



## Evaluation of concordance among surgeons and pathologists regarding the diagnosis and classification of acute appendicitis in children

Eliana Rodríguez <sup>a,\*</sup>, Juan Valero <sup>b</sup>, Lina Jaramillo <sup>c</sup>, María Teresa Vallejo-Ortega <sup>d</sup>, Luisa Lagos <sup>e</sup>

<sup>a</sup> Resident of Pediatric Surgery, Department of Surgery, Faculty of Medicine, Universidad Nacional de Colombia, Colombia

<sup>b</sup> Pediatric Surgeon, Fundación Hospital Pediátrico la Misericordia. Assistant Professor, Department of Surgery, Faculty of Medicine, Universidad Nacional de Colombia, Colombia

<sup>c</sup> Pathologist, Fundación Hospital Pediátrico la Misericordia. Tenur Proffessor, Department of Pathology, Faculty of Medicine, Universidad Nacional de Colombia, Colombia

<sup>d</sup> Epidemiologist, Universidad Nacional de Colombia, Colombia.

<sup>e</sup> Resident of Pediatrics, Department of Pediatrics, Faculty of Medicine, Universidad Nacional de Colombia, Colombia.

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### ABSTRACT

Acute appendicitis is the most frequent urgent abdominal surgical pathology in children. Therapeutic decisions in patients who have undergone an appendectomy are made based on the macroscopic findings at the moment of surgery. There is high variability between surgical and histopathological findings.

**Method:** Concordance among surgeons and pathologists regarding the diagnosis and classification of acute appendicitis was assessed in children who have undergone an appendectomy. Surgical site infection (SSI) incidence was measured for both the surgical and pathological classification.

**Results:** The statistical analysis included 1092 children. The pathologists confirmed the presence of appendicitis in 90.4% of the patients. Concordance in the diagnosis of appendicitis among surgeons and pathologists was weak ( $\kappa$  0.57), while concordance in the classification of perforated or non-perforated appendicitis was moderate ( $\kappa$  0.7). There were no significant differences in these findings determined by the surgeons' experience or the open or laparoscopic approach. In the discordant group of 70 patients in which the surgeon classified the appendicitis as non-perforated but the pathologist classified as perforated, just one patient developed an intra-abdominal abscess.

**Conclusions:** The classification of appendicitis as perforated or non-perforated shows moderate concordance between the surgical and histopathological diagnosis. This concordance is not determined by the surgeons' experience or the surgical approach.

**Type of Study:** Diagnostic Test

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Appendicitis is the most frequent urgent abdominal pathology in pediatric surgery. Therefore, the search for predictors of associated complications is continuously evolving. Among the factors that influence the appearance of complications, the most relevant is surgical and histopathological classification [1,2]. However, the degree of severity of the appendicitis has been difficult to standardize [3–6], resulting in significant disagreements among surgeons and institutions [7,8]. Most of the world medical literature classifies appendicitis as simple or complex, the latter including both the perforated and the gangrenous types. Regarding complex classification, a high concordance (90%–93%) between the clinical and the pathological findings has been demonstrated for

simple appendicitis (edematous and fibrinopurulent) while this figure drops by 50% for complex appendicitis [9]. This disparity may be due to the notable heterogeneity in gangrenous appendicitis assessments [10]. The lack of standardized criteria for the appropriate classification of appendicitis complicates the management of children who present this pathology [8,9].

In 2008, a classification was proposed based on surgical findings in which the condition was divided into perforated appendicitis (PA) or non-perforated appendicitis (NPA) [3]. The Fundación Hospital Pediátrico la Misericordia (HOMI) adopted this classification in 2011 [4], using the criteria of St. Peter et al [3]. Currently, it is uncertain whether this surgical-based classification is more accurate when compared to the pathological findings, which have been the gold standard in pediatric surgery. With this in mind, this study was designed with the objective of estimating the concordance in the diagnosis of appendicitis and the classification of

\* Corresponding author.

E-mail address: [elianarodriguezmd@gmail.com](mailto:elianarodriguezmd@gmail.com) (E. Rodríguez).

<sup>1</sup> Mailing Address: Carrera 57 # 53-50. Ap. 3-421, Bogotá, Colombia.

perforated/non-perforated appendicitis between surgeons and pathologists.

## 1. Methods

The study was conducted at HOMI, a renowned university hospital for children in Bogota, Colombia. After being granted approval by the HOMI Ethics Committee, a retrospective review was performed of the clinical charts of children under 18 years of age who underwent surgery for appendicitis between January 1st and December 31, 2014; this particular year was chosen because HOMI has dramatically reduced the number of open appendectomies performed since then. Patients excluded were those who had an interval appendectomy, an incidental appendectomy as a part of another surgery, or who had an unspecified classification.

