

Assessing two methods of repair of duodenal defects, jejunal serosal patch and jejunal pedicled flap, (an experimental animal study)

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Abstract

Objective: To evaluate the outcomes of jejunal serosal patch and jejunal pedicled flap procedures for the repair of duodenal injuries.

Methods: The experimental animal-model study was conducted at Shiraz University of Medical Sciences, Iran, in February 2013. Ten mixed-breed male dogs were selected and randomly divided into groups A and B. After general anaesthesia, a large duodenal defect was created in all animals. The defect was repaired with jejunal pedicled flap in group A and jejunal serosal patch in group B. Microscopic healing was scored according to epithelialisation, collagenisation, inflammation, ulcer and necrosis of samples. Kolmogorov-Smirnov and independent t-test were used to indicate normal distributions of data and statistical differences between the two groups respectively.

Results: The weight of the animals ranged between 23 and 37kg and the age range was 12-16 months. All dogs survived the procedures. Anastomotic leakage, intra-abdominal abscess or intestinal obstructions were not detected in gross examination. Healing score was significantly higher in the group A than group B ($p < 0.011$). However, in terms of surgical findings, no significant difference was detected between the groups ($p > 0.05$).

Conclusion: Applying jejunal pedicled flap for repairing large duodenal defects would lead to better histologic outcomes compared to jejunal serosal patch in dogs.

Keywords: Duodenal injury, Wound healing, Experimental study, Surgery. (JPMA 64: 907; 2014)

Introduction

One of the most difficult procedures in clinical surgery is repairing duodenal injuries.¹ Duodenal defects result from blunt or penetrating injuries and resection of infiltrating tumours of colon and kidney.² About 75% of duodenal defects can be safely repaired with primary repair or duodenorrhaphy, but surgical management of severe injuries and large defects are more challenging. They are technically difficult to repair and are associated with high morbidity and mortality rates.^{1,3,4}

Repair of duodenal defects has been the concern of many experimental and clinical researches. Various surgical techniques such as pedicled flap, duodenal resection with end-to-end duodenostomy, pyloric exclusion, application of a synthetic mesh and jejunal serosal patching have been used to manage severe duodenal defects.^{3,5-10}

However, some obstacles such as limitation of the operation site, segmental blood supply and alkaline content of duodenum prevented surgeons from following a clear-cut algorithm to approach this problem.^{11,12} Utilising pedicled jejunal flap (PJF) has been an acceptable

technique to deal with large duodenal defects.¹³ Applying jejunal serosal patch (JSP) is another common method in this regard.⁵

The current study was planned to compare clinical and histological outcomes of these two methods in a canine model. A scoring system was used to evaluate histologic findings in a repaired duodenal defect to provide a quantitative comparative context.

Material and Methods

The experimental animal-model study was conducted at Shiraz University of Medical Sciences (SUMS), Iran, in February 2013. Ten mixed-breed male dogs were selected with simple random sampling from 34 previously coded dogs from the animal laboratory of SUMS. Permuted blocked randomisation was used to allocate the dogs to two equal groups. All procedures and subsequent handling of the animals were approved by institutional research and ethics committee in accordance with the criteria of National Society for Medical Research¹⁴ and that published by the National Institute of Health. Animals were housed in separate cages.¹⁵

All procedures were carried out under aseptic conditions. Protocols of anaesthesia, post-operative care and sacrifice were identical for all animals. Anaesthesia was induced by intra-venous (IV) thiopental (15mg/kg) after

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endotracheal intubation. Then animals were maintained on controlled ventilation with halothane and 100% oxygen. Normal saline was given intravenously throughout the procedure at the rate of 10ml/kg/h. Laying animal supine, the abdomen was shaved and prepared with bethadine solution. The area was draped as a sterile field and a 20cm midline incision was made. The duodenum was found and defects in the second portion of duodenum were created by excising a portion of the anti-mesenteric wall comprising 50 per cent of the circumference and measuring 6-9cm in length. The duodenal diameter of all dogs was measured. Then abdomen was closed by skin suturing and left for 6 hours to produce peritonitis.

After 6 hours, the abdomen was opened again. In the first five dogs (group A), a short loop from the proximal jejunum of equal length with duodenal defect was isolated on its vascular pedicle. A flap was then created by opening the segment along its anti-mesenteric border and used as a full thickness flap to cover the duodenal defect. Intestinal continuity was restored with an end-to-end anastomosis. Each anastomosis was sutured in one layer with vicryl 3-0 continuously.

In the second batch of five dogs (group B), a loop of proximal jejunum within the first 30cm of treitz ligament (a serosal patch) was approximated to the duodenal defect and sutured circumferentially by using 3-0 vicryl suture.

Abdominal closure was done in all layers with a running suture using a 0 nylon for fascia, a 3-0 chromic for subcutaneous plane and a 3-0 nylon for skin. Cefazolin (40mg/kg) was given intravenously at the induction of anaesthesia. In addition, post-operation intramuscular (IM) cefazolin (40mg/kg/d) was administered for a total of 10 days. No oral feeding was given in the first post-operation day; fluid was resumed on the second day and full alimentation was resumed after the third post-operative day. Other care was as per routine.

