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ScienceDirect

Journal of the Chinese Medical Association 78 (2015) 395−399

www.jcma-online.com

Original Article

Appendectomy timing: Will delayed surgery increase the complications?

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Received December 9, 2013; accepted February 3, 2015

Abstract

Background: This study investigated whether the time from emergency room registration to appendectomy (ETA) would affect the incidence of perforation and postoperative complications in patients with acute appendicitis.
Methods: Patients who underwent an appendectomy at the Ren-Ai branch of Taipei City Hospital between January 2010 and October 2012 were retrospectively reviewed. Their demographics, white blood cell count, C-reactive protein, body temperature, computed tomography scan usage, operation method, pathology report, postoperative complication, length of hospital stay, and ETA were abstracted. Multivariate analysis was performed to search the predictors, including ETA, of outcomes for the perforation and postoperative complication rates.
Results: A total of 236 patients were included in the study. Perforation occurred in 12.7% (30/236) and postoperative complications developed in 24.1% (57/236) of these patients. There were 121 patients with ETA <8 hours, 88 patients with ETA of 8−24 hours, and 27 patients with ETA >24 hours; patients with ETA >24 hours had significantly longer hospital stay. Univariate analysis showed that perforated patients were significantly older, and had higher C-reactive protein level, longer hospital stay, and higher complication rate. Patients who developed postoperative complications were significantly older, and had higher neutrophil count, less use of computed tomography, and higher open appendectomy rate. After multivariate analysis, age ≥55 years was the only predictor for perforation [odds ratio (OR) = 3.65; 95% confidence interval (CI), 1.54−8.68]; for postoperative complications, age ≥55 years (OR = 1.65; 95% CI, 1.84−3.25), perforated appendicitis (OR = 3.17; 95% CI, 1.28−7.85), and open appendectomy (OR = 3.21; 95% CI, 1.36−7.58) were associated. ETA was not a significant predictor in both analyses.
Conclusion: In our study, it was observed that although longer ETA was associated with longer hospitalization, ETA was not correlated with postoperative complications. Our results inclined toward the position that appendectomy can be performed as a semielective surgery.

Keywords: appendectomy; complication; delay; outcome

1. Introduction

Acute appendicitis, the term we use today and the pathophysiological abnormality we understand in the 21st century, is attributed to Fitz.[1] Appendicitis remains one of the most common conditions requiring acute surgical intervention.[2] The time-honored notion that the "goal should be to accelerate diagnosis and to operate before perforation occurs" has been challenged from child groups to adult groups in the past 5−10 years.[3] Recent studies suggest that after antibiotics therapy has been initiated, appendicitis can be managed with a semielective strategy.[4−7] Appendectomy in the daytime decreases the use of nursing, anesthesia, and surgical staff during the night hours and may prevent medical errors from overloading. However, some studies show that delayed appendectomy is unsafe and increases the risk of surgical site infection in patients with nonperforated appendicitis.[8,9]

Conflicts of interest: The authors declare that there are no conflicts of interest related to the subject matter or materials discussed in this article.

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http://dx.doi.org/10.1016/j.jcma.2015.04.001

Further study is required to clarify the controversy. The present study was designed to evaluate the association between the time from emergency room to the performance of appendectomy and the rates of perforation and postoperative complications.

2. Methods

After gaining approval from the institutional review board of the Ren-Ai branch of Taipei City Hospital, Taipei, Taiwan, we made a retrospective review of the records of all patients diagnosed with appendicitis who were admitted to the Ren-Ai branch of Taipei City Hospital, Taipei, Taiwan from January 2010 to October 2012. The hospital is a regional teaching hospital with surgical facilities available 24 hours a day and admits 100 patients with a diagnosis of acute appendicitis per year.

This study included all patients who underwent appendectomy after a preoperative diagnosis of acute appendicitis and were confirmed by postoperative pathological examination during the study period. We excluded patients who underwent negative appendectomy, incidental appendectomy, or interval appendectomy. Patient characteristics including age, sex, white blood cell count, C-reactive protein, body temperature at admission, abdominal computed tomography (CT) finding (if available), surgical approach (laparoscopic vs. open), time from emergency room to appendectomy (ETA), operation time, final pathology report, length of stay, and complications were obtained from medical records. Outcome measures included the presence of perforation and the development of complications. Complications were defined as the documented development of wound infection, intra-abdominal abscess, or septic shock until 4 weeks after discharge.