In 2014, HOMI had 10 pediatric surgeons with between 1 and 40 years of experience, and two pathologists with at least 10 years of experience, who examined all the appendices. The classification of appendicitis was made independently by the two departments.

During surgery, pediatric surgeons decided if the patient had appendicitis or not based on macroscopic findings. If appendicitis was confirmed, they classified it as PA or NPA according to the intraoperative findings. A PA occurs when the appendix has a hole or a fecalith is visible in the abdominal cavity [3,4]. All patients received preoperative antibiotic prophylaxis. The patients with NPA received just one preoperative dose of antibiotics and were discharged within 24 hours following surgery, once pain was under control and oral intake was tolerated. Patients with PA were hospitalized and received either 5 or 7 days of intravenous antibiotic treatment depending on whether they had local or generalized peritonitis (defined as more than two quadrants filled with purulent fluid).

The pathology department established the diagnosis of acute appendicitis based on the presence of inflammatory infiltrates of polymorphonuclear neutrophils in the lamina propria, frequently associated with ulcers of the mucous layer and usually with extension to the submucous and muscular layers of the appendix. The histological criterion to classify PA was the finding of interruption or destruction of the muscle layer of the appendix caused by inflammatory necrosis [2].

### 1.1. Data analysis

Information was collected by two researchers and reviewed by a third investigator. The variables evaluated were demographic data, macroscopic diagnosis and classification of appendicitis, surgical technique, experience of the surgeon, histopathological diagnosis and classification of the appendix, and postoperative presence of intra-abdominal abscesses (IA).

A descriptive analysis of all the collected data was conducted, while concordance of PA/NPA classification was estimated using Cohen's kappa. The classification of kappa proposed by McHugh [11] was used to describe the levels of agreement in which the kappa value of 0–0.20 indicates a non-agreement, a kappa of 0.21–0.39 indicates a minimal agreement, a kappa of 0.40–0.59 indicates a weak agreement, a kappa of 0.60–0.79 indicates a moderate agreement, a kappa of 0.80–0.90 indicates a strong agreement, and a kappa above 0.90 indicates an almost perfect agreement. In order to detect potential confounding factors of concordance related with the heterogeneity of the surgeons, the level of concordance between the surgical and the pathological findings were evaluated according to the surgical technique [open appendectomy (OA) and laparoscopic appendectomy (LA)] and the surgeon's experience. All the analyses were performed in Stata 11.

## 2. Results

In total, 1094 patients met the inclusion criteria. Two patients were excluded due to an incomplete clinical history and 1092 were included in the statistical analysis.

### 2.1. Characteristics of the population

Table 1 shows the characteristics of the population. The median age was 10 years (range: 1 to 17 years). The surgeons classified appendicitis as PA in 38%. Sixty-one percent of patients received antibiotic prophylaxis only, without additional intravenous treatment (all NPA), and 9.6% of the children developed SSI.

### 2.2. Comparative analysis: diagnosis of surgeons and pathologists

#### 2.2.1. Concordance in the diagnosis of appendicitis

The percentage of negative appendectomies, according to the surgical diagnosis, was 10.3%, and according to the pathologist was 9.6% (Table 2). Among the 113 patients that the surgeons diagnosed with negative appendicitis, the pathologist diagnosed 46 patients (40.7%) with appendicitis. Concordance among surgeons and pathologists in the diagnosis of acute appendicitis was weak (Kappa 0.57, 95%CI: 0.49 to 0.65) (Table 2).

#### 2.2.2. Concordance in the diagnosis of PA/NPA

The percentage of appendices with macroscopic perforation provided by surgeons was 38%, while the percentage obtained by pathologists was 36.6%. Concordance among surgeons and pathologists to classify patients as PA or NPA was moderate (Kappa 0.7, CI 95%: 0.65–0.74) (Table 2).

#### 2.2.3. Concordance among sub-groups (Table 3)

There were no significant differences in the level of concordance of either the diagnosis of appendicitis and the classification of appendicitis into NPA or PA among surgeons with more than 5 years of experience compared with surgeons with less time, or between surgeons who completed less/more than 2 appendectomies per week, or between de OA or LA.

