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Laparoscopic Partial Splenectomy in Dogs

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Abstract: Laparoscopic partial splenectomy was performed in18 local breed dogs of both sexes divided into 3 groups (A-C) of 6 dogs in each. In group A, the dogs underwent laparoscopic partial splenectomy with adrenaline injection in the parenchyma of the spleen and titanium clips application on the stump in group B, partial splenectomy performed with a new laparoscopic thermocautery device, while group C, the same procedure as in group A, except the application of intracorporeal suturing on the stump instead of titanium clips. All the operations were performed under general anesthesia using Ketamine- xylazine combination. Three ports were induced on the abdominal wall, one for the telescope insertion, while the remaining 2 ports for insertion of the laparoscopic instruments. The gross and histopathological changes was studied in the 3 groups at 15 and 30 postoperative days. Titanium clips in group A, highly efficient in controlling the bleeding from the stump in addition of adrenaline injection, the time needed for this technique was (30±4.6 min). An excellent result was achieved by the new thermocautery device in group B, the device produced coagulation and partial cutting of the spleen without the need of blood vessel ligation or adrenaline injection, no bleeding was observed from the stump so, it does not need the application of clips or suturing, thermocautery technique consume less time than group A and C (22.5±4.6 min). In group C, the operation consumed the longest time when compared with group A and B (74±4.7 min), that most of the time was needed for the intracorporeal suturing of the stump. The only gross pathological change observed in the 3 groups that of omental adhesion with the stump. The histopathology revealed space formation at the site of clips application in group A and the formation of large necrotic area in group B due burning of tissue produced by the thermocautery, while in group C, presence of large nodules of fibrosis surrounded the suture material.

Key words: Laparoscopy, splenectomy, titanium clips, thermocautery, suture, dogs

INTRODUCTION

The major complication of splenic surgery is hemorrhage. This is more of a problem with splenic biopsy or partial splenectomy than with total splenectomy, providing proper technique is used for vessel ligation (Fossum, 2007). Spleen salvage techniques, which includes partial splenectomy was used instead of total splenectomy to preserve splenic function (Uranues *et al*., 2007). It was reported that splenic function could be kept when at least 25% of splenic tissue was saved (Malagoni *et al*., 1985; Traub *et al*., 1987). In partial splenectomy the major problem facing this operation is the bleeding control (Habib *et al*., 2003), so many techniques were developed to minimize such bleeding as much as possible like the use of radiofrequency energy (bloodless method) for cutting of splenic tissue (Habib *et al*., 2003; Itamoto *et al*., 2006), or the use of ultrasonically activated scalpel (Royals *et al*., 2005). Advances in laparoscopy have enabled minimally invasive surgical treatment of splenic diseases and although, laparoscopic total splenectomy represents an established surgical procedure, there are few reports on spleen preserving surgical techniques (Breitenstein *et al*., 2007). Recently, a new laparoscopic thermocautery was designed and manufactured by Aziz *et al*. (2008), they used it successfully for laparoscopic ovariectomy in donkeys. The aim of this study was to evaluate the laparoscopic partial splenectomy in dogs to evaluate the newly designed thermocautery instrument for such operation, as well as the using of titanium clips on the splenic stump and compare it with the intracorporeal suturing using absorbable suture for controlling of bleeding that accompanied partial splenectomy.

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MATERIALS AND METHODS

The study was conducted on 18 local breed dogs of both sexes, aged between 8 months to 2 years, while their weights ranged between 15-25 kg. They divided randomly into 3 groups of 6 dogs in each as follows:

Group A: In which laparoscopic partial splenectomy performed with laparoscopic scissors after injection of adrenaline and application of 6 titanium clips size (med-large 10) on the stump.

Group B: In this group, the animals underwent partial laparoscopic splenectomy with the using of the thermocautery device and without adrenaline injection or blood vessels ligation and the stump left without closing.

Group C: The partial laparoscopic splenectomy was performed as in group A, but the stump was closed with 2:0 vicryl suture using intracorporeal simple continuous technique.

