National Trends in Diagnostic Approaches for Pediatric Appendicitis: A Nationwide Cohort Study

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Abstract

Background: To define the benefits of different diagnostic methods for pediatric appendicitis in Taiwan, a nationwide cohort study was used for analysis.

Methods: We identified 44,529 patients under 18 years old who had been hospitalized with a diagnosis of acute appendicitis between 2003 and 2012. We analyzed the percentages of cases in which ultrasound (US) and/or computed tomography (CT) were performed and non-perforated and perforated appendicitis were diagnosed for each year. Multivariate logistic regression analyses were performed to evaluate risk factors for the perforation rate.

Results: There were more cases of non-perforated appendicitis (n=32,491) than perforated appendicitis (n=12,038). The rate of non-perforated cases were 0.068% in 2003 and decreased to 0.049% in 2012; perforated cases remained relatively stable at 0.024%–0.023% from 2003 to 2004, to 0.020% in 2012; and undergoing US or both US and CT were similarly similar from 2003 to 2012. The proportion of children without a CT or US evaluation gradually decreased from 97% and 95% in 2003 and 2004, respectively, to 79% in 2012. The odds ratios (ORs) of a perforated appendix for those patients diagnosed by US, CT, and US and CT were 1.227 (95% CI=0.914–1.646; p=0.173), 2.744 (95% CI=2.550–2.953; p<0.001), and 5.062 (95% CI=3.136–8.170; p<0.001), respectively, compared to patients without US or CT. The ORs of a perforated appendix for those patients 7-12 and ≤ 6 years old were 1.756 (95% CI=1.672–1.844; p<0.001) and 3.094 (95% CI=2.867–3.339; p<0.001), respectively, compared to those 13-18 years old.

Conclusions: Our study demonstrated that using CT scan as a diagnostic tool increased every year; most patients especially those ≤ 6 years old who received a CT scan had a greater proportion of perforated appendicitis. We think that experienced pediatric surgeons should well discuss with radiologists to make more proper radiologic investigations.

Keywords: Appendicitis; Ultrasound (US); Computed tomogram scan; NHIRD

Introduction

Appendectomies are one of the most common general surgical procedures performed in the pediatric population. Traditionally, a diagnosis of appendicitis in both children and adults is made by history taking and a physical examination. In general, it is more difficult to obtain a clear history and elicit specific physical examination findings in children of all ages compared to adults [1]. A clinical diagnosis of appendicitis is often difficult, and a delayed diagnosis may result in perforation of the inflamed appendix, peritonitis, or intra-abdominal abscess formation.

Recently, ultrasound (US) and computed tomography (CT) have been used to assist in diagnosing appendicitis. US was initially used [2], but focused CT has become increasingly common as a diagnostic tool in both adults and children to rule out appendicitis in hopes of improving the diagnostic accuracy [3,4]. Both diagnostic procedures have proven to be much sensitive and specific [5]. However, there are still critics who question the overlap of these two diagnostic procedures and the benefits of CT over US in terms of the clinical diagnosis [6-8]. As the use of CT and US appears to be increasing, we sought to analyze a large, national database over a 10-year period to evaluate changes in the incidences of diagnostic approaches and the impact on perforate rates.

Methods

Database

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

We used data sourced between 2003 and 2012 from the NHI database (NHIRD) 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 our Institutional Review Board (IRB) after consulting with the director of the Taipei Medical University IRB since the NHIRD consists of anonymous secondary data released to the public for research purposes.

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Study sample

We identified 44,529 pediatric patients less than 18 years of age who had a first-time discharge diagnosis of acute appendicitis (International Classification of Disease, Ninth Revision, clinical Modification (ICD-9-CM) codes 540.0, 540.1, and 540.9) between January 2003 and December 2012. If a patient had two or more hospitalizations within a 30-day period, they were regarded as the same episode, and we only included the first hospitalization.

Patients were divided into three groups by age: ≤6, 7-12, and 13-18 years old. The incidence of disease and the severity of disease were compared among groups. The types of diagnosis were categorized as follows: US (19005B), CT (33070B and 33071B), both US and CT, and neither US nor CT.

We calculated the percentages of cases on which the four categories of diagnostic tools were performed for each year, and also calculated the percentages of non-perforated and perforated appendicitis cases diagnosed each year.

Statistical analysis

Chi-squared tests were used to examine the difference between the perforated and non-perforated (control) groups. We then performed a multivariate logistic regression to explore the odds ratios (ORs) and the related 95% confidence intervals (CIs) of perforated appendicitis cases among the different age groups, between genders, and among different diagnostic groups. All statistical analyses were performed using SAS vers. 9.3 (SAS Institute, Cary, NC), and p<0.05 was considered statistically significant.

Result

Characteristic of the study population

Table 1 shows the distributions of rates of non-perforated and perforated appendicitis cases between genders and among different age groups. Of the 44,529 pediatric patients under 18 years old admitted for treatment of acute appendicitis between January 2003 and December 2012, 26,792 (60%) were boys and 17,737 (40%) were girls. There were more cases of non-perforated appendicitis (n=32,491) than perforated appendicitis (n=12,038).

The largest number of patients was in the 7-18-year age group, representing 90% of the total population. Only 9.9% of children were ≤6 years old. Although smaller in numbers, the youngest (≤6 year) age group experienced the largest percentage of perforations (46%), which decreased to 31% in 7-12 year olds and then to 21% in children older than 12 years.