Four weeks later, after inducing general anaesthesia, the animals were put to death by an intravenous overdose of

potassium chloride. The abdomen was then entered into, using antiseptic precautions like the initial operation. Both aerobic and anaerobic cultures were taken on entry to the peritoneal cavity. Abdominal cavity was examined with respect to the presence of leakage, abscesses and adhesions. The repaired segment of duodenum (about 30cm) was excised. Proximal and distal ends were clumped, a 16f catheter was fixed with silk1 to the distal part and the animal was sent to the fluoroscopy ward. Then 300-500ml of thin barium sulphate was introduced, and serial X-ray films were taken. The duodenal diameter was measured in all animals again.

The specimens were fixed in formaldehyde 10% solution (formalin). The samples were blindly labelled and sent to the Shiraz Faculty of Medicine's Department of Pathology. Histological sampling, tissue processing, slide preparation and haematoxylin and eosin (H&E) staining were performed. The slides were blindly studied by one pathologist. Histo-pathological findings were examined for each sample on the basis of the modified scoring system that was used for the study. Based on literature,¹⁶ the major item modified was histological evidence of tissue necrosis (Table-1).

Data was analysed using SPSS 16. Kolmogorov-Smirnov test was used to evaluate the normality of data distribution. Data was expressed as mean±standard deviation (SD). Because of normal distribution, we used student t-test for the evaluation of significant difference. $P < 0.05$ was considered significant.

Results

The weight of the animals ranged between 23 and 37kg and the age range was 12-16 months. All dogs survived the procedures till they were put to death for the purpose of the study. Anastomotic leakage, intra-abdominal abscess or intestinal obstructions were not detected in gross examination. However, minor adhesions were found in the site of repair of both groups. Only 1(20%) case in group B (serosal patch) demonstrated significant local adhesion in the right upper quadrant.

Both groups showed a healed suture line. In group A,

Table-1: Wound-Healing Histological Scoring System.

Score	Epithelialisation	Collagenisation	Inflammation	Neovascularisation	Necrosis	Granulation tissue
0	Non	Non	Severe	Non	Extensive	Non
1	Non	Non	Moderate	Non	Focal	Immature
2	Partial	Partial	Mild	HPF<5	Non	Mild mature
3	Complete, immature	Complete, irregular	Non	HPF/ 6-10	Non	Mod. mature
4	Complete mature	Complete, regular	Non	HPF >10	Non	Fully mature

HPF: High-power field.

Table-2: Luminal diameter.

Cases	Jejunal pedicled flap (Group A)		Jejunal serosal patch (Group B)	
	Before operation diameter/cm	After operation diameter/cm	Before operation diameter/cm	After operation diameter/cm
Dog 1	1.6	1.6	1.6	1.5
Dog 2	1.7	1.6	1.6	1.5
Dog 3	1.5	1.5	1.6	1.6
Dog 4	1.6	1.6	1.7	1.6
Dog 5	1.7	1.7	1.5	1.5

Table-3: Histologic scores of cases.

	Case 1	Case 2	Case 3	Case 4	Case 5	P-value
Mucosal patch group	21	16	18	20	15	0.011
Serosal patch group	14	15	13	12	15	

there was no grossly visible evidence pointing to pedicles vascular problem of jejunal flaps.

Contrast study demonstrated no significant difference between the two groups. Due to normal distribution of data, according to Kolmogorov-Smirnov test, student's t-test revealed no significant differences between the decreases of duodenal diameter in the two groups ($p < 0.242$) (Table-2).

On histological examination of transverse sections, the modified scoring system was applied and findings were noted (Table-3).

The mean scores of groups A and B were 18 ± 2.55 and 13.8 ± 1.30 respectively ($p = 0.011$).

Discussion

Our findings showed that repairing large duodenal defects with PJF lead to better results compared to JSP. The finding is generally in concordance with other similar studies. For instance, Elnemer examined PJF in an experimental study and reported better surgical and histologic outcomes compared to simple repair.¹⁷

Other pedicled flap methods have also been utilised to repair large duodenal defects. For instance, Aslan and Elpeck used a pedicled gastric sero-muscular flap in rats and found satisfactory outcomes such as "new mucosal barrier overlaying the patch".¹⁸ In addition, applying ileal flap with desirable outcomes dates back to more than 40 years.¹⁹

There are certain reasons that explain the superiority of PJF over other methods. Firstly, an autologous graft does not trigger reaction in the damaged organ. Thus, it would

not disrupt the healing process. Furthermore, since injured duodenum is usually diagnosed late, therefore, the risk of infection is higher. Under such circumstances, PJF would not increase potential risk of infection in comparison with prostheses as foreign bodies.^{17,20} In this study, no infection was reported. Moreover, in terms of anatomic and physiologic characteristics, PJF has preferences over other flaps.^{21,22}

In contrast, more intra-abdominal manipulation, longer operation time and creation of an extra-anastomotic site should be considered drawbacks of PJF compared to JSP.¹⁸ At the same time, limited number of cases and the anatomic and physiologic differences between dogs and humans should be taken into account as limitations of this study.