Anesthesia: All the operations were performed under general anesthesia using a combination of Xylazine (CEVA France) 5 mg kg^{-1} and Ketamine (Yuhan Korea) 15 mg kg^{-1} given by intramuscular route in the thigh muscle.

Surgical procedures: A laparoscopic system (Karl Storz, Germany) was used in this study. The ventral aspect of the abdomen was prepared for aseptic surgery and the animal was fixed on the surgical table in a dorsal recumbency position. A veress needle was inserted in the abdominal cavity at the site of umbilicus to establish pneumoperitoneum with CO_2 gas (Fig. 1). The key parameter of the insufflator was fixed at 12 mmHg intra abdominal pressure and a flow rate of 5 L min^{-1}. The insufflator was turned on or off automatically to maintain the demanded intra abdominal pressure during the operation. After the abdomen was distended enough, the Veress needle was withdrawn, the trocar-cannula size 10 mm was inserted into the abdominal cavity at the same site of Veress needle, through which the telescope was introduced to image the abdominal cavity on the monitor (Fig. 2). Another, 2 ports were selected near the umbilicus for introducing the laparoscopic instruments.

Group A: One mL of 1:10,000 adrenaline was injected in the parenchyma of the spleen by transabdominal approach (Fig. 3), the vessels which supplying the part to be resected was occluded with titanium clips dorsally and ventrally and the vessel was severed in between (Fig. 4)

Fig. 1: Insertion of Veress needle at the site of umbilicus to establish pneumoperitoneum

Fig. 2: Insertion of trocar-cannula No. 10 at the same site of Veress needle to introduce the telescope

Fig. 3: Transabdominal injection of adrenaline into the parenchyma of spleen

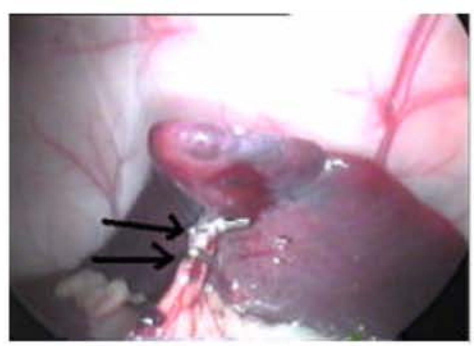

Fig. 4: Closing of blood vessels supplying the part to be resected with titanium clips (arrows)

and then the partial splenectomy was performed with the laparoscopic scissors. The resected piece was withdrawn through one of the ports at the abdominal wall, after that a 6 titanium clips were applied by using of the clip applier on the stump to control hemorrhage (Fig. 5).

Group B: In this group, partial laparoscopic splenectomy was performed with the aid of the thermocautery device without ligation of the blood vessels and also without injection of adrenaline.

The part to be resected with its attachments and blood supply were encircled with the loop of the thermal wire (Fig. 6). For coagulation of the blood vessels and the mesenteric attachment, numerous pulsation for about 5 sec were given until the tissue at the site of thermal wire became, white indicating adequate coagulation. Then the power was given continuously for about 1 min to resects part of the spleen. The stump was left without clips application or suturing and was observed closely and carefully for any possible bleeding (Fig. 7).

Group C: The same surgical procedure as in group A was done here, except the stump was closed with 2:0 vicryl suture by simple continuous intracorporeal technique to control hemorrhage (Fig. 8).

In all 3 groups, about 20% of the splenic tissue was resected and the incisions of the ports were closed with No. 1 silk, one stitch of horizontal mattress for each port. All the animals were received penicillin-streptomycin injection (Combi- Kel 20 + 20, Kela Laboratoria, Belgium) for 5 postoperative days.

Gross pathological changes and biopsy collection: By conventional laparotomy, the gross pathological changes and biopsy collection from the stump were performed in 3 animals of each group at 15 postoperative day, while the remaining 3 animals of each group were studied at the 30 postoperative day.

