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ORIGINAL ARTICLE

Comparison of superficial surgical site infection between delayed primary and primary wound closures in ruptured appendicitis

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Summary *Background:* Delayed primary (DPC) and primary (PC) wound closures have been applied in ruptured appendicitis, but results were controversial. This study aims at comparing the rate of superficial surgical site infection (SSI) in ruptured appendicitis between DPC and PC.
Methods: A retrospective cohort of ruptured appendicitis was conducted between October 2006 and November 2009. Demographic, operative findings and postoperative infection data were retrieved. The superficial SSI rates between groups were compared using an exact test. An odds ratio of SSI was then estimated.
Results: One-hundred and twenty eight patients with ruptured appendicitis were eligible and their data were retrieved; 115 (90%) patients had received DPC and 13 (10%) patients had received PC. The SSI rate was much lower in PC patients than in DPC patients, i.e., 7.7% [95% confidence interval (CI): 0.02, 36.0] versus 27.8% (95% CI: 19.9, 37.0), respectively. There was an approximately 72% lower risk of SSI in the PC group than in the DPC group, but this did not reach statistical significance ($p = 0.18$).
Conclusion: Our study suggested that PC does not increase risk of SSI in low SSI risk patients with ruptured appendicitis. DPC should not be routinely done.

Conflicts of interest: The authors declare that they have no financial or non-financial conflicts of interest related to the subject matter or materials discussed in the manuscript.

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1. Introduction

Appendectomy is one of the most common emergency surgical procedures in the world.[1,2] The most common postoperative complication after appendectomy is superficial surgical site infection (SSI),[3] which especially occurs in complicated appendicitis (i.e., gangrenous, and ruptured appendicitis).[4] Superficial SSI causes readmission, increases the length of stay, nursing care, and prolonged antibiotic treatment.[5,6] Consequently, this results in an increase of both direct and indirect medical costs to both health care providers and patients.[5–7]

Postoperative SSI can be minimized by reducing risk factors (e.g., smoking, or glucose control),[8,9] or use of established preventive procedures (e.g., prophylactic antibiotics, avoid surgical drain, and unnecessary hair removal).[9] Closure of the wound with delayed primary closure (DPC) for a contaminated wound also affected SSIs.[9–11] Instead of closing a wound primarily, the wound is left open with standard wound care and then is closed on the 3rd to 5th day afterward.[12,13] This procedure is claimed to increase local wound resistance[14] and decrease bacterial contamination,[11,15] which results in a decrease in superficial SSIs.[9,11,13,14] However, DPC has disadvantages compared to primary closure (PC); these are patient discomfort and pain from dressing, increased length of stay, and increased cost of treatment.[16] Nevertheless, DPC is still currently used and recommended in surgical practice by standard textbooks,[3] with consideration of the wound classification and the attitude of the surgeon. We therefore conducted a retrospective cohort study with the aim of comparing superficial SSIs between DPC and PC in patients with ruptured appendicitis.

2. Methods

The study was approved by the Ethical Committee Board of Faculty of Medicine, Thammasat University. The study design was a retrospective cohort study. All patients with ruptured appendicitis that would be coded as acute appendicitis with peritonitis (ICD10 coding of K350), admitted to Thammasat University Hospital between October 2006 and November 2009, were identified from medical databases, and medical records were reviewed for eligibility. Patients were eligible if they were aged $\geq$15 years, had an appendectomy with right lower quadrant incision, and had pathological diagnosis of ruptured appendicitis. Patients with an additional midline incision, apart from the right lower quadrant incision, were excluded.

Data were retrieved from both inpatient and outpatient medical records using a standardized case record form. Baseline characteristics of the patients (sex and age), clinical data [diabetes, immunocompromised host (i.e., HIV, currently on immunosuppressive drugs), and ASA classification], and surgical data (operative time, use of surgical drain, and antibiotic prophylaxis) were retrieved.[9] Intraoperative factors that might alter the magnitude of wound contamination (i.e., the presence of phlegmon, pus, and intraoperative rupture) were also collected.

