Original Article

Laparoscopic versus Open Appendectomy: A Retrospective Cohort Study on the Management of Acute Appendicitis (Simple and Complicated) in Children under 13 Years of Age

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Abstract

Introduction: Acute appendicitis is the most common surgical emergency with a lifetime incidence of 7%–8%. There are two operative modalities that are currently used for the management of this condition in the paediatric population. The objective of this cohort study was to review the outcome of the management of paediatric surgical patients presenting with acute appendicitis after either an open appendectomy (OA) or laparoscopic appendectomy (LA) was performed. **Methods:** This was a 2-year retrospective study conducted from 01 January 2016 until 31 December 2017 on paediatric surgical patients < 13 years of age undergoing appendectomies. Eighty-one (n = 81) files of patients were reviewed, and data analysis was performed on two comparative groups namely the OA group and LA group, with the aid of the SAS system with statistical significance based on $P < 0.05$. **Results:** During the study period, 81 children (male: female ratio of 2:1) underwent appendectomies. Nearly 38% (n = 31) of the cases had an OA, with 62% (n = 50) of the cases having an LA. Seven (14%) LA cases were converted to OA. Simple appendicitis accounted for 16% (n = 13) of the patients, with complicated appendicitis accounting for 79% (n = 64) and other pathologies accounting for 5% (n = 4). There were no post-operative complications in the cases of simple appendicitis. Six cases (15.38%) in the LA group versus two cases (5.26%) in the OA group developed intra-abdominal collections, which was statistically significant (P = 0.018). One (2.56%) patient in the LA group versus two patients (7.89%) in the OA group developed intestinal ileus (P = 0.09). Two patients (5.13%) in the LA group versus six patients (15.79%) in the OA group developed surgical-site infection, which was statistically significant (P = 0.013). The mean days of hospital stay was 4.51 days in the LA group versus 5.34 days in the OA group, which was statistically significant (P = 0.016). There were no re-admissions or re-operations in the simple appendicitis group. In the complicated appendicitis cases, five cases (12.82%) were re-admitted in the LA group compared to five cases (13.16%) in the OA group (P = 0.943). Two (5.13%) cases had a re-operation in the LA group compared to one case (2.63%) in the OA group (P = 0.360). **Conclusion:** Considering that there was an increased incidence of complicated cases and operations being performed by trainees, LA appears feasible at a tertiary-level hospital in a developing country, as shown in this study. Therefore, cases of simple appendicitis can be performed laparoscopically; however with regard to complicated appendicitis, there is no superiority between the two operative modalities in this study, which is consistent with international literature. However, in this study, it can be postulated that the learning curve was a major contributory factor to the increased levels of complications, as all operations were performed by trainees. Therefore, we recommend implementation of adequate simulation practices in laparoscopy in the setting of a developing country to attain the laparoscopic expertise of our international counterparts in order to improve the standard of care.

Keywords: Acute appendicitis, appendectomy, comparative study, laparoscopic appendectomy, minimal invasive surgery, open appendectomy, paediatric surgery

Introduction

Acute appendicitis is the most common surgical emergency with a lifetime incidence of 7%–8%.[1] There are two operative modalities (open appendectomy [OA] and laparoscopic

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appendectomy [LA]) that are currently used for the management of this condition in the paediatric population. The novel operative modality of natural orifice transluminal endoscopic surgery has not gained popularity in the paediatric population yet.[2]

The benefits of LA have been well accepted at the international level with its use for simple appendicitis, namely better visualisation for the surgeon and associate staff, reduced wound infection and reduced post-operative pain and ileus, with subsequent earlier mobilisation and shorter length of hospital stay and superior cosmetic results.[3-8]

However, controversy exists with that of complicated appendicitis.[9-14] There have been numerous trials and systemic reviews showing increased incidence of intra-abdominal collections in patients undergoing laparoscopic appendectomies for complicated appendicitis,[3-5,7] with subsequent increased morbidity for the patient and additional costs to the institution with regard to investigations, re-admissions and possibility of relook operations. Factors leading to increased incidence of intra-abdominal collections in acute appendicitis include delayed presentation with a complicated appendicitis and the experience or expertise of the surgeon in performing either LA or OA.[7] With LA during the induction of pneumoperitoneum, the infected contents from a complicated appendicitis can seed across the abdomen, providing sources for post-operative abscess formation.[5] During irrigation, inadequate suctioning of fluid will provide a source for abscess formation.[5]

