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The Effect of Environmental Factors on the Incidence of Complicated Appendicitis in Mongolian Paediatric Population

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Abstract

Introduction: Acute appendicitis (AA) in children is the primary cause of urgent surgery in pediatric patients. Diagnosis of AA continues to be a challenge, especially in the youngest children, who often present with abdominal pain accompanied by nonspecific signs. As epidemiological data on the relationship between acute appendicitis and environmental factors are relatively few and the issue is still controversial, we conducted this study which compared two groups of patients with complicated and noncomplicated appendicitis in a sample of patients admitted to a MNCMCH. The aim of this study was to determine the risk factors for complications in acute appendicitis in the paediatric population. **Methods:** Our study was performed on 1003 children admitted for suspected acute appendicitis and underwent appendectomy at the MNCMCH, Ulaanbaatar Mongolia, between January 2019 and December 2019. The diagnosis was based on the results of pathological examination. The two groups of complicated (gangrenous and perforated) and noncomplicated (catarrhal and phlegmonous) acute appendicitis were compared. **Results:** 1003 pediatric patients (≤18 years old) were suspected of having acute appendicitis and subsequently underwent surgery. From a total of 967 patients, 56% (n = 542) were male, 44% (n = 425) were female (gender ratio was 1.3:1). The histological examination noted that 33.1% were uncomplicated, 66.9% were complicated. While the incidence of acute appendicitis was higher during winter, the highest incidence of complicated appendicitis was observed equally in winter and autumn without significant association ($p = 0.541$). The months of December and March were marked by the highest incidence of AA. The highest incidence of complicated appendicitis was observed during the month of December (45%) with statistically significant difference ($p < 0.001$). Our study of the incidence of family history, allergy and family members was noted in complicated and noncomplicated group with statistically significant difference ($p < 0.001$). **Conclusions:** Pediatric acute appendicitis incidence is increased in winter months in Mongolia. Preventive measures to decrease morbidity and mortality associated with this disease can be taken during the winter seasons from December to March. However, further large-scale studies are needed to support this conclusion.

Keywords

Acute Appendicitis, Pediatric Patients, Environmental Factor

1. Introduction

Acute appendicitis (AA) in children is the primary cause of urgent surgery in pediatric patients. Diagnosis of AA continues to be a challenge, especially in the youngest children, who often present with abdominal pain accompanied by nonspecific signs. However, about 40% of people do not have these typical symptoms. If undetected, acute appendicitis can progress to perforated appendicitis, giving rise to severe complications like painful inflammation of the inner lining of the abdominal wall (peritonitis) and sepsis. Acute appendicitis affects 1.5 - 1.9 individuals in a population of 100,000 and is 1.4 times more common in men. The lifetime risk of suffering from acute appendicitis is 7%, with perforation rates being 17% - 20%. The mortality risk of this condition is less than 1% in the general population but can rise to 50% among the elderly population. According to clinical features and pathological anatomy changes, it is divided into acute simple appendicitis, acute purulent appendicitis, acute gangrenous or perforated appendicitis, and periappendiceal abscess. In present literatures, the first 2 types of pathology have often been called uncomplicated appendicitis (UA), and the latter two have been called complicated appendicitis (CA) or progressive appendicitis. CA accounts for 20% to 30% of acute appendicitis cases, while UA accounts for 68% to 90% of cases in children. A multifactorial understanding of its causation has emerged along with increasing evidence of seasonal variation [1]. Epidemiological data indicate that the incidence of acute appendicitis varies widely between countries, among regions within the same country, and between different racial and occupational groups [2] [3]. The incidence of acute appendicitis (AA) has been reported to vary substantially by country and geographic region, but the reasons for this variation are unknown [4]. Association with factors like diet and hygienic conditions have been suggested, but are not widely accepted [5] [6]. Moreover, the etiology of the appendicitis still remains unclear and multifactorial. The disease has been attributed to a variety of possible causes which include mechanical obstruction [7], inadequate dietary fibre, smoking [7], air pollution and familial susceptibility [8]. Acute appendicitis presents throughout the year but incidence is increased in some particular months [9]. There are many variations in the incidence of acute appendicitis. Various studies have been done to determine the seasonal variation of acute appendicitis but with variable results [10]. Many studies have shown that the incidence of AA is higher in the summer [9] [11] [12], however, the reason for this phenomenon remains unclear. Temperature, rainfall, atmospheric pressure [13], food [14], and dietary fibre [15] [16], air pollution [17], allergic reaction to pollen [9] and seasonal gastrointestinal infections [2] are factors contributing to the higher incidence of AA [18]. As epidemiological data on the relationship between acute appendicitis and environmental factors are relatively few and the issue is still controversial, we conducted this study which compared two groups of patients with complicated and noncomplicated appendicitis in a sample of patients admitted to an MNCMCH. The aim of this study was to determine the risk factors for complications in acute appendicitis in the paediatric population.

