

Open versus laparoscopic appendectomy in children: a comparative, prospective study from a tertiary public hospital

Apendicectomia aberta versus videolaparoscópica em crianças: estudo prospectivo em hospital público terciário

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ABSTRACT: *Introduction:* Appendectomy is one of the most performed surgical procedures in children and is the choice of therapy in the treatment of acute appendicitis. There is evidence in the literature that favors the performance of surgery via laparoscopic route over the open route in the pediatric population. *Objective:* to compare open and laparoscopic appendectomy in the treatment of acute appendicitis in children in a public tertiary hospital in Brazil. *Methods:* prospective observational study comparing open and laparoscopic appendectomies performed in pediatric patients with acute appendicitis treated between March/2017 and March/2018. Epidemiological; preoperative (clinical, laboratory and imaging tests, time between admission and procedure); intraoperative (procedure time, technique); postoperative (time of hospitalization; complications) aspects were analyzed. *Results:* Sample of 63 patients, with an average age of 8 years. 80.9% had vomiting, Blumberg sign in 63.5% and diffuse abdominal pain in 71.4%. Blood count was performed in 43 patients, with 72% leukocytosis and 51.2% bastonetosis; abdominal X-ray on 12 and ultrasound in 47.6%. 31.7% had laparoscopic appendectomy, while 68.3% had open appendectomy. There was no difference between groups regarding cavity conditions and appendix characteristics. The

open surgery group had 52.3% complicated appendectomies, 2.3% postoperative complications and an average hospital stay of 3 days, while in the laparoscopic group, 60% were complicated, 10% with postoperative complications and 2.9 days of average length of stay. *Conclusion:* Conclusion: the present study allows us to state, with statistical limitations, that there is no difference between open and laparoscopic appendectomy as to the time between admission and the procedure, time of hospitalization and postoperative complications; however, the difference in the procedure time has shown to be relevant.

Keywords: Appendectomy; Appendicitis; Surgery; Laparoscopy; Pediatric surgery.

RESUMO: *Introdução:* Apendicectomia é um dos procedimentos cirúrgicos mais realizados em crianças e é a terapia de escolha no tratamento da apendicite aguda. Há evidências na literatura que favorecem a realização da cirurgia pela via laparoscópica em detrimento da via aberta na população pediátrica. *Objetivo:* comparar a apendicectomia aberta e laparoscópica no tratamento da apendicite aguda em crianças em um hospital terciário público do Brasil. *Métodos:* estudo observacional prospectivo comparando

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apendicectomias abertas e videolaparoscópicas realizadas em pacientes pediátricos com apendicite aguda atendidos entre março/2017 e março/2018. Foram analisados aspectos epidemiológicos; pré-operatórios (clínica, exames laboratoriais e de imagem, tempo entre admissão e procedimento); intra-operatórios (tempo de procedimento, técnica); pós-operatório (tempo de internação; complicações). *Resultados:* amostra de 63 pacientes, com média de idade de 8 anos. 80,9% apresentavam vômitos, sinal de Bloomberg em 63,5% e dor abdominal difusa em 71,4%. Realizado hemograma em 43 pacientes, com 72% de leucocitose e 51,2%, bastonetose; radiografia abdominal em 12 e ultrassonografia em 47,6%. 31,7% realizaram apendicectomia laparoscópica, enquanto 68,3%, apendicectomia aberta. Não houve diferença entre os grupos quanto as condições da cavidade e

características do apêndice. O grupo da cirurgia aberta teve 52,3% de apendicectomias complicadas, complicação pós-operatória em 2,3% e tempo de internação médio de 3 dias, já no da laparoscopia, 60% foram complicadas, 10% com complicação pós-operatória e 2,9 dias de tempo de internação médio. *Conclusão:* o presente estudo permite afirmar, com limitações estatísticas, que não há diferença entre apendicectomia aberta e videolaparoscópica quanto ao tempo entre a admissão e o procedimento, tempo de internação e complicações pós-operatórias, sendo relevante a diferença no tempo do procedimento.