Fig. 5: Application of titanium clips on the stump with clip applier

Fig. 6: Encircling a piece of spleen to be resected with the wire of the newly designed laparoscopic thermocautery

Fig. 7: The resultant stump of thermocautery device, note the regular cut of the stump without any hemorrhage

Fig. 8: Intracorporeal suturing of the stump

RESULTS

Laparoscopic partial splenectomy was performed successfully in all the experimental dogs without any obvious complications. In group A, the surgical technique is safe and fast, the time required (30±4.6 min) and the application of 6 titanium clips on the stump was found to be a very fast and high efficient technique to close the stump and in turn the control of hemorrhage, as well as the injection of adrenaline play an important role in shrinkage of the spleen and reducing the bleeding to high extent.

In group B, the using of the new laparoscopic thermocautery device was achieved high degree of success in coagulation of blood vessels and the partial cutting of the spleen without any bleeding or oozing of blood and the resultant stump was clean regular that not need application of clips or suturing. This technique was consumed less time when compared with group A and C (22.5±4.6 min), while the only problem of this technique was the smoke produced during burning of the tissue by the thermocautery, which little obscure the image, so it need frequent gas evacuation through the laparoscopic cannula valves. In group C, the partial splenectomy was performed perfectly as in group A, but it was time consuming due to the application of the intracorporeal suturing, the time needed for this technique was more than in group A and B (74±4.7 min).

Gross pathological changes: No serious gross pathological changes were reported, except that of omental adhesion with the stump in the 3 groups examined at 15 and 30 postoperative days, no adhesions with any other abdominal viscera were noticed. When the omental adhesion was detached from the spleen, the edges of the stump were showed a good healing that became nearly in contact (Fig. 9a, b).

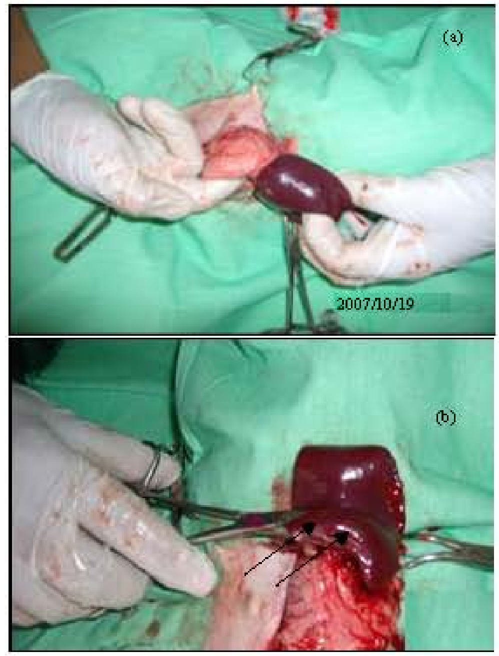

Fig. 9: Omental adhesion to the stump (arrow) (a). The stump after detachment of adhesion showing a perfect healing (arrows) (b)

Histopathology: In group A, the histopathology after 15 days revealed presence of spaces in the parenchyma produced by the titanium clips, surrounded by fibrous tissue with infiltration of inflammatory cells specially lymphocytes, scattered necrotic foci in the red pulp was also noticed (Fig. 10). After 30 days, the spaces produced by the clips were reduced to a high extent by proliferation of fibrous tissue, with the presence of necrotic foci in the red pulp (Fig. 11). In group B, the histopathology of the spleen treated with thermocautery after 15 days revealed the presence of large area of necrosis surrounded by inflammatory cells specially lymphocytes with deposition of hemosiderin pigments (Fig. 12), additionally there was thickening of the trabecula with congestion of trabecular and splenic blood vessels (Fig. 13). After 30 days, the necrotic foci still existed with the presence of calcification foci due to deposition of calcium salts (Fig. 14). In group C, the histopathology of the spleen treated with intracorporeal suturing after 15 days revealed areas of fibrosis in the red pulp particularly in the points of suture material penetration, the suture material was underwent disintegration and surrounded by fibrous tissue with infiltration with lymphocytes with hyperplasia of white pulp (Fig. 15). After 30 days, histopathology revealed a thick area of fibrous tissue replaced the white and red pulp, which consists of collagen fibers and fibrocytes (Fig. 16).

