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PARTIAL SPLENECTOMY USING RELOADABLE LINEAR STAPLERS IN DOGS

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Background: *The aim of this study was to test the efficiency and safty of using reloadable linear staplers in partial splenectomy.*

Methods: *This was an experimental study on dogs. Partial splenectomy was performed in 20 adult mongrel healthy dogs using reloadable linear staplers (RL — 90) [*1]. Another 10 dogs were sham -operated as a control group. The dogs were followed up post operatively by close observation and by hematological parameters including erythrocytic count, haemoglobin level, packed cell volume (PCV) and total leucoytic count. After one month the dogs were sacrificed and autopsy was performed.*

Results: *Intra-operative bleeding was negligible during resection of the spleen and there was no clinical or laboratory signs of post operative hemorrhage in all the operated dogs. They all survived for one month without complications.*

Conclusion and Recommendations: *The use of stapling technique in partial splenectomy in dogs was quite safe, ensured excellent heamostasis and shortened the time of operation. Nevertheless, due to the specification of the instrument, its application in humans might be suggested to be restricted to those having a thin spleen allows the use of the stapler as in case of young children with localized pathology in their spleen.*

INTRODUCTION

Splenic preservation and conservation management are now accepted norms when dealing with splenic pathologic conditions[1]. Various procedures were described for partial splenectomy especially in cases of splenic cysts, abscesses, tumours and rupture[2]. Human and animals that had been subjected to total splenectomy showed marked alteration in their blood picture as well as serum proteins[3,4,5]. Current techniques were carried out to replace the complete removal of the spleen. One of them was done by ligature of the stem vessel of the splenic part underwent excision as near as to its origin and a pedicled omentum was tied over the raw cut surface for hemostasis[6]. Other procedures were performed in a comparative experimental study for partial splenectomy by electrocautery and CO_2 laser[7]. Laparoscopic partial splenectomy was also described[1]. The present work was contemplated to the use of mechanical stapling machine (reloadable linear staplers) to ensure effective haemostasis by placing one row of staples across the spleen near the line of demarcation between the vascularized and devascularized portion.

MATERIAL AND METHODS

This study included thirty adult male mongrel dogs, weighing 15 — 20 kg. Twenty of them were subjected to partial splenectomy using the reloadable linear stapler and in the remaining 10 dogs sham-operation was carried out as a control. The dogs were housed in separate kennels. They were kept under observation for 14 days before surgery. The animal room was sprayed with Neocidal [*2] 1/1000 solution every 2 weeks to guard against external

[*1] - Ethicon, Inc. a Johnson & Johnson company.
[*2] - Diazenon 60 EC; manufactured by Ciba-Geigy Switzerland.

parasites. The dogs were also injected subcutaneously with Ivermectin[*3] in a dose of 200 mg/kg body weight to protect the dogs against internal and external parasites. The dogs were fed on boiled horse meat, fowl viscera, bread and milk. Water was ad libitum.

One day prior to operation no food was given to the selected dog which was bathed and dried. The abdomen was clipped and shaved. Skin was washed with soap and water after shaving.

Bowel decontamination was carried out by oral administration of 5gm. neomycin and 5gm streptomycin three days before surgery. One day before surgery preoperative prophylactic antibiotics were administered via intramuscular route in the form of ampicillin 25 mg/kg and gentamycin 5 mg/kg.

The dogs were premedicated by atropine sulphate in a dose of 0.04 mg/kg subcutaneously and sparine[*4] in a dose of 2 — 3 mg/kg by intramuscular injection.