Descritores: Apendicectomia; Apendicite; Cirurgia; Videolaparoscopia; Cirurgia pediátrica.

INTRODUCTION

Acute appendicitis is one of the most prevalent surgical emergencies in the world, with an estimated life risk of 7-8%. Developed countries have a prevalence rate of 90-100 patients per 100,000 inhabitants per year¹.

Performed as early as 1880 by Robert Lawson Tait² and first described by McBurney in 1894, open appendectomy (OA) has been widely used as a standard in the treatment of appendicitis³, as it allows the surgeon to have direct access to the organ⁴. However, it has been replaced by the laparoscopic approach³, introduced by Semm in 1983, in which three trocars are used⁵.

According to a Canadian study, laparoscopy has the advantages of lower risk of surgical wound infection, reduced postoperative pain, shorter hospital stay and early return to normal activities. It also highlights the absence of significant differences between the two techniques. Among the disadvantages, the longer duration and the high cost stand out⁶. Another study points to even higher risk of intra-abdominal abscess in laparoscopy³. A study conducted in Sweden denies statistically significant differences between the two techniques regarding surgical wound infection, abscess formation, reoperation and readmission². When choosing the method, the patient's characteristics and the surgeon's experience should be considered⁶.

Another important factor analyzed was the cost of the procedure in the pediatric population. Michailidou et al.⁷, 2015, showed that this tends to be higher in laparoscopy, especially in cases of perforated appendicitis with little clinical response. However, in hospitals with a preference for the minimally invasive technique, the length of stay was shorter and the total costs did not differ between them⁸.

Performing the TULAA procedure, which stands for Laparoscopically Assisted Transumbilical Appendectomy, would be another viable alternative, as it combines the use of trocars for exteriorization of the appendix and continuity of the procedure extracorporeally⁵. Nonetheless, this technique has limitations for complicated cases, because it requires longer surgical time and increases the risk of intra-abdominal abscess⁵.

In adults, the advantages of the laparoscopic approach seem to be well accepted, however, they are still widely debated in the pediatric population⁵, since appendectomy is the most performed emergency surgical procedure in children². Therefore, it is necessary to produce specific studies that evaluate treatment options and their outcomes in children and adolescents³.

The aim of the study is to compare open and laparoscopic appendectomy in the treatment of acute appendicitis in children in a tertiary hospital in Brazil, regarding aspects of intraoperative and postoperative complications.

METHODS

Prospective comparative study between open and laparoscopic appendectomies performed in pediatric patients (0 to 14 years old) diagnosed with acute appendicitis, treated by the Pediatric Surgery Service of a public tertiary university hospital in Paraná, between March 2017 and March 2018.

This was not a randomized study, the choice of open or laparoscopic technique was at the discretion of the pediatric surgeon on duty, based on his expertise in laparoscopic surgery. The study was approved by the Human Research Ethics Committee (62320416.9.0000.096 number 2.985.580).

The use of antibiotic therapy, concomitant with the surgical procedure, is part of the protocol developed by this service based on previous studies. Therefore, in order to avoid bias in data analysis, a therapeutic standard of antibiotic therapy was followed for all patients.

Epidemiological aspects were analyzed; preoperative (clinical history, laboratory and imaging tests, time between admission and surgery); intraoperative (cavity, appendix characteristics, procedure time, chosen technique and intraoperative complications); and postoperative (return to oral diet, length of stay, anatomopathological examination of the specimen and complications).

The data obtained were expressed as percentage, absolute numbers, mean, median and standard deviation. Student t-test, nonparametric Mann-Whitney test or Fisher's exact test were used, when pertinent. Statistical

significance was established at 5% ($p < 0.05$) and 95% confidence interval.

