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The influence of the COVID-19 pandemic on appendicitis in children: the experience of a public hospital in Brazil

A influência da pandemia de COVID-19 na apendicite em crianças: experiência de um hospital público no Brasil

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Abstract
In the SARS-CoV-2 pandemic, children and adults with non-COVID-19 emergencies, such as acute appendicitis (AA), requiring surgical treatment, may have had longer disease evolution times with possible repercussions on the results and use of open appendectomies. ***Objective:*** *To compare the evolution and severity of AA in children and the results of laparoscopic and open appendectomies in the trans-pandemic period with the pre-pandemic period.* ***Methodology****: Retrospective study evaluating two series of children who underwent appendectomy at a public reference hospital, between March 2019 and February 2020 (pre-pandemic) and the same period from 2020 to 2021 (trans-pandemic). The analysis included the time of symptom progression, severity, types of appendectomy, and outcomes.* ***Results****: In these 2 years, 249 appendectomies were performed in children under 15: 131 in the pre-pandemic period and 118 in the trans-pandemic period. 218 (87.5%) procedures were by laparotomy and 31 (12.5%) procedures were laparoscopically. The duration of symptoms was 3.2±2.9 days in the pre-pandemic period and 3.3±2.8 days in the trans-pandemic period, and there was a lower number of children admitted within 24 hours (20.3%) of the onset of symptoms before the pandemic (vs. 34.1%). Complication rates were 32.9% with laparotomy and 12.9% with laparoscopy. Reoperations were more frequent in the pandemic than in the pre-pandemic period (11.0% vs. 4.6%) and the hospital stay was longer (5.6±4.3 vs. 4.7±2.9 days).* ***Conclusion*** *– During the pandemic, children with AA took longer to have access to surgical treatment and had more complications, reoperations, and longer hospitalization time, especially with open appendectomy*
Keywords: Acute abdomen. COVID-19 pandemic. Appendectomy. Children. Teenager.

Resumo
Introdução: *Na pandemia do SARS-CoV-2 crianças e adultos com urgências não-COVID-19, como apendicite aguda (AA), demandando tratamento cirúrgico, podem ter tido maiores tempos de evolução da doença com possíveis reflexos nos resultados e uso de apendicectomias abertas.* **Objetivo:** *Comparar evolução e gravidade da AA em crianças e resultados das apendicectomias laparoscópica e aberta no período transpandemia com o período de pré-pandemia.* **Metodologia***: Estudo retrospectivo avaliando duas séries de crianças submetidas à apendicectomia em hospital público de referência, entre março/2019 e fevereiro/2020 (pré-pandemia) e igual período de 2020-2021 (transpandemia). A análise incluiu o tempo de evolução de sintomas, gravidade, tipos de apendicectomia e resultados.* **Resultados***: Nesses 2 anos, foram realizadas 249 apendicectomias em menores de 15 anos: 131 na pré-pandemia e 118 na transpandemia. Dessas, 218 (87,5%) por laparotomia e 31 (12,5%) por laparoscopia. A duração dos sintomas foi de 3,2±2,9 dias na pré-pandemia e de 3,3±2,8 dias na transpandemia e houve menor número de crianças admitidas até 24 horas (20,3%) do início de sintomas antes da pandemia (vs. 34,1%). As taxas de complicações foram: 32,9% com laparotomia e 12,9% com laparoscopia. As reoperações foram mais frequentes na pandemia que na pré-pandemia (11,0% vs. 4,6%) e foi maior a permanência hospitalar (5,6±4,3 vs. 4,7±2,9 dias).* **Conclusão** *– Na pandemia crianças com AA demoraram mais para ter acesso ao tratamento cirúrgico e tiveram mais complicações, reoperações e maior tempo de hospitalização, principalmente com a apendicectomia aberta.*
Palavras-chave: *Abdome agudo. Pandemia de COVID-19. Apendicectomia. Criança. Adolescente.*