Anesthesia Technique [8]: -

After establishment of an intravenous line in the cephalic vein (fore-limb) or in the recurrent tarsal vein (hind-limb), induction of anaesthesia was done by sodium thiopentone 2.5% solution intravenously in a dose of 20 — 30 mg/kg body weight followed by injection of gallamine 0.3 mg/kg to relax the laryngeal muscles. While, the dog was placed in supine position with stretched head and neck, the relaxed jaws were held opened by spring mouth gag-fixed to the canine teeth. The tongue was grasped by tongue forceps and pulled downward and forward. The tip of the epiglottis was grasped by a long non-traumatizing Babcock's forceps and withdrawn upward and forward. Both tongue forceps and Babcock's forceps were controlled by the left hand, and with the right hand a suitable size of cuffed endotracheal tube lubricated with "K-Y" jell [*5] was pushed between arytenoids. The cuff was inflated and the tube was connected to a mechanical ventilator. Aneasthesia was maintained by inhalation of mixture of oxygen at a rate of 1 — 1.5 liter/min, nitrous oxide at a rate of 0.3 — 0.5 liter/min and halothane at a rate of 0.5 — 2.0 %. For enhancing recovery from anaesthesia prostigmine and atropine sulphate were given I.M after closure of the abdominal wall. Oxygen only was given for 5 — 10 minutes till spontaneous breathing started then the endotracheal tube was removed.

Surgical Technique: —

After aseptic preparation and surgical draping of the dog's abdomen, a 10cm long, ventral midline celiotomy incision was done in the epigastric region. The tela subserosa "properitoneal fat" was incised with control of bleeding. The spleen was then delivered from the left hypochondrium region into the abdominal wound, with gentle traction to expose the gastrosplenic ligament and the splenic hilum. Through a window in the gastrosplenic ligament, near to its hilum, the stem vessel of the part of the spleen to be resected was divided between two ligatures (Fig. 1) after which the line of demarcation at the splenic parenchyma was observed. Along this line the reloadable linear stapler (loaded with 33 staples) was applied and fired to resect the parenchyma of the spleen (Fig. 2). After release of the stapler, the fired staples were checked to detect any missed or inappropriately placed one, and the raw surface of the resected parenchyma of the splenic remnant was observed for any evidence of bleeding which could be dealt with using separate stitches (Fig.3). Mass closure of the abdominal wall using "0" polypropalene continuous sutures sparing the skin which was closed separately using subcuticular continuous "0" polypropalene sutures.

The control group in this study included 10 dogs. Each animal in this groups was subjected to sham operation in which laparotomy, exploration of the abdominal organs and manipulation of the spleen were carried out. The abdomen was closed in the same manner like that in the animals of the partial splenectomy group.

Postoperative Follow up: -

Dogs were transferred to the cages and the room was warmed. Each dog received a single dose of I.M Ampicillin (25mg/kg/day) and gentamycin (5mg/kg/day) for 5 days. All the operated dogs were kept under observation for one month. Jugular blood samples from the operated and control dogs were collected before surgery and afterwards at intervals of 24h, 48h, 72h, 1 week, 2weeks, 3weeks, and one month. These blood samples were analyzed for total erythrocytic count, total leucocytic count, blood hemoglobin and PCV%.

After elapse of the month, the dogs were sacrificed by rapid injection of sodium thiopental (2 grams intravenously) and autopsy was performed.

RESULTS

In this study, dogs proved to be a good model for partial splenectomy. The animals had withstood general anaesthesia as well as the surgical procedures. No single case of mortality was reported in this study.

In this work the operative time needed for stapling the spleen did not exceed 5 minutes. There was no significant bleeding during the procedure. All the fired staples were soundly placed and there was no need for any additional stitches. Also, there was no considerable splenic raw surface left behind after partial splenectomy using a reloadable linear stapler.

[*3] - Ivomec; manufactured by Merk Sharp & Dohme Co. Inc. U.S.A
[*4] - Promazine Hcl, Wyeth Laboratories Inc. Philadelphia, PA 1901, USA.
[*5] - Johnson and Johnson, Ltd, England

Fig. (4 to 7) showed the haematological changes in the four parameters used in this study. They were total erythrocytic count in millions /µl, the heamoglobin level in g/dl, the total leucoytic count in thousand /dl and the PCV% (Table 1, 2). All values in this study were expressed as mean ± standard error (SE).