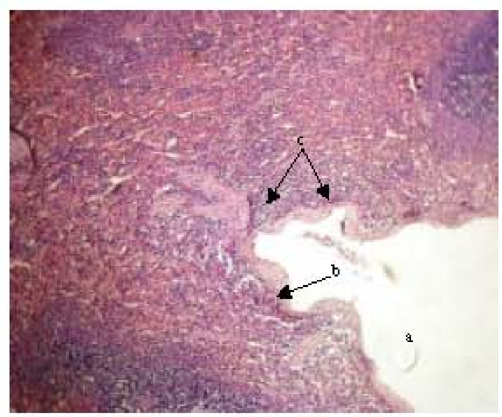

Fig. 10: Photomicrograph of spleen treated with titanium clips after 15 days, a): Presence of spaces produced by titanium clips, b): This spaces surrounded fibrous tissue, c): With infiltration of inflammatory cells specially lymphocytes (H and E 90×)

Fig. 11: Photomicrograph of spleen treated with clips after 30 days, a): Marked reduction of the spaces by proliferation of fibrous tissue and b) Necrotic foci in the red pulp (H and E 165×)

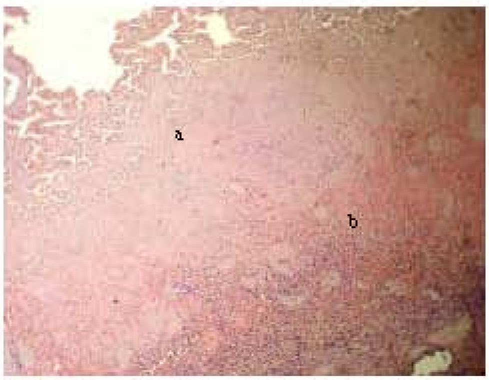

Fig. 12: Photomicrograph of spleen treated with thermocautery after 15 day, a): Large area of necrosis and b) Surrounded by inflammatory cells specially lymphocytes with deposition of hemosiderin pigments (H and E 90×)

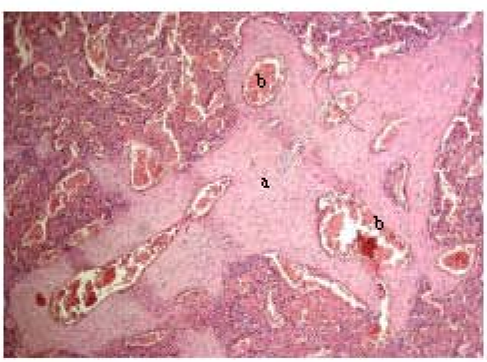

Fig. 13: Photomicrograph of spleen treated with thermocautery after 15 days, a): Thickening of trabecula and b): With congestion of trabecular and splenic blood vessels (H and E 90×)

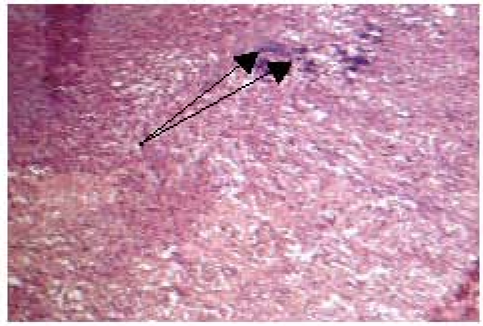

Fig. 14: Photomicrograph of spleen treated with thermocautery after 30 day, showing deposition of ca salts in the necrotic areas (arrows) (H and E 165×)