To the best of our knowledge, this was the first time that a scoring system was used to evaluate histologic findings in a repaired duodenal defect. This modified scoring system standardised histologic features of the repaired organ and provided a quantitative comparative context. While quantitative evaluation of the wound healing process is challenging, it would help researchers with more accurate comparisons.¹⁶

Conclusion

Applying PJF for repairing large duodenal defects in dogs led to better histologic outcomes compared to JSP. However, in terms of surgical findings, no significant difference was detected.

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References

1. Nikeghbalian S, Atefi S, Kazemi K, Jalaeian H, Roshan N, Naderi N, et al. Repairing large duodenal injuries in dogs by expanded polytetrafluoroethylene patch. *J Surg Res* 2008; 144: 17-21.
2. Ishiguro S, Moriura S, Kobayashi I, Tabata T, Yoshioka Y, Matsumoto T. Pedicled ileal flap to repair large duodenal defect after right hemicolectomy for right colon cancer invading the duodenum. *Surg Today* 2004; 34: 386-8.
3. Hosseini SV, Abbasi HR, Rezvani H, Vasei M, Ashraf MJ. Comparison between gallbladder serosal and mucosal patch in duodenal injuries repair in dogs. *J Invest Surg* 2009; 22: 148-53.
4. Bhattacharjee HK, Misra MC, Kumar S, Bansal VK. Duodenal perforation following blunt abdominal trauma. *J Emerg Trauma Shock* 2011; 4: 514-7.
5. Astarcioglu H, Kocdor MA, Sokmen S, Karademir S, Ozer E, Bora S. Comparison of different surgical repairs in the treatment of experimental duodenal injuries. *Am J Surg* 2001; 181: 309-12.
6. Lal P, Vindal A, Hadke NS. Controlled tube duodenostomy in the management of giant duodenal ulcer perforation: a new technique for a surgically challenging condition. *Am J Surg* 2009; 198: 319-23.
7. Jani K, Saxena AK, Vaghasia R. Omental plugging for large-sized duodenal peptic perforations: A prospective randomized study of 100 patients. *South Med J* 2006; 99: 467-71.
8. Chen GQ, Yang H. Management of duodenal trauma. *Chin J Traumatol* 2011; 14: 61-4.
9. Degiannis E, Boffard K. Duodenal injuries. *Br J Surg* 2000; 87: 1473-9.
10. Rao R, Ivatury MD, Malhotra AK, Aboutanos MB, Duane TM. Duodenal Injuries: A Review. *Eur J Trauma Emerg Surg* 2007; 33: 231-7.
11. Pandey S, Niranjana A, Mishra S, Agrawal T, Singhal BM, Prakash A, et al. Retrospective analysis of duodenal injuries: a comprehensive overview. *Saudi J Gastroenterol* 2011; 17: 142-4.
12. Cogbill TH, Moore EE, Feliciano DV, Hoyt DB, Jurkovich GJ, Morris JA, et al. Conservative management of duodenal trauma: a multicenter perspective. *J Trauma* 1990; 30: 1469-75.
13. DeShazo CV, Snyder WH, Daugherty CG, Crenshaw CA. Mucosal pedicle graft of jejunum for large gastroduodenal defects. *Am J Surg* 1972; 124: 671-2.
14. National Society for Medical Research. Principles of Laboratory Animal Care. Biomedical Purview 1961; 1: 14.
15. National Research Council (US) Committee for the update of the Guide for the care and use of laboratory animals. Guide for the care and use of laboratory animals. 8th ed. Washington (DC): National Academies Press (US), 2011.
16. Abramov Y, Golden B, Sullivan M, Botros SM, Miller JJ, Alshahrour A, et al. Histologic characterization of vaginal vs. abdominal surgical wound healing in a rabbit model. *Wound Repair Regen* 2007; 15: 80-6.
17. Elnemr A. comparison of various techniques for repair of large duodenal wall defects: an experimental study. *Ann Pediatr Surg* 2006; 2: 139-150.
18. Aslan A, Elpek O. The repair of a large duodenal defect by a pedicled gastric seromuscular flap. *Surg Today* 2009; 39: 689-94.
19. Seidel BJ, Maddison FE, Evans WE. Pedicle grafts of ileum for the repair of large duodenal defects. *Am J Surg* 1971; 121: 206-8.
20. Eckert MJ, Perry JT, Sohn VY, Keylock JB, Munaretto JA, Beekley AC, et al. Bioprosthetic repair of complex duodenal injury in a porcine model. *J Trauma* 2009; 66: 103-9.
21. Storkholm JH, Villadsen GE, Jensen SL, Gregersen H. Mechanical properties and collagen content differ between isolated guinea pig duodenum, jejunum, and distal ileum. *Dig Dis Sci* 1998; 43: 2034-41.
22. Kararli TT. Comparison of the gastrointestinal anatomy, physiology, and biochemistry of humans and commonly used laboratory animals. *Biopharm Drug Dispos* 1995; 16: 351-80.