



ORIGINAL ARTICLE

# Does age affect the outcomes and management of pediatric appendicitis in Taiwan?



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## KEYWORDS

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**Abstract** *Background:* The comprehensive coverage offered by the Taiwan National Health Insurance program enabled us to effectively evaluate the effect of age on postoperative morbidity.

*Purposes:* To investigate whether age affected the outcomes and management of appendicitis in children in Taiwan.

*Methods:* We use the Collaboration Center for Health Information Application database to identify 21,827 patients  $\leq 18$  years of age with a diagnosis of acute appendicitis between 2007 and 2012 in Taiwan. Study outcomes included postoperative morbidity, undergoing laparoscopic appendectomy (LA) or open appendectomy (OA), and the length of hospitalization. Postoperative morbidity included the incidence of intra-abdominal abscesses (IAAs) and postoperative bowel obstructions (PBOs). Patients were divided into:  $\leq 6$ , 7–12, and 13–18 years. Data were calculated using Chi-squared test and multivariate logistic regression models.

Conflicts of interest: All authors declare no conflicts of interest.

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**Results:** The perforation rate was highest for patients  $\leq 6$  years old and also an LA was least often performed in younger children compared with those aged 7–12 years 13–18 years; ( $p < 0.0001$ ). In the multivariable analysis, the ORs for IAAs and PBOs for patients aged 7–12 and 13–18 years who had a perforated appendicitis and underwent an LA were (0.66;  $p = 0.0182$ ), (0.51;  $p = 0.0001$ ); and (0.49;  $p = 0.0125$ ), (0.41;  $p = 0.0014$ ), respectively, compared with those aged  $\leq 6$  years. Our study demonstrates that children in the ( $\leq 6$  years) age group had a high rate of appendix perforation and required fewer LAs; when LAs were performed on children in this age group to treat perforated appendicitis, IAA and PBO risks were higher than other older age groups.

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## 1. Introduction

Appendicitis is a common pediatric surgical emergency. Despite widespread familiarity with this disease, appendicitis continues to pose a significant diagnostic challenge to clinicians.<sup>1</sup> Two previous reports showed that despite advances in ultrasound and computed tomography imaging, perforation rates in children  $\leq 6$  years have ranged from 54% to 74% over the past three decades.<sup>2,3</sup>

Because Taiwan National Health Insurance (NHI) provides comprehensive coverage to the population, we were able to use its data archives to evaluate the effect of age on postoperative morbidity. Our study investigated whether age affected the outcomes and management of appendicitis in children in Taiwan.

## 2. Materials and methods

### 2.1. Database

This study was a nationwide, retrospective, population-based analysis of insurance-claims data from 23 million insured people obtained from the NHI program. The Bureau of NHI (BNHI) in Taiwan released a research-oriented database through the Collaboration Center for Health Information Application (CCHIA). Taiwan launched the NHI program in 1995, and 99% of the population of Taiwan was covered by 2007. Therefore, the BNHI allows researchers to trace almost all use of medical services for all children with appendicitis in Taiwan.

We used data from between 2007 and 2012 that were sourced from the NHI Research Database (NHIRD) and released by the BNHI through the CCHIA. The database includes all original claims data and registration files for beneficiaries enrolled under Taiwan's NHI program.

This study was exempted from full review by the Taipei Medical University (TMU)-Joint Institutional Review Board, and the NHIRD consists of anonymous secondary data released to the public for research purposes.

### 2.2. Study Sample

We identified 21,827 pediatric patients  $\leq 18$  years of age that had a first-time discharge diagnosis of acute

appendicitis and postoperative complications based on International Classification of Disease, Ninth Revision, Clinical Modification (ICD-9-CM) codes between January 2007 and December 2012. The principal ICD-9 diagnosis codes for nonperforated appendicitis (540.0) and perforated appendicitis (540.1 and 540.9) were used. Codes for complications from intra-abdominal abscesses (IAAs; 998.59) and postoperative bowel obstructions (PBO; 560.81 or 997.4) were also used.

Patients were divided into three groups by age:  $\leq 6$  years, 7–12 years, and 13–18 years. The principal ICD-9 procedure code for an open appendectomy (OA; 740.2) and laparoscopic appendectomy (LA; 740.4) were used. Patients who underwent an incidental appendectomy were excluded from our analysis.