The mean total erythrocytic count showed more or less the same trend for cases and controls. Their values decreased slightly after the operation and then increased to reach almost the original levels at one month after the operation (Fig. 4).

The haemoglobin level and the PCV% showed more or less the same trend. The levels had increased at 72 hours after the operation but retained almost the original values after that. (Fig. 6,7).

Fig. (5) showed increase in mean total leucocytic count 24 hours after the operation through the first week then decreased to nearly a plateau level at the end of the experiment.

The results of the present study showed that the trend of the haematological changes was the same for both, cases and controls.

At autopsy, both partially splenectomized and control groups showed no collection, significant adhesions or any signs suggestive of intra-abdominal sepsis (Fig. 8).

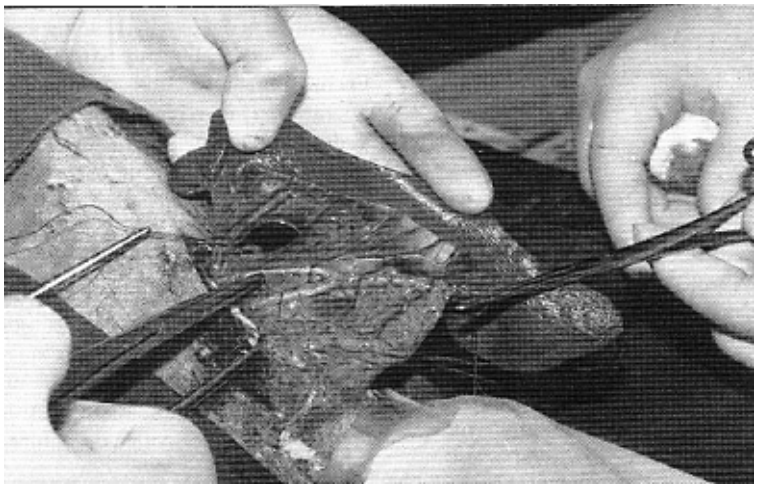


Fig. (1) : Vascular control of the splenic segment to be resected

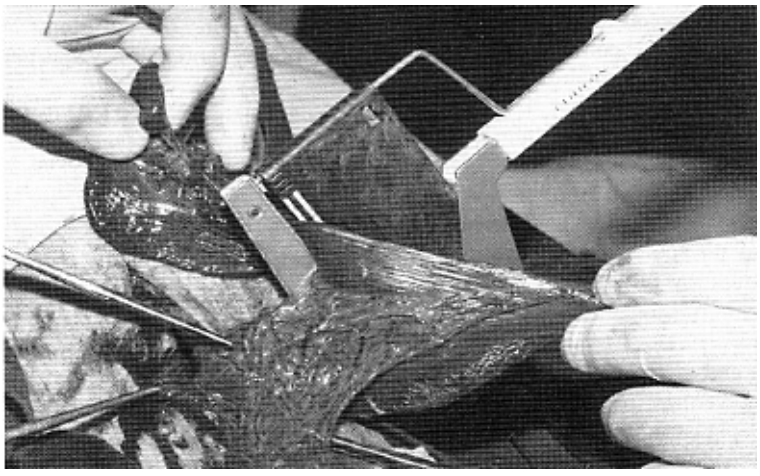


Fig. (2): RL — 90- stapler application along the line of demarcation of the splenic parenchyma.

Fig. (3): The raw surface of the splenic parenchyma after resection using RL — 90- stapler.

