ORIGINAL ARTICLE

การศึกษาแบบย้อนหลังเรื่องปัจจัยเสี่ยงของการติดเชื้อที่แผลผ่าตัดไส้ติ่งอักเสบในผู้ป่วยเด็กที่โรงพยาบาลวชิระ

Retrospective Study for Risk Factors of Surgical Site infection After Appendectomy in Pediatric Patients at Vajira Hospital

จิตรลดา โกญจนาท, พ.บ., ว.ว.กุมารศัลยศาสตร์

Jitlada Konjanat, M.D., Dip.Thai Board of Pediatric Surgery

ภาควิชาศัลยศาสตร์ คณะแพทยศาสตร์วชิรพยาบาล มหาวิทยาลัยนวมินทราธิราช

Department of Surgery, Faculty of Medicine, Navamindradhiraj

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บทคัดย่อ

ที่มาของปัญหา: ภาวะแทรกซ้อนที่พบเป็นส่วนใหญ่ของการผ่าตัดทางศัลยกรรม คือ แผลผ่าตัดมีการอักเสบติดเชื้อ ส่งผลให้ระยะเวลานอนโรงพยาบาลนานขึ้นและค่ารักษามากขึ้น การผ่าตัดไส้ติ่งอักเสบเป็นการผ่าตัดที่พบได้บ่อยทางศัลยกรรมและพบว่าหลังผ่าตัดมีการเกิดแผลผ่าตัดไส้ติ่งอักเสบติดเชื้อได้บ่อย ถึงแม้ว่าจะมีการให้ยาปฏิชีวนะก่อนผ่าตัดเพื่อป้องกันการติดเชื้อที่แผลผ่าตัดการเกิดแผลผ่าตัดติดเชื้อก็ยังพบได้บ่อย และทำให้เกิดความไม่สบายกับผู้ป่วย

วัตถุประสงค์: เพื่อศึกษาปัจจัยเสี่ยงของการเกิดแผลผ่าตัดไส้ติ่งอักเสบติดเชื้อในผู้ป่วยเด็กที่โรงพยาบาลวชิระ ในช่วงระยะเวลา 5 ปี

วิธีการศึกษา: เป็นการศึกษาโดยการเก็บข้อมูลย้อนหลังในผู้ป่วยเด็กอายุ 0-15 ปี ที่เข้ารับการผ่าตัดไส้ติ่งอักเสบในโรงพยาบาลวชิระ ระหว่างมกราคม พ.ศ. 2560 ถึงธันวาคม พ.ศ. 2564 โดยการเก็บข้อมูลทั่วไปของผู้ป่วย การวินิจฉัยโรค ลักษณะที่พบจากการผ่าตัด ปัจจัยที่เกี่ยวข้องกับโรค เพื่อนำมาวิเคราะห์ทางสถิติ

ผลการศึกษา: มีผู้ป่วยเด็กทั้งหมด 335 ราย ที่ได้เข้ารับการผ่าตัดพบว่ามีแผลผ่าตัดไส้ติ่งอักเสบติดเชื้อในผู้ป่วย 15 ราย (ร้อยละ 4.4) จากการวิเคราะห์ตัวแปรตัวเดียวทางสถิติพบว่าระยะเวลาการผ่าตัดมากกว่า 60 นาที และค่าดัชนีมวลกายต่ออายุตั้งแต่เปอร์เซ็นไทล์ที่ 95 หรือมากกว่าสัมพันธ์กับการเกิดแผลผ่าตัดติดเชื้อ เมื่อวิเคราะห์การถดถอยโลจิสติคแบบสองกลุ่มพบว่าค่าดัชนีมวลกายต่ออายุตั้งแต่เปอร์เซ็นไทล์ที่ 95 หรือมากกว่าจะมีความสัมพันธ์กับการเกิดแผลผ่าตัดไส้ติ่งอักเสบติดเชื้อในผู้ป่วยเด็กอย่างมีนัยสำคัญ (OR 4.58;95%CI 1.13-18.54)

สรุป: ค่าดัชนีมวลกายต่ออายุตั้งแต่เปอร์เซ็นไทล์ที่ 95 หรือมากกว่า (ภาวะเด็กอ้วน) เป็นปัจจัยเสี่ยงที่สำคัญของการเกิดแผลติดเชื้อหลังผ่าตัดไส้ติ่งอักเสบในผู้ป่วยเด็ก

คำสำคัญ: แผลผ่าตัดติดเชื้อ, การผ่าตัดไส้ติ่ง, ดัชนีมวลกายต่ออายุ, ภาวะอ้วน

ABSTRACT

BACKGROUND: The most common complication of a surgical operation is surgical site infection (SSI). SSI is associated with an increased length of stay and healthcare cost. Appendectomy is the most common surgical operation and infections at the site of the surgery are the most frequently observed complications following an appendectomy. Although antibiotic prophylaxis would be used, the wound infection at the surgical incision could increase morbidity in the patients.

