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Incidence of Acute Nonperforated and Perforated Appendicitis: Age-specific and Sex-specific Analysis

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Abstract. This prospective study was performed to investigate epidemiological characteristics in terms of the age- and sex-specific incidence in patients with perforated and nonperforated appendicitis. The study population comprised 1486 consecutive patients who underwent appendectomy for suspected acute appendicitis between 1989 and 1993. Two patient cohorts [*n* = 544 (37%)] were analyzed with regard to prehospitalization duration of symptoms and in-hospital observation time. The crude incidence of acute appendicitis was 86 per 100,000 per year. Although the incidence of nonperforated appendicitis was highest among adolescents and young adults (13–40 years of age), perforated appendicitis occurred at almost the same incidence in all sex and age groups. The diagnostic accuracy was 76%. Perforated appendicitis occurred in 19%, with higher rates in small children and the elderly, irrespective of gender. A high diagnostic accuracy was not associated with an increased rate of perforation. In small children and the elderly, the diagnostic accuracy was low and the perforation rate high. Patients with perforation had a significantly longer duration of symptoms as well as in-hospital observation time than did patients with nonperforated appendicitis. Perforated appendicitis showed a different incidence pattern than nonperforated appendicitis and was associated with a significantly longer duration of symptoms and in-hospital observation time, probably due to patient-related factors. We suggest this observation deserves attention regarding clinical diagnosis and treatment decision-making for patients with suspected acute appendicitis.

To understand the etiology of acute appendicitis, much attention has been paid to the incidence of this common disease [1–3]. According to population-based reports from Scandinavia, the annual incidence of acute appendicitis is 110 to 140 per 100,000, with its highest incidence in patients 13 to 40 years of age [4, 5]. Interpretation of results has been difficult because of patient selection bias and lack of definition of acute appendicitis in many series [6].

It has been shown that the postoperative complication rate is significantly increased among those with perforated appendicitis [7, 8]. Therefore a low threshold for the decision to operate has been recommended to decrease the perforation rate [2, 9]. This surgical attitude has not been endorsed by others, however [10]. Epidemiological reports have hypothesized that perforated appendicitis may be a different disease from nonperforated appendicitis, and the importance of recording the incidence of perforating and nonperforating appendicitis separately has been emphasized [4, 11].

This study was done to calculate the age- and sex-specific incidence of acute nonperforated and perforated appendicitis in a large series of nonselected, consecutive patients from a single institution. A second objective was to correlate those findings to preoperative time periods in the various patient groups.

Materials and Methods

Patients

Our hospital is an institution in an urban and rural catchment area with 265,000 inhabitants. Between 1989 and 1993 a total of 1486 patients, 794 (53%) men and 692 (47%) women, underwent surgery for suspected acute appendicitis. Calculation of the incidence was based on official population figures from the government, as seen in Table 1. Age-specific analysis was employed on five clinically relevant age groups: small children (0–4 years), children (5–12 years), adolescents and young adults (13–40 years), adults (41–65 years), and the elderly (> 65 years).

Definitions

Diagnostic accuracy (DA) was defined as the percentage of removed appendices with a histologic diagnosis of acute appendicitis from the total number of performed appendectomies. *Perforation rate* was defined as the proportion of perforated appendices of all patients with acute appendicitis. *Positive laparotomy rate* was calculated from the number of patients for whom surgical treatment was required for various reasons, including acute appendicitis.

Time Relations

In the 1990 and 1992 patient cohorts (*n* = 544), clinical data were collected as part of a prospective study on the diagnostic features of acute appendicitis. Several preoperative time intervals were recorded for all patients: the time from onset of symptoms until hospital admission, the length of the in-hospital observation

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Table 1. Age- and sex-specific incidence of acute appendicitis for 1989–1993 and number of performed laparotomies.

Age (years)	Incidence/ 100,000/year		No. of patients with *confirmed* appendicitis (n = 1129)		Average population by age and gender		No. of performed laparotomies for *suspected* appendicitis (n = 1486)	
	Males	Females	Males	Females	Males	Females	Males	Females
0–4	3.5	11.4	2	6	11,407	10,543	5	8
5–12	100.6	99.8	78	75	15,502	15,031	105	95
13–40	160.4	104.3	469	292	58,472	55,997	559	442
41–65	48.9	40.8	80	64	32,752	31,382	87	87
> 65	40.1	38.0	27	36	13,456	18,934	38	60

Table 2. Histopathologic classification by grade of inflammation of acute appendicitis.