Patient factors included age (years), sex (male or female), the presence of perforation (nonperforated or perforated), and whether they underwent an OA or LA. Outcome variables were IAA, PBO, and length of hospitalization (LOH). Outcomes between the different age groups were compared.

### 2.3. Statistical Analysis

We concluded univariate statistical comparisons by using Chi-square tests. We then performed a multivariate logistic regression to explore the odds ratios (ORs) and the related 95% confidence intervals (CIs) of complications according to different age groups, sex, different methods, and different severities of appendicitis. All statistical analyses were performed using Statistical Analysis System version 9.3 (SAS Institute, Cary, NC, USA), and  $p < 0.05$  was considered statistically significant.

## 3. Results

A total of 21,827 patients were identified, and Table 1 shows the overall demographic data. Participants aged  $\leq 6$  years composed 5.6% of the sample, and 61% of the patients were male. Laparoscopy was used in only 41% of children, and the total IAA and PBO complication rates were 1.8% and 0.6%, respectively. The median LOH was 3.4 days.

Table 2 presents a summary of the results of the univariate analysis. The perforation rate was highest for

**Table 1** Demographic data for all patients.

Total number of patients	21,827
≤6 y	1221 (5.59%)
7–12 y	7154 (32.78%)
13–18 y	13,452 (61.63%)
Male	13,351 (61.17%)
LA	8894 (40.75%)
IAA	386 (1.77%)
PBO	127 (0.58%)
Mean LOH (days)	4.15 (SD 2.93)

IAA, intra-abdominal abscess; LA, laparoscopic appendectomy; LOH, length of hospitalization; PBO, postoperative bowel obstruction; SD, standard deviation.

patient aged ≤6 years at 51% as compared with 32% of patients aged 7–12 years and 24% of patients aged 13–18 years ( $p < 0.0001$ ). An LA procedure was least often performed in the youngest children (24% of patients aged ≤6 years, 37% of those aged 7–12 years, and 44% of those aged 13–18 years;  $p < 0.0001$ ). Postoperative complication rates for IAA and PBO with perforated appendicitis were highest in the youngest children: 5% of patients aged ≤6 years, 2.4% of those aged 7–12 years, and 1.5% of those aged 13–18 years ( $p < 0.0001$ ); and 1.9% of those aged ≤6 years, 0.7% of those aged 7–12 years, and 0.5% of those aged 13–18 years ( $p < 0.0001$ ), respectively. The LOH was longer among young children with perforated appendicitis.

Table 3 provides a summary of the multivariate analysis of postoperative complications, controlling for potential confounders of age, sex, perforation status, and operative procedure (OA or LA). **Sex did not affect the of IAA or PBO rates.** The respective adjusted ORs for IAA and PBO for patients with perforated and nonperforated appendicitis were 5.90 (95% CI: 4.73–7.35;  $p < 0.001$ ) and 7.13 (95% CI: 4.80–10.59;  $p < 0.001$ ). As expected, perforated appendicitis increased the risks for IAA and PBO. The adjusted ORs for IAA and PBO for patients aged 7–12 years and 13–18 years who had perforated appendicitis and underwent LA were 0.66 (95% CI: 0.469–0.932;  $p = 0.0182$ ) and 0.51 (95% CI: 0.37–0.72;  $p = 0.0001$ ); and 0.49 (95% CI: 0.28–0.86;  $p = 0.0125$ ) and 0.41 (95% CI: 0.23–0.71;  $p = 0.0014$ ), respectively, as compared with those aged ≤6 years.

**Table 3** Multivariate logistic regression of factors affecting rates of intra-abdominal abscess and postoperative bowel obstruction.

	OR	95% CI	<i>p</i>
IAA			
13–18 y	0.514	0.366–0.722	0.0001
7–12 y	0.661	0.469–0.932	0.0182
≤6 y	Reference		
Female	0.898	0.725–1.112	0.3239
Perforated	5.897	4.731–7.351	<0.0001
LA vs. OA	0.504	0.401–0.633	<0.0001
PBO			
13–18 years	0.406	0.233–0.705	0.0014
7–12 years	0.485	0.275–0.855	0.0125
≤6 years	Reference		
Female	0.703	0.480–1.028	0.0688
Perforated	7.128	4.800–10.585	<0.0001
LA vs. OA	2.11	1.471–3.026	<0.0001

CI, confidence interval; IAA, intra-abdominal abscess; LA, laparoscopic appendectomy; OA, open appendectomy; OR, odds ratio; PBO, postoperative bowel obstruction.