Figure (4): Mean total erythrocytic count

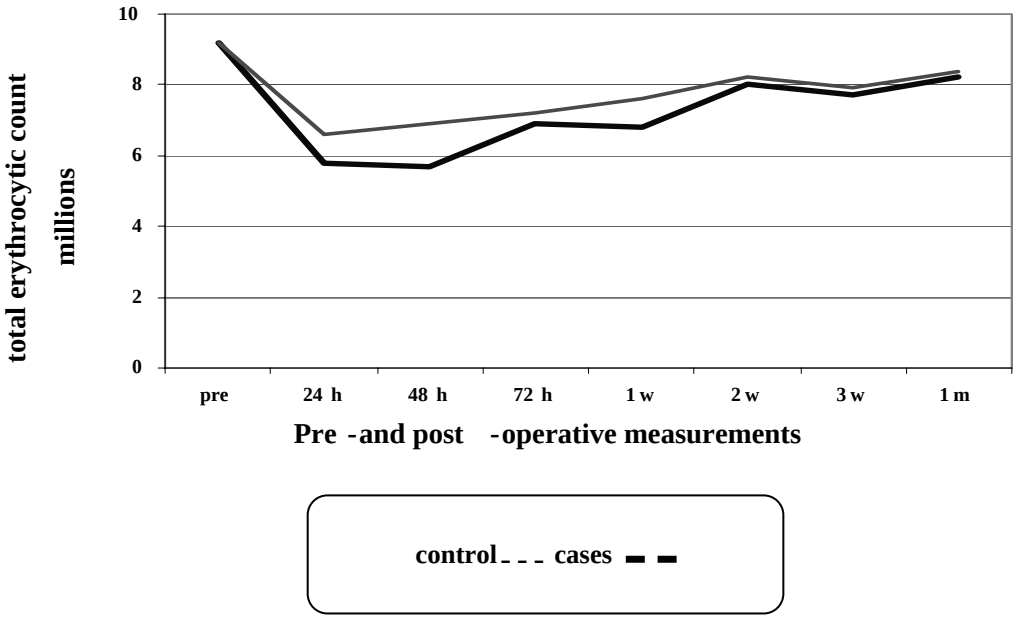


Figure (6): Mean haemoglobin level (g/dl)

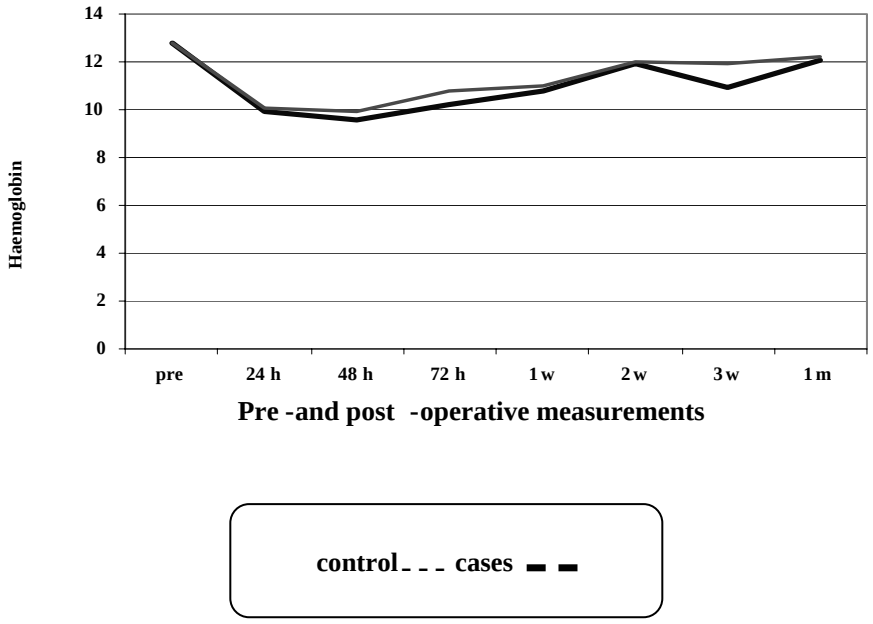
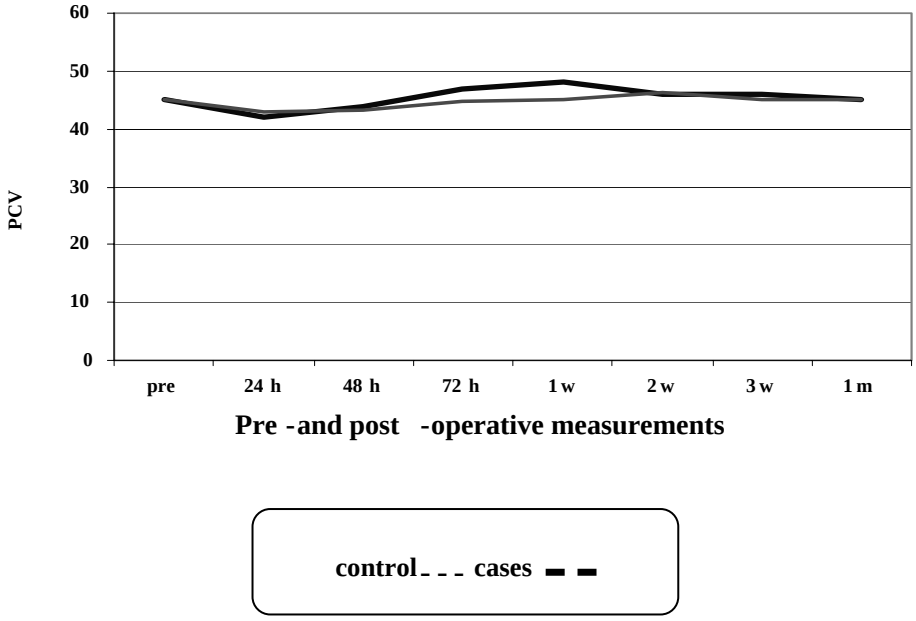


