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Propensity Score-Matched Analysis of Fast Track Pathway versus Conventional Pathway for Acute Perforated Appendicitis Patients with Type 2 Diabetes

*Weijie Chen, Shengnan Zhou, Jianchun Xiao, Qiang Qu and Xiaodong He**

Department of General Surgery, Peking Union Medical College Hospital, Chinese Academy of Medical Sciences, P. R. China

Abstract

Objective: The implementation of fast track pathways in perforated appendicitis patients with diabetes remains challenging. Our aim was to investigate the feasibility of our fast track pathway.

Methods: We reviewed a series of patients on a fast track pathway recovery (FP group) and patients on a conventional pathway recovery (CP group) between January 2019 and December 2020, and used a propensity score matched comparison to analyze outcomes.

Results: The study included 96 acute perforated appendicitis patients with diabetes, 35 pairs of patients were successful matched according to levels of the white blood level, fasting blood glucose level and hemoglobin A1c level using propensity scores. In the matched cohort, the surgery duration in the FP group was shorter than that of the CP group (38.4 ± 9.1 min *vs.* 58.1 ± 8.7 min, P<0.001). The patients in the FP group suffered less pain (VAS, 2.7 ± 0.7 *vs.* 4.3 ± 1.1, P<0.001), stayed shorter in hospital (2.2 ± 0.5 d *vs.* 6.0 ± 1.5 d, P<0.001), and generated lower hospital costs (15442.6 ± 6306.3 Yuan *vs.* 26025.9 ± 10443.7 Yuan, P<0.001) than that did patients in the CP group. Besides, the rate of complication occurrence did not increase in the FP group.

Conclusion: The fast track pathway offers significant fast recovery and healthcare saving without increasing postoperative morbidity.

Keywords: Emergency medical services; Perforated appendicitis; Diabetes

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Correspondence:
Xiaodong He, Department of Surgery, Peking Union Medical College Hospital, Chinese Academy of Medical Sciences, Shuaifuyuan 1#, Beijing 100730, P. R. China, Tel: +86 01069152611; Fax: 0086 01069156002; E-mail: hxdpumch@163.com

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Abbreviations

ASA: American Society of Anesthesiologists; CNY: China Yuan; CP group: Conventional Recovery Pathway Group; FP group: Fast Track Pathway Group; SD: Standard Deviation; VAS: Visual Analogue Score; WBC: White Blood Cells

Introduction

Fast track pathways or enhanced recovery after surgery are spreading worldwide with good outcomes in selective surgeries. They have been demonstrated a shorter length of hospital stay, fewer complications, fewer readmissions, and reduction in total medical cost compared to standard recovery [1]. Because shorter stay in emergency department is now a need and reality in many surgery units, the implementation of fast track pathway in emergency department is being explored and remains a new concept [2]. An optimized recovery pathway could facilitate same day discharge and help reduce inconvenience, cost and pressure on hospital beds.

Acute appendicitis is a common abdominal surgical emergency affecting 5.7 to 57 per 100,000 individuals each year [3]. Twenty to twenty-five percent of acute appendicitis patients suffer a free perforation of the appendix [4]. Compared to simple appendicitis, perforated appendicitis has greater severity of inflammation and complexity of anatomy. Moreover, diabetes brings a higher risk of developing surgical site infections and longer hospital stay than patients without diabetes [5]. Perforated appendicitis patients with diabetes present more possibility of abdominal infection, comorbidities and complications [6]. To our knowledge, there is no fast track pathway for the management of perforated appendicitis with diabetes to date. The study aimed to investigate the security and efficiency of our fast track pathway for acute perforated appendicitis patients with diabetes.