#### 2.2.4. Postoperative presence of IA

When evaluating the impact of concordance in appendicitis classification and occurrence of SSI, 105 patients developed an SSI (9.6%) and,

**Table 1**  
Characteristics of the population

Variable	n	%
Patients	1092	100
Age mean (SD)	10.2 (3.7)	NA
Age median (range)	10 (1–17)	NA
Sex		
Male	559	51.2%
Female	533	48.8%
Surgical findings		
Appendicitis	979	89.7%
Perforation on the appendix	415	38%
Pathological findings		
Appendicitis	987	90.38%
Perforation on the appendix	400	36.6%
Antibiotics		
Preoperative only	666	61%
Pre and postoperative	426	39%
SSI		
Yes	105	9.6%
No	987	90.4%
SSI type		
Superficial	46	4.2%
Organ/space (IA)	54	4.9%
Superficial and organ/space	3	0.3%
Deep	2	0.2%
SSI: Surgical Site Infection		
IA: Intra-abdominal abscesses		

**Table 2**

Concordance table comparing the diagnosis of appendicitis and perforation among surgeons and pathologists.

Surgical Diagnosis	Pathologic Diagnosis			Total	Concordance kappa (95CI%)
	Appendicitis	Yes	No		
<b>Yes</b>		941 (96.1%)	38 (3.9%)	979 (89.7%)	0.57 (0.49 to 0.65)
<b>No</b>		46 (40.7%)	67 (59.3%)	113 (10.3%)	
<b>Total</b>		987 (90.4%)	105 (9.6%)	1092	
<b>Perforation</b>		<b>Yes</b>	<b>No</b>	<b>Total</b>	<b>Concordance kappa (95CI%)</b>
<b>Yes</b>		330 (79.5%)	85 (20.5%)	415 (38%)	0.7 (0.65 to 0.74)
<b>No</b>		70 (10.3%)	607 (89.7%)	677 (62%)	
<b>Total</b>		400 (36.6%)	692 (63.4%)	1092	

among them, IA was the most frequent (54 children) (Table 1). The incidence of IA in pathologically-determined negative appendectomies was 0.95%. In the group of 987 patients with appendicitis confirmed by the pathologist, the incidence of IA was 12.1% (Table 4). When both the surgeon and the pathologist classified appendicitis as perforated (concordant group), there was a 14.5% incidence of IA. On the contrary, in the subgroup of 70 children who were classified as non-perforated by the surgeon and as perforated by the pathologist (discordant group), only 1 child developed IA (1.4%). In the other discordant group, when the surgeon classified appendicitis as perforated and the pathologist as non-perforated, the incidence of IA was greater (2.4%).

### 3. Discussion

The concordance in the diagnosis of appendicitis among surgeons and pathologists is weak in this paper (kappa 0.57) and differs from that reported in other studies [12,13] (Table 5). This phenomenon could be explained by two main reasons. First, secondary changes in acute appendicitis start in the mucosa (not visible for the surgeon), and then become more evident in the serosa. Second, once an irreversible tissue injury has been generated, it leads to cell death and initial ultrastructural changes are observed. If the lesion persists over time, then changes are detected with a light microscope (only observed by the pathologist); finally, a longer duration of the injury will generate morphological changes that will be macroscopically evident [14]. Many authors conclude [15–17] that the appendix should be removed when there is a preoperative suspicion of appendicitis. This is due to the fact that no macroscopic alterations are found in patients with histologically confirmed appendicitis (40% in this study). These authors argue that leaving histologically abnormal appendix increases the risk of perforations, abscesses, tumors, and chronic appendicitis.

There are several classifications of acute appendicitis, however, many groups divide it into simple or complex, the latter being stratified as gangrenous or perforated [7,8,13,16]. In this paper, the team used the PA/NPA classification. The results show moderate concordance (kappa

0.7, 95%CI: 0.65–0.74) between surgeons and pathologists to detect perforation, regardless of the surgeon's expertise and the surgical approach. The results are better than those found in other existing publications that used different classifications (Table 5) [7,8,13,16,18]. Farzal et al used the PA/NPA classification and evaluated concordance between medical specialties in the diagnosis of perforation, finding a discordance of 11% in the group comparing pathologists and surgeons (the kappa coefficient was not used for the study, making the comparison difficult).

The low concordance within other classifications could be due to the usage of different definitions to classify appendicitis and different classification systems used by surgeons and pathologists. Also, it is possible that the health professionals considered other patient characteristics [19], leading to a bias in the evaluation of the findings and a tendency among surgeons to overestimate the severity of certain cases of appendicitis [20,21].

The problem of discordant classification not only involves surgeons but pathologists too, who do not seem to use a standardized methodology to examine the pediatric appendix [9] added to the fact that there are multiple concepts of each degree of appendicitis, especially the gangrenous type [8]. Furthermore, there is a variation in the descriptive nomenclature used in pathology reports, including the use of confusing terms such as catharral and necrotizing appendicitis [5].

With regards to the frequency of SSI, this study found that there were no significant differences in the frequency of organ-space SSI, both in the cases where the surgeon and pathologist agreed in the classification as NPA (1%), and in the cases where the surgeon classified the patient as NPA and the pathologist indicated perforation (1.4%). These findings show that the micro-perforations found in the pathology seem to have minor clinical implications for the development of SSI, hence the importance that surgeons have a clear and objective classification of appendicitis in order to determine the length of antibiotics and to avoid unrealistic rates of postoperative abscesses.