INTRODUCTION

In the first months of the COVID-19 pandemic, the health system with overloaded services and hospital beds had to maintain priority in treating non-COVID-19 pediatric emergencies, such as acute appendicitis (AA). In this context, the concerns of parents and guardians with safety in health units and the capacity of the system may have influenced access to hospitals. There were records of a decrease in appendicitis cases and the presentation of children with more advanced stages of the disease in the first months of the pandemic[1-3] and higher rates of perforated appendicitis than pre-pandemic historical controls, attributed to the impact of the pandemic on the health system[3]. A study in the United Kingdom with children up to 15 years old with AA showed that the results during the pandemic were similar to the pre-pandemic period, differing by the greater use of imaging

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exams, adoption of NOM (non-operative management), and laparoscopic appendectomy in up to 62.4% of children[4]. Another study of children with appendicitis within six months of the pandemic found no delay in presenting children for care and no more complicated cases of appendicitis[5]. These findings may differ in our health system due to socioeconomic and cultural differences.

Acute appendicitis is the most frequent cause of emergency abdominal surgery in children, affecting 86 children per 100,000 individuals in the United States[6]. It is estimated that AA affects between 7% and 8% of the population, with men predominating over women (1.4:1.0)[6-7]. The peak incidence of AA occurs in the second and third decades of life, decreases in younger children, and is rare before one year old. Mortality, which is generally low, rises between one and four years old[8].

Our city hospital is a regional reference in abdominal surgery and emergency care for adults and children in the Brazilian public health system. Its emergency services receive children from other public units, offering pediatric intensive care and minimally invasive surgery. In the context of the pandemic, it assisted COVID-19 patients, with a surgical center prepared for urgencies and emergencies.

This study aimed to assess whether the COVID-19 pandemic has resulted in a longer time to treatment for AA in children and whether this has influenced the progression of the disease. To this end, the forms of presentation of AA in children pre-pandemic and trans-pandemic and the types of surgical treatment are described, with analysis of presentation variables, such as duration of symptoms, severity, and clinical outcomes.

MATERIALS AND METHODS

A retrospective and descriptive study that evaluated data from medical records of children under 15 years old submitted to emergency appendectomies at the city hospital in two seasonally similar periods of one year, pre-pandemic (03/01/2019 to 02/28/2020) and trans-pandemic (03/01/2020 to 02/28/2021). The study project was approved by the Research Ethics Committee of the Institute of Health Sciences, at the Federal University of Bahia (Plataforma Brasil, CAAE 44730921.9.0000.5662)[9].

Statistical analyses were carried out using the R Project for Statistical Computing, version 4.3.2, considering a significance level of 5%. Descriptive analyses are reported as absolute and relative frequencies, means, standard deviations, and medians. Associations between variables were analyzed using the chi-square and Fisher's exact tests. Effect sizes (w) were also calculated according to Cohen (1992)[10], as small (w=0.10), medium (w=0.30), and large (w=0.50). Comparisons between the groups regarding age were made using the Student's t-test. The Mann-Whitney non-parametric test was used for comparisons of symptom duration. In these cases, effect sizes (Cohen's d) were classified as small (d=0.20), medium (d=0.50), and large (d=0.80). Multiple hypothesis tests were applied, and p-values were adjusted to control the false discovery rate (FDR), as Benjamini and Hochberg (1995)[11].

In addition, the odds ratio (OR) was estimated, with the respective confidence intervals (95% CI). The variables that showed p<0.20 in the individual analyses were studied in multiple logistic regression models, remaining in the final models the variables that had p≤0.05 in the multiple models, such as age, duration of symptoms, severity of AA, complications, and outcomes.