Type of inflammation	Histologic criteria
Appendicitis with minor inflammation	Focal acute inflammation in the mucosa
Phlegmonous	Polymorphonuclear infiltration of the entire appendiceal wall without evidence of necrosis
Gangrenous	Phlegmonous type but presence of necrosis
Appendicitis with perforation	Rupture of the appendiceal wall to the serosal surface
Periappendicitis	Inflammation in the serosa, eventually affecting the longitudinal muscular layer

period to time of operation, and the time from decision to operate until the start of surgery.

Histology

All specimens were routinely examined morphologically, and our final diagnosis was based on histology. The criteria used for the histologic diagnosis [12] are shown in Table 2. Nonperforated appendicitis was defined as an inflamed appendix without the presence of free pus in the peritoneal cavity and without evidence of macroscopic perforation. The diagnosis of perforation was made according to intraoperative findings by the surgeon.

Statistical Analysis

The chi-square test was used for categorical data, the Mantel-Haenszel's chi-square test for stratified categorical data, and the Whitney-Mann U-test for numerical variables when appropriate. Probability values < 0.05 were considered statistically significant.

Results

The age and sex distributions of the patients are shown in Table 1. The median age was 22 years (range 2–93 years, interquartiles 15–35 years). Most of the patients (65%) were adolescents and young adults. The overall age distribution was similiar for males and females. The male/female ratio was 1.14:1.00.

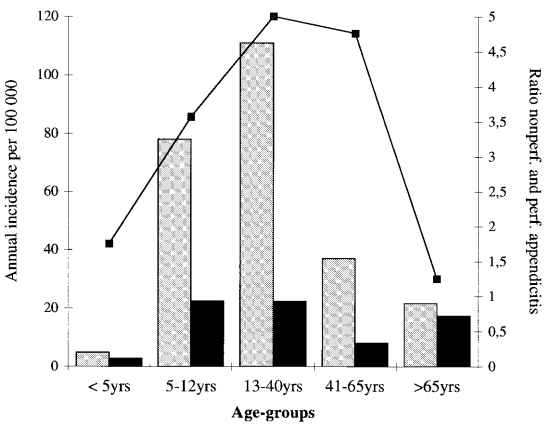

Fig. 1. Age-specific incidence of nonperforated (gray bars) and perforated (black bars) appendicitis (left y-axis) per 100,000 per year. Ratio of incidences of nonperforated and perforated appendicitis (line with squares) per age group (right y-axis, line plot).

Incidence of Nonperforated and Perforated Appendicitis

The diagnosis of acute appendicitis was confirmed in 76% of the patients (82% in males, 68% in females; $p < 0.001$). The crude incidence of acute appendicitis was 86 per 100,000 inhabitants per year, varying between 74 and 96 per 100,000 during the 5-year period. The frequency of laparotomy during the same time period was 113 per 100,000 per year, varying between 90 and 128 per 100,000. A peak incidence of acute appendicitis was found in patients 13 to 40 years of age, and males were more frequently encountered in this age group (ratio 1.34:1.00). Among small children and elderly people, significantly ($p < 0.002$) more females were found to have acute appendicitis (Table 1).

The incidence of nonperforated appendicitis varied among the age groups, occurring most frequently in patients 13 to 40 years of age (Fig. 1). In contrast, perforated appendicitis occurred with a similar incidence in all age groups, irrespective of gender. The laparotomy rates per age group paralleled the incidence of nonperforated appendicitis, in contrast to that of perforated appendicitis. Perforated appendicitis occurred with a frequency similar to that for nonperforated appendicitis in small children and the elderly, whereas nonperforated appendicitis was most frequently encountered in the other age groups (Fig. 1).

Diagnostic Accuracy and Perforation Rate

The overall DA was 76%. Histologic findings of the specimens are shown in Table 3. DA was significantly higher ($p < 0.001$) in males than in females: 82% and 68%, respectively. Among the 544 patients operated during 1990 and 1992 there were 110 (70%) of 156 females ages 13 to 40 years who had acute appendicitis. Among the remaining 46 females, 14 (30%) had gynecologic diseases (two had an extrauterine pregnancy, five had ruptured ovarian follicles, three had ovary torsion, and four had salpingitis). The DA was significantly lower in children less than 5 years of age and in elderly patients over 65 years than in the other age groups,

Table 3. Age-specific distribution of acute appendicitis by grade of inflammation (n = 434): 1990 and 1992 cohorts.