ETA was defined as the period from emergency department registration to the time of skin incision. For more than one-half of our patients who had ETA of <8 hours, we used 8 hours as the cut point for the immediate and early delayed surgery groups, and 24 hours for the late delayed surgery group. Patients were then divided into three groups. The first group consisted of appendectomy patients with ETA of <8 hours. Group 2 included appendectomy patients with ETA of 8−24 hours. Group 3 consisted of patients who had appendectomy >24 hours after emergency department registration.

Data analyses were performed using SPSS 17.0 for Windows (SPSS Inc., Chicago, IL, USA). All continuous data were expressed as mean ± standard deviation. One-way analysis of variance was used for comparison of independent continuous variables; Scheffe's test was used for *post hoc* examination. For categorical data, a cross table with the Chi-square test was used. To clarify the effect of ETA and other potential effectors on appendix perforation and postoperative complication, multiple logistic regression analysis was used. A p value of <0.05 was accepted as significant.

3. Results

A total of 236 patients with acute appendicitis underwent appendectomy at the Ren-Ai branch of Taipei City Hospital between January 2010 and October 2012. Perforation occurred in 12.7% (30/236) and postoperative complications developed in 24.1% (57/236) of these patients. There were 121 patients with ETA <8 hours, 88 with ETA of 8−24 hours, and 27 with ETA >24 hours; patients with ETA >24 hours had a significantly longer hospital stay ($p < 0.01$, compared with the other 2 groups; Table 1).

The overall mean age was 42.5 ± 19.1 years. Female patients accounted for 56.4% (133/236) and leukocytosis (>16,000) presented in 28.4% (67/236) of all patients. One hundred and forty-two (60.2%) patients received abdominal CT prior to the operation. No CT reports definitively described perforation of the appendicitis. Despite pathologic examination demonstrating the presence of perforation in 30 (12.7%) of the surgical specimens, none of the patients had a

Table 1
Patient characteristics and comparison between different ETA groups.

	ETA < 8 h (n = 121)	ETA 8−24 h (n = 88)	ETA > 24 h (n = 27)	p
Age (y)	43.7 ± 19.4	39.2 ± 18.5	48.0 ± 18.7	0.068
Female	65 (53.7)	52 (59.0)	16 (59.3)	0.669
WBC count	13,487 ± 5264	14,691 ± 4522	12,677 ± 3688	0.089
Neutrophil count (%)	80.4 ± 9.7	81 ± 8.5	79.5 ± 8.6	0.786
Lymphocyte count (%)	13.6 ± 9.7	13.0 ± 7.2	13.7 ± 7.2	0.865
CRP	37.4 ± 31.8	37.0 ± 35.2	50.2 ± 33.1	0.387
Body temperature (°C)	37.7 ± 1.2	37.9 ± 0.8	37.5 ± 0.9	0.319
With computed tomography	67 (55.4)	56 (63.6)	19 (70.4)	0.422
Operation method				0.706
Laparoscopic appendectomy	82 (67.5)	57 (64.8)	16 (59.3)	
Open appendectomy	39 (32.5)	31 (35.2)	11 (40.7)	
Complication				
Mortality	0	0	0	
Nil	86 (71.1)	69 (79.3)	23 (85.2)	0.176
Perforated appendicitis	16 (13.2)	10 (11.4)	4 (14.8)	0.864
Length of hospital stay (d)	5.0 ± 4.3	4.4 ± 2.2	8.0 ± 7.4	0.001

Data are presented as n (%) or mean ± SD.
CRP = C-reactive protein; ETA = time from emergency room to appendectomy; WBC = white blood cell count.

Table 2
Overall patient characteristics and comparison between nonperforated and perforated groups.