RESULTS

Within one year, 63 patients were treated, with a mean age of 8 years (minimum of 2 years and maximum of 14 years); in the open approach the mean was 7.8 years and in the laparoscopic approach 9.8 years ($p = 0.023$, Student t-Tests, $p < 0.05$). As for gender, 52.4% were female and 47.6% male.

Regarding the initial signs and symptoms that were reported by the patients: nausea in 76.2% ($n = 48$), vomiting in 80.9% ($n = 51$), anorexia in 46% ($n = 29$), pain migration in 27% ($n = 17$), stopping the elimination of feces and flatus

in 23.8% ($n = 15$), positive Blumberg sign in 63.5% ($n = 40$), generalized abdominal pain in 71.4% ($n = 45$), fever in 50.8% ($n = 32$), difficulty walking in 20.6% ($n = 13$).

Blood counts were performed in 68.2% ($n = 43$) of patients. Of these, 72.1% ($n = 31$) had increased leukocytes and 51.2% ($n = 22$) bacteriemia. Abdominal X-ray was performed in 19% ($n = 12$), fecalith was found in 8.3% ($n = 1$) and dopsoas shadow blurring in 16.7% ($n = 2$). Abdominal ultrasound was performed in 47.6% ($n = 30$) patients, in one (3.3%) fecalith was identified and six (20%) presented non-compressible appendix. A computed tomography of the abdomen was performed. The information regarding the demographics of patients and their clinical characteristics are shown in Table 1.

Table 1 – Clinical-demographic characteristics of patients.

| | Surgical technique | Open Appendectomy | Laparoscopic Appendectomy | Total |
|---------------------------|--|------------------------------|--------------------------------------|--------------|
| | n | 43 (68.3%) | 20 (31.7%) | 63 |
| | Age (mean) | 7.8 | 9.8 | 8.4 |
| Gender | Female | 17 (51.5%) | 16 (48.5%) | 33 |
| | Male | 26 (86.7%) | 4 (13.3%) | 30 |
| Signs and symptoms | Nausea | 33 (68.7%) | 15 (31.3%) | 48 |
| | Vomiting | 34 (66.7%) | 17 (33.3%) | 51 |
| | Anorexia | 20 (69%) | 9 (31%) | 29 |
| | Positive Blumberg Sign | 27 (67.5%) | 13 (32.5%) | 40 |
| | Pain Migration | 13 (76.5%) | 4 (23.5%) | 17 |
| | Stopping the Elimination of Feces and Flatus | 10 (66.7%) | 5 (33.3%) | 15 |
| | Generalized Abdominal Pain | 31 (68.9%) | 14 (31.1%) | 45 |
| | Fever | 22 (68.7%) | 10 (31.3%) | 32 |
| | Difficulty Walking | 8 (61.5%) | 5 (38.3%) | 13 |
| | Blood Count | 31 (72.1%) | 12 (27.9%) | 43 |
| Tests | Abdominal X-ray | 11 (91.7%) | 1 (8.3%) | 12 |
| | Abdominal ultrasound | 21 (70%) | 9 (30%) | 30 |

Regarding the type of surgical technique chosen, 68.3% ($n = 43$) were operated via the open route and 31.7% ($n = 20$) via laparoscopy, according to the surgeon's choice.

The average time between hospital admission and the surgery was 309 minutes in patients operated laparoscopically versus approximately 313 minutes in those undergoing laparotomy ($p = 0.72$, Mann-Whitney U test, $p < 0.05$). The mean procedure time in laparoscopic appendectomy was 151 minutes versus 92 minutes in laparotomy ($p = 0.000002$, Mann-Whitney U test, $p < 0.05$).