Methods

We reviewed a series of patients on the fast track pathway recovery (FP group) and patients on the conventional pathway (CP group) between January 2019 and December 2020. Our emergency surgical group performed a fast track pathway for the management of perforated appendicitis with diabetes in 2016. We suggested the fast track pathway for all patients, the choice of fast track pathway was made by patients after informed consents. But the fast track pathway was not accepted by all patients. About a half of patients still insist on a conventional pathway. These patients who underwent emergency laparoscopic appendectomy at our hospital with a discharge diagnosis of perforated appendicitis and type 2 diabetes were included. Perforated appendicitis was confirmed clinically and pathologically based on preoperative CT (free intraperitoneal air), intraoperative findings or postoperative pathological results (Figure 1). Exclusion criteria was age <19, pregnancy, tumor or autoimmune disease currently in treatment. We also excluded periappendiceal abscess as these patients might accept percutaneous drainage.

Laparoscopic appendectomy was performed by a same surgical team. Some procedures in the FP group were improved. The laparoscopic appendectomy was performed with residual root sutured using absorbable suture without embedding. Abdominal pus and pus mosses were erased as clean as possible using laparoscopic gauze. A peritoneal drain tube was left to discharge the residual pus or transudate, and removed 24 h later. Volume and cultures of peritoneal fluid did not dictate the remove time of drainage tube and the choice of antibiotics. Parenteral Ertapenem (1 g/d) was administered until the patient was able to tolerate oral liquids according to the joint Surgical Infection Society and the Infectious Diseases Society of America guidelines on the management of complicated intra-abdominal infections published in 2010 [7]. Besides, the fast track pathway included perioperative education, early mobilization and nutrition. A liquid diet was initiated immediately postoperative and advancement to a semi-liquid diet occurred as tolerated, usually on postoperative day 1. Patients were then switched to oral amoxicillin/clavulanic acid on postoperative day 1 and continued for 7 days [8]. Patients were discharged from the hospital when they had adequate pain control and food intake, usually on postoperative day 2. And the blood glucose needs to be monitored home at least 2 weeks.

On a conventional pathway, the appendix was removed laparoscopically with residual root sutured and embedded using absorbable suture. The abdominal pus was cleaned thorough peritoneal lavage according to European guidelines [9]. The peritoneal drain was left during the operation and removed when the volume was less than 20 ml and peritoneal fluid culture was negative. Parenteral Ertapenem (1 g/d) was given after operation and stopped when the white blood cell level was normal, no oral antibiotics was applied. A liquid diet was initiated when patients farted, usually on postoperative day 2. And patients were discharged when they had no abdominal pain, fever, or peritoneal drain tube, and intake was adequate.

Clinical records and follow-up information of these perforated appendicitis patients were retrieved from a database of the Hospital Information System. Clinical and pathological information was collated and analyzed, including demographics, clinical presentation, diabetes status, imaging features, operative method, surgery duration and treatment outcomes. These patients were followed up for at least 6 months. Fistula was defined as an abnormal connection between the root of the appendix and the abdominal cavity or the skin. Wound infection was defined as an infection of the surgical site within 30 days after the operative procedure [10].

Statistical analysis

The statistic difference was performed by using Student T test and chi-square (SPSS 19, SPSS, Inc, Chicago). We also used a Propensity Score (PS)- matched comparison to reduce confounding bias using Empower Stats (X&Y Solutions, Inc, Boston). We matched FP patients with CP patients (1:1) within the caliper width at 0.05 standard deviation of the PS. Variable in the PS model included the white blood level, fasting blood glucose level and hemoglobin A1c level. Differences associated with a P value less than 0.05 were considered statistically significant.

Results

Patients

Total 96 acute perforated appendicitis patients with diabetes were included in the analysis. There were 40 patients treated on the fast track way and 56 patients on the conventional way. And 35 pairs of patients were successful matched according to levels of the white blood level, fasting blood glucose level and hemoglobin A1c level. Besides, there was no significant differences in terms of age (P=0.597), gender ratio (P=0.811), body mass index (P=0.245) or American Society of Anesthesiologists degree (P=0.788) between these two groups (Table 1).

Baseline before operation

All 35 paired patients had fever before operation, the body temperature of FP patients was 38.7 ± 0.5°C and that of CP patients was 38.5 ± 0.5°C (P=0.628, Table 1). The abdominal pain symptom last (3.2 ± 0.9) days in the FP group and (3.2 ± 1.2) days in the CP group before surgery (P=0.893). Besides, para-appendiceal fluid was found in all patients (100%) in two groups. Appendicolith was found in 35 patients (100%) in the FP group and in 34 patients (97.1%) in the CP group (P=0.314).