	Total (n = 236)	Nonperforated (n = 206)	Perforated (n = 30)	p
Age (y)	42.5 ± 19.1	41.4 ± 18.3	50.5 ± 22.8	0.015
Age ≥ 55 y	71 (30)	55 (26.7)	16 (53.3)	0.003
Female	133 (56.4)	119 (57.8)	14 (46.7)	0.252
WBC count	13,802 ± 4895	13,801 ± 4973	13,809 ± 4402	0.993
Leukocytosis of >16,000	67 (28.4)	60 (29.1)	7 (23.3)	0.511
Neutrophil count (%)	80.5 ± 9.9	80 ± 10.2	84.2 ± 7.0	0.034
Lymphocyte count (%)	13.4 ± 8.6	13.9 ± 8.8	10.3 ± 5.8	0.041
CRP	38.6 ± 33.1	36.2 ± 33	53.1 ± 30.7	0.039
Body temperature (°C)	37.7 ± 1.0	37.7 ± 1.0	38.0 ± 1.1	0.119
With computed tomography	142 (60.2)	124 (60.2)	18 (60)	0.377
ETA				
≤8 h	121 (51.3)	105 (50.7)	16 (58.4)	
8–24 h	88 (37.3)	78 (38.1)	10 (33.3)	
>24 h	27 (11.4)	23 (11.2)	4 (13.3)	
Operation method				0.142
Laparoscopic appendectomy	154 (65.2)	138 (67.0)	16 (53.3)	
Open appendectomy	82 (34.8)	68 (33.0)	14 (46.7)	
Complication				
Mortality	0	0	0	
Nil	178 (75.7)	163 (79.1)	15 (51.7)	0.001
Wound infection	37 (15.7)	27 (13.1)	10 (34.5)	
Intra-abdominal abscess	10 (4.3)	8 (3.9)	2 (6.9)	
Septic shock	2 (0.9)	1 (0.5)	1 (3.5)	
Others	8 (3.4)	7 (3.4)	1 (3.5)	
Length of hospital stay (d)	5.1 ± 4.3	4.8 ± 3.6	7.2 ± 6.9	0.004

Data are presented as n (%) or mean ± SD.
CRP = C-reactive protein; ETA = time from emergency room to appendectomy; WBC = white blood cell count.

preoperative diagnosis of perforated appendicitis. Overall, 154 (65.2%) of the appendectomies were performed as laparoscopic procedures (Table 2).

The patients with perforated appendicitis were more likely to be aged ≥ 55 years (53.3% vs. 26.7%, $p = 0.003$) and more likely to have higher neutrophil count, lower lymphocyte count, and higher C-reactive protein than patients without perforation (Table 2). The length of ETA was not significantly different between the two groups. Open appendectomy was more frequently chosen in perforated appendicitis (46.7% vs. 33.0%), although no significant difference was observed ($p = 0.142$). Comparison of outcomes between the two groups demonstrated that patients with perforated appendicitis were more likely to develop complications ($p = 0.001$), such as intra-abdominal abscess (6.9% vs. 3.9%) and sepsis (3.5% vs. 0.5%), and more likely to have a significantly longer hospitalization (7.2 ± 6.9 days vs. 4.8 ± 3.6 days, $p = 0.004$; Table 2). After logistic regression was applied, only age ≥ 55 years (odds ratio = 3.65; 95% confidence interval, 1.54–8.68) remained significant (Table 3).

Table 3
Predictors of perforated appendicitis after logistic regression.

Factor	Adjusted OR (95% CI)	p
Age ≥ 55 y	3.65 (1.54–8.68)	0.003
Female	0.64 (0.29–1.38)	0.255
Leukocytosis (>16,000)	1.67 (0.89–3.16)	0.111
ETA (>8 h)	1.11 (0.45–2.75)	0.824

CI = confidence interval; ETA = time from emergency room to appendectomy; OR = odds ratio.

Table 4
Comparison of characteristics between patients with and without complications.