OBJECTIVE: This study sought to assess the risk factors associated with postoperative infections at the site of the surgery after an appendectomy in pediatric patients at Vajira Hospital, Bangkok, Thailand over a five-year period.

METHODS: A retrospective study of appendectomy patients aged from 0 to 15 years whose appendicitis treatment was performed from January 2017 to December 2021, at Vajira Hospital. The demographic data of the patients, diagnosis, operative findings, and disease-related factors were analyzed.

RESULTS: The sample comprised 335 pediatric patients. Fifteen patients (4.4%) developed an SSI. In the univariable analysis, the longer operative time >60 minutes and the BMI for age of a 95th percentile or greater was associated with SSI. After binary logistic regression analysis, the BMI for age of the 95th percentile or higher showed a significant risk of infection at the site of surgery (OR 4.58; 95%CI 1.13-18.54).

CONCLUSIONS: BMI for age of the 95th percentile or greater (obesity) was the risk factor for SSI after an appendectomy in pediatric patients.

KEYWORDS: surgical site infection, appendectomy, BMI for age, obesity

INTRODUCTION

Acute abdominal pain from a surgical condition in developed countries is often caused by acute appendicitis,[1] which the conventional treatment is an appendectomy.[2,3] The prevalence rate of surgical site infection (SSI) after appendectomy in Brazil, China, Sweden, and the United States has been described as 7.2%, 6.2%, 5.9%, and 2.9%, respectively[4]. The risk of an SSI has been based on multiple factors, such as age and comorbidities of the patient, operative time, wound classification, and antibiotic prophylaxis.[5] Several studies have also reported that obese patients face an elevated risk of infection at the site of surgery.[6] Additionally, SSI considerably increases the hospital stay and cost.[7] Hence, accurate surveillance of SSI would be helpful for the management and setting up of risk stratification.[8] Therefore, this research study was conducted in order to evaluate the various risk factors associated with infection at the site of surgery after an appendectomy in children.

METHODS

This research took the format of a retrospective case control study involving appendectomy patients aged under 15 years whose surgery was carried out at Vajira Hospital, Bangkok, Thailand from January 2017 to December 2021. Patients with acute appendicitis who underwent an appendectomy were included in the study, whereas patients who underwent an appendectomy for chronic appendicitis or carcinoma were excluded. The data were collected from complete medical records that included the patient's characteristics, duration of the symptoms, temperature, laboratory findings, operative records, and pathological report to the case record form. Antibiotic prophylaxis before surgery was used to prevent SSI in all patients. Most patients received 50 mg/kg/dose of ceftriaxone and 10 mg/kg/dose of metronidazole intravenously within half an hour before the surgical incision. Demographic and preoperative data, such as age, gender, BMI for age, ASA classification, white blood cell (WBC) count, body temperature, the time from the onset of the symptoms until surgery, operative time, and severity of the appendicitis were recorded. The patients were divided into an SSI group and non SSI group. SSI was described according to the Centers for Disease Control and Prevention (CDC)'s definition. Most patients were operated on by an open appendectomy through an oblique (Gridiron's incision) or transverse incision (McBurney's incision) at the right lower quadrant of the abdomen. Most patients with a gangrenous or ruptured appendix received a postoperative intravenous antibiotic for 3-5 days to reduce any postoperative complications. Data analysis was performed using SPSS. The characteristic data pertaining to the patients in the study were displayed appropriately in the form of percentages, mean ± standard deviation, or median (range). The differences among the data groups were analyzed through the application of using a Chi-square test, Fisher's exact test, unpaired t-test, or Mann-Whitney U test in accordance with the type of data involved. Univariate analysis of the SSI risk factors was carried out using binary logistic regression. Factors with $p<0.20$ were included with the multivariate analysis. Adjusted odds ratios and 95% confidence intervals (95%CI) were then determined via the use of multivariate logistic regression models, thus allowing the risk factors to undergo analysis following adjustment to take the effects of the confounding factors into consideration. The statistical significance was indicated by $p<0.05$.