Superficial incisional SSI was defined according to CDC criteria[17] as follows: (1) infection occurring within 30 days postoperatively; and (2) involving only skin and subcutaneous tissue of the incision. One of the following conditions must also be met: (1) purulent drainage from the superficial incision; (2) organisms isolated from an aseptic culture of fluid or tissue from the superficial incision; (3) had at least one of the signs and symptoms (i.e., pain or tenderness, localized swelling, redness, or heat); or (4) superficial incision was deliberately opened by the surgeon with or without positive culture. DPC was defined as a wound that was left open initially after completion of an operation, whereas PC was a wound that was suture-closed immediately after an operation. The date of suturing in DPC to close the wound was also recorded. The ASA classification was re-categorized as <III and $\geq$ III according to the National Nosocomial Infections Surveillance System Risk Index (NNIS index).[18] Operative time was classified as $\leq$75th and >75th percentile[18] of the average duration, which was 60 minutes; this is the time used for wound classification in appendectomy by the NNIS.[4]

2.1. Statistical analysis

Baseline characteristics of the patients were described using mean (or median where appropriate) and frequencies for continuous and categorical data, respectively. Demographic data, clinical data, and surgical factors mentioned previously were compared between DPC and PC groups using the *t* test (or Mann-Whitney test where appropriate) and Chi-square test (or Fisher's exact test) for continuous and categorical data, respectively. The rate of SSIs between groups and the 95% confidence intervals (CI) were estimated. The risk ratio (RR) of superficial SSI for PC versus DPC was then estimated. Analysis was performed by STATA version 12.0; $p < 0.05$ was considered as statistically significant.

3. Results

The medical records of 184 cases identified during the study period were reviewed. Among them, 20 patients were <15 years old, 17 patients had additional midline incisions, leaving 147 patients who met the eligibility criteria. Of these, 19 (13%) patients did not have data for superficial SSI, leaving 128 patients for analysis.

The mean age of the 147 patients was 37 years (SD = 17) and 96 (65%) were men. Nine (6%) patients had diabetes and none were taking immunosuppressive drugs. All patients were prescribed a prophylaxis antibiotic. The median duration of symptoms before admission was 24 hours, with a range of 1–96 hours. One-hundred and thirty eight patients (94%) were categorized in ASA Class I and II, and 9 (6%) patients were ASA Class III or higher. The median operative time was 75 minutes, with a range of 25–405 minutes. The average duration of re-suture after DPC was 4 days (SD = 1.9) post-operation. The average length of stay (LOS) was 6.5 days (SD = 3).

Among 128 patients, 115 (90%) and 13 (10%) patients received DPC and PC, respectively. Characteristics of the patients were compared between the two groups (Table 1). Thirty-three patients had superficial incisional SSI, with an overall rate of 25.7% (95% CI: 18.5, 34.3). The SSI rate

Table 1 Baseline characteristics of patients compared between groups with and without delayed primary closure.

Variables	PC	DPC	p
	$n = 13$ (10%)	$n = 115$ (90%)	
Age (y)[a]	37 (17)	41 (18)	0.42
Sex			
Male	8 (62%)	87 (65%)	0.77
Female	5 (38%)	47 (35%)	
Diabetes	1 (8%)	8 (6%)	0.58
Symptom duration (h)[b]	24 (1, 96)	24 (14, 48)	0.99*
ASA classification			
ASA 1,2	12 (92%)	108 (94%)	0.59
ASA 3,4	1 (8%)	7 (6%)	
Operative duration			
≤60 min	4 (31%)	48 (42%)	0.45*
>60 min	9 (69%)	67 (58%)	
Presence of phlegmon	3 (23%)	9 (8%)	0.10
Presence of pus	5 (38%)	40 (35%)	0.77
Intraoperative rupture	2 (15%)	13 (11%)	0.65
Drain placement	2 (15%)	7 (6%)	0.23

* Chi-square test.
DPC = delayed primary closure; PC = primary closure.
[a] Mean (SD).
[b] Median (range).