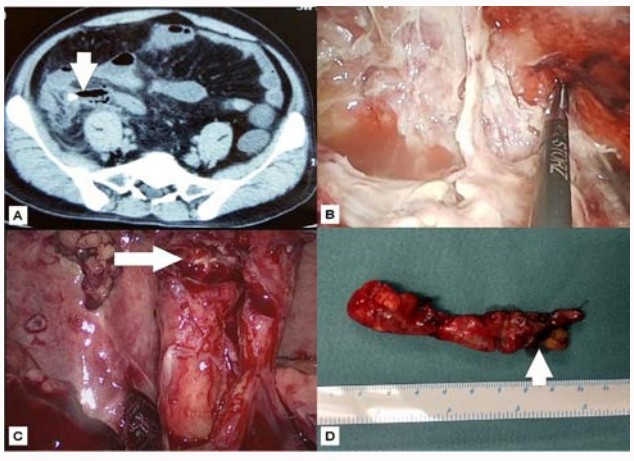

Figure 1: The clinical manifestation of this acute perforated appendicitis. A) The CT scan of acute perforated appendicitis. The arrow indicated the free abdominal gas (perforated location) and high density shadow (appendicolith). B) The intra-operative view of acute perforated appendicitis before appendectomy. Severe adhesions and pus mosses were showed. C) The intra-operative view after cleaning abdominal pus and pus mosses using laparoscopic gauze. The arrow indicated the perforated location. D) The appendix removed by laparoscopic surgery. The arrow indicated the perforated location and appendicolith.

Table 1: Baseline characteristics of patients.

	Fast track (n=35)	Conventional (n=35)	P
Age, year, mean (SD)	66.9 (6.5)	66.1 (7.4)	0.597
Male/Female (n)	18.0/17.0	16.0/19.0	0.811
BMI, kg/m^2, mean (SD)	23.9 (4.8)	22.9 (2.3)	0.245
Smoking, Number (%)	9.0 (25.7)	8.0 (22.9)	0.78
ASA Classification, Number (%)			
Class I+II	25.0 (71.4)	26.0 (74.3)	
Class III+IV	10.0 (28.6)	9.0 (25.7)	0.788
Diabetes duration, year, mean (SD)	4.6 (3.1)	4.1 (2.3)	0.11
Treat with insulin, number (%)	7.0 (20.0)	6.0 (17.1)	
Using oral hypoglycemic drug, number (%)	28.0 (80.0)	29.0 (82.9)	0.759
Fasting plasma glucose, mmol/L, mean (SD)	11.7 (3.0)	11.7 (3.0)	0.24
Hemoglobin A1c, %, mean (SD)	9.7 (1.6)	9.5 (1.8)	0.291
Hypertension, number (%)	25.0 (71.4)	29.0 (82.9)	0.255
Symptom onset, d, mean (SD)	3.2 (0.9)	3.2 (1.2)	0.893
Body temperature, ^{O}C, mean (SD)	38.7 (0.5)	38.5 (0.5)	0.628
Fever, number (%)	35(100.0)	35 (100.0)	
≥ 37.8^{O}C	33 (94.3)	32 (91.4)	0.643
White blood cell count, cell/mm3, mean (SD)	15.0 (3.6)	15.2 (3.5)	0.129
Image Results			
Appendicolith, number (%)	35 (100.0)	34 (97.1)	0.314
Para-appendiceal fluid, number (%)	35 (100.0)	35 (100.0)	

ASA: American Society of Anesthesiologists; IQR: Interquartile Range; SD: Standard Deviation

Recovery after surgery

All laparoscopic appendectomies were performed successfully. The procedure duration in the FP group was shorter than that of the CP group (38.4 ± 9.1 min *vs.* 58.1 ± 8.7 min, P<0.001, Table 2). Peritoneal drain tubes were left in all patients' abdominal cavities. The drainage volume of the FP group was less than that of the CP on the first postoperative day (28.0 ± 9.3 ml *vs.* 59.6 ± 19.6 ml, P<0.001). Drain tubes in the FP group were removed 24 h after surgery, while drain tubes in the CP group were kept for (5.2 ± 2.1) days (P<0.001) until the volume and fluid culture satisfied criteria.