RESULTS

The sample comprised 335 pediatric patients (aged 0-15 years) who underwent an appendectomy. The demographic data of the patients are shown in Table 1. The sample consisted of 58.2% of males, whereas females comprised 41.8%. The mean age was 11.0±2.9 years. Most patients (98.5%) had no disease comorbidities and were categorized in

ASA classification 1, but five cases (1.5%) were ASA classification 2. Most patients were operated on by open appendectomy, and three cases were operated on by laparoscopic appendectomy. Eighty patients (23.9%) had a complicated appendix, 49 patients were diagnosed with a ruptured appendix, and 31 patients were diagnosed with a gangrenous appendix. SSI was found in 15 cases (4.4%), 14 patients (93.3%) developed superficial SSI, and one patient developed deep SSI. The first physical examination showed that the mean body temperature was not significantly different compared to non SSI patients (37.7±0.9vs 37.6±0.9; p=0.63). The mean time from the onset of the symptoms to the surgical operation was 40.4±33.7 hours and 28.8±18.5 hours, respectively for patients with SSI versus non SSI (p=0.22). The patients with a ruptured appendix were not significantly different. The patients with SSI had a significant longer operative time >60 minutes than those in the non SSI group (p<0.05). The BMI for age was a 95th percentile or greater (obesity) that was significantly greater in the SSI group (p<0.05). There was a significantly longer period recorded for the length of stay in the SSI group than for the non SSI group (p<0.001). The results obtained for the binary logistic regression analysis are shown in Table 2. The BMI for age of the 95th percentile or greater (obesity) showed an independent relationship to SSI (OR 4.58; 95%CI 1.13-18.54) (p=0.03).

Table 1 Patient's characteristics according to SSI.

Demographic Data	Overall (n=335)	SSI (n=15)	Non SSI (n=320)	*p*-value
Gender				0.50
Male	195 (58.2)	10 (66.7)	185 (57.8)	
Female	140 (41.8)	5 (33.3)	135 (42.2)	
Age (Years)	11.0±2.9	10.7±2.6	11.0±3.0	0.74
BMI (kg/m^2)	19.4±4.4	21.0±6.1	19.3±4.3	0.14
BMI for Age				0.19
<5th percentile (underweight)	34 (10.1)	1 (6.7)	33 (10.3)	
5th to <85th percentile (normal)	185 (55.2)	6 (40.0)	179 (55.9)	
85th to <95th percentile (overweight)	68 (20.3)	3 (20.0)	65 (20.3)	
95th percentile or over (obesity)	48 (14.3)	5 (33.3)	43 (13.4)	
BMI for Age				<0.05
Non-obesity	287 (85.7)	10 (66.7)	277 (86.6)	
obesity	48 (14.3)	5 (33.3)	43 (13.4)	
ASA				0.63
Class 1	330 (98.5)	15 (100.0)	315 (98.4)	
Class 2	5 (1.5)	0 (0.0)	5 (1.6)	
Onset of the symptoms to the operation (Hours)	29.3±19.5	40.4±33.7	28.8±18.5	0.22
>24 hours	143 (42.7)	9 (60.0)	134 (41.9)	0.17
Body temperature (°C)	37.6±0.9	37.7±0.9	37.6±0.9	0.63
Fever temperature > 38°C	109 (32.5)	8 (53.3)	101 (31.6)	0.08
WBC count (10^3/uL)	15.5 (12.5-18.9)	13.5 (11.1-17.0)	15.6 (12.5-18.9)	0.10
>16,000 cell/uL	157 (46.9)	5 (33.3)	152 (47.5)	0.28
Appendix				0.17
Gangrenous	31 (9.3)	2 (13.3)	29 (9.1)	
Inflamed	153 (45.7)	5 (33.3)	148 (46.3)	
Suppurative	102 (30.4)	3 (20.0)	98 (30.9)	
Ruptured	49 (14.6)	5 (33.3)	44 (13.8)	

Table 1 Patient's characteristics according to SSI.

Demographic Data	Overall (n=335)	SSI (n=15)	Non SSI (n=320)	*p*-value
Appendix				0.05
Non-ruptured	286 (85.4)	10 (66.7)	276 (86.2)	
Ruptured	49 (14.6)	5 (33.3)	44 (13.8)	
Operative time (Minutes)	60 (60-90)	80 (60 -90)	60 (60-90)	0.25
>60 minutes	98 (29.3)	8 (53.3)	90 (28.1)	<0.05
Length of stay (Days)	3 (3-4)	22 (12-30)	3 (3-4)	<0.001
>3 days	165 (49.3)	14 (93.3)	151 (47.2)	<0.001

Data are shown as a percentage, mean ± standard deviation, or median (inter-quartile range).