Intraoperatively, characteristics of the abdominal

cavity and appendix were evaluated. In laparoscopic appendectomy, 30% ($n = 6$) of patients had cavity without pus, 40% ($n = 8$) with localized pus and 30% ($n = 6$) with generalized pus. In the open, 34.9% ($n = 15$) without pus, 25.6% ($n = 11$) with localized pus, 34.9% ($n = 11$) with generalized pus and 13.9% ($n = 6$) were not reported in the surgical description. Between the two groups (open versus laparoscopy) there was no difference in cavity findings ($p = 0.669$, Chi-square test, $p < 0.05$).

Regarding the appendix, in the open group: 13.9% ($n = 6$) of the catarrhal type were observed, 30.2% ($n = 13$)

phlegmonous, 16.3% (n=7) necrotic, 27.9% (n=12) perforated and 11.6% (n=5) were not reported; in the laparoscopy group, 15% (n=3) was classified as catarrhal, 10% (n=2) phlegmonous, 20% (n=4) necrotic and 55% (n=11) perforated. 52.3% (n=23) of the open surgery group and 60% (n=12) of the laparoscopy group were considered complicated appendicitis ($p=0.600$, Fisher's exact test, $p<0.05$). Thus, even though the choice of technique is at the surgeon's discretion, based on their expertise or not for laparoscopy, both groups did not differ in relation to the percentage of complicated appendicitis.

Oral diet was introduced on the first postoperative day in 67% (n=29) of patients submitted to open appendectomy and in 75% (n=15) of patients submitted to laparoscopy ($p=0.769$, Fisher's exact test, $p<0.05$).

After the surgical procedure, the anatomopathological characteristics of the appendix were evaluated. Among the patients operated laparoscopically, 5% (n=1) had initial acute appendicitis; 35% (n=7) acute phlegmonous appendicitis; 40% (n=8) acute gangrenous appendicitis; 20% (n=4) acute suppurative appendicitis. As for those who underwent laparotomy, 11.6% (n=5) were reported as initial acute appendicitis; 9.3% (n=4) acute appendicitis with lymphoid hyperplasia; 27.9% (n=12) acute phlegmonous

appendicitis; 2.3% (n=1) in acute appendicitis in fibrinous phase; 39.5% (n=17) acute gangrenous appendicitis; 9.3% (n=4) acute suppurative appendicitis. The number of gangrenous or suppurated appendixes was similar in both groups ($p=0.432$, Fisher's exact test, $p<0.05$).

Moreover, the average time of hospitalization of the patients submitted to laparoscopy was 2.9 days, and for those treated via laparotomy it was 3 days ($p=0.58$, Mann-Whitney U test, $p<0.05$).

No patients had intraoperative complications. Postoperative complications were observed in 1 patient (2%) who underwent open appendectomy - operative wound infection in the 3rd postoperative day. Among those approached laparoscopically, 2 patients (10%) had complications: umbilical wound infection (patient who underwent a video-assisted appendectomy) in the 7th postoperative day; and another patient with intracavitary abscess in the 15th postoperative day, requiring antibiotic therapy. There was no statistically significant difference between the two groups ($p=0.234$, Fisher's exact test, $p<0.05$).

No patient needed to be re-operated. Table 2 summarizes the data on surgical and postoperative treatment of patients.

Table 2 - Surgical and postoperative treatment.

| Surgical technique | Open Appendectomy | Laparoscopic Appendectomy | p |
|--|-------------------|---------------------------|------------------------------------|
| Time between the patient's hospitalization and the surgery in minutes (mean) | 313 | 309 | 0.72 (Mann-Whitney U test) |
| Surgery duration in minutes (mean) | 92 | 151 | 0.0000002 (Mann-Whitney U test) |
| Time of hospitalization (mean) | 3 | 2.9 | 0.58 (Mann-Whitney U test) |
| Oral diet in the first postoperative day | 29 | 15 | 0.769 (Fisher's exact test) |
| Complicated appendicitis | 23 (53.4%) | 12 (60%) | 0.600 (Fisher's exact test) |
| Postoperative complications | 1 (2.32%) | 2 (10%) | 0.234 (Fisher's exact test) |