Figure (7): Mean PCV (%)



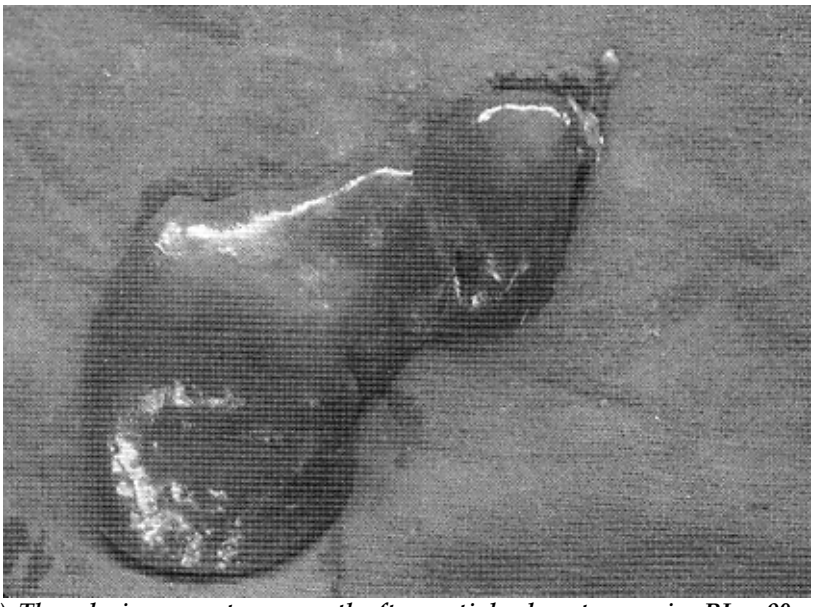


Fig. (8): The splenic remnant, one month after partial splenectomy using RL — 90-stapler.

Table (1): ***Haematological changes in Partial splenectomized animals (mean ± *S.E.)***

Parameter	*Pre - Operative 30 Dogs*	*Postoperative (20 Dogs)*						
		24 h	*48 h*	*72 h*	*1 week*	*2 weeks*	*3 weeks*	*One month*
Total erythrocytic count x10^6 / µl	9.2 ± 0.40	5.8 ± 0.22	5.7 ± 0.84	6.9 ± 0.63	6.8 ± 0.84	8.0 ± 0.24	7.7 ± 0.62	8.2 ± 0.26
Total leucocytic count x10^3 / µl	9.500 ± 0.32	9.800 ± 0.45	11.000 ± 0.92	12.000 ± 0.52	10.200 ± 0.33	9.700 ± 0.55	9.900 ± 0.62	9.800 ± 0.33
Hemoglobin g/dl	12.8 ± 0.9	9.9 ± 0.6	9.6 ± 0.9	10.2 ± 0.7	10.8 ± 0.9	11.9 ± 0.6	10.9 ± 0.6	12.1 ± 0.7
** PCV %	45.0 ± 0.43	42.0 ± 0.38	44.0 ± 0.24	47.0 ± 0.36	48.0 ± 0.66	46.0 ± 0.89	46.0 ± 0.12	45.0 ± 0.12