	Without (n = 179)	With (n = 57)	p
Age (y)	41.0 ± 18.1	46.7 ± 21.2	0.047
Age ≥ 55 y	46 (25.8)	24 (42.1)	0.02
Female	106 (59.6)	26 (45.6)	0.065
WBC count	13,613 ± 4872	14,498 ± 4942	0.239
Leukocytosis of >16,000	46 (25.8)	21 (36.8)	0.109
Neutrophil count (%)	79.8 ± 10.0	83.0 ± 9.5	0.04
Lymphocyte count (%)	14.0 ± 8.6	11.4 ± 8.1	0.051
CRP	35.9 ± 29.3	45.4 ± 39.8	0.17
Body temperature (°C)	37.6 ± 0.9	38.0 ± 1.2	0.039
With computed tomography	114 (64.0)	27 (47.4)	0.017
ETA			0.176
≤8 h	86 (48.0)	35 (61.4)	
8–24 h	69 (39.0)	18 (31.6)	
>24 h	23 (13.0)	4 (7.0)	
Operation method			0.001
Laparoscopic appendectomy, n (%)	127 (70.8)	27 (47.4)	
Open appendectomy, n (%)	52 (29.2)	30 (52.6)	
Perforated appendicitis, n (%)	15 (8.4)	14 (24.6)	0.001
Length of hospital stay, mean ± SD (d)	4.3 ± 2.1	7.7 ± 7.3	0.001

Data are presented as n (%) or mean ± SD.
CRP = C-reactive protein; ETA = time from emergency room to appendectomy; WBC = white blood cell count.

Table 5
Factors associated with complication after logistic regression.

Factor	Adjusted OR (95% CI)	p
Age ≥ 55 y	1.65 (1.84–3.25)	0.008
Female	0.57 (0.29–1.09)	0.149
Leukocytosis (>16,000)	1.67 (0.89–3.16)	0.111
ETA (>8 h)	0.58 (0.28–1.19)	0.071
Perforated appendicitis	3.17 (1.28–7.85)	0.018
Open appendectomy	3.21 (1.36–7.58)	0.013

CI = confidence interval; ETA = time from emergency room to appendectomy; OR = odds ratio.

Patients who developed complications were more likely to be older, and to have higher neutrophil count, higher body temperature, higher open appendectomy rate, higher perforation rate, and longer hospitalization than patients without complications (Table 4). ETA was not significantly associated with development of complication(s). After logistic regression analysis, age ≥ 55 years, perforated appendicitis, and open appendectomy were found to be independently associated with an increase in development of complications (Table 5).

4. Discussion

Studies have suggested that delayed appendectomy for acute appendicitis is unsafe because of the risk of developing advanced pathology and postoperative complications increasing with time following the appearance of symptoms.[8] Recently, more and more evidence has shown a conservative attitude toward urgent—but not emergency—surgery for acute appendicitis. The large study by Teixeira et al[9] demonstrated that delayed appendectomy did not increase the risk of perforation but was associated with a significantly increased risk of surgical site infection in patients with nonperforated appendicitis. Other recent studies suggested that delayed appendectomy does not result in increased morbidity and that appendicitis could be managed as a semielective condition.[4–7] Yardeni et al[4] demonstrated that a semielective approach to acute appendicitis affords a better work environment for the entire operating room team and has substantial implications for health care workers in case of work-hours limitations.

The findings in our study demonstrated that delay of appendectomy (>8 hours after ER admission) did not increase the appendix perforation and postoperative complication rate, although there was a trend toward significance ($p = 0.071$, Table 5) in the prediction of postoperative complications. Our findings supported the semielective attitude in approaching patients with acute appendicitis, despite ETA of >24 hours being associated with longer hospitalization stay. The longer hospitalization without significantly increased complication rate in the group of patients with ETA >24 hours might be attributed to the patients' (older) age in this population (Table 1). Although we did not analyze the comorbidity in this study, the higher incidence of comorbidity in the elderly might result in longer hospital stay.

Increased postoperative complications, with or without perforation of the appendicitis, have been attributed to a negative impact on outcome associated with delayed appendectomy. Busch et al[10] found that an appendectomy delayed for >12 hours was associated with a significant increase in the rate of perforations (30% vs. 23%, $p = 0.01$). However, in our study, delayed appendectomy was not a factor of perforation, which is in agreement with Teixerira et al,[9] who demonstrated that delays of up to 48 hours were not associated with increased perforation rates.