Age (years)	Minor		Phlegmonous		Gangrene		Perforated		Total	
	No.	%[a]	No.	%	No.	%	No.	%	No.	%
0–4	0	0	1	33	0	0	2	67	3	100
5–12	0	0	41	65	14	22	8	13	63	100
13–40	1	0.4	181	62	87	30	21	7.6	290	100
41–65	0	0	26	49	18	34	9	17	53	100
> 65	0	0	12	48	4	16	9	36	25	100
Total	1	0	261	60	123	28	49	12	434	100

[a]Percentage per age group.

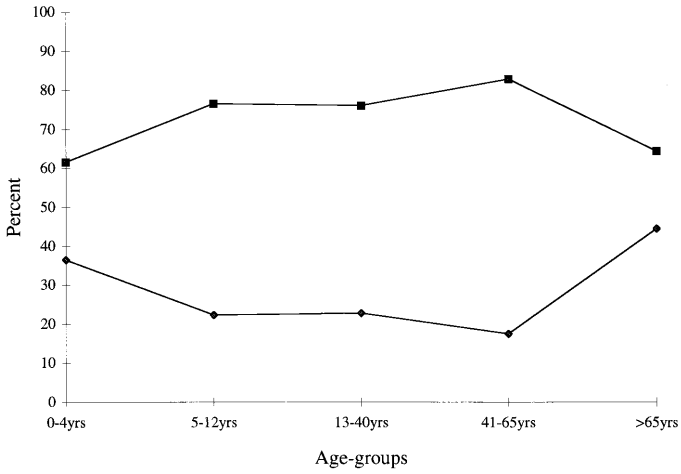

Fig. 2. Perforation rate (line with diamonds) and diagnostic accuracy (line with squares) in different age groups.

62% and 64% versus 78%, respectively ($p < 0.01$). The overall positive laparotomy rate was 3% higher than the DA, and no difference was found among the various age groups.

The overall perforation rate was 19%, being significantly ($p < 0.0001$) higher in elderly patients (44%) and small children (36%). No differences between genders were found in the various age groups. The perforation rate was low in age groups with a high DA (children, adolescents, young adults) and high in the groups with a low DA (i.e., elderly and small children) (Fig. 2).

Time Relations: Observation Rate, Perforation Rate

The results of recording preoperative time intervals for 544 patients (1990 and 1992 cohorts) are shown in Table 4. The median duration from the onset of symptoms until admission to hospital for all patients was 20 hours (range 1–254 hours). Among the 434 patients with a proved diagnosis of acute appendicitis, this median time period was significantly longer ($p < 0.0001$) for patients with perforated appendicitis (n = 88) than for those with nonperforated appendicitis (n = 346): 32.5 and 17.0 hours, respectively. The duration of symptoms was not related to age or gender.

For 139 (32%) of the 434 patients in 36% (32/88) with perforated appendicitis and 31% (34/107) with nonperforated appendicitis the in-hospital preoperative observation time was

Table 4. Duration of symptoms, observation time, and waiting time from decision to operate until start of operation (1990 and 1992 cohorts) among patients with acute appendicitis (n = 434/544).

Time intervals	Duration (hours)		p
	Nonperforated appendicitis	Perforated appendicitis	
Prehospital duration (n = 434)	17 (1–120) (n = 346; 80%)	32.5 (4–254) (n = 88; 20%)	< 0.0001
In-hospital observation before decision to operate (n = 139) (32%)	6.25 (0.75–48) (n = 107; 77%)	9.25 (1.8–107) (n = 32; 23%)	< 0.04
Time from decision to operation until start of operation (n = 434), median and range	2.25 (0–17.5) (n = 346; 80%)	2.7 (0–9.6) (n = 88; 20%)	0.24

decided by the surgeon in charge. The median observation time was 6.8 hours (range 1–107 hours). Patients admitted at nighttime (between 10.00 p.m. and 7.30 a.m.) were observed significantly longer ($p < 0.004$) than patients admitted during the daytime hours: 11 and 5 hours, respectively. However, the DA and perforation rate were similar regardless of the time of admission.