Table 2 Outcome of the risk factors for SSI by univariate and multivariate analyses.

Predictors	Univariate Analysis		Multivariate Analysis	
	Unadjusted OR (95% CI)	*p*-value	Adjusted OR (95% CI)	*p*-value
BMI for Age		0.04		0.03
Non-obesity	Reference		Reference	
obesity	3.22 (1.05, 9.88)		4.58 (1.13, 18.54)	
Onset of the symptoms to the operation (Hours)		0.17		0.96
≤24 hours	Reference		Reference	
>24 hours	1.97 (0.67, 5.81)		0.97 (0.29, 3.20)	
Body temperature		0.08		0.45
≤38 °C	Reference		Reference	
>38 °C	2.48 (0.88, 7.02)		1.55 (0.50, 4.78)	
Appendix		0.05		0.26
Non-ruptured	Reference		Reference	
Ruptured	3.14 (1.02, 9.61)		2.16 (0.57, 8.24)	
Operative time (Minutes)		0.04		0.21
≤60 minutes	Reference		Reference	
>60 minutes	2.92 (1.03, 8.29)		2.06 (0.67, 6.35)	
Length of stay (Days)		<0.001		0.02
≤3 days	Reference		Reference	
>3 days	15.67 (2.04, 120.58)		12.14 (1.44, 102.05)	

Table 3 Subgroup analysis of the BMI for age and appendicitis.

	No SSI (n=320) n (%)	SSI (n=15) n (%)	Odds Ratio (95% CI)	*p*-value
BMI for age and appendicitis				
Non-obesity and non-ruptured	235 (97.5)	6 (2.5)	Reference	
Non-obesity and ruptured	42 (91.3)	4 (8.7)	3.73 (1.01, 13.78)	0.05
Obesity and non-ruptured	41 (91.1)	4 (8.9)	3.82 (1.03, 14.13)	0.05
Obesity and ruptured	2 (66.7)	1 (33.3)	19.58 (1.55, 246.71)	0.02

Table 3 shows that the non-obesity patients with a ruptured appendix had an increased risk for SSI of 8.7%, obesity patients with a non-ruptured appendix had an increased risk for SSI of 8.9%, and obesity patients with ruptured appendix had an increased risk for SSI of 33.3%, which was more than

other groups and was statistically significant. The risk factor for SSI in obesity patients with a ruptured appendix was 19.6 times greater than non-obesity patients with a non-ruptured appendix.

DISCUSSION

SSI could be categorized as i) a superficial incisional SSI, ii) deep incisional SSI, or iii) organ/space SSI. The least severe of the three is the superficial incisional SSI, which is an infection at the surgical incision occurring within 30 days after surgery that involves only the surface of the skin and the subcutaneous tissue that lies just below the skin. In contrast, the deep incisional SSI refers to an infection which arises from 30 to 90 days after surgery that involves the muscle and fascia of the surgical wound.[9] This study showed the SSI appearing in 4.4% of pediatric patients after an appendectomy. The major associated factor of the SSI was the BMI for age that was of the 95th percentile or greater (obesity) (OR 4.58; 95%CI 1.13-18.54) (p<0.05). The ruptured appendix and operative time >60 minutes were not statistically significant in the multivariate analysis, which could be due to the small number of patients. The BMI value of children of the same age and gender was evaluated by the BMI for age. A child who has a percentile for age that is a 5th percentile or greater and less than an 85th percentile is classified as healthy weight. Overweight is defined as a BMI for age as an 85th percentile or greater and less than a 95th percentile. Obesity is defined as a BMI for age as a 95th percentile or greater[10]. Several studies have reported the higher risk of postoperative complications in obese patients. Delgado-Miguel et al. showed the higher risk of SSI in obese patients was twice as much as normal weight patients.[11] In addition, obese patients that have numerous adipose tissue would have a more difficult open surgery. Moreover, the intra-abdominal organ is large and enforcing special consideration in operative surgery, such as larger skin incision, would result in increased intraoperative blood loss.[12,13] Blackwood et al. studied postoperative wound infection in pediatric patients. Their study showed that children with an elevated BMI had an increased risk for surgical wound infection.[14] As such, the surgical option for pediatric obesity would be a laparoscopic appendectomy to reduce SSI because it would make a smaller incision. Mahmood et al. found that SSI in a laparoscopic appendectomy was less than that of an open appendectomy.[15]

Hence, the need to focus on SSI surveillance in the postoperative period, such as clinical monitoring and wound assessment, could possibly decrease the risk of SSI after an appendectomy in overweight children. Therefore, the data would be useful for evaluating pediatric patients for surgery and counseling the parents.

