Seasonal variation of acute appendicitis and fecaliths in children

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Research article

Keywords: appendicitis, seasons, fecalith

Posted Date: September 23rd, 2019

DOI: https://doi.org/10.21203/rs.2.14801/v1

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Version of Record: A version of this preprint was published on November 16th, 2019. See the published version at https://doi.org/10.1186/s12887-019-1824-9.
Abstract

Purpose  A higher incidence of acute appendicitis (AA) in summer has been reported. The reason of this observation is uncertain. The purpose of this study is to analyze the difference of the clinical findings between summer and non-summer AA. Methods  We reviewed the clinical data of 171 patients who had an appendectomy from 2013 to 2016. The patients were under 18 years of age by the time of surgery. Laboratory data, CT scans, pathologic reports and operative records were reviewed. Results  More appendectomies were performed in summer than non-summer months (101 patients vs 70 patients). There is no significant difference of laboratory results between the summer and non-summer patients. The percentage of AA patients with a fecalith is significantly lower in the summer (33.6%) than non-summer months (55.7%). There was no significant difference in appendiceal perforation/abscess between summer and non-summer months. Conclusions  We observed a lower percentage of AA with a fecalith in summer. To our knowledge, this observation has not been reported in literature. The increase of AA in summer may be a result of more lymphoid hyperplasia in summer. This may correlate with the yearly outbreak of enteroviral infections in this area.

Background

Many studies showed a seasonal variation in the incidence of acute appendicitis (AA). In most of the reports, the incidence of AA is higher in summer [1,2,3]. This phenomenon may be multifactorial. Temperature, rainfall, atmospheric pressure [4], food [5] and dietary fiber [6] [7], air pollution [8], allergic reaction to pollen [2], and seasonal gastrointestinal infections [9] had been considered to affect the incidence.

In this study, we analyzed the clinical data of the AA patients in our institution. The purpose of the study is to provide more evidence of this phenomenon by comparing the clinical information of the AA patients in summer and non-summer months.

Methods

This is a retrospective study of the patients who had appendectomies for AA in our institution from January 2013 to December 2016. The study was approved by the Institutional Review Board of the hospital (IRB number 170710). All the patients were under 18 years of age at the time of surgery. Patients who had an interval appendectomy or a normal appendix were excluded. The age, gender, white cell count (WBC), differential counts, and C reactive protein (CRP) of these patients were analyzed. The presence of a fecalith, and an appendiceal perforation/abscess (perf/abs) was identified by reviewing CT scans and pathological reports.

Taiwan is situated in the subtropical zone with relatively warm temperature. The monthly temperature can be obtained from the internet site of Central Weather Bureau [10]. High temperature (>25°C) was observed from May to October in middle Taiwan where our institution is located. We divided a year into
summer (from May to October) and non-summer months (November through April) according to the temperature of the months (Table 1).

Table 1. The average temperature in Central Taiwan in recent 30 years

|       | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Temp(˚C) | 16.6 | 17.3 | 20.0 | 23.1 | 26.0 | 27.6 | 28.6 | 28.3 | 27.0 | 25.2 | 21.9 | 18.1 |
| Season*  | NS  | NS  | NS  | NS  | S   | S   | S   | S   | S   | S   | NS  | NS  |

*S: summer  NS: non-summer

We compared the value of laboratory data, the presence of a fecalith, and appendiceal perf/abs in summer and non-summer months. We used Chi square and Student’s T-test for statistical evaluation. A p value<0.05 was considered to be significant.

Results

One hundred and seventy-one patients had appendectomies during the study period. Among the 171 patients, 160 had a preoperative CT scan, and all patients had a pathology report. Thirty-four patients had a fecalith in CT scans, 18 patients had a fecalith in pathology reports, 21 patients had a fecalith in both CT scans and pathology reports. One hundred and one patients were operated in the summer months, 70 patients were operated in non-summer months. In summer, 34 patients had a fecalith, and 26 had perf/abs. In non-summer, 39 patients had a fecalith, and 25 had perf/abs (Table 2).

Table 2. The patient data in summer and non-summer.

|                  | Summer  | Non-summer | p value |
|------------------|---------|------------|---------|
| Patient number   | 101     | 70         |         |
| Age (year)       | 12.2±3.7| 11.4±4.2   | 0.290#  |
| Male: female     | 70:31 (2.3:1)| 45:25 (1.8:1)| 0.363*  |
| With fecalith    | 34 (33.6%)| 39(55.7%)  | 0.004*  |
| Perforation/abscess | 26      | 25         | 0.161*  |
| CRP (mg/dL)      | 6.64±7.78| 9.06±9.61  | 0.087#  |
| WBC*1000         | 16.1±5.0 | 15.4±4.9   | 0.392#  |
| Neutrophil (%)   | 81.46±9.67| 81.57±7.96| 0.938#  |
| Lymphocyte (%)   | 10.97±7.47| 10.44±6.59| 0.643#  |
| Monocyte (%)     | 6.53±2.73 | 7.23±2.80  | 0.115#  |

*Chi-square test; # t-test
The numbers of AA and AA patients with a fecalith in each month were shown in Figure 1. The number of AA patients increased obviously in summer, mainly due to more patients without a fecalith in summer. The patients with a fecalith remained relative stable in numbers throughout the year. The % of AA patients with a fecalith is significantly higher in the non-summer months (55.7%) than summer (33.6%) (Table 3) because of fewer total AA patients in that period.