RESULTS

The medical records of 249 children under 15 years of both sexes were reviewed: 131 operated on pre-pandemic and 118 operated on in the first year of the pandemic, that is, 11% fewer appendectomies (Table 1). The care of these children represented 27.9% of the total number of appendectomies pre-pandemic and 28.6% during the trans-pandemic (p>0.05). The average ages were respectively 9.3±3.4 years in the pre-pandemic and 9.2±3.2 years in the trans-pandemic, and medians of 9.5 years in both periods. In children up to 4 years old (11.2%), from 5 to 9 (44.2%), and from 10 to 14 years old (44.6%), the frequencies of appendectomies were very similar in both groups (p>0 .05), as well as the predominance of 61.5% in males (1.6:1.0). In the pre-pandemic group, 64.1% were male, and in the trans-pandemic group, 58.5% were male (p>0.05). These similarities in the age and sex profiles of the children in the two series allowed comparisons regarding severity and outcomes.

The indication and use of diagnostic imaging tests in AA, such as abdominal ultrasound (USG) and tomography (CT), remained the same during the pandemic as before. Most children (96.4%) underwent abdominal ultrasound; in both series studied, 33% of children underwent CT (Table 1).

The average time of symptoms until hospital admission and surgical intervention respectively were 3.2±2.9 and 3.9±3.0 days in the pre-pandemic period and 3.3± 2.8 and 3.9±2.9 days in the trans-pandemic (Table 1). However, in the pre-pandemic period, approximately 33.6% of children were evaluated within the first 24 hours of symptoms compared to 21.2% during the trans-pandemic period. About 32.8% of children in the pre-pandemic and 36.3% in the trans-pandemic were treated with more than three days of symptoms, p>0.05 (Table 1).

The general condition of children with AA was assessed using the ASA (American Society of Anesthesiologists) classification, which reflects the preoperative condition[12]. 93.9% of children were classified as ASA I in the pre-pandemic, while 93.8% of children were equally classified in the pandemic. This profile was similar in both series, with 98.5% of children in the pre-pandemic and 99.1% in the trans-pandemic as ASA I or II.

Two hundred eighteen (87.6%) open appendectomies and 31 (12.4%) laparoscopic appendectomies were performed, totaling 249 interventions. Five appendectomies in children who had AA with symptoms associated with COVID-19 were excluded from the results analysis. These cases were confirmed by serological examination and/or positive nasal test and AA histopathology. Thus, the analysis of the results refers to 244 post-appendectomy children and adolescents.