DISCUSSION

Acute appendicitis is one of the most prevalent surgical emergencies in the world, and developed countries have a prevalence rate of 0.1% per year¹. It is known that inflammation occurs more quickly in the appendix of younger patients⁹. The mean age found in the cohort of this study was 8 years old, being 52.38% female, contrary to the information found in the literature, in which boys tend to be more affected than girls, in a ratio of 1.4:1¹⁰. Löfvenberg et al.¹¹, 2016, also showed prevalence of males (52.6%), as well as the Chinese retrospective study¹² with 55.5% (n=216) boys, a total of 389 patients who underwent appendectomy.

Acute appendicitis may clinically present itself in a nonspecific manner with overlapping symptoms with other common childhood diseases¹³, as well as evolve with periumbilical abdominal pain migrating to the right lower quadrant, followed by low-grade fever, nausea or vomiting¹⁴. In the study in question, nausea was observed in 76.2% of patients, vomiting in 80.9%, history of anorexia in 46% and pain migration in only 27%. These percentages are in line with other studies, in which less than 50% of the subjects presented a classic clinical picture, and varied manifestations were observed¹⁵.

Laboratory tests such as absolute neutrophil count and leukocyte count have long been used in the diagnosis of appendicitis¹⁶. Leukocytosis is often found in acute

appendicitis, but it is a non-specific and non-sensitive laboratory parameter¹². Reis et al.¹⁷, 2008, conducted a retrospective study with cases of acute appendicitis in children and adolescents, in which leukocytosis was present in 82.9% of the 249 tests performed, with deviation to the left in 72.1%. However, its value in the clinical decision-making process remains uncertain¹⁶. In the present study, 72% of the patients who had a blood count had increased leukocytes and 51.1%, left deviation, which are lower values compared to the literature.

Radiographic findings suggestive of acute appendicitis are right lateral scoliosis, localized ileum, intestinal obstruction, free fluid in the peritoneal cavity and fecalith, the latter most specifically in acute appendicitis. Fecalith is found in 28-33% of patients with inflamed appendix and in less than 1-2% of cases without inflammation¹³. Abdominal X-ray was performed in 18.7% of the study patients; fecalith was found in 8.3% and blurring of the appendix in 16.6% of them.

Ultrasound has become increasingly useful in the diagnosis of appendicitis, and its overall diagnostic accuracy is satisfactory¹⁴. Their sensitivity and specificity range from 80 to 92% and 86 to 98%, respectively¹³. There are several factors that can make it difficult to visualize the appendix: inability to detect changes early, experience of the ultrasound technician, patient's physique, pain condition and sensitivity, location of the appendix. Unfortunately, many of these factors cannot be controlled, therefore the result may end up ignored by the surgeon in the impossibility of clinical correlation with the image¹⁸. Less than half of the patients in the present study underwent ultrasound (n=30).

Open appendectomy has been widely used as a standard in the treatment of appendicitis, but it has been replaced by the laparoscopic approach³. Of the patients analyzed, 68.2% were operated via laparotomy and 31.7% were operated via laparoscopy. A retrospective study¹⁹ identified 4,489 appendectomies in the pediatric population in 2015, according to the national clinical data base in Japan, in which 3,166 (70.5%) laparoscopic surgeries were performed. A German meta-analysis²⁰ analyzed 8,110 patients between 2010 and 2012; 75% were submitted to laparoscopy, 23.8% to the open mode, and another 1.2% were initially submitted to laparoscopy and later converted to open. According to the literature, it is observed that, more recently, laparoscopy has been the most prevalent form of appendectomy²⁰. Despite this trend, in our service, most appendectomies were performed through the open route. This can be explained by logistical issues – at night, when most patients are operated, it is more difficult to have the laparoscopy material available. In addition, the team has some surgeons who are not trained in laparoscopy.