The purpose of this 2-year retrospective cohort study at Dr George Mukhari Academic Hospital (DGMAH) was to describe and compare the management of acute appendicitis in paediatric surgical patients (under the age of 13 years), that had undergone either an OA or LA following admission from 01 January 2016 until 31 December 2017. The accepted management of simple appendicitis globally is to offer LA, with there being controversy regarding complicated appendicitis. In a developing country with presentations of acute appendicitis being more complicated due to delayed health-seeking behaviours as well as reduced accessibility to health services, the question then can be asked whether the outcomes of laparoscopy will be more beneficial when compared to that of the open approach?

Methods

Study design, sample and setting

This was a 2-year retrospective cohort study of the management of acute appendicitis at Department of Paediatric Surgery, DGMAH. DGMAH is a tertiary-level hospital in the Gauteng Province of South Africa. Patients referred for acute appendicitis are often from the nearby secondary-level hospitals in the Gauteng province as well as referrals from the hospital's casualties or paediatric wards.

The Paediatric Surgery Department consists of two consultants and five residents in training as well as trainees rotating from the general surgery department on a 3-monthly basis. Operations for acute appendicitis are performed by trainees.

This study included all paediatric surgical patients (under the age of 13 years), that had undergone either an OA or LA for acute appendicitis following admission from 01 January 2016 until 31 December 2017.

Ethical consideration

The study commenced only after obtaining permission by the chief executive officer of DGMAH and approval by Sefako Makgatho University's Research Ethics Committee (SMUREC/M/49/2018: PG). Patients' identities remained anonymous.

Operative procedures

The decision on operative modality (OA versus LA) was based on the discretion of the admitting clinician or trainee, with the clinical condition being taken into consideration. All operations were performed by the trainees in the department.

LA was performed using the three-port approach with the telescope port either at the Palmaris point or umbilicus often through a 10-mm- or 5-mm-sized port using a 30° telescope. One working port (5 mm) in the left lower quadrant and a second 10-mm working port were placed in the supra-pubic region. The appendix was removed via the suprapubic port 10-mm port.

OA was performed using the following incisions:

1. Lanz incision
2. McBurney's incision
3. Lower midline incision.

Patients with simple appendicitis (non-perforated appendix, i.e., AAST Grade I)[15] received an appendectomy with no further interventions. Patients with complicated-localised appendicitis (perforated appendix with right iliac fossa and/or pelvis pus collection, i.e., AAST Grade III)[15] received an appendectomy and based on the discretion of the operating surgeon, a pencil drain would be placed in the right iliac region and pelvis. Patients with complicated-generalised appendicitis (perforated appendix with four-quadrant pus collection, i.e., AAST Grade V)[15] would receive an appendectomy and depending on the surgeon an irrigation would or would not be performed and a pencil drain would or would not be placed in the previously described area. As this is a retrospective study, information with regard to pencil drain insertion or irrigation was not always available, therefore it was not included in the results. However, it is a common practice in the department not to perform an irrigation, as a prospective randomised controlled trial was performed by the General Surgery Department at Sefako Makgatho Health Sciences University on adult patients with complicated appendicitis, which revealed potential harm with irrigation.[16]

Data analysis

All data were entered into an Excel Spreadsheet on a personal computer. All cases were reviewed over a 1-year

period post-surgical intervention in order to include the development of any post-operative complications. The data analysis used in this study consisted of two main statistical analysis: descriptive and inferential statistics. Continuous variables (e.g., age) were summarised by mean, standard deviation and minimum and maximum values. Categorical variables (e.g., gender) were summarised by frequency counts and percentage calculations. On the other hand, inferential analysis was performed on the duration of symptoms and the length of hospital stay. The results of these are illustrated in tables, graphs and charts. Conclusions with regard to statistical significance were based on $P < 0.05$. All statistical procedures were performed on SAS (SAS Institute Inc., Carey, NC, USA), Release 9.4, running under Microsoft Windows on a personal computer.