*SE= Standard Error.
**PCV= Packed Cell Volume.

Table (2): ***Haematological changes after sham operations (mean ± *S.E.)***

Parameter	*Preoperative 30 Dogs*	*Postoperative (10 Dogs)*						
		24 h	*48 h*	*72 h*	*1 week*	*2 weeks*	*3 weeks*	*one month*
Total erythrocytic count x 10^6 / µl	9.2 ± 0.40	6.6 ± 0.42	6.9 ± 0.68	7.2 ± 0.42	7.6 ± 0.32	8.2 ± 0.72	7.9 ± 0.82	8.4 ± 0.74
Total leucocytic count x 10^3 / µl	9.500 ± 0.32	9.900 ± 0.45	10.200 ± 0.24	11.200 ± 0.72	10.100 ± 0.82	9.900 ± 0.22	9.600 ± 0.84	9.700 ± 0.32
Hemoglobin g/dl	12.8 ± 0.9	10.1 ± 0.2	9.9 ± 0.8	10.8 ± 0.8	11.0 ± 0.2	12.0 ± 0.2	11.9 ± 0.2	12.2 ± 0.8
**PCV%	45.0 ± 0.43	43.0 ± 0.24	43.4 ± 0.72	44.9 ± 0.84	45.1 ± 0.22	46.2 ± 0.24	45.2 ± 0.62	45.2 ± 0.44

*SE= Standard Error
**PCV= Packed Cell Volume

DISCUSSION

The spleen was regarded as unnecessary for life or good health by Hippocrates and Aristole. Aristole even believed that the position of the spleen on the left side of the upper abdomen was only for symmetrical reasons to balance the liver on the right side[9]. Modern day understanding the role of the spleen can be dated to the work of Virchow 1846 through his histologic descriptions of this organ as well as to physiologic studies done by several other investigators including Ponfick in 1883[9]. Over the past several decades, the spleen has been recognized as having an important role especially with respect to enhanced immunologic and phagocytic activities. It is now well accepted that the spleen has multiple functions including the following: reservoir for circulating platelets, haematopoiesis in the fetus, removal of abnormal intracellular erythrocyte particles, removal of erythrocytes with abnormal membranes and production of tuftsin and opsonins[6]. Patients who have had splenectomy have an increased risk for fulminate sepsis. This was initially observed in children and later described by king and Shumaker as over whelming post-splenectomy infection[10]. Overwhelming post-splenectomy infection (OPSI) is the principal hazard for patients who have undergone splenectomy. There is evidence that up to 3% of adults and 6% of children who have undergone splenectomy may die of OPSI. Though the precise risk remains uncertain, possible reasons for septic consequences of splenectomy are: diminished phagocytic activity, reduction in both the number and function of T and B lymphocytes, low plasma immunoglobulin levels, diminished opsonic activities and decreased levels of complement[7].

Partial splenectomy is often prefered to total splenectomy as a method to prevent serious postoperative sepsis. It has become the recommended technique in patients with various disease of spleen, particularly in children. Several studies have reported the value of partial splenectomy in the management of splenic pathology as epidermoid cyst[11], splenic trauma[12], Gaucher disease[13,14], splenic hyperfunction[15], staging laparotomy for Hodgkin's disease[16], hereditary spherocytosis[17], thrombotic thrombocytopenic purpura [18], sickle cell / beta thalassaemia[19,20], refractory idiopathic thrombocytopenic purpura [21]. haemoglobinopathy[22] and splenic cyst[23].