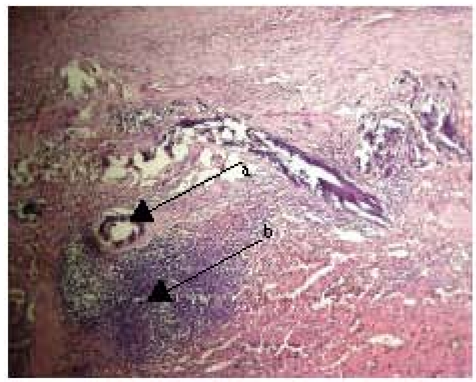

Fig. 15: Photomicrograph of spleen treated with suturing after 15 day a): Disintegrated suture material surrounded by fibrous tissue, b): with infiltration of inflammatory cells, specially lymphocytes with hyperplasia of white pulp (H and E 90×)

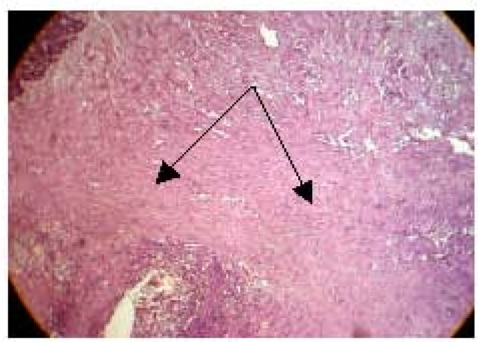

Fig. 16: Photomicrograph of spleen treated with suture material after 30 day, showing a thick area of fibrous tissue replaced the white and red pulp, which consist of collagen fibers and fibrocytes (Arrows) (H and E 90×)

DISCUSSION

The study revealed that the use of laparoscopy for partial splenectomy was feasible and safe method, less invasive, less time consuming and more cosmetic when compared with open surgery. The advantages of laparoscopic surgery of spleen versus open surgery was ascertained by many researchers, these advantages includes, smaller and more cosmetically acceptable incisions, more rapid return to a regular diet and faster return to normal activity (Richardson *et al*., 1997; Terrosu *et al*., 1998; Cordera *et al*., 2003). The using of adrenaline injection in the parenchyma of the spleen in group A and C was considered a very important aid to control bleeding in the partial splenectomy. The adrenaline was used widely for controlling bleeding of gastric ulcers by endoscopic injection (Chung *et al*., 1988; Kubba *et al*., 1996; Worthley and Frazer, 2005). Many researchers suggest the injection of (1:10,000) adrenaline in a dose of 1 mL in the parenchyma or in the splenic artery without any side effects (Palmer, 2002), also used during total splenectomy operations to reduce the size the spleen suffering of splenomegaly (Shaw and Clark, 2005; Bo *et al*., 2008).

In group A, the using of titanium clips approved high efficiency for occlusion of the blood vessels, which supplying part of the spleen to be resected, it produced a perfect control of bleeding when these vessels were severed. Titanium clips having the ability to control bleeding and closing of the different size arteries and veins (Harold *et al*., 2003; Tan *et al*., 2003; Chen *et al*., 2007). The application of titanium clips on the stump is a successful method for controlling the hemorrhage, as well as reducing the surgical time and keeping the edges of the stump in a relatively close apposition, these characters were reported with the using of automated stapling devices for partial splenectomy, however, there is some risk that if the staples are not secured in sufficient tissue, they will loosen and allow hemorrhage to occur from the stump (Fossum, 2007).

Recently, excellent result achieved with stapled partial splenectomy combined with fibrin glue and collagen fleece in human (Uranues and Alimogluo, 2005). Titanium clips are acceptable material used widely in laparoscopic surgery as a substitute of suturing and closing of ducts and wounds of some visceral organs (Leepäniemi *et al*., 1997, 1998; Calles-Vazquez *et al*., 2006).

In group B, an excellent result was achieved with the thermocautery device for laparoscopic partial splenectomy, characterized by very short time operation and complete control of bleeding, as this device produce coagulation of blood vessels and cutting of the spleen at the same time, this is in agreement with the results achieved by Aziz *et al.* (2008), when they use the same device for ovariectomy in donkeys without ligation of ovarian artery and vein, as the device produce coagulation of the vessels and cutting of mesovarium without any bleeding.