2. Materials and Methods

2.1. Subject

Our study was performed on 1003 children admitted for suspected acute appendicitis and underwent appendectomy at the MNCMCH, Ulaanbaatar Mongolia, between January 2019 and December 2019. All patients (aged 0 to 18 years) who presented in the emergency department with right lower quadrant pain and underwent appendectomy were enrolled in the study. Informed written consent was taken for participation in the study after explaining the objectives, benefits and drawbacks of the study. All patients received routine medical attention for acute appendicitis including detailed medical history and required investigations. Surgeries were performed by consultant surgeons and residents in surgery. Post operatively Specimens were sent to histopathology department of MNCMCH.

2.1.1. Exclusion Criteria

- Patients with a diagnosis that did not meet the inclusion criteria.
- Incomplete medical records.
- Undergoing abdominal surgery.
- Chronic disease.
- Patients with mental illness.

2.1.2. Inclusion Criteria

- Age of <18 years old.
- Underwent appendectomy.
- The patients and their families agreed and provided a signed informed consent.

2.2. Histological Examination

The diagnosis was based on the results of pathological examination. The two groups of complicated (gangrenous and perforated) and noncomplicated (cattarhal and phlegmonous) acute appendicitis were compared. According to the histopathological results, patients were classified into the following groups: Normal appendix (no evidence of any inflammation in any layer of appendix), Acute mucosal inflammation (catarrhal inflammation) (neutrophils within mucosa and mucosal ulceration, with or without intraluminal neutrophils), Suppurative acute appendicitis (phlegmonous appendicitis) (defined as neutrophiilc infiltration of mucosa, submucosa, and muscularis propria; transmural inflammation, extensive ulceration, and intramural abscesses common; vascular thrombosis), gangrenous appendicitis (diffuse infiltration of granulocytes or areas of necrosis extending through the wall) and perforated appendicitis.

2.3. Environmental Factors

Ulaanbaatar is a city located in the Center of Mongolia. It belongs to the lower semi-arid bioclimatic stage and has a 4-season climate. Temperatures are generally extreme continental climate: −24.5˚C for the month of January (the coldest month) and 30.5˚C for the month of July (the hottest month). The monthly thermal amplitudes are generally less than 15˚C. The period from September to November was defined as "Autumn season". December to February was defined as "Winter season". March to May was defined "Spring season". June to August was defined as "Summer season".

2.4. Statistical Analysis

All the collected data were entered in Microsoft Excel spread sheet. The differences between complicated and non complicated appendicitis groups in terms were analyzed using Mann-Whitney U test. Mean ages were compared using Student's t test. Chi-square test was used for the comparison of nominal data. A p value less than 0.05 was considered statistically significant. All data was analyzed using SPSS (Version 23.0, SPSS Inc., Chicago, IL, USA).

2.5. Ethical Statements

The study proposal was approved by the Research Ethics Committee at the Mongolian National University of Medical Sciences (Reg. No. 2018/9-10). All participants were informed about the study and gave written informed consent from the caregivers before the study.

3. Result

3.1. Baseline Characteristics

1003 pediatric patients (≤18 years old) were suspected of having acute appendicitis and subsequently underwent surgery. 36 patients did not meet the selection criteria for this study and were excluded. From a total of 967 patients, 56% (n = 542) were male, 44% (n = 425) were female (gender ratio was 1.3:1). The mean age was 10.57 ± 3.53. The mean duration of pain was 58 ± 49.8 hours and 93.3%

of the patients presented with pain in the right lower quadrant. The histological examination noted that 33.1% were uncomplicated, 66.9% were complicated.