Regarding the time between the patient's hospitalization and the beginning of surgery, there was no statistical difference between the two techniques. This

average waiting time, of about 5 hours (300 minutes), which we consider high, may reflect the slowness in the flow of care of a patient in the public health service.

As for the duration of the surgery, laparotomy proved to be faster, with an average of 92 minutes of duration compared to 151 minutes of laparoscopy, a statistically relevant difference. Such a finding has support in the literature. Svensson et al.², 2016, demonstrated laparoscopic appendectomy in pediatric patients with longer surgical time (51 minutes on average), compared to 37 minutes for the open procedure. As for complicated appendicitis, there was also no significant statistical difference between the two groups ($p=0.600$, Fisher's exact test, $p<0.05$) that could justify a favorable outcome or possible complications based on the surgical technique used.

As for the reintroduction of the oral diet in the postoperative period, there was also no difference between the groups. Most patients in both groups received diet in the first postoperative day (75% in the laparoscopy group and 67.4% in the open surgery group). The systematic review carried out by Quah et al.²¹, 2019, shows 12 studies in which patients who performed laparoscopy returned to the oral diet in 2.7 days, compared to 3.7 days of the open technique. In our service, the introduction of the diet was very early in both groups, according to what is more modernly recommended.

In the literature, there is evidence that laparoscopy has the advantages of lower risk of surgical wound infection, reduced postoperative pain, shorter hospital stay and early return to normal activities⁶. Gosemann et al.²⁰, 2016, reveals an association of laparoscopy with shorter hospital stay not only in uncomplicated appendicitis but also in complicated ones, with even lower readmission rates due to post-surgical complications. In the study by Pogorelic et al.²², 2019, the mean hospitalization time was 3 days in the laparoscopic group compared to 6 days in the open group ($p<0.001$). On the other hand, the results analyzed in our study demonstrate that there is no statistically relevant difference in the time of hospitalization compared the two surgical methods, with an average time of approximately 3 days in both groups. Fujishiro et al.¹⁹, 2020, as well as our study, found no statistical difference in terms of hospitalization time, with a median of 4 days in both groups.

Also in relation to postoperative complications, Aneiros et al.¹⁴, 2019, and Fujishiro et al.¹⁹, 2020, evaluated the frequency of appendectomy complications in pediatric patients and found no difference between the laparoscopic group and open appendectomy, as observed in this study. Liu Y. et al.¹², 2017, showed that the rate of complications after surgery in the laparoscopic group was significantly lower than in the open appendectomy group (13% vs. 27%, $p<0.05$), but with an overall incidence of complications much higher than the present study. Pogorelic et al.²²,

2019, showed that there was a significantly higher number of wound infections in the open group (n = 21; 3.9%) compared to the laparoscopic group (n = 3; 1%) (p= 0.014), and the frequency of reoperation in both groups was equal (1.3%).

This is an observational study to evaluate the results of the service, and it has limitations regarding the criteria for choosing the surgical technique. It was decided by the

surgeon, based on his expertise in video surgery.

The analysis of the present study allows us to affirm, within the statistical limitations, that there is no difference between open and laparoscopic appendectomy, considering the time of hospitalization, introduction of the oral diet and postoperative complications, with only one significant difference, the surgical time, which was longer in the laparoscopy group.

Contribution: Oliveira L, Aquino AKF, Tognolo CM, Oliveira G, Dias AIBS, Fachin CG designed the work; Schroeder AZ, Almeida PA, Romaniello G, Meskau MPA, Castilho BCM performed the experiments and contributed to data collection; Oliveira L, Aquino AKF, Tognolo CM, Oliveira G, Dias AIBS, Fachin CG developed the method and performed the measurements; Schroeder AZ, Almeida PA, Romaniello G, Meskau MPA contributed to data analysis and interpretation; Schroeder AZ, Almeida PA, Romaniello G prepared the figures; Schroeder AZ, Almeida PA, Romaniello G, Meskau MPA contributed to the revision of the manuscript.

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