Table 2 Univariate analysis of risk factors for post-operative superficial surgical site infection.

Factors	Superficial SSI		p
	Yes ($n = 33$)	No ($n = 95$)	
Type of closures			
DPC	32 (97%)	83 (87%)	0.12
PC	1 (3%)	12 (13%)	
Age (y)[a]	35 (16)	38 (17)	0.34
Sex			
Male	19 (58%)	65 (68%)	0.43*
Female	14 (42%)	30 (32%)	
Diabetes	2 (6%)	6 (6%)	1.00
Symptom duration (h)[b]	32 (6,72)	24 (1,96)	0.62
ASA classification			
ASA I, II	30 (91%)	90 (95%)	0.77
ASA III, IV	3 (9%)	5 (5%)	
Operative time			
≤60 min	9 (27%)	43 (45%)	0.07*
>60 min	24 (73%)	52 (55%)	
Presence of phlegmon	1 (3%)	11 (12%)	0.19
Presence of pus	12 (36%)	33 (35%)	0.87*
Intraoperative rupture	4 (12%)	11 (12%)	1.00
Drain placement	2 (6%)	7 (7%)	1.00

* Chi-square test.
DPC = delayed primary closure; PC = primary closure; SSI = surgical site infection.
[a] Mean (SD).
[b] Median (range).

tended to be lower in the PC than the DPC group, with rates of 7.7% (95% CI: 0.02, 36.0) versus 27.8% (95% CI: 19.9, 37.0), respectively (Table 2). The estimated RR was 0.28 (95% CI: 0.04, 1.86), i.e., patients who received PC would be at an approximately 72% lower risk of SSI than patients who received DPC, but this was not significantly different. LOS was 6.6 days (SD = 3.1) and 5.8 days (SD = 2.5) after DPC and PC, respectively ($p = 0.36$). The average day of re-suture after DPC were 4.8 days (SD = 2.4) and 4.3 days (SD = 1.6) in SSI and non-SSI, respectively. No other risk factors were significantly associated with SSI, except duration of operation, which showed a trend of association with the estimated RR of 1.82 (95% CI: 0.92, 3.60; $p = 0.07$). This suggested that an operative time > 60 minutes might increase the risk of wound infection.

4. Discussion

We conducted a retrospective cohort study including 128 patients with ruptured appendicitis. The superficial SSI rate was approximately 72% lower in PC than in DPC patients, although this was not significant. An operative time > 60 minutes seemed to be a risk factor for SSI.

Our results are similar to those of a previous systematic review and meta-analysis in pediatric patients[19] and a randomized controlled trial of ileostomy closure,[20] which found that PC did not increase the rate of wound infection after operation, thus encouraging applying PC due to the lack of benefit of DPC. By contrast, some studies found a considerable benefit of DPC. For instance, Duttaroy et al[11] conducted a randomized controlled trial in peritonitis patients with a midline abdominal incision. They found that superficial SSI was significantly lower in the DPC group than in the PC group (42.5% vs. 2.7%), with a number needed to treat of 2.5. This finding is also observed after DPC in other types of patients (i.e., contaminated wound[21,22] and open tibial fracture[23]). These discrepant results might be due to heterogeneous patients with different types of operation (appendicitis, other procedures), types of patients (adult, children), and incision (midline, right lower quadrant). As a result, there should be caution in applying the results of these findings to patients.

The prevalence of superficial SSI after PC in ruptured appendicitis varied from 9% to 50%.[10,24–26] This may be explained by a different definition of superficial SSI, different care, and setting of patients. DPC may be of benefit if the SSI rate is low, as demonstrated by one cost-utility analysis.[27] Improvement of healthcare and operative techniques can decrease postoperative superficial SSIs and thus DPC may be required less.