3.2. Uncomplicated Appendicitis versus Complicated Appendicitis

On histopathology the appendix was Catarrhal appendicitis in 156 patients, phlegmonous appendicitis in 491 patients, CA which included perforated and gangrenous appendicitis in 320 patients. Thus, one-third patients presented with CA.

The mean age was 10.6 years in the group of complicated appendicitis versus 10.8 years in the noncomplicated appendicitis group, with no statistically significant difference (p = 0.724). Male predominance was noted in both groups (59.7% versus 54%) with no statistically significant difference (p = 0.598) (**Table 1**). While the incidence of acute appendicitis was higher during winter, the highest incidence of perforated appendicitis was observed equally in winter and autumn (**Figure 1**) without significant association (p = 0.541). The months of December and March were marked by the highest incidence of AA. The highest incidence of complicated appendicitis was observed during the month of December (45%) (**Figure 2**) with statistically significant difference (p < 0.001). Our study the incidence of family history, allergy and family members was noted in complicated and noncomplicated group with statistically significant difference (**Table 2**).

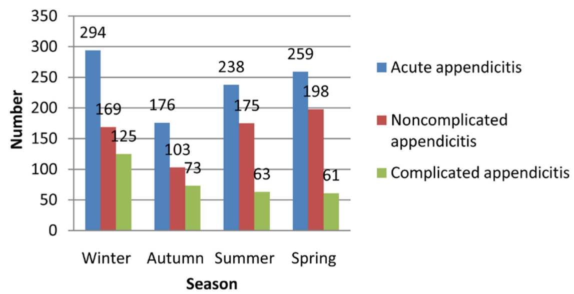

Figure 1. Distribution of acute appendicitis, complicated and noncomplicated appendicitis by season.

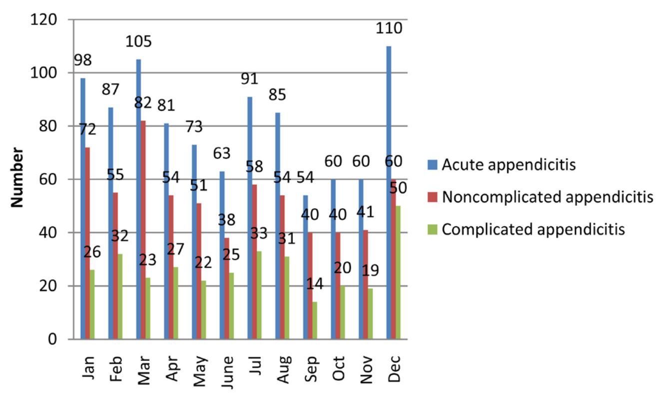

Figure 2. Distribution of acute appendicitis, complicated and noncomplicated appendicitis by month.

Table 1. Association between complicated, noncomplicated appendicitis histological diagnosis and others.

	Complicated n = 320	Noncomplicated n = 647	p value
Age (mean)	10.6	10.8	0.724
Gender			0.598
Female	128 (40%)	294 (45.4%)	
Male	192 (60%)	353 (54.6%)	
Surgical type			-
Laparoscopic	0	0	
Open	320 (100%)	647 (100%)	
Affiliation			<0.001
Rural	92 (28.8%)	46 (7.1%)	
Urban	228 (71.2%)	601 (92.9%)	
Histological diagnosis			-
Catarrhal	-	156 (24.1%)	
Phelegmoneus	-	491 (75.9%)	
Gangrenous	210 (65.6%)	-	
Perforated	110 (34.4%)	-	
Length of hospital stay	3.8	2.8	<0.001
Reoperation			<0.001
Yes	96 (30%)	18 (2.78%)	
No	224 (70%)	629 (97.22%)	

Table 2. Association between complicated, noncomplicated appendicitis some indications.