Numerous methods were used for coagulation and cutting of spleen, like the use of ultrasonic scalpel (Hodgson and McElhinney, 1982), microwave coagulator (Chen and Yon, 1993), as well as radiofrequency device (Itamoto *et al*., 2006). In spite of the fact that these devices are working by different ways, they have a similar effect on tissue that is increasing of tissue temperature, which leads to coagulation formation. The thermocautery device used in this study had the same effect by increasing the splenic tissue temperature to produce coagulation of the blood vessels and the partial cutting of the spleen.

In group C, the technique was time consuming due to the application of intracorporeal suturing, laparoscopic suturing and knot tying represent the most practical, yet difficult laparoscopic surgical technique (Fischer, 2002), the use of suture in laparoscopic surgery requires patience, persistence and practice, as well as it is time consuming (Waldron and Robertson, 1995; Boure *et al*., 2005).

Gross pathology: In the 3 groups, the only gross pathology recorded that of omental adhesion with the stump, which is actually an expected phenomenon. This omental adhesion was reported with partial splenectomy by the use of Argon beam coagulator in rabbits (Stylianos *et al*., 1991), also reported in partial splenectomy with suturing of the stump in rats (Paulo, 2006). In this study, this type of adhesion could be considered as advantage more than disadvantage, because the adhesion was limited only to the stump, that made a barrier preventing the likelihood additional adhesions with the other neighbouring viscera, furthermore preventing the possible postoperative bleeding.

Many surgeons used the practice of applying omental flap on the stump in partial splenectomy operations to control bleeding during surgery and prevention of postoperative bleeding from the stump (Hoekstra *et al*., 1994; Hery *et al*., 2008; Greef *et al*., 2008), additionally the omental flap was applied on the site of splenic cyst after its excision from spleen to reduce bleeding and to prevent fluid accumulation in the abdominal cavity in the postoperative period (Seshadri *et al*., 1998; Vanderzee *et al*., 1999; Chawla *et al*., 2005).

Histopathology: In group A, the histopathology revealed presence of necrotic foci, which infiltrated with lymphocytes, this could be due to the pressure produced by the clips (pressure necrosis), also spaces were observed at the site of clips application surrounded with fibrous tissue, this result was in agreement with (Leepäniemi *et al*., 1997, 1998). The titanium considered as an inert material so there was mild infiltration of inflammatory cells in the pulp when compared with other suture materials, this is agreed with (Hess *et al*., 1981; Hanson *et al*., 1988).

In group B, histopathology revealed presence of large area necrosis with focus of calcification, that may be due to the thermal injury produced by the thermocautery device, the same finding was reported by Goldenberg *et al*. (1985), when they use the laser for partial splenectomy in dogs and also reported by Zacharoulis *et al*. (2008) in using radiofrequency device for partial splenectomy in pigs.

In group C, the histopathology revealed fibrosis in the red pulp particularly at the site of suture material penetration with a heavy collagen fiber layer and the suture material was surrounded with fibrous tissue, the same result was concluded by Paulo *et al*. (2006) when they used suture material for partial splenectomy in rats. No areas of necrosis were observed in histopathology in this group as with titanium clips or thermocautery, same observation was reported by Goldenberg *et al*. (1985).

CONCLUSION

Laparoscopic partial splenectomy is easy technique, associated with minimal complications and the inducing of 3 ports on the abdominal wall are enough for this operation. The new thermocautery laparoscopic device was approved a high efficiency in partial splenectomy without need of blood vessels ligation or adrenaline injection, as well as it was a fast technique. The present study concluded that adrenaline injection was a very important factor to control bleeding especially, when thermocautery was not used. Also, this study concluded the efficiency of titanium clips application on the stump for controlling bleeding and closing of the stump, it is a fast technique, when compared with the intracorporeal suturing, so it reduces the operation time, which is useful in patients that cannot tolerates long time under anesthesia.

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