Risk factors for postoperative SSI may subjectively influence a physician's judgment to apply or not apply DPC, other than wound classification (i.e., clean, clean-contaminated, contaminated, and dirty). Some risk factors (i.e., operative duration and ASA classification) other than wound classification have been validated and included in risk classification scores by NNIS[4] for better prediction of postoperative superficial SSI. However, some other risk factors that can influence a physician's judgment to apply DPC have not been studied with regards to their magnitude of association. These include the degree of wound contamination (e.g., degree of intraoperative contamination of incision with pus or feculent content), and the host defense mechanism (i.e., subcutaneous fat thickness, age, immunosuppressive, diabetes, and other comorbidity). More accurate risk classification scores, by including all possible risk factors, can help a physician to more accurately estimate the probability of postoperative superficial SSI and lead to better wound management decisions.

Our study was a retrospective cohort which was prone to bias from the selection of patients. Since DPC was the standard wound management for ruptured appendicitis in our setting, only about 10% of patients received PC. Patients with a good prognosis might be selected by surgeons to received PC rather than DPC, thus resulting in an unbalanced prognosis between the groups. However, exploring the baseline characteristic of patients between the two groups suggested opposite trends to those expected, i.e., more patients with diabetes, the presence of pus, higher ASA class, intraoperative rupture, and a longer operative time were more common in the PC group than in the DPC group. Although these were not statistically significant, a few of them (i.e., operative time, diabetes) might be clinically meaningful. To prove PC efficacy with minimized bias, a further randomized controlled trial with a proper sample size is needed. Our study was also faced with a lack of power of detection of a difference in SSIs. With a sample size of 128, we had a power of test of only 62%; at least 224 patients are required to reach 80% power of test.

Although the mean re-suturing day was Day 4 after an operation, some wounds were sutured after 1 week, which did not meet with the standard practice of the 3rd to 7th day.[12,13,28] These patients may be appropriately managed by secondary intention, to prevent SSI after re-suturing. However, we did not find a difference in re-suturing day between SSI and non-SSI in the DPC group. Our results demonstrated that the risk of SSI after DPC is high (about 28%), which emphasized the necessity of developing decision criteria for re-suturing, and that some patients may benefit from secondary intention instead. Patients with low-risk ruptured appendicitis (e.g., non-diabetes, ASA classification 1—2, short operative time, minimal contamination) may be safely sutured closed.

5. Conclusion

Our study suggested that the risk of SSI in ruptured appendicitis was not different between PC and DPC techniques. Our results might be prone to selection and confounding biases, therefore, a further large scale randomized clinical trial, with good research methodology, should be conducted. Cost-utility analysis of PC versus DPC should be also further determined.

