the abdominal cavity was examined. Each gastrotomy site was inspected for adhesions and the presence/ absence of visible leakage at closure sites. Gastrotomy sites were then isolated in 10% neutral buffered formalin for further evaluation.

2.6. Statistical Analysis

The data were statistically analyzed using IBM SPSS statistical software for windows, version 25.0, Armonk, NY: IBM Crop. The data were normally distributed and were represented as mean±

stander deviation (SD). The comparison between the two groups of dogs in gastric wall thickness and gastric contractions after 30 minutes of drinking was done using an independent sample T-test at a significant of $p \leq 0.05$.

3. Results

3.1 Surgery

Gastric closure time with barbed sutures (8.4 ± 0.6 min) was significantly faster than with polyglactin 910 (10.75 ± 0.8 min) ($P < 0.05$). No intraoperative complications were reported during surgeries.

3.2. Clinical evaluation

The animals' weights were recorded before surgery (Day 0) and after surgery (Days 7, 14, and 21) and no significant differences ($p > 0.05$) were detected between the two groups. No wound-healing complications, fever, vomiting, anorexia, lethargy, nor diarrhea were noted in either group except one dog in group A showed inappetence manifested by decreased food intake in the first 3 postoperative days. All dogs appeared physically healthy. All dogs survived without any deaths. No dogs had clinical or necropsy evidence of leakage from any gastrotomy site during the study.

3.3. Ultrasound examination

A sliding motion was present at the gastric sutures site as the dog breathed. There was no evidence of focal or generalized peritonitis. The dogs in group A had a moderate thickening of the gastric wall at the site of gastric surgery more than dogs in group B (Figs. 1,2). Mean gastric wall thickness in group A was (0.37 ± 0.04 cm) in comparison to group B that was (0.31 ± 0.06 cm). Statistically, there was a significant difference between the two groups of gastric wall thickness ($p = 0.03$), (Fig. 3). In addition, the mean value of gastric wall contractions after 30 minutes of water drinking in group A was (4.0 ± 0.4 contractions/min) and in group B was (5.0 ± 0.62 contractions/min) and statistically, there is a highly significant difference between the two groups in gastric contraction at ($p = 0.008$), (Fig. 4).

3.4. Radiographic examination

Time of stomach emptying was performed weekly after surgery using contrast radiography showing no significant difference between the two groups (Figs. 5,6).

3.5. Necropsy

No adhesions at all between the stomach and other organs, omentum, or body wall in both groups.

3.6. Histopathology

Histopathological view of gastric wound healing in Group A (using Polyglactin 910/Vicryle) showed clear inflammatory signs during the healing process represented in dilated blood vessels engorged with blood cells, severe inflammatory cells infiltration, but with normal gastric glands. Group B (using Barbed suture/Stratafix) showed a complete healing process with complete regeneration represented in normal gastric mucosa, normal gastric glands, and normal blood vessels. In conclusion, both sutures showed regenerative ability. However, the barbed suture revealed a marked decrease of inflammation between the regenerated mucosa. Also, the regeneration ability showed marked enhancement (Fig. 7).