Table 1 – *Appendectomies in children and adolescents in both periods*

Variables	PRE-PANDEMIC		TRANSPANDEMIC		All		Adjusted p-value	Size effect	Classification of size effect	Significance (Benjamini-Hochberg)
	n	%	n	%	n	%				
CHILDREN	131		118*		249*		-	-	-	-
Age (years)										
< 5	15	11.5%	13	11.0%	28	11,2%	1.0000	0.0143	small	ns
5 - 9	57	43.5%	53	44.9%	110	44.2%				
10 - 14	59	45.0%	52	44.1%	111	44.6%				
Average (SD)	9.3 (3.4)		9.2 (3.2)		9.2 (3.4)		1.0000	0.0302	small	ns
Median	9.5		9.5		9.5					
Sex										
Male	84	64.1%	69	58.5%	153	61.5%	0.6611	0.0579	small	ns
Female	47	35.9%	49	41.5%	96	38.5%				
Symptoms duration (days)										
To presentation										
Average (SD)	3.2 (2.9)		3.3 (2.8)		3.2 (2.9)		0.4050	0.0351	small	ns
Median	2.0		3.0		2.5					
To intervention										
Avarage (SD)	3.9 (3.0)		3.9 (2.8)		3.9 (2.9)		0.7766	0.000	small	ns
Median	2.9		3.2		3.1					
Presentation time to surgery (hours)										
Average (SD) -	18 (13.8)		14 (9.6)		16.1 (12.1)		0.1848	0.3365	small to medium	ns
Median	16.0		14.0		15.0					
Preoperative status										
ASA I	123	93.9%	111	94.1%	234	94.0%	1.0000	0.0614	small	ns
ASA II	6	4.6%	6	5.1%	12	4.9%				
ASA III	1	0.8%	1	0.9%	2	0.1%				
ASA IV	1	0.8%	0	0.0%	1	0.0%				
Anesthesy										
General	114	87.0%	90	76.3%	204	81.9%	0.1848	0.1395	Small to medium	ns
Spinal	17	13.0%	28	23.7%	45	18.1%				
AA severity (AAST)										
0	2	1.6%	0	0.0%	2	0,8%	0.4816	0.1837	Small to medium	ns
1	40	31.5%	37	31.4%	77	31.4%				
2	54	42.5%	40	33.9%	94	38.4%				
3	12	9.7%	9	7.6%	21	8.6%				
4	9	7.1%	16	13.6%	25	10.2%				
5	6	4.7%	12	10.2%	18	7.4%				
NA**	4	3.2%	4	3.4%	8	3.4%				
Uncomplicated AA	99	72.5%	77	67.5%	176	73.0%	0.2534	0.1163	Small to medium	ns
Perforated AA	28	22.0%	37	32.5%	65	27.0%				
Operative time (minutes)										
Average (SD)	42.3 (21.0)		44.2 (21.2)		43.2 (21.1)		0.6611	0.0900	small	ns
Median	40.0		40.0		40.0					
Open appendectomy	114	87.0%	104	88.1%	218	87.6%	1.0000	0.0168	small	ns
Laparoscopic appendectomy	17	13.0%	14	11.9%	31	12.4%				
Image exams[1]	129	98.5%	111	94.1%	240	96.4%	0.2803	0.1179	small to medium	ns
US [2]	122	93.1%	100	84.7%	222	89.2%	0.1848	0.1346	small to medium	ns
CT [3]	44	33.6%	39	33.1%	83	33.3%	1.0000	0.0057	small	ns
MRI [4]	1	0.8%	0	0.0%	1	0.4%	1.0000	0.0603	small	ns

Effect sizes (Cohen): **ns:** *not significant. *Included the five cases of children with AA and COVID-10;* **SD***: standard deviation;* **ASA***: American Society of Anesthesiologists;* **AAST** *- American Association for the Surgery of Trauma; **NA-not available: insufficient records for classification; [1]image exams; decisive examination in each case (some underwent external USG and CT); [2]abdominal ultrasound; [3]abdominal computed tomography; [4] abdominal MRI.*

In the pre-pandemic period, 114 (87.0%) appendectomies were performed by open techniques and 17 (13.0%) laparoscopic appendectomies; in the trans-pandemic, there were 104 (88.1%) open appendectomies and 14 (11.9%) laparoscopic appendectomies.

The severity of AA was assessed by grades according to the classification of the American Association for the Surgery of Trauma (AAST) [13,14]. Grades 1 and 2 are considered uncomplicated and 3 to 5 comprise cases of perforated AA, with or without collections, local or generalized peritonitis in the intervention. Perforated AA (AAST grades 3 to 5) was found in 22.0% of children in the pre-pandemic and 30.3% in the trans-pandemic, with a non-significant p>0.05 (Table 1).

The average time of symptoms at child presentation was 3.2±2.9 days before the pandemic and 3.3±2.8 days during the pandemic (medians of 2.0 and 3.0 days). Until the intervention, these times were, respectively, 3.9±3.0 and 3.9±2.8 (medians of 2.9 and 3.2 days).