References

1. Lee JH, Park YS, Choi JS. The epidemiology of appendicitis and appendectomy in South Korea: national registry data. *J Epidemiol*. 2010;20:97—105.
2. Noudeh YJ, Sadigh N, Ahmadnia AY. Epidemiologic features, seasonal variations and false positive rate of acute appendicitis in Shahr-e-Rey, Tehran. *Int J Surg*. 2007;5:95—98.
3. Jaffe BM, Beger DH. The Appendix. In: Brunicardi FC, ed. *Schwartz's Principles of Surgery*. United States of America: McGraw-Hill Books; 2010:1073—1092.
4. National Nosocomial Infections Surveillance (NNIS) System Report. Data summary from January 1992 through June 2004, issued October 2004. *Am J Infect Control*. 2004;32:470—485.
5. Urban JA. Cost analysis of surgical site infections. *Surg Infect (Larchmt)*. 2006;7(Suppl. 1):S19—S22.
6. Penel N, Lefebvre JL, Cazin JL, et al. Additional direct medical costs associated with nosocomial infections after head and neck cancer surgery: a hospital-perspective analysis. *Int J Oral Maxillofac Surg*. 2008;37:135—139.
7. Olsen MA, Chu-Ongsakul S, Brandt KE, Dietz JR, Mayfield J, Fraser VJ. Hospital-associated costs due to surgical site infection after breast surgery. *Arch Surg*. 2008;143:53—60 discussion 61.
8. Souba WW, Fink MP, Jurkovich GJ, Kaiser LR, Pearce WH, Pemberton JH, Soper NJ, eds. *ACS Surgery Principles and Practice*. 6th ed. WebMD; 2007.
9. Kirby JP, Mazuski JE. Prevention of surgical site infection. *Surg Clin North Am*. 2009;89:365—389 viii.
10. Cohn SM, Giannotti G, Ong AW, et al. Prospective randomized trial of two wound management strategies for dirty abdominal wounds. *Ann Surg*. 2001;233:409—413.
11. Duttaroy DD, Jitendra J, Duttaroy B, et al. Management strategy for dirty abdominal incisions: primary or delayed primary closure? A randomized trial. *Surg Infect (Larchmt)*. 2009; 10:129—136.
12. Hepburn HH. Delayed primary suture of wounds. *Br Med J*. 1919;1:181—183.
13. Verrier ED, Bossart KJ, Heer FW. Reduction of infection rates in abdominal incisions by delayed wound closure techniques. *Am J Surg*. 1979;138:22—28.
14. Stone HH, Hester Jr TR. Incisional and peritoneal infection after emergency celiotomy. *Ann Surg*. 1973;177:669—678.
15. Weiss Y. Delayed closure in the management of the contaminated wound. *Int Surg*. 1982;67(4 Suppl.):403—404.
16. Burnweit C, Bilik R, Shandling B. Primary closure of contaminated wounds in perforated appendicitis. *J Pediatr Surg*. 1991; 26:1362—1365.
17. Horan TC, Andrus M, Dudeck MA. CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting. *Am J Infect Control*. 2008;36:309—332.
18. Ercole FF, Starling CE, Chianca TC, Carneiro M. Applicability of the national nosocomial infections surveillance system risk index for the prediction of surgical site infections: a review. *Braz J Infect Dis*. 2007;11:134—141.
19. Henry MC, Moss RL. Primary versus delayed wound closure in complicated appendicitis: an international systematic review and meta-analysis. *Pediatr Surg Int*. 2005;21:625—630.
20. Lahat G, Tulchinsky H, Goldman G, Klauzner JM, Rabau M. Wound infection after ileostomy closure: a prospective randomized study comparing primary vs. delayed primary closure techniques. *Tech Coloproctol*. 2005;9:206—208.
21. Iqbal M, Khan JA, Shafique ur R, et al. Comparative study of potentially contaminated wound healing in primarily applied skin stitches and delayed primary closure. *J Coll Physicians Surg Pak*. 1999;9:480—482.
22. Smilanich RP, Bonnet I, Kirkpatrick JR. Contaminated wounds: the effect of initial management on outcome. *American Surgeon*. 1995;61:427—430.
23. Russell GG, Henderson R, Arnett G. Primary or delayed closure for open tibial fractures. *J Bone Joint Surg Br*. 1990;72: 125—128.
24. Chatwiriyacharoen W. Surgical wound infection post surgery in perforated appendicitis in children. *J Med Assoc Thai*. 2002;85: 572—576.

25. Khammash M, Ayyash K. Wound infection in primary versus delayed primary wound closure in cases of perforated and gangrenous appendicitis. *Saudi Med J*. 1994;15:408—410.
26. Chiang RA, Chen SL, Tsai YC, Bair MJ. Comparison of primary wound closure versus open wound management in perforated appendicitis. *J Formos Med Assoc*. 2006;105:791—795.
27. Brasel KJ, Borgstrom DC, Weigelt JA. Cost-utility analysis of contaminated appendectomy wounds. *J Am Coll Surg*. 1997; 184:23—30.
28. Fogdestam I. A biomechanical study of healing rat skin incisions after delayed primary closure. *Surg Gynecol Obstet*. 1981;153: 191—199.