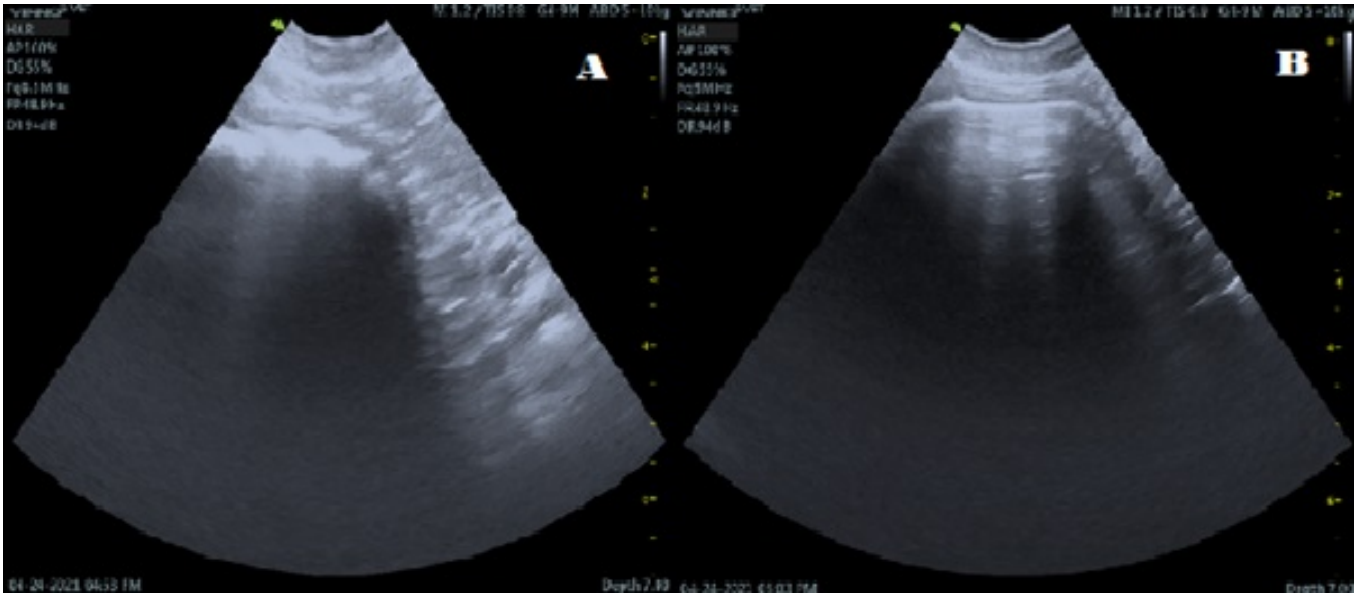

Fig. 1. Ultrasonographic images of the stomach after feeding in group A and group B. Image A, is showing an increase in gastric wall thickness with corrugations especially in gastric mucosa with loss of gastric wall layers demarcation.