In our study, we found that age (>55 years) was the only important risk factor for perforation and one of the predictors for postoperative complication besides perforated appendicitis and open appendectomy. Decreased immune defense and physiology reserve from stress, the more ambiguous symptoms of appendicitis, and presence of comorbidity can all culminate in a higher incidence of complication rate in older patients. Our results indicated that a more sophisticated management approach for acute appendicitis would be needed in older patients. ETA did not seem to alter the outcome despite age being controlled in the present analysis; however, the sample size in this subgroup may not be large enough to reach statistical significance.

Controversial results have also demonstrated that delayed appendectomy did not increase the length of hospital stay.[4,11] Our study, meanwhile, revealed that appendectomy delayed >24 hours increased the length of hospital stay. This result was in agreement with that reported by Omundsen and Dennett,[12] who demonstrated that appendectomy delayed >24 hours increased the postoperative length of stay. Ingraham et al's[7] population-based study using the American College of Surgeons National Surgical Quality Improvement Program database likewise showed a compatible result.

The present study has several limitations. This was a retrospective study, and the number of patients involved may not be large enough to avoid type 2 errors in statistics. Because the diagnosis and surgical decision were dependent solely on the decisions of consulted surgeons, we could not evaluate, in a retrospective manner, the reasons for the different ETA periods. Moreover, the ETA did not reflect the time that lapsed from initial symptoms to the operation, which may be more accurate in evaluating the interplay of time delay and appendicitis complications. Although a prospective-design study may clarify the debate, our study did not find that delayed appendectomy had a negative impact on patients except for the longer hospitalization.

In conclusion, in our study, although longer ETA led to a longer hospitalization, ETA was not correlated with postoperative complications. Our results incline toward the position that appendectomy can be performed as a semielective surgery.

References

1. Fitz RH. Perforating inflammation of the vermiform appendix, with special reference to its early diagnosis and treatment. *Trans Assoc Am Physicians* 1886;**1**:107–44.
2. Owings MF, Kozak LJ. Ambulatory and inpatient procedures in the United States, 1996. *Vital Health Stat* 1998;**13**:1–119.
3. Berry Jr J, Malt RA. Appendicitis near its centenary. *Ann Surg* 1984;**200**:567–75.

4. Yardeni D, Hirschl RB, Drongowski RA, Teitelbaum DH, Geiger JD, Coran AG. Delayed versus immediate surgery in acute appendicitis: do we need to operate during the night? *J Pediatr Surg* 2004;**39**:464−9.
5. Stahlfeld K, Hower J, Homitsky S, Madden J. Is acute appendicitis a surgical emergency? *Am Surg* 2007;**73**:626−9.
6. Kearney D, Cahill RA, O'Brien E, Kirwan WO, Redmond HP. Influence of delays on perforation risk in adults with acute appendicitis. *Dis Colon Rectum* 2008;**51**:1823−7.
7. Ingraham AM, Cohen ME, Bilimoria KY, Ko CY, Hall BL, Russell TR, et al. Effect of delay to operation on outcomes in adults with acute appendicitis. *Arch Surg* 2010;**145**:886−92.
8. Ditillo MF, Dziura JD, Rabinovici R. Is it safe to delay appendectomy in adults with acute appendicitis? *Ann Surg* 2006;**244**:656−60.
9. Teixeira PG, Sivrikoz E, Inaba K, Talving P, Lam L, Demetriades D. Appendectomy timing: waiting until the next morning increases the risk of surgical site infections. *Ann Surg* 2012;**256**:538−43.
10. Busch M, Gutzwiller FS, Aellig S, Kuettel R, Metzger U, Zingg U. In-hospital delay increases the risk of perforation in adults with appendicitis. *World J Surg* 2011;**35**:1626−33.
11. Abou-Nukta F, Bakhos C, Arroyo K, Koo Y, Martin J, Reinhold R, et al. Effects of delaying appendectomy for acute appendicitis for 12 to 24 hours. *Arch Surg* 2006;**141**:504−6.
12. Omundsen M, Dennett E. Delay to appendectomy and associated morbidity: a retrospective review. *ANZ J Surg* 2006;**76**:153−5.