SSI is the cause of morbidity and mortality, as well as increases the length of stay and cost for healthcare. Additionally, obese children have an increased risk for SSI. However, this research study had limitations that it followed a retrospective approach. In addition, since the patient sample size was relatively small, the number of risk factors observed would be similarly limited, thus potentially affecting the general applicability of the statistical analysis. Thus, a multicenter study with a large population size would provide better generalizability of the outcomes.

Conflicts of interest: none

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Reference

1. Birnbaum BA, Wilson SR. Appendicitis at the millennium. Radiology 2000;215:337–48.
2. Ansaloni L, Catena F, Coccolini F, Ercolani G, Gazzotti F, Pasqualini E, et al. Surgery versus conservative antibiotic treatment in acute appendicitis: a systematic review and meta-analysis of randomized controlled trials. Dig Surg 2011;28:210–21.
3. Paajanen H, Grönroos JM, Rautio T, Nordström P, Aarnio M, Rantanen T, et al. A prospective randomized controlled multicenter trial comparing antibiotic therapy

with appendectomy in the treatment of uncomplicated acute appendicitis (APPAC trial). BMC Surg [Internet]. 2013 [cited 2023 Apr 8];13:3. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3585698/pdf/1471-2482-13-3.pdf

4. Rosenthal VD, Richtmann R, Singh S, Apisarnthanarak A, Kübler A, Viet-Hung N, et al. Surgical site infections, International Nosocomial Infection Control Consortium (INICC) report, data summary of 30 countries, 2005-2010. Infect Control Hosp Epidemiol 2013;34:597–604.
5. Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for prevention of surgical site infection, 1999. Centers for disease control and prevention (CDC) hospital infection control practices advisory committee. Am J Infect Control 1999;27:97-132.
6. Dindo D, Muller MK, Weber M. Obesity in general elective surgery. Lancet 2003;362(9383): 577-8.
7. Sullivan E, Gupta A, Cook CH. Cost and consequences of surgical site infections: a call to arms. Surg Infect 2017;18:451–4.
8. Collins GS, Reitsma JB, Altman DG, Moons KG. Transparent Reporting of a multivariable prediction model for Individual Prognosis Or Diagnosis (TRIPOD): the TRIPOD Statement. Br J Surg 2015;102: 148–58.
9. National Healthcare Safety Network (NHSN). Patient Safety Component Manual [Internet]. Atlanta: NHSN; 2023. Chapter 9, Surgical Site Infection Event (SSI). [cited 2023 Apr 8]. Available from: https://www.cdc.gov/nhsn/pdfs/pscmanual/pcsmanual_current.pdf
10. Chung S. Body mass index and body composition scaling to height in children and adolescent. Ann Pediatr Endocrinol Metab 2015;20:125–9.
11. Delgado-Miguel C, Muñoz-Serrano AJ, Barrena Delfa S, Núñez Cerezo V, Velayos M, Estefanía K, et al. Influence of overweight and obesity on acute appendicitis in children. A cohort study. Cir Pediatr 2020;33:20-4.
12. Meijs AP, Koek MBG, Vos MC, Geerlings SE, Vogely HC, de Greeff SC, et al. The effect of body mass index on the risk of surgical site infection. Infect Control Hosp Epidemiol 2019; 40:991-6.
13. Thelwall S, Harrington P, Sheridan E, Lamagni T. Impact of obesity on the risk of wound infection following surgery: Results from a nationwide prospective multicentre cohort study in England. Clin Microbiol Infect [Internet]. 2015 [cited 2023 Apr 8]; 21(11):1008.e1-8. Available from: https://www.clinicalmicrobiologyandinfection.com/article/S1198-743X(15)00719-3/fulltext
14. Blackwood BP, Gause CD, Harris JC, Theodorou CM, Helenowski I, Lautz TB, et al. Overweight and obese pediatric patients have an increased risk of developing a surgical site infection. Surg Infect (Larchmt) 2017;18: 491-7
15. Mahmood MM, Shahab A, Razzaq MA. Surgical site infection in open versus laparoscopic appendectomy. Pakistan journal of medical and health sciences 2016;10:1076-8.