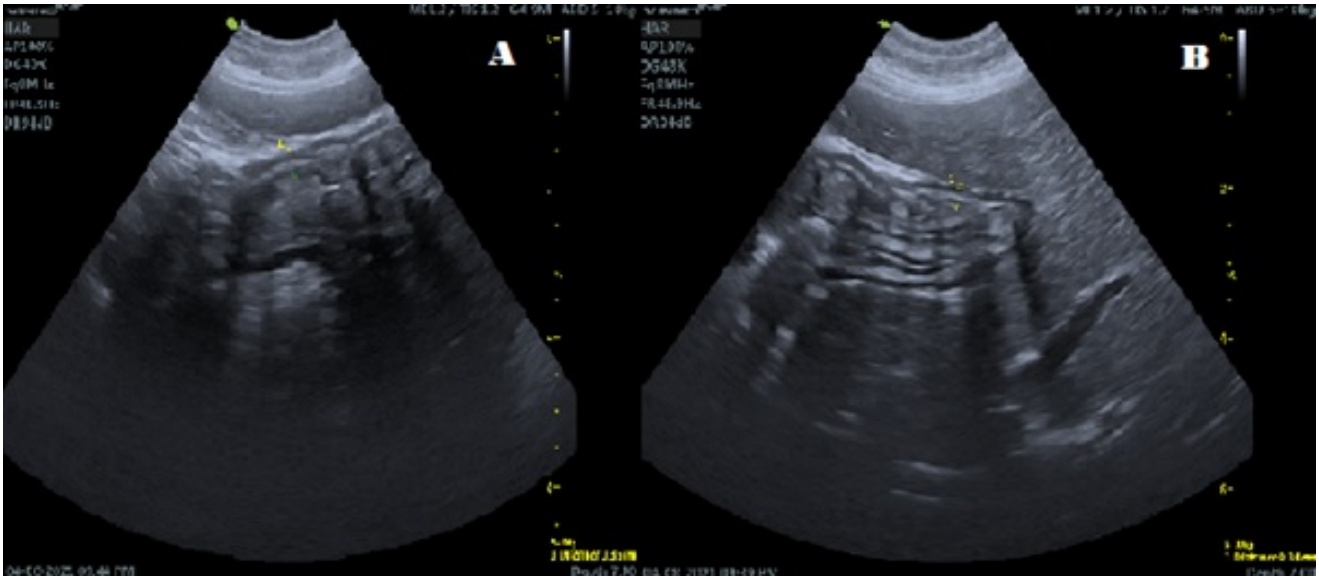

Fig. 2. Ultrasonographic images of the gastric wall in two groups of fasting dogs' group A and group B showing the method of measuring of gastric wall thickness using an electric caliper in an ultrasonographic system. A showed a slight increase in gastric wall thickness (0.35cm) while B showed that gastric wall thickness is 0.24cm.

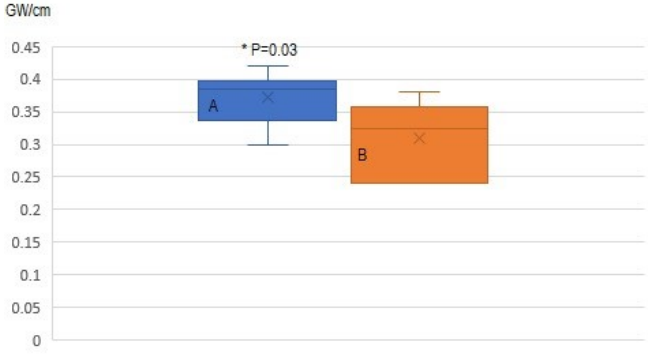

Fig. 3. Comparison in gastric wall (GW) thickness between dogs in group A using polyglactin 910 Sutures and dogs in group B using barbed suture, showing a significant increase (p = 0.03) in gastric wall thickness in group A than in group B.

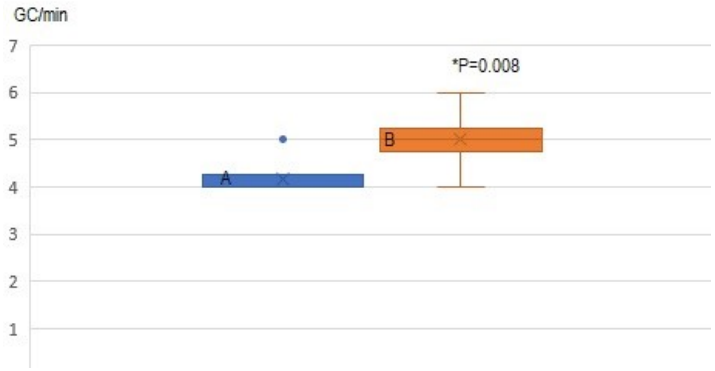

Fig. 4. Comparison in gastric contraction (GC)/min between dogs in group A using polyglactin 910 Sutures and dogs in group B using barbed suture, showing a significant increase (p = 0.008) in the gastric contraction/min in group B than in group A.