Discussion

Our study population was a complete consecutive series with a prospective registration of all patients operated on for suspected acute appendicitis in our department during a 5-year period. This study population comprised unselected patients, epidemiologically representative for a general Scandinavian population.

The incidence of acute appendicitis in our study was similar to that reported by others [1, 4, 13–16]. The disease was rare in small children (i.e., < 5 years of age), with the highest incidence found in young adults. For the ages 13 to 40 years of age, male patients were most often encountered.

In contrast to nonperforated appendicitis, perforated appendicitis was unrelated to age and gender and occurred at an almost constant rate, as has been reported by others [3, 4, 11]. Perforated appendicitis and nonperforated appendicitis occurred with an almost similar frequency in small children and the elderly, whereas nonperforated appendicitis was most common in the other three age groups (Fig. 1). Explanations for these two incidence patterns are unknown. Some authors [7, 17] have suggested an increased propensity to perforate in small children and the elderly as a possible cause for perforation. Different progression rates of the inflammatory process between individual patients and immunologic factors have been discussed [8]; and because of the different incidence patterns Anderson et al. and others [4, 11] suggested that perforated appendicitis is an entity different from nonperforated appendicitis.

Our patients with perforated appendicitis had a significantly longer prehospitalization duration of symptoms and in-hospital

observation time (until the decision to operate) compared to patients with nonperforated appendicitis. As reported by others [18–20], we found that patients with perforated appendicitis had a longer prehospitalization duration of symptoms, which may indicate that most perforations occurred before admittance to hospital. A significantly longer prehospitalization duration of symptoms among patients with perforation support the theory that patient-related factors might in part be responsible for delayed diagnosis of the disease. It may also indicate that age-related clinical responses to abdominal complaints by small children and the elderly, compared to older children and adults, caused contact with the health care system to be delayed, allowing the inflammatory process to continue. The longer time spent before admission to hospital among patients with perforation is consistent with less obvious symptoms in small children and elderly and may also partly explain the longer in-hospital observation time required by the surgeon for those age groups. Although patients with perforation had a longer preoperative observation time, the proportions of patients observed, with or without perforating appendicitis, were similar. Thus factors inherent to these two particular patient groups might partly explain the different incidence figures.

Some authors have reported that an increased perforation rate was related to high DA [21, 22], and a liberal indication for laparotomy has been recommended to prevent perforation [2, 9]. The perforation rate in our study was not associated with the DA, as has also been shown by others [10]. Our DA was significantly lower in age groups with a high perforation rate (Fig. 2), which indicates that in those groups more negative laparotomies were undertaken, probably because of an uncertain preoperative diagnosis. In our opinion, performing an invasive procedure (e.g., diagnostic laparoscopy) would probably not reduce the number of perforations in doubtful cases. As several patient-related factors are involved, we think that the perforation rate alone is not a useful measure of the quality of the diagnostic workup and treatment of acute appendicitis.

The hypothesis stated by Anderson et al. [4] and Luckmann [11] that perforated and nonperforated appendicitis are different entities remains to be proved, and further studies are warranted. Our findings indicate that perforated and nonperforated appendicitis are two clinically different features of one disease. The first seems to appear most often in very young and elderly patients, and the latter predominates in adolescents and adults. We think this observation is important and deserves attention in the diagnostic workup and clinical decision-making process of this common surgical disease.