Table 3. The number of patients with and without fecaliths in summer and non-summer months.

|                | Summer | Non-summer | Total   |
|----------------|--------|------------|---------|
| With fecalith  | 34 (33.6%) | 39 (55.7%) | 73 (42.7%) |
| Without fecalith | 67 (66.4%) | 31 (44.3%) | 98 (57.3%) |
| Total          | 101 (100%) | 70 (100%) | 171 (100%) |

The chi-square statistic is 8.2171. The p-value is 0.00415. This result is significant at p < .05

The presence of a fecalith had an association with appendiceal perf/abs (Table 4, p=0.000036), however, the incidence of perf/abs had no significant difference between the summer and the non-summer months (Table 5, p=0.161056).

Table 4. The correlation of appendiceal perforation/abscess with fecaliths.

|                | With fecalith | Without fecalith | Total |
|----------------|--------------|-----------------|-------|
| Perf/abs       | 34           | 17              | 51    |
| No perf/abs    | 39           | 81              | 120   |
| Total          | 73           | 98              | 171   |

The chi-square statistic is 17.0767. The p-value is 0.000036. This result is significant at p < .05

Table 5. The number of appendiceal perforation/abscess in summer and non-summer months.

|                | Summer       | Non-summer   | Total     |
|----------------|--------------|--------------|-----------|
| Perf/abs       | 26 (25.7%)   | 25 (35.7%)   | 51 (29.8%)|
| No perf/abs    | 75 (74.3%)   | 45 (64.3%)   | 120 (70.2%)|
| Total          | 101 (100%)   | 70 (100%)    | 171 (100%)|

The chi-square statistic is 1.9643. The p-value is 0.161056. This result is not significant at p < .05

There is no significant difference in age, gender between the summer and the non-summer months.
The average CRP level was higher in the non-summer months, but the difference was not statistically significant when compared with summer (Table 2). There was also no significant difference in other laboratory results between the summer and the non-summer months.

Discussion

A seasonal pattern of AA had been reported since decades ago. In 1990, Addiss et al reported an 11% increase in cases from May to August compared with November through February [9]. Other researchers also demonstrated a higher incidence of AA in summer (except Turkey) [11]. Many factors may lead to this phenomenon. The appendix is a blind-ended structure, the obstruction of its outlet will cause mucus and bacterial flora accumulation, and results in AA. Since lymphoid hyperplasia and fecaliths are the main causes of an appendiceal outlet obstruction, factors alter the status of lymphoid tissue or the fecalith formation will affect the incidence of AA. Factors such as climate, types of diets, viral or bacterial infections had been proposed by some researchers.

We believe AA without a fecalith is mainly a result of lymphoid hyperplasia. Lymphoid hyperplasia, either caused by a viral or bacterial infection, or by an immune response to the environment or food, can have a seasonal change. In our study, we found a significant increase of the cases of AA without a fecalith in summer, while the cases of AA with a fecalith was relatively constant throughout the year. To our knowledge, the correlation of seasons and fecaliths has not been reported in the literature. The Taiwan Centers for Disease Control reported a yearly outbreak of enterovirus infection from May to October in the recent years [12] (Figure 2). Among other viral infections, enterovirus is the only virus which causes an obvious outbreak in summer (May to October). These findings suggest that the rise of AA in summer may have a correlation with this viral outbreak.

The reported incidence of AA with a fecalith varied from 13% [13] to 52% [8]. Fecaliths are more common in pediatric AA patients [14]. We also observed a high incidence of fecaliths in our patients (42.7%). We combined the findings of CT scans and pathologic reports to define the presence of a fecalith, this may explain the high incidence in our series.

The association of a fecalith and appendiceal perf/abs had been reported. Alaeeiden et al showed the appendix was perforated in 57% of patients who had a fecalith vs 36% in patients without a fecalith [15]. We also found a significant correlation between a fecalith and appendiceal perf/abs in our patients (Table 4). Our result showed a higher incidence of perf/abs in the non-summer months, but the increase did not reach statistical significance (Table 5).

The average CRP level was higher in the non-summer patients, but the difference was not significant when compared to the summer patients. There is also no significant difference in the level of white cell counts between the two patient groups. Since the value of these tests varies with the duration and the severity of infection, it is not surprising to see such laboratory results.
Conclusions

This study shows the differences of summer and non-summer AA. We believe the rise of summer AA is a result of lymphoid hyperplasia, which may have a correlation with the yearly outbreak of enteroviral infection in this region. Further researches involving multiple institutions are needed to confirm the correlation.

List Of Abbreviations

AA: acute appendicitis

perf/abs: perforation/abscess

Declarations

Ethics approval and consent to participate

All procedures performed in studies involving human participants were in accordance with the ethical standards of the Changhua Christian Hospital institutional research committee (approved number 170710) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Competing Interests:

All authors declare no conflict of interest in the study

Funding:

This study did not receive any funding.

Authors' contributions

YJH collected the patient data, and was a major contributor in writing the manuscript.

YWF analysed the data and performed statistic analysis.
TC initiated and organized the research, finalized the manuscript.

All authors read and approved the final manuscript.

**Acknowledgements**

Not Applicable

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**Figures**
Figure 1

The figure shows the case number of AA patients and AA patients with a fecalith vs months. The total case number of AA was higher in summer, but the number of the AA patients with a fecalith was relatively similar in each month.

Figure 2

Ratio of enteroviral infection patients in OPD and ER (0/00)
The figure shows the ratio (0/00) of patient visits with a diagnosis of enteroviral infection (open source from Taiwan National Infectious Disease Statistics System, Taiwan Centers for Disease Control)