## 4. Discussion

To the best of our knowledge, few reports<sup>4,5</sup> used a large nationwide database to investigate how age affects therapeutic approaches and outcomes for appendicitis in children. The data herein demonstrated that >50% of the youngest children (≤6 years) presented with perforated appendicitis, and that LA was performed in only 24% of these children. We also found that children ≤6 years who presented perforated appendicitis and received an LA exhibited increased risks of IAA and PBO, in addition to a longer LOH.

Despite widespread familiarity with this disease, perforation rates in children were reported to be 30% over the last three decades.<sup>1</sup> This is particularly true in the youngest children, whose history is not typical and whose examination results are unreliable.<sup>6,7</sup> Despite many advances in ultrasound and computed tomography imaging, the youngest (≤6 years) age group in our study experienced the highest percentage of perforations (51%). Various studies reported perforated appendicitis rates of 54% to 74%.<sup>2,3</sup>

**Table 2** Results of univariate analysis of outcomes between age groups.

	≤6 y (n = 1221)	7–12 y (n = 7154)	13–18 y (n = 13,452)	<i>p</i>
With perforation (%)	628 (51.43)	2296 (32.09)	3266 (24.28)	<0.0001
LA (%)	289 (23.67)	2649 (37.03)	5956 (44.28)	<0.0001
Nonoperative management (%)	302 (24.73)	635 (8.87)	1054 (7.83)	<0.0001
IAA (%)	46 (3.77)	154 (2.15)	186 (1.38)	<0.0001
PBO (%)	17 (1.39)	46 (0.64)	64 (0.48)	<0.0001
LOH (day), mean (SD)	6.31 (4.38)	4.42 (3.16)	3.84 (2.58)	

IAA, intra-abdominal abscess; LA, laparoscopic appendectomy; LOH, length of hospitalization; PBO, postoperative bowel obstruction; SD, standard deviation.

In our previous report,<sup>8</sup> the incidence of LA in Taiwan was found to have increased from 29.2% in 2007 to 57.4% in 2012. An LA was performed in 41% of children in the current study. The advantages of an LA over an OA in younger children remain controversial<sup>9,10</sup>; however, more recent studies demonstrated that children with perforated appendicitis had lower IAA and PBO rates undergoing an LA as compared with when an OA was performed.<sup>11–17</sup> Additionally, we observed a significant difference in laparoscopy use according to age in our study. An LA was performed in only 24% of the youngest children (aged  $\leq 6$  years), 37% of children aged 7–12 years, and 44% of children aged 13–18 years. We determined that the rate of LA was higher in the middle-aged pediatric group in our data. Considering the different operative methods and severities of appendicitis, we performed a multivariate analysis to investigate the effect of age on postoperative IAAs and PBOs. The adjusted ORs for IAAs and PBOs for patients aged 7–12 years and 13–18 years who had perforated appendicitis and underwent an LA were 0.66 ( $p = 0.0182$ ) and 0.51 ( $p = 0.0001$ ), and 0.49 ( $p = 0.0125$ ) and 0.41 ( $p = 0.0014$ ), respectively, as compared with those aged  $\leq 6$  years. We found that higher IAA and PBO rates following an LA in children who were aged  $\leq 6$  years presented perforated appendicitis.

This study had several limitations. Perforated appendicitis covers a broad range of severity, ranging from a microperforation to frank stool in the abdomen. The results of our analysis were derived from our population-based database; however, the detailed pathologic confirmation of appendicitis was not available, and the definition of appendicitis mainly depended upon ICD-9 codes. Additionally, we could not account for the fact that the choice of the operative-management modality was dependent upon the preference of individual surgeons.

The main strength of our study was that it is the first to utilize a population-based database to trace how age affects the outcomes and management of appendicitis in children. Our data encompassed all pediatric appendicitis cases in Taiwan, thus demonstrating robust findings from a large and diverse population. Therefore, estimates from our study likely approximate those of the general population, and thus avoiding single-institutional biases.

## 5. Conclusion

Our study used nationwide data to demonstrate that the youngest children ( $\leq 6$  years) have a high perforation rate of appendicitis, fewer LA procedures performed, and frequently undergo nonoperative treatment. Children of the youngest age ( $\leq 6$  years) who underwent LA for perforated appendicitis had higher risks of IAA and PBO than did other

older age groups. The findings of this study may encourage surgeons to increase the level of care with which they diagnose and treat pediatric appendicitis in this age group.

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