Comparison of the incidence rate of disease for each year

<table>
<thead>
<tr>
<th>Age group (y/o)*</th>
<th>Acute non-perforated appendicitis (n=32,491)</th>
<th>Acute perforated appendicitis (n=12,038)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>Male</td>
<td>19,494</td>
<td>-60</td>
</tr>
<tr>
<td>Female</td>
<td>12,997</td>
<td>-40</td>
</tr>
</tbody>
</table>

Table 1: Baseline patient characteristics.
Appendicitis is the most common surgical emergency in children. Our population-based study demonstrated that the largest number of patients was in the 11-18-year age group, which represented 75% of the total population. The ratio of boys to girls was about 1.5:1. A previous report showed an incidence peak in the 10–19-year age group, and it was estimated that the risks of appendicitis were 8.6% for men and 6.7% for women [9]. In our study, the number of cases of non-perforated appendicitis (n=32,491) was higher than that of perforated appendicitis (n=12,038).

Despite great familiarity with this disease, appendicitis continues to pose a significant diagnostic challenge for clinicians [10]. This is especially true in very young children whose history is not typical and whose examination results are also unreliable [11,12]. In the early 1990s, multiple institutions advocated US as a useful adjunct for diagnosing appendicitis [13-15]. In addition, initial reports by Rao using CT scans to diagnose appendicitis in adults in 1997 led to it being used more frequently in pediatric populations [3,4]. Both diagnostic procedures have proven to be very sensitive and specific, and appeared to be the preferred imaging modalities for appendicitis in children in our country since 2003. In our series, the use of CT scan increased over the 10-year period. The proportion of children having CT scans increased from 3% and 4% in 2003 and 2004, to 20% in 2012; and undergoing US or both US and CT were relatively similar from 2003 to 2012. Over the same period, the proportion of children proceeding to an appendectomy without CT or US evaluation gradually decreased from 97% and 95% in 2003 and 2004, respectively, to 79% in 2012.

Previous studies debated the impacts of CT scans on negative appendectomy and perforation rates [7,16,17]. In our series, the proportion of non-perforated appendicitis significantly decreased over the study time course. Interestingly, the rate of perforations remained relatively stable at 0.024%–0.023% from 2003 to 2012. The data of ORs demonstrated that patients who received CT or US and CT had higher proportional rates of perforated appendicitis, especially patients who were ≤6 years old. In our series, the youngest (≤6 year) age group experienced the largest percentage of perforations (46%). Various studies have reported ruptured appendicitis rates of 30%–45% [18].

There are some limitations to this study. First, the detailed pathologic confirmation of appendicitis was not available from the database we used, and the definition of appendicitis mainly depended on ICD-9 codes. There were no exact data about the proportion of negative appendectomies in our study; according to the data, the proportion of non-perforated appendicitis cases significantly decreased, so we may think that a significant number of negative appendectomies was possibly avoided though CT examination. Second, the dataset in this study had no data on pre-hospital care (the time from the onset of symptoms to first seeking medical attention) of the duration of this study had no data on pre-hospital care (the time from the onset of symptoms to first seeking medical attention) of the duration of advanced testing. Therefore, these potentially confounding factors could not be considered in our analysis.

Knowledge of the risks of cumulative radiation exposure from radiographic procedures has led to campaigns aimed at increasing awareness and decreasing radiation exposure [19-21]. Children are more radiosensitive, receive large effective doses for a given level of radiation, and have a longer life expectancy during which to develop cancer [22,23]. Some recent reports advocated the use of US followed by CT scans [24,25]. The accuracy of pediatric US in those reports varies from 44% to 94% and the specificity from 47% to 95%. In our series, using US was not popular over the 10-year period. We suggest that using US instead of CT as the initial modality of diagnosing appendicitis can be done to reduce radiation exposure.

In conclusion, our study demonstrated that using CT scan as a diagnostic tool increased every year we evaluated. Fortunately, 79% of patients with appendicitis were still managed without US or CT in our country, and most patients especially those ≤6 years old who received a CT scan had a greater proportion of perforated appendicitis. We think that pediatric surgeons should well discuss with radiologists to make more proper radiologic investigations.

Table 2: Adjusted odds ratios (ORs) for perforated appendicitis.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Odds ratio</th>
<th>95% confidence interval</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Female</td>
<td>0.985</td>
<td>0.939-1.033</td>
<td>0.5372</td>
</tr>
<tr>
<td>Age group (y/o)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13-18</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>7-12</td>
<td>1.756</td>
<td>1.672-1.844</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>&lt;=6</td>
<td>3.094</td>
<td>2.867-3.339</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Type of diagnosis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without US or CT</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ultrasound (US)</td>
<td>1.227</td>
<td>0.914-1.646</td>
<td>0.1729</td>
</tr>
<tr>
<td>Computed tomography (CT)*</td>
<td>2.744</td>
<td>2.55-2.953</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Both US and CT*</td>
<td>5.062</td>
<td>3.136-8.17</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Figure 2: Percentages of patients who received ultrasound (US), computed tomography (CT), US were 0.06% in 2003, 0.066% in 2004, and decreased to 0.055% in 2011 and 0.049% in 2012. and CT, and no CT or US from 2003 to 2012.
References