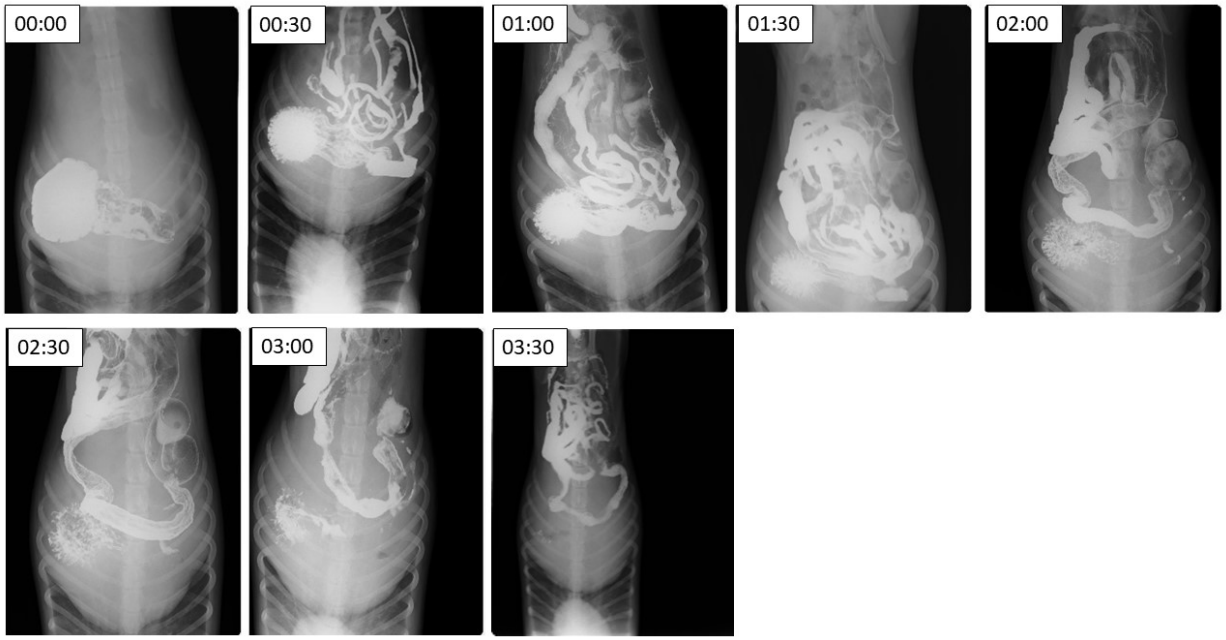

Fig. 5. Gastric emptying time in group A at 30th day after surgery using positive contrast radiography. The total time of gastric emptying was 4 hours.