Résumé

Cette étude prospective a eu comme but de déterminer les caractéristiques épidémiologiques de l'incidence d'appendicite perforée ou non-perforée selon l'âge et le sexe. La population étudiée comprenait 1486 patients consécutifs qui ont eu une appendicectomie pour appendicite aiguë entre 1989 et 1993. Deux cohortes de patients (n = 544 [37%] ont été analysées en ce qui concerne la durée des symptômes avant l'hospitalisation et la durée de la période d'observation hospitalière. L'incidence brute d'appendicite aiguë était de 86 pour 100000 par an. Alors que l'incidence de l'appendicite aiguë non perforée était plus élevée parmi les adolescents et les adultes jeunes (13–40 ans), la perforation appendiculaire avait presque la même incidence quel que soit l'âge ou le sexe. La précision diagnostique était de 76%. L'incidence de la perforation appendiculaire a été de 19%, plus fréquente chez l'enfant jeune et le sujet âgé, indépendamment du sexe. Augmenter la précision diagnostique n'était pas accompagné d'une incidence plus élevée de perforation. Chez l'enfant plus petit et chez le sujet âgé, la précision diagnostique était élevée et le taux de perforation bas. La durée des symptômes avant l'hospitalisation et la durée de la période d'observation des patients ayant perforé leur appendice était plus longue comparée à celle des patients n'ayant pas perforé leur appendice. Les caractéristiques de l'incidence de la perforation appendiculaire diffèrent selon qu'il s'agit d'une appendicite perforée ou non car la durée des symptômes avant l'hospitalisation et la durée de la période d'observation des patients ayant perforé leur appendice est plus longue probablement en rapport avec des facteurs individuels liés au patient. Nous suggérons que cette constatation mérite considération en ce qui concerne le diagnostic clinique et la décision thérapeutique chez le patient ayant une suspicion de perforation d'appendice.

Resumen

El presente estudio prospectivo fue realizado con el fin de investigar las características epidemiológicas, en términos de incidencia según edad y sexo, en pacientes con apendicitis perforada y no perforada. La población sujeto del estudio comprendió 1.486 pacientes consecutivos sometidos a apendicectomía por apendicitis aguda presumible, en el período entre 1989 y 1993. Dos cohortes de pacientes (n = 3D544 [37%]) fueron analizadas en relación con la duración prehospitalaria de los síntomas y con el tiempo intrahospitalario de observación. La incidencia cruda de apendicitis aguda fue de 86 por 100.000 y por año. En tanto que la incidencia de apendicitis aguda no perforada fue máxima en adolescentes y adultos jóvenes (13–40 años de edad), la apendicitis perforada se presentó con casi la misma incidencia en todos los grupos según sexo y edad. La certeza diagnóstica fue de 76%. La apendicitis perforada se presentó en tasa de 19%, con tasas mayores en niños menores y en ancianos, sin diferencia en cuanto a sexo. No se encontró asociación entre la mayor certeza diagnóstica y una mayor rata de perforación. En los niños menores y en los ancianos, la certeza diagnóstica fue baja y la rata de perforación alta. Los pacientes con perforación exhibieron una duración de los síntomas más prolongada, así como un mayor tiempo de observación intrahospitalaria, en comparación con pacientes con apendicitis no perforada. La apendicitis perforada demostró un patrón diferente de incidencia en comparación con la apendicitis no perforada, y apareció asociada con una significativa mayor duración de los síntomas y del tiempo de observación intrahospitalaria, probablemente debido a factores relacionados con el paciente. Sugerimos que esta observación merece atención en lo referente al diagnóstico clínico y a la decisión sobre tratamiento en pacientes con la presunción de apendicitis.

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Invited Commentary

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The study by Korner et al. is unique in that the study population was confined to a single institution in a well defined area. They demonstrated that the incidence of perforated appendicitis was similar among all age groups; but compared with nonperforated cases there were more patients in the under-5-year and over 65-year age groups with perforated appendicitis. Their ability to document, prospectively, the duration of symptoms before admission to hospital and the duration of observation before decision for surgery is to be congratulated; and these factors were shown to correlate with perforation of the appendix. The authors concluded that perforation of acute appendicitis was mainly due to patient-related factors.

Not mentioned in the manuscript was the number of doctors the patients had consulted before they were admitted. If the patients had been seen by their family doctors and observation was recommended, the perforation would not be entirely due to patient-related factors. If failure of elderly patients (> 65 years) or small children (< 5 years) to communicate adequately with the doctors had been the cause of delay, the perforation would have been patient-related. Even though the patients were admitted, the decision to observe them, especially overnight, contributed to the delay and therefore possibly to the perforation. In my opinion these factors were not necessarily patient-related. Increased awareness of such conditions by doctors from both outside and inside the hospital is mandatory to reduce the perforation rate.

The consequences of perforated appendicitis was not mentioned in the study. Presumably, postoperative morbidity, drug expenditure, duration of hospital stay, and absence from work would be much increased. The lesson learned from this study is that vigilance during the diagnostic workup and a second or even third opinion from a senior surgeon for such seemingly minor abdominal cases is warranted.