Table 2. *Types of appendectomies in children in the two periods*

Variables	OPEN APPENDECTOMIES		LAPAROSCOPIC APPENDECTOMIES		Both		Adjusted p-value	Effect size	Classification of effect size	Significância (Benjamini-Hochberg)
	n	%	n	%	n	%				
CHILDREN	**218***	**87.6%**	**31**	**12.4%**	**249***	**100%**	-	-	-	-
PRÉ-PANDEMIC	114	87.0%	17	13.0%	218	87.6%	1.0000	0.0168	small	ns
TRANSPANDEMIC	104	88.1%	14	11.9%	31	12.4%				
AGE (years)										
< 5	27	12.4%	1	3.2%	28	11.2%				
5 - 9	91	41.7%	19	61.3%	110	44.2%				
10 - 14	100	45.9%	11	35.5%	111	44.6%				
Average ± SD	9.2 ± 3.3		9.5 ± 3.1		9.3 ± 3.3					
Median	9.6		9.5		9.6					
DURATION OF SYMPTOMS (days)										
To presentation										
Average (SD)	3.4 (3.0)		2.1 (1.6)		3.3 (2.9)		0.1848	0.5407	Medium	ns
Median	3.0		2.0		3.0					
To appendectomy (days)										
Average (SD)	4.1 (3.0)		2.9 (1.5)		3.9 (2.9)		0.1954	0.5060	Medium	ns
Median	3.2		2.8		3.1					
PRÉ-OPERATIVE STATUS										
ASA I	199	93.4%	16	94.1%	234	94.0%	1.0000	0.0333	small	ns
ASA II	11	5.2%	1	5.9%	12	4.9%				
ASA III	2	0.9%	0	0.0%	2	0.1%				
ASA IV	1	0.5%	0	0.0%	1	0.04%				
SEVERITY (AAST)	218		31							
0	2	0.9%	0	0.0%	2	0.8%	1.0000	0.1296	small to medium	ns
1	63	29.9%	14	46.6%	77	32.0%				
2	86	41.3%	11	36.7%	97	40.2%				
3	20	30.8%	2	6.7%	22	9.1%				
4	23	10.9%	2	6.7%	25	10.4%				
5	17	8.1%	1	3.3%	18	7.5%				
NA**	7	3.2%	1	5.8%	8	3.2%				
Uncomplicated AA	149	71.3%	25	83.3%	176	73.6%	0.4050	0.0897	small	ns
Perforated AA	60	27.2%	5	16.7%	65	27.2%				
LOS (days)										
Average (SD)	3.6±2.3		5.3±3.7		5.1±3.6					
Median	2.9		4.6		4.5					

Including the five cases of AA and COVID-19;* **ns: *not significant; **Insufficient records for classification.* **SD***: standard deviation;* **ASA***: American*

Society of Anesthesiologists classification; **AAST***: American Association for the Surgery of Trauma scores.*

In both periods, open techniques predominated (87.6%) compared to the laparoscopic technique (12.4%), with similar anesthetic risk profiles (ASA I and II) in both techniques in 98.6% and 100% of the children. Regarding the characteristics of age, severity, and type of surgery, when comparing the rates of perforated appendicitis by type of procedure, there was no difference since it was 27.2% with both techniques (p=0.405, Table 2).

Of the 28 children under 5, only one (3.2%) used the laparoscopic technique, while the other 27 (96.4%) had open appendectomies. Of the laparoscopic appendectomies in the two periods, 19/31 were performed on children aged 5 to 9 and 11/31 on those aged 10 to 14, i.e. 96.8% on children aged 5 or over. The average time of symptoms in open appendectomies was 3.4±3.0 days and in laparoscopic appendectomies 2.1±1.6 days (p>0.05).

In the pre-pandemic period, 29.0% of the children had postoperative complications, and in the pandemic period, 31.9% (p>0.05), excluding cases of association between AA and COVID-19. Regarding the complications that resulted in reoperations, in the pre-pandemic 4.6% of the children (6/131) were reoperated and in the pandemic increased to 14.2%, (16/113), p<0.05 (Table 3). These reoperations, including complications, occurred due to postoperative collections and abscesses that did not respond to antimicrobial treatment, dehiscence, cases that evolved with intestinal obstruction, which required new laparoscopy or laparotomy, as well as surgical wound resutures.

Hospital length of stay (LOS) of more than four days (prolonged) occurred in 52.7% of pre-pandemic children and 58.4% of trans-pandemic children. The comparative analysis between their series and the surgical techniques used revealed a significant association between the pandemic and longer hospital stays (p<0.05, Table 3). In laparoscopic appendectomies, the average hospital stay was 3.6±2.3 days, while in open appendectomies, it was 5.3±3.7 days. Of the children who underwent open appendectomy, 63.6% stayed in the hospital for more than four days, compared to 21.4% of those who underwent laparoscopic surgery (p<0.05, Table 4).