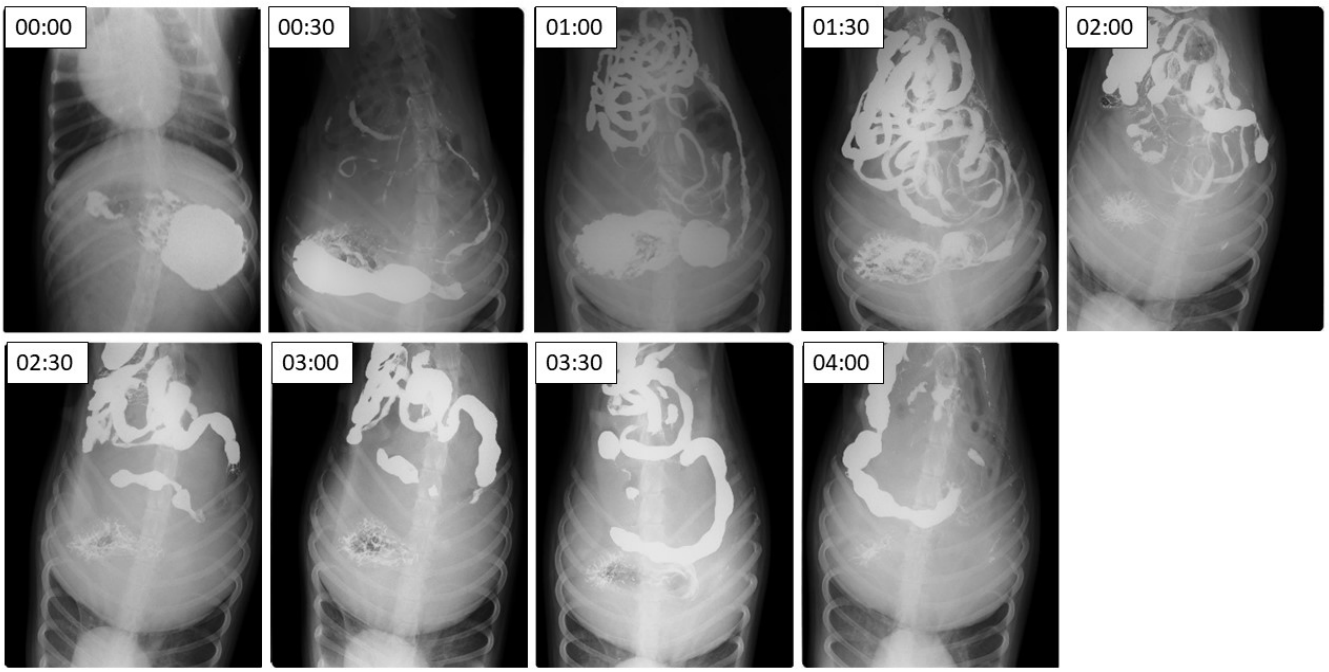

Fig. 6. Gastric emptying time in group B 30th day after surgery using a positive contrast radiography. The total time of gastric emptying was 3.5 hours.