	Overall = 967	Noncomplicated n = 647	Complicated n = 320	p value
Family history of acute appendicitis				<0.001
Yes	548 (56.6%)	326 (50.42%)	222 (69.3%)	
No	419 (43.4%)	321 (49.58%)	98 (30.7%)	
Vegetable consumption (7 days)				<0.001
<3 *day*	813 (82.7%)	507 (78.3%)	306 (95.7%)	
3 *day*<	154 (17.3%)	140 (21.7%)	14 (4.3%)	
Gastrointestinal tract Infections				0.848
Yes	224 (23.4%)	152 (23.55%)	72 (22.6%)	
No	743 (76.6%)	495 (76.45%)	248 (77.4%)	
Allergy				<0.001
Yes	538 (60%)	473 (73.1%)	65 (20.2%)	
No	429 (40%)	174 (26.9%)	255 (79.8%)	

Continued

Second-hand smoking				0.498
Yes	797 (82.7%)	539 (83.4%)	258 (80.6%)	
No	170 (17.3%)	108 (16.6%)	62 (19.4%)	
Family members				<0.001
1 - 3	292 (32.5%)	254 (39.3%)	38 (11.8%)	
3 - 6	610 (61.8%)	374 (57.8%)	236 (73.9%)	
≥6	65 (5.6%)	19 (2.8%)	46 (14.3%)	
Toilet				0.772
Outside	576 (59.4%)	382 (59%)	194 (60.5%)	
Inside	391 (40.6%)	265 (41%)	126 (39.5%)	
Water supply				
Yes	391 (40.6%)	265 (41%)	126 (39.5%)	0.772
No	576 (59.4%)	382 (59%)	194 (60.5%)	
***Family monthly budget* 1 *USD* = 2850**				<0.001
<500,000	233 (23.3%)	136 (21%)	97 (30.3%)	
500,000 - 800,000	302 (30.2%)	176 (27.2%)	126 (39.4%)	
>800,000	432 (46.5)	335 (51.8%)	97 (30.3%)	

Patients with complicated appendicitis were significantly positive family history, with allergy, lower level of vegetable consumption and family budget, rural patients. However, there was no significant difference in gender, age, gastrointestinal tract Infections, secondhand smoking, toilet, and water supply (**Table 2**). Peritonitis constituted the majority of complication assessments during surgery. There were significant differences in terms of interval between the reoperation, affiliation, and length of hospital stay ($p < 0.001$).

3.3. Multivariable Analysis

The results of the multivariable analysis are summarized in (**Table 3**). The strongest predictor of complicated appendicitis was family history (odds ratio [OR] = 4.276, 95% confidence interval [CI] = 3.508 - 8.945, $p < 0.001$). Other predictors for complicated appendicitis included vegetable consumption (OR = 3.184, 95% CI = 2.041 - 4.913, $p < 0.001$), allergy (OR = 2.789, 95% CI = 1.512 - 6.651, $p < 0.001$), affiliation (OR = 2.502, 95% CI = 0.675 - 7.120, $p < 0.001$) and gender (OR = 1.61, 95% CI = 0.14 - 8.31, $p = 0.625$). There was no association between complicated appendicitis and age, second-hand smoking.

4. Discussion

Acute appendicitis is a common entity with a relatively high rate of misdiagnosis (12% - 30%). Nevertheless, various studies on risk factors for complicated appendicitis suggested that health care providers all over the world desire to be

Table 3. Risk factors predicting complicated appendicitis by multivariate logistic regression analysis.

			95% Cl	
	p	Odds ratio	Lower limit	Upper limit
Age (year)	0.798	0.23	0.13	0.48
Gender	0.625	1.61	0.14	18.31
Family history of acute appendicitis	<0.001	4.276	3.508	8.945
Vegetable consumption	<0.001	3.184	2.041	4.913
Allergy	<0.001	2.789	1.512	6.651
Affiliation	<0.001	2.502	0.675	7.120
Secondhand smoking	0.512	0.168	0.023	0.257