The association between postoperative complications and the type of surgery was only significant when the two years were considered together, regardless of the pandemic. In this case, 32.9% and 12.9% of children with open and laparoscopic surgeries, respectively, presented postoperative complications (p=0.045) and 9.4% of children with open appendectomies required reoperation, compared to 6.4%. of laparoscopy cases (Table 4).

Thirty-day operative mortality remained at around 0.6% in both periods, with 0.9% and 1.0% after open appendectomy, and there were no deaths among children treated with laparoscopy (Table 4), nor among the five children (excluded) from open appendectomy due to AA and COVID-19.

Table 3 - *Postoperative complications of appendectomies by period.*

Variables	Category	Period		Adjusted p-value	[1]Effect size w	[1]Classification of effect size	Significance (Benjamini-Hochberg)
		Pre-pandemic	Transpandemic				
		Frequency ([2]%)					
PO complications	No	93 (71.0%)	75 (66.4%)	0.6935	0.0370	small	ns
	Yes	38 (29.0%)	36 (31.9%)				
	Not informed	0 (0.0%)	2 (1.8%)				
Reoperations	No	125 (95.4%)	96 (85.0%)	0.0195	0.1663	small to medium	*
	Yes	6 (4.6%)	16 (14.2%)				
	Not informed	0 (0.0%)	1 (0.9%)				
Hospital LOS (days)	≤ 4	62 (47.3%)	47 (41.6%)	0.4807	0.0574	small	ns
	> 4	69 (52.7%)	66 (58.4%)				
Average (SD)		4.7 ± 2.9	5.6 ± 4.3				
Median		4.4	4.7				

[1]Cohen (1992); [2]Percentages in columns; **ns:** *not significant *Significant. (AA and COVID-19 not included).*

Table 4 - *Complications and outcomes by type of appendectomy.*

Variables	Patient profile	Category	Period					
			PRE-PANDEMIC		TRANSPANDEMIC		Global	
			Appendectomy		Appendectomy		Appendectomy	
			Open	Laparoscopic	Open	Laparoscopic	Open	Laparoscopic
			n (²%)					
PO Complications	**Children / teenagers**	No	78 (68.4%)	15 (88.2%)	63 (63.6%)	12 (85.7%)	141 (66.2%)	27 (87.1%)
		Yes	36 (31.6%)	2 (11.8%)	34 (34.3%)	2 (14.3%)	70 (32.9%)	4 (12.9%)
		Not informed	0 (0.0%)	0 (0.0%)	2 (2.0%)	0 (0.0%)	2 (0.9%)	0 (0.0%)
	Adjusted p-value		0.2304		0.4589		0.0455	
	Effect size w		0.1467		0.1555		0.1455	
Reoperations	**Children / teenagers**	No	110 (96.5%)	15 (88.2%)	82 (82.8%)	14 (100.0%)	192 (90.1%)	29 (93.6%)
		Yes	4 (3.5%)	2 (11.8%)	16 (16.2%)	0 (0.0%)	20 (9.4%)	2 (6.4%)
		Not informed	0 (0.0%)	0 (0.0%)	1 (1.0%)	0 (0.0%)	1 (0.5%)	0 (0.0%)
	Adjusted p-value		0.2579		0.3063		0.8702	
	Effect size w		0.1327		0.1543		0.0347	
Hospital LOS	**Children / teenagers**	≤ 4 days	52 (45.6%)	10 (58.8%)	36 (36.4%)	11 (78.6%)	88 (41.3%)	21 (67.7%)
		> 4 days	62 (54.4%)	7 (41.2%)	63 (63.6%)	3 (21.4%)	125 (58.7%)	10 (32.3%)
	Adjusted p-value		0.4285		0.0073		0.0136	
	Effect size w		0.0889		0.2821		0.1770	
Outcomes	**Children / teenagers**	Discharge	113 (99.1%)	17 (100.0%)	98 (99.0%)	14 (100.0%)	211 (99.1%)	31 (100.0%)
		PO death	1 (0.9%)	0 (0.0%)	1 (1.0%)	0 (0.0%)	2 (0.9%)	0 (0.0%)
	Adjusted p-value		1.0000		1.0000		1.0000	
	Effect size w		0.0339		0.0355		0.0347	