Most patients had a reduction in the white blood cell count and remission of general symptoms. The white blood cell level decreased to (10.4 ± 3.3) × 10^9/L in the FP group and (11.8 ± 3.9) × 10^9/L in the CP group on the first postoperative day (P=0.029). After pain management in the FP group, the wound pain of patients on the first postoperative day was 2.7 ± 0.7 on a 10-point visual analogue scale, while it was 4.3 ± 1.1 in the CP group (P<0.001). The patients in the FP group stayed shorter in hospital (2.2± 0.5d *vs.* 6.0 ± 1.5 d, P<0.001), and generated lower hospital costs (15442.6 ± 6306.3 China Yuan *vs.* 26025.9 ± 10443.7 China Yuan, P<0.001) than that did the patients in the CP group.

Complications

A total of 6 patients in the FP group and 3 patients in the CP group developed complications (P=0.284). Wound infections occurred in 2 patients (5.7%) in the FP group and 2 patients (5.7%) in the CP group (P=1.000). A periappendiceal abscess was found in 3 patients (8.6%) in the FP group and 1patients (2.9%) in the CP group (P=0.303). And intestinal obstruction was found in 1 patient (2.9%) in the FP group and no patient in the CP group (P=0.314). No patients experienced bleeding, stump leak or fistula after surgery. No statistically significant differences were observed between these two groups. Re-interventions were required in 3 patients (8.6%) in the FP group and no patients in the CP group (P=0.077). Nobody was readmitted or underwent reoperation.

Table 2: Operative characteristics and treatment outcomes of the patients.

	Fast track (n=35)	Conventional (n=35)	P
Operative time, min, mean (SD)	38.4 (9.1)	58.1 (8.7)	0
Status on the first postoperative day			
Drainage volume, ml, mean (SD)	28.0 (9.3)	59.6 (19.6)	0
Wound pain, VAS, mean (SD)	2.7 (0.7)	4.3 (1.1)	0
Body temperature, ^{O}C, mean (SD)	37.8 (0.7)	38.3 (0.6)	0.002
White blood cell count, cell/mm3, mean (SD)	10.4 (3.3)	11.8 (3.9)	0.029
Drainage duration, day, mean (SD)	1.0 (0)	5.2 (2.1)	0
Hospital duration, day, mean (SD)	2.2 (0.5)	6.0 (1.5)	0
Treatment cost, CNY, mean (SD)	15442.6 (6306.3)	26025.9 (10443.7)	0
Complications			
Wound infection, number (%)	2 (5.7)	2 (5.7)	1
Fistula, number (%)	0	0	
Periappendiceal abscess, number (%)	3 (8.6)	1 (2.9)	0.303
Intestinal obstruction, number (%)	1 (2.9)	0	0.314
Reoperation, number (%)	0	0	
Re-interventions, number (%)	3 (8.6)	0	0.077

VAS: Visual Analogue Score; WBC: White Blood Cells; CNY: China Yuan

Discussion

Fast track pathways or enhanced recover after surgery began in the 1990s when surgeons found patients could "fast track" recovery by using a protocolized, multimodal approach [11]. Fast track pathways have shown significant promise in the reduction of length of hospital stay for a variety of abdominal surgeries. In some extent, it is not only a kind of technical improvement, but an idea to update and replace traditional treatment and care ways, including perioperative education, nutrition, minimally invasive surgery, avoidance of drains, and early mobilization. If these protocols have been proved as an efficient ways and gained wider acceptance in the surgical community, they would be proposed as a new "standard of care".