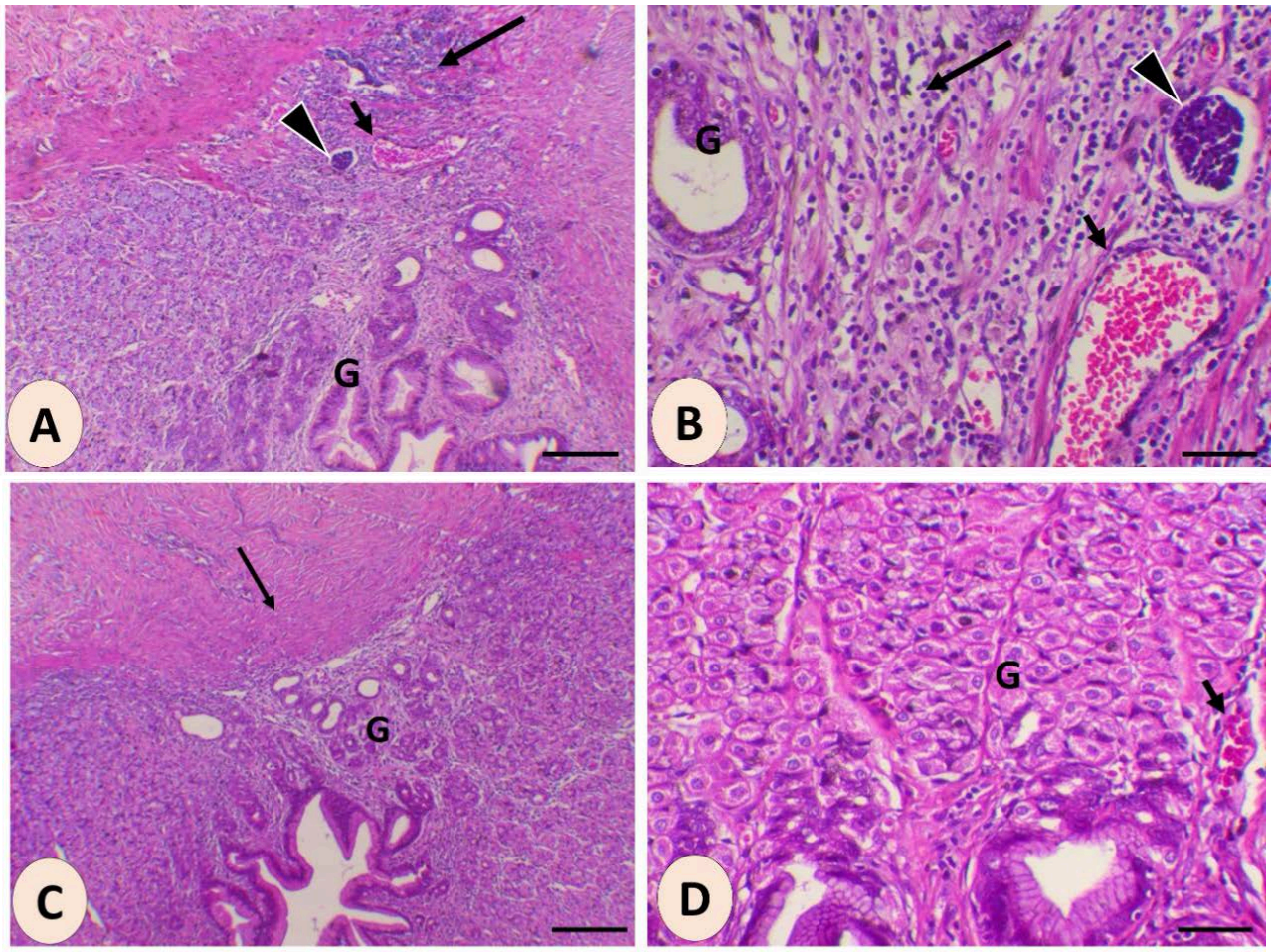

Fig. 7: Histopathological view of gastric wound healing in dog. Group A (using Polyglactin 910/Vicryle) showed dilated blood vessels engorged with blood cells (short arrow), sever inflammatory cells infiltration (long arrow), remnants of suturing material (arrowhead) however, and normal gastric glands (G). Group B (using Barbed suture/Stratafix) showed normal gastric mucosa (long arrow), normal gastric glands (G) and normal blood vessels (short arrow). Stain H&E. Bar= 200 µm (A, C) and 100 µm (B, D).

4. Discussion

The gastric incision is usually closed in two layers (Fossum, 2002). The first suture layer should appose mucosa with a continuous running suture pattern to prevent postoperative hemorrhage, the second suture layer includes serosa, muscularis, and submucosa in an inverting Cushing suture pattern (Fossum, 2002). The postoperative results in this study showed no complications (no leakage, no adhesions, no deaths), and this verifies that two-layer gastric closure is very suitable (Fossum, 2002).

Short operative time is the main advantage of using barbed sutures in minimally invasive surgeries (Ruff, 2013). In this study barbed suture showed a non-significant advantage over the polyglactin 910 in operative time. Maximum apposition is the main advantage of using barbed sutures in plastic surgeries (Rosen, 2013). The histopathology of the current study showed an advantage of using barbed sutures in regeneration ability of gastric wall and marked decrease of inflammation between the regenerated mucosa than using polyglactin 910.

Ultrasonography is a non-invasive, well-tolerated method widely used for the assessment of gastric wall thickness and gastric motility in dogs (Beck et al., 2001). In the present study, ultrasonographic images of the gastric wall showed a significant increase in gastric wall thickness in group A than in group B. This was confirmed by histopathological examination and was attributed to the edema and inflammation post-surgery. The surgical knots in polyglactin 910 Sutures in group A represents the highest amount and density of foreign body material in any given suture line. The volume of a knot is directly related to the total amount of surrounding inflammatory reaction (Molokova et al., 2007). This explaining the inflammatory reaction of polyglactin 910 Sutures in group A. In addition, minimizing the inflammatory reaction in a wound is very important for optimized wound healing as in barbed suture causes a more uniform distribution of wound tension across the suture line than with conventional smooth suture that yields more consistent wound opposition (Greenberg, 2010).

Furthermore, inflammatory reactions in the gut are usually accompanied by alteration of gut motility associated with alteration in the function of enteric nerves or smooth muscle (Akiho et al., 2011). This was evidenced by a significant delay in gastric contraction in group A than in group B. The gastric emptying time was within the normal range of 4.7 ± 0.67 hours (Miyabayashi and Morgan, 1984) in both groups with a non-significant advantage to group B.

Conclusion

In conclusion, the barbed suture is recommended in invasive double-layer gastrostomy closure due to the short operative time, less inflammatory reaction, and maximum tissue regeneration.

Conflict of interest

The authors declare that they have no conflict of interest.

Research Ethics Committee Permission

This study was approved by the local Ethics and guides of the Faculty of Veterinary Medicine, Kafrelsheikh University, Egypt.

Authors' contribution

A Ghazy designed and conducted the study. N Gomaa performed the ultrasound study. Both authors collected and analyzed the data. A Ghazy drafted the manuscript. The final version of the manuscript was revised and approved by A Ghazy and N Gomaa.

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