Children = under 15 years old. [1]Cohen (1992); [2]Percentages in columns. PO: post-operative; LOS: length of stay.

In addition, data from logistic regression analyses with the calculation of the odds ratio (OR), compared to other age groups, showed that children and adolescents were more likely to present complicated forms (grades 3 to 5) and had more complications than those aged between 15 and 59 (OR=1.88; 95%CI: 1.30-2.73), p<0.05. Patients, in general, who arrived for treatment with more than two days of symptoms were eight times more likely to have perforated appendicitis (grades 3 to 5)[9]. Children also had a higher chance of prolonged hospital stay than adults, except the elderly (OR=12.61; 95%CI: 8.06-19.71), p<0.05. And those with complicated AA had a higher chance of prolonged hospital stay (OR=4.42; 95%CI: 4.58-7.57), p<0.05, and of requiring reoperation (OR=5.02; 95%CI: 2.99-8.44), p<0.05[9].

DISCUSSION

In the present study, the time of symptoms when the children arrived for admission (presentation), the surgical treatment of 3.2 and 3.3 days, and the rate of perforated AA, which rose from 22.0% to 32.5%, reflect a characteristic of this population, both before and during the pandemic.

AA presents in two distinct forms, one simple or "uncomplicated", without necrosis or perforation, and the other "complicated", with appendicular necrosis or perforation, which does not appear to be an evolution of the first. Complicated AA is characterized by a specific immune response, genetic factors, and appendicular obstruction[15,16]. In addition to obstruction of the lumen by fecalith or lymphoid hyperplasia, bacterial and viral infections have been linked to the pathogenesis of AA[15-17]. Obstruction of the appendix lumen acts as a trigger and aggravates inflammation, resulting in mucus accumulation, bacterial proliferation, microcirculatory difficulties in the organ wall, and even necrosis and perforation in complicated forms[17]. The uncomplicated form accounts for around 70% to 80% of cases and has been the subject of rediscussion over the last decade, especially during the pandemic, with NOM (on-operative management) protocols selectively administered with systemic antimicrobials [2,18-19]. This interesting approach, surrounded by caution, is based on studies with at least two findings: (1) some cases of uncomplicated AA evolve with spontaneous resolution (>10%) and, (2) in cases of NOM failure (20% in thirty days and up to 40% in one year) that require surgical treatment, there was no increase in mortality[20,21]. However, NOM was not used in these children, and, in general, the first-line treatment for AA continues to be appendectomy, which treats both simple cases and complicated forms of the disease.

The natural history of severe acute appendicitis understands its evolution as time-dependent, especially due to complications such as perforation, abscesses, and peritonitis, and the delay in treatment can be decisive in the more complicated forms[22]. It is estimated that, in children, appendicular perforation tends to occur after 24 to 36 hours of symptoms, with a high rate below the age of 5[23-25]. Perforated AA should be characterized by a visible hole in the appendix or by the presence of fecalith in the cavity[26], as well as the presence of diffuse fibrinopurulent exudate or abscess, which are considered independent factors for complicated AA in children[27].

Symptom duration of more than 24 hours has also been considered an independent factor determining the greater occurrence of complications in appendicitis[28]. In both groups of children in this study, the time of arrival at hospital care was dilated, with averages of 3.2 and 3.3 days and 3.9 to 4.0 days until surgical intervention, respectively before and during the pandemic. In the trans-pandemic, only 21.2% of children arrived in the first 24 hours of symptoms, less than the 33.6% of the previous year. Also, in the trans-pandemic, more children arrived after three days of symptoms than in the early year (36.3% vs. 32.8%). The data indicate a tendency to seek or access treatment with a delay in both series and greater in the pandemic (p>0.05).