able to predict cases with less favorable outcomes and to be prepared for such circumstances. The socioeconomic status of populations have received attention in health studies, both in the past and present, where family history, allergy and Gastrointestinal tract Infections have been considered as components of this parameter. Various risk factors associated with increased incidence of complicated appendicitis have been studied which includes; extremes of ages, male sex, race, rural locality, delays in presentation or diagnosis, lack of insurance or financial coverage status, hospital volume, presence of appendicolith, elevation in the blood parameters, namely neutrophils count and CRP. Young children have less ability to understand or articulate their developing symptomatology compared with adolescents, the accuracy of diagnosis in this age group is also less, the immaturity of omentum and the reduction of defence mechanism results higher complicated rate. Perforation rates have been reported to be as high as 82% in children younger than 5 years and nearly 100% of 1-year-old. The variation in the incidence of appendicitis between different countries [19] [20] with a marked decrease in developed countries over the last few decades matching with the enactment of legislation that led to reductions in the concentrations of several outdoor air [21] support this theory. In our study, the highest incidence of AA was observed in winter and spring, while the lowest was observed in autumn and summer. Our results are consistent with studies in Sulu B *et al.* [11], in their study conducted in Kars, a city located in the eastern most part of Turkey, the frequency of appendicitis was the highest during winter. These findings were also noted in Kirman [22], a region with an altitude similar to that of Kars. The authors suggested a role of altitude in the seasonal variation of AA rate [11]. This increase may also reflect an infectious etiology [2] [12] [23]. Such hypothesis was supported by the presence of concomitant peaks for other enteric infections [23]. Some infectious agents with an etiological role in the development of appendicitis may be active at certain altitudes, and their virulence or frequency may increase when temperature falls below a certain degree, resulting in high perforation rates. The presence of seasonal variation shows the possibility of heterogenous extrinsic factors such as, humidity, allergens, sun radiation, and viral and bacterial infections in the etiogenesis of appendicitis.

In an epidemiologic study by Alder *et al.* (2010), a correlation between influenza and AA was reported [24]. However, influenza is more common in winter. The authors suggested a role of altitude in the seasonal variation of AA rate [11]. Thus, for low altitude regions such as Ontario [25], Jersey City [26], Ferrara [27] and Shahr-e-Rey [10], an increase in appendectomy rates was observed during summer. In contrast, according to South Korea [20], the United States [2] and India [6] show a peak during the summer season and a lowest incidence during the winter season. The reasons for increased incidence of AA during the warm period are not clear, although various speculations have been proposed such as the effect of dehydration, lower bowel movements or the effects of diet. Otherwise, in northern Saudi Arabia, incidence of acute appendicitis increased in the spring months coinciding with the onset of the sandstorm season [28]. This increase has been explained by the intense challenge to the mucosa associated lymphoid tissue from allergens, bacteria and viruses present in the dust. According to Oguntola [9], incidence of AA was higher during the rainy season (April to September) in Nigeria. Higher prevalence of humidity, infections and pollen allergens during this period could contribute to a higher incidence of appendicitis.

Other authors also postulated that seasonal variation in exposure to allergens and viral and bacterial infections, as well as changes in humidity, would explain the seasonal variation in AA. In our study, the highest incidence of complicated appendicitis was noted in winter and summer with a non-statistically significant difference ($p = 0.745$). Thus, it does not appear to be influenced by seasonal variations. Our results agree with those found by Al-Omran Mand [25] who described that the influence of seasonal variations is less evident in the case of complicated appendicitis. For Sulu B [11], complicated appendicitis was seen in summer and autumn (for both, 27.6%; $p < 0.05$). Similarly, Nabipour [7] reported higher frequencies of complicated appendicitis at the same period ($p = 0.031$). In our study the incidence of family history, allergy and family member was noted in complicated and noncomplicated group with statistically significant difference. There are some limitations to this study this is a single-institution study with a limited number of patients.

5. Conclusion

In conclusion, similar to previous studies, we also demonstrated the influence of age and sex on the development of acute appendicitis. However, we described additional factors that may influence the rate of complicated appendicitis such as seasonal variations, month variations, vegetable consumption, allergy, affiliation and secondhand smoking. Patients with complicated appendicitis have prolonged hospital stay and a higher incidence of reoperation. Pediatric acute appendicitis incidence is increased in winter months in Mongolia. Preventive measures to decrease morbidity and mortality associated with this disease can be taken during the winter seasons from December to March. Seasonal variation observed in the present study may be related to the dominance of certain infectious agents during the winter. However, further large-scale studies are needed to support this conclusion.

Limitation

Since the study population was from a single medical center, the results may be less generalizable than those from multicenter studies.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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