Fast track pathways for emergency surgery are only recently being investigated. Gonenc et al. [12] reported use of a fast track pathway for the surgical treatment of perforated gastroduodenal ulcers and proposed it as a feasible option. Frazee et al. [13] described successful use of a fast track pathway for outpatient management of uncomplicated appendicitis. Perforated appendicitis and diabetes add to the complexity of fast track pathways due to the infectious component of this process (Figure 1). It was not suitable to perform laparoscopic appendectomy because of higher rates of intraoperative complications (odd ratio, 1.61) and postoperative complications, such as intra-abdominal abscess, wound infection, and postoperative paralytic ileus (39% *vs.* 8%) (4,14). Over decades of technique development, intraoperative complications, surgical and general postoperative complications, conversion rates and hospital stays associated with laparoscopic appendectomy have all significantly decreased [15].

The laparoscopic approach is a key component in fast track pathways. Laparoscopic operation could significantly reduce pain and facilitate the return to oral intake and normal ambulation in patients recovering from abdominal operations [16,17]. Laparoscopy provides a broadened operative field by carbon dioxide insufflation and a magnified optimal visual view. With these advantages, the appendix can be quickly exposed and removed, even when it is behind the cecum. The abdominal or pelvic abscesses could be cleaned as much as possible. Therefore, the white blood cell counts of FP patients decreased significantly, and only 4 patients developed the intra-abdominal abscess.

There are different methods to clean abdominal abscesses. We used to cleaned abdominal pus and pus mosses thorough peritoneal lavage. That might lead to spread the infectious materials and increase the residual lavage fluid. One comparative study documented a higher abscess rate when irrigation was used during appendectomy for perforated appendicitis [18]. Then we use laparoscopic gauze to clean pus to reduce fluid collections and thus reduce postoperative intra-abdominal infectious complications. Without lavage, the peritoneal drain volume was less than that of the CP group on the first postoperative day. And the white blood cell counts decreased more significantly than that of the CP group.

Drainage placing is debating in emergency appendectomy, considering that it is unnecessary in most elective surgical settings. Sleem et al. [19] has found placement of a pelvic drain did not reduce the rate of intra abdominal abscess. The patients without drain had significantly less overall complications (7.7% *vs.* 18.5%, P=0.01) [20]. A review of open appendectomy found very low quality evidence for drainage and suggested drains may delay discharge from hospital [21]. Fast track pathway specifies avoidance of drainage because it probably hinders mobilization. However, many surgeons place drains after appendectomy for perforated appendicitis when pus is present or resident. We also left pelvic drainage worrying about resident pus. In case of residual pus, the positioning of a drain for the aspiration of the residual fluid in the first 24 h postoperatively might lower the incidence of abscess [9]. But we removed the drainage tube 24 h after surgery to reach early mobilization.

Besides, wound pain control and oral administration of medication are important for early mobilization. With oral analgesics, the pain of 3 Trocar wounds was much tolerable. These FP patients were discharged earlier than CP patients. Traditionally, patients have been hospitalized and treated with intravenous antibiotics for at least 5 days postoperatively [8]. Both Gollin and Frazee proposed a protocol of intravenous antibiotics until patients were tolerating oral intake and completing a 7-day course of oral amoxicillin/clavulanic acid, because oral amoxicillin/clavulanic acid has been shown to be equally effective as parenteral metronidazole/gentamycin for the prevention of infections following appendectomy [8]. We adopted a similar approach in our adult population with perforated appendicitis and diabetes. After at least 6-month follow up, there was no statistically significant differences in complication rate between these two groups. Re-intervention rate was also similar. Nobody was readmitted and no one underwent reoperation. The patients generated lower hospital costs because of shorter hospital stay.

Admittedly, our study has the weaknesses associated with a retrospective observational study. It was difficult to make a defined diagnosis preoperatively, and to perform a randomized controlled study. Though further investigations are needed, our results confirm the effectiveness of this fast track pathway. In future, ambulatory surgery might be acceptable for the perforated appendicitis with diabetes.

Conclusion

All in all, our study recommends a fast track pathway as a safe treatment applied in acute perforated appendicitis patients with type 2 diabetes. This approach offers significant healthcare saving without increasing postoperative morbidity. I hope that would be gained wider acceptance in the surgical community.

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