A study of children before the pandemic evaluating symptom times concluded that delays of 16 hours for care and up to 12 hours from admission to appendectomy did not result in an increased risk of surgical site infection[29]. In these periods there is an opportunity to start treatment with preoperative antimicrobials[6]. Bethel et al. (2022) recorded more imaging and NOM exams in children up to 15 years of age during the pandemic period, and laparoscopic appendectomy was used in 66.6% and 62.4% of children before and during the pandemic, with similar results[4]. Hegde et al. (2023) performed more NOM in 6014 children during the pandemic and found no differences in the rates of complicated AA (34.6% vs. 35.2%) concerning the pre-pandemic period, nor in the results[30].

In the two groups evaluated in this study, acute perforated AA was found in 22.9% of children in the pre-pandemic and 30.3% in the trans-pandemic, a higher rate of complicated AA. With a majority of open appendectomies in children (87.6%) in both groups in this study, postoperative complications, reoperations, and length of hospital stay were analyzed. There was a higher rate of complications in open appendectomies (32.9%) than in laparoscopic ones (12.9%). Reoperation rates were also higher for open appendectomies (9.4%) than for laparoscopic ones (6.4%). Reoperations in children were significantly more frequent in the trans-pandemic (14.2%) than in the previous year (4.6%). And longer hospital stays during the pandemic and in both periods in open surgery (63.6%) than in laparoscopic surgery (21.4%). These findings should encourage greater use of laparoscopic appendectomy in children.

Although mortality from AA is between 0.09% and 0.24% in general, in developing countries, mortality is between 1 and 4%[7,8]. In both periods observed in this study, operative mortality (one case in each group, up to 30 days postoperatively) remained at around 0.6%, with around 0.9% to 1.0% in open appendectomies and no deaths in children who underwent laparoscopy. There were also no deaths in the 5 cases (excluded) of open appendectomies of children with COVID-19.

Comparative analyses with other age groups showed that these patients under the age of 15 were more likely to have complicated forms of AA, higher rates of postoperative complications, and longer hospital stays than young adults (15 to 59 years old), although less so than the elderly people aged 60 and over (p<0.05).

Data from the literature allow us to evaluate the adoption of a NOM protocol in uncomplicated AA in children over 5 years of age and the early preoperative administration of antimicrobials[6].

LIMITATIONS AND CONTRIBUTIONS

The data comes from a single public hospital center, with two groups of sociodemographic characteristics representative of the population diversity, with non-early access to the hospital, even before the pandemic. The findings may differ from other experiences in hospitals across Brazil, whether they maintained COVID-19 care or used laparoscopy more frequently. At the hospital, emergency surgery was prioritized, but the social context and the health system may have influenced the referral flows of patients from other units. The statistical analyses only showed part of the differences between the periods, but they do point to pre-pandemic data. The smaller number of laparoscopic appendectomies in the two series limits the comparison of results with open surgeries and differs from the approach to adults with AA. There are opportunities for more laparoscopy in children due to the known advantages and even for the planned use of a NOM protocol in cases of uncomplicated AA. The time taken to access treatment can be reduced by promoting more information and ensuring more agile flows in the public health system.

CONCLUSION

During the COVID-19 pandemic, children who underwent an appendectomy in a prolonged time to access treatment showed a longer duration of symptoms, a lower number of cases of early-stage AA, and a higher frequency of cases of perforated AA. Although with similar severity profiles, there were more postoperative complications, reoperations, and extended hospital stays during the pandemic. With open appendectomy being used much more frequently in both periods, postoperative complications, reoperations and length of hospital stay were clearly higher in open surgery when compared to laparoscopic appendectomy.

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