Results

There were a total of 81 patients that underwent appendectomy; 52 males and 29 females. Therefore, the male: female ratio was approximately 2:1. LA was performed in 50 (62%) patients and 31 (38%) patients had OA, however 7 (14%) patients from the LA group were converted to OA and therefore added to the OA group.

The mean age in the LA group was 9.44 years and 9.03 years in the OA group, with $P = 0.453$, which was statistically insignificant [Table 1]. Patients in the LA group presented with a mean duration of symptoms of 2.97 days compared to 4.40 in the OA group, which was statistically significant with $P = 0.0006$ [Table 1].

Only 16% ($n = 13$) of the patients presented with simple appendicitis and 5% ($n = 4$) of the patients had another pathology that was not acute appendicitis [Figure 1].

The remaining 79% ($n = 64$) of the patients had a complicated appendicitis [Figure 1]. All patients had a 1-year follow-up period in order to assess for the development of any complications [Table 2]. None of the patients identified with simple appendicitis developed a complication (viz., intra-abdominal collections, intestinal ileus or surgical-site infection [SSI]). In the LA group, 15.38% of the patients ($n = 6$) developed intra-abdominal collections versus 5.26% ($n = 1$) in the OA group, which was statistically significantly higher with $P = 0.018$. In the OA group, 15.79% of the patients ($n = 6$) developed SSI versus 5.13% ($n = 2$) in the LA group, which was statistically significantly higher with $P = 0.013$. There was no statistically significant difference when it came to the development on intestinal ileus between the two groups: LA 2.56% ($n = 1$) versus OA 7.89% ($n = 3$) with $P = 0.09$.

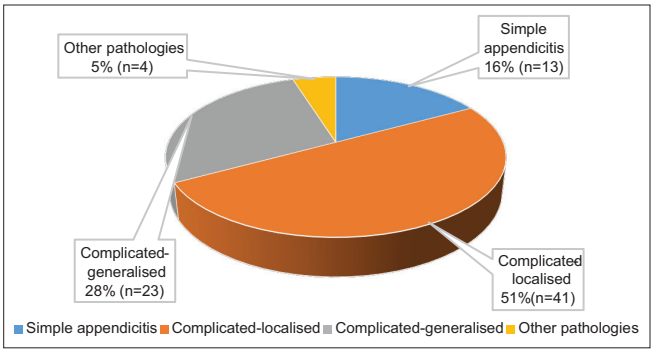

Figure 1: Pathologies

The length of hospital stay post-operatively was statistically significantly lower in the LA group 4.51 days versus 5.34 days in the OA group ($P = 0.016$) [Table 2]. None of the patients with simple appendicitis were re-admitted or re-operated upon. In this study, there was a re-admission rate of 12.82% ($n = 5$) in the LA group versus 13.16% ($n = 5$) in the OA group with no statistically significant difference ($P = 0.943$) [Table 2].

There was a 5.13% ($n = 2$) chance of re-operation in the LA group with 2.63% ($n = 1$) chance in the OA group, which was not statistically significant ($P = 0.360$) [Table 2].

Discussion

Acute appendicitis is the most common emergency amongst all abdominal emergencies in paediatrics with a male preponderance.[1] In the sample population of this study, the male: female ratio was approximately 2:1, which is in keeping with literature.[2,12] The mean age was 9.44 years in the LA group and 9.03 years in the OA group, with no statistical significant difference in the two comparative groups.