The immunological and heamatological advantages of segmental or partial splenectomy over total splenectomy have been extensively studied before and were beyond the scope of the present study. This study concerned with the evaluation of the feasibility and safty of partial splenectomy using RL — 90 stapler in dogs particularly its haemostatic effect.

The intraoperative testing of reloadable linear stapler during partial splenectomy in dogs proved to be a safe and quick technique. The time for stapling the spleen did not exceed 5 minutes in any of the animals included in this study. This would shorten the entire operative time of the procedure with its advantages especially in case of clinical application in diseased children.

Also, the blood loss during stapling of the spleen in dogs was negligible. In clinical application, this technique is expected to spare the patients the potential risk of intraoperative blood transfusion particulary in compromised children with blood diseases.

In humans, the postoperative follow up for bleeding from the splenic remnant or its bed is easily achieved by using suction drain or repeated radiological examination with ultrasonography. But the situation seems to be more difficult in dogs, as dogs do not comply drain insertion, besides there is no facilities for ultrasound follow up in the animal house. For these mentioned reasons, haematological parameters including total erythrocytic count, total leucocytic count, hemoglobin level and PCV% of the peripheral venous blood were used in this study to follow up intra-abdominal bleeding and septic complications indirectly.

The total erythrocytic count and hemoglobin level showed mild initial decrease during the 2nd and 3rd days after partial splenectomy, then started to increase again and restored its normal pre-operative levels 2 weeks postoperatively. Also, the PCV% values did not show considerable changes postoperatively. There was no remarkable difference between these haematological changes in dogs subjected to partial splenectomy using RL — 90, stapler and those in dogs of the control group where no splenic resection was carried out. These results suggested that the haematological changes in this study must be due to the usual mild expected blood loss during laparotomy rather than bleeding from the splenic stump.

Also, the postoperative follow up with total leucocytic count did not show evidences of sepsis in any of the animals included in this study.

At autopsy, the abdominal exploration of each dog one month postoperatively did not show any evidence of significant adhesions or intra - abdominal sepsis in animals subjected to partial splenectomy using RL — 90 stapler compared with those of the control group.

Conclusion and recommendations

This study proved that partial splenectomy in dogs using RL — 90 stapler is feasible. It is also documented to be a quick and safe technique which provided excellent haemostasis.

This experimental work might recommend clinical application of this technique when partial splenectomy is indicated particularly in frail young children having a

localized pathology in their thin spleen allows the use of stapler to shorten the entire operative time and to save them the potential risk of intraoperative blood transfusion.

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REFERENCES

1. Seshadri Pa, Poulin EC, Mamazza J, and Schlachta CM: Technique for laparoscopic partial splenectomy. Surg. Laprosc. Endosc. Percutan. Tech. 10 (2) : 106 – 109, 2000 Apr.

2. Fouad K, Ahmed AS, Gohar H M, El-Keiey MT, Ibrahim IM and Bakeir A: Partial splenectomy in donkeys. Assiut Veterinary Medical Journal 20 (40), 144 – 147, 1988.

3. Anosa VO, Isoun TT and Oladosu LA: Splenectomy in sheep; technique, haematological changes and the haematology of the precipitated Anaplasmosis and Babesiosis.Zbl. Vet. Med. A. 26, 327 – 336, 1979.

4. Bolbol AE, Hassan MS, Hassaan NK and Misk NA: Long term hematological and serum protein changes following splenectomy in sheep. Vet. Res. Communications. 5 (4): 383 – 387, 1982.

5. El-Zomor ST: Comparative studies on splenectomy procedures in certain farm animals. M.Sc. thesis, 1985, Faculty of Vet. Medicine, Cairo University, Egypt

6. Britt LD and Berger J: Splenic repair and partial splenectomy. In: Nyhus LM, Baker RJ and Fisher JI (editors). Mastry of Surgery, 3rd edition, Volume II, Little Brown and Company. Boston, New York, Toronto, London. P: 1276 – 81, 1997.

7. McMahon MJ: Salvaging the spleen. Surgery (international edition), Puslished by: The Medicine Group (UK) Ltd, (2): 1348 – 50, 1988.

8. Hall LW and Clarke KW: Veterinary anaesthesia. 9th edition. Bailliere, Tindall, London, 1991.

9. Schiller M: The spleen. In: O'Neill JA, Rowe MI, Grosfel JL, Fonkalsrud SW and Coran AG (editors): Pediatric Surgery, fifth edition by Mosby – Year Book, Inc. 1545 – 1554, 1998.

10. King H and Shumaker HB Jr: Splenic studies. Susceptibility to infection after splenectomy performed in infancy.Ann. Surg. 136: 239, 1952.

11. Yamamoto H, Ohshiro H, Lee KT, Yoshida M and Sera Y: Partial splenectomy for epidermoid cyst using TA- stapler. Journal of pediateric Surgery. 34 (10): 1582 – 3, 1999 Oct.

12. Sykes LN: An improved technique for partial splenectomy. American Surgeon. 55 (8): 508 – 10, 1989 Aug.

13. Fleshner PR, Astion DJ, Ludman MD, Aufses AHJr, Grabowski GA, and Dolgin SE: Gaucher disease; fate of the splenic remnant after partial splenectomy – a case of rapid enlargement. Journal of Pediatric Surgery. 24 (6): 610 – 612, 1989 Jun.

14. Freud E, Cohen IJ, Mor C, Golinsky D, Blumenfeld A, and Zer M: Splenic regeneration after partial splenectomy for Gaucher disease; histological features. Blood Cells Mol. Dis. 24 (3) : 309 – 16, 1998 Sep.

15. Witte CL, Van Wyck DB, Witte MH, Corrigan JJ, Zukoski CF, Pond GD and Woolfenden JM: Ischaemia and partial resection for control of splenic hyperfunction. British Journal of Surg. 96 (9): 531 –5, 1982 Sep.

16. Bloes ET, Haase GM and Hamoudi AB: Partial splenectomy in staging laparotomy for Hodgkin's disease; an alternative approach. Journal of Pediatric Surgery 13 (60): 581–6, 1978 Dec.

17. Pavon Moran V, Estrada del cueto M, Fernandez Delegado N, Sanchez Damas M, Vergara Riverpo R, Gonzalez Otero A, Vilorio Barreras P and Svarch E: Effectiveness of partial splenectomy in the treatment of hereditary Spherocytoosis. Revista de Investigation Clinic. 52 (3): 229: 33, 2000 May- Jun. (Spanish, English abstract).

18. Mant MT, Turner AR, Brice D, Ritchie C and Larratt LM: Splenectomy during partial remission in thrombotic thombocytopenic purpura with prolonged plasma exchange dependency. Am. J. Hematol. 62 (1): 56 – 7, 1999 Sep.

19. Al — Salem AH, Al — Dabbous I and Bhamidibati P: The role of partial splenectomy in children with thalassaema. Eur. J. ped. Surg. 8 (6): 334 – 8, 1998 Dec.

20. Svarch E, Nordet I and Gonzalez A: Overwhelming septicaemia in a patient with sickle cell beta thalassaemia and partial splenectomy. Br. J. Haematol. 104 (4): 930, 1999 Mar.

21. Sadamoto Y, Abe Y, Kato K and Nishimura J: Partial splenic embolization as a preoperative treatment for refractory idiopathic thrambocytopenic purpura). Rinsho Ketsueki. 39 (12): 1194 – 6, 1998 Dec. (Japanese, English abstract)

22. Idown O and Hayes – Jordan A partial splenectomy in children under 4 years of age with hemoglobinopathy. Journal of Pediatric Surgery. 33 (8): 1251 – 3, 1998 Aug.

23. Yavorski CC, Greason KL and Egan MC: Splenic cysts; a new approach to partial splenectomy – case report and review of the literature.Am. Surg. 46 (8): 795 – 8, 1998 Aug.