Bliss et al [9] used the complicated and non-complicated appendicitis classification and they found that the concordance with pathologists improves with the surgeon's experience. This paper, using the PA/NPA classification, did not find a significant difference upon detailed analysis of concordance between the group of surgeons with more than 5 years of experience. Additionally, there was no significant difference between the surgeons that performed more than 2 appendectomies per week (Table 3). This suggests that the greater concordance among pathologists and surgeons found in this study is the result of a more objective

**Table 3**

Concordance in the diagnosis of appendicitis or perforation according to the experience of the surgeon and the surgical approach

Type of concordance	Diagnosis of appendicitis kappa (0.95%CI)	Diagnosis of perforation kappa (0.95%CI)
Surgeons with less than 5 years of experience (n=219)	0.52 (0.35 to 0.69)	0.67 (0.57 to 0.77)
Surgeons with 5 or more years of experience (n=873)	0.59 (0.5 to 0.69)	0.70 (0.66 to 0.75)
Surgeons who completed less than 2 appendectomies per week (n=786)	0.54 (0.37 to 0.71)	0.69 (0.61 to 0.77)
Surgeons who completed 2 or more appendectomies per week (n=306)	0.58 (0.49 to 0.68)	0.70 (0.65 to 0.75)
Open Surgery (n=475)	0.53 (0.37 to 0.70)	0.68 (0.61 to 0.75)
Laparoscopic Surgery (n=617)	0.58 (0.48 to 0.68)	0.71 (0.64 to 0.76)

**Table 4**

2×2 Table of the instances of Surgical Site Infection (SSI) in patients with histopathologically proven appendicitis.

		Pathologic determination	
		Perforation	No perforation
Surgical determination	Perforation	48/330 (14.5%)	2/83 (2.4%)
	No perforation	1/70 (1.4%)	5/504 (1%)

**Table 5**  
Comparison of the degree of concordance in various studies between surgeon and pathologist

Study name	Number of patients	Evaluated concordance	kappa in diagnosis	kappa in classification
Hussain 2009 [12]	200	Appendicitis vs. No appendicitis	0.68 <sup>Y</sup>	
Bliss 2010, open surgery [9]	133	Acute, gangrenous and perforated appendicitis and normal		0.57 <sup>Y</sup>
Bliss 2010, laparoscopic surgery [9]	122	Acute, gangrenous and perforated appendicitis and normal		0.56 <sup>Y</sup>
Zarandi 2014 [13]	342	Appendicitis vs. No appendicitis	0.33 <sup>Y</sup>	
Fallon 2015 [8]	1166	Acute, suppurative, gangrenous, perforated appendicitis and normal		0.289
Farach 2015 [7]	326	Simple and complicated appendicitis		0.173
This study	1092	Perforated and non-perforated appendicitis	0.57	0.7

<sup>Y</sup> Estimated concordance in published data

classification of appendicitis as perforated or non-perforated. Since the surgeon makes an immediate clinical decision regarding treatment, it is imperative that the surgeon and the pathologist have a high degree of concordance, regardless of the experience of the surgeon.

The laparoscopic approach has the advantage of the magnification of the surgical camp, however LA did not show better higher levels of concordance with pathological findings (Table 3), which coincides with the studies by Bliss et al. [9] and Sadot et al. [17].

This study contributes statistical findings regarding levels of concordance in the diagnosis of appendicitis among surgeons and pathologists. It also provides a useful classification of PA and NPA using a statistical technique that allows to ascertain if the agreement reached is greater than what can be expected by random. Its potential limitations include a risk of bias related to the independence of the measurement due to the fact that pathologists had access to the patients' electronical medical history. Also, external validity may be limited because this study was conducted in a single context and pediatric teaching center; in consequence, the findings should be validated in multicenter studies that include hospitals of different characteristics.

In conclusion, we consider that the pathological findings must continue to be the gold standard for the diagnosis of appendicitis, since there is a weak concordance between surgeons and pathologists and there are cases of malignancy where histology and pathology determine the treatment [13,15,22].

The classification of PA/NPA is objective and leads to greater concordance between the pathological and the surgical diagnosis. This approach should be used by both surgeons and pathologists. However, in the PA/NPA classification, the gold standard should be the surgeon's classification; this is because the pathology result is often not available for many days and, more importantly, the surgeon's classification predicts adequately the SSI (Table 4). Also, the experience of the surgeon does not alter concordance among diagnosis, nor does the open or laparoscopic approach.

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