In younger children and patients from a lower socio-economic background, diagnosis is often delayed by 2–3 days due to delayed health-seeking behaviour.[13,14] In addition to a delayed clinical presentation in younger children, they also

Table 1: Age distribution, duration of symptoms. *Wilcoxon two-sample test[10,11]

	LA (n=43) Mean (Std)	OA (n=38) Mean (Std)	P
Age distribution	9.44 (1.97)	9.03 (2.20)	0.453*
Duration of symptoms	2.97 (1.74)	4.40 (2.02)	0.0006*

Table 2: Post-operative complications, length of hospital stay, re-admissions, re-operations. *Wilcoxon two-sample test,[10,11] ^Z-score test[10,11]

	LA (n=39) Mean (Std)	OA (n=38) Mean (Std)	P
Complication: Intra-abdominal collections	6 (15.38%)	2 (5.26%)	0.018*
Complication: Intestinal ileus	1 (2.56%)	3 (7.89%)	0.09*
Complication: Surgical site infection	2 (5.13%)	6 (15.79%)	0.013*
Length of hospital stay	4.51(2.20)	5.34 (1.83)	0.016*
Re-admissions	5 (12.82%)	5 (13.16%)	0.943^
Re-operations	2 (5.13%)	1 (2.63%)	0.360^

have specific anatomic and pathophysiologic elements for developing complicated appendicitis.[13] These include a rather short appendix with a thin appendicular wall and an underdeveloped omentum, and toddlers are particularly exposed to gastrointestinal viruses that leave a transient immunosuppression with subsequent possible bacterial overgrowth.[13] In this study, only 10% (n = 8) of the cases presented within the first day of the development of clinical symptoms. In addition, there was a significant difference regarding the duration of symptoms between the two operative modality groups (OA = 4.40 mean days vs. LA = 2.97 mean days) with P = 0.0006. Because the choice of operative modality was based on the surgeon's discretion, it can be postulated that the delayed nature of presentation prompted surgeons to perform the OA modality in this group of patients due to presumed complicated disease.

There was a predominance of complicated appendicitis cases, 79% (n = 63), with only 16% (n = 13) of the sample population presenting with simple appendicitis. Also of note, 5% (n = 4) of the total number of cases had another pathology, which was not consistent with acute appendicitis; all of whom were in the LA group. This is one of the known advantages of laparoscopy with the ability to inspect the abdominal cavity for other intra-abdominal pathologies.[3-8,12,13]

In developed countries, LA has been accepted as the operative management for acute appendicitis (non-perforated), however controversy still exists on the best operative modality in the complicated appendicitis population.[3-5,7] In this study, 62% of the cases (n = 50) were performed laparoscopically versus 38% (n = 38) being performed by the open operative modality. However, the conversion rate in LA group to open operative modality was 14% (n = 7). This is higher when compared to that of other developing countries with conversion rate of 8% demonstrated by Abdelaty *et al*. in Egypt.[9] Because all operations were performed by trainees, it can be postulated that a learning curve is contributory to this high conversion rate.

During the induction of pneumoperitoneum in LA, the infected contents from a complicated appendicitis can seed across the abdomen, providing sources for post-operative abscess formation.[5] And also, during irrigation, inadequate suctioning of fluid will provide a source for abscess formation.[5] Due to the retrospective nature of this study, we were unable to explore the issues of cost and length of operative time as these were not documented in the records. However, efforts to reduce intra-abdominal collections in complicated appendicitis were addressed by departmental practice of avoiding irrigation in these cases supported by a prospective randomised controlled trial which was performed by the General Surgery Department at Sefako Makgatho Health Sciences University on adult patients with complicated appendicitis, which revealed potential harm with irrigation.[16]

Nataraja *et al.* stated rates of intra-abdominal collections to be 2.9% in LA versus 2.7% in OA with no statistically significant difference (P = 0.25).[8] Markar *et al*. stated rates of intestinal ileus of 0.25% post-LA versus 0.23% post-OA with no statistically significant difference (P = 0.6).[5] Markar *et al.* stated rates of SSI of 0.76% post-LA versus 0.99% post-OA with no statistically significant difference (P = 0.13).[5] When compared to our international counterparts, it is evident that we have a relatively increased rate of complications, namely intra-abdominal collections, intestinal ileus and SSI. It can be postulated that this finding may be due to higher rate of complicated appendicitis, 79% (n = 63), as well as operations being performed by trainees, hence contribution of the learning curve towards these complications.

The rate of re-operation was 5.13% (n = 2) in the LA group versus 2.63% (n = 1) in the OA group with no statistically significant difference (P = 0.446) between the two cohorts. One patient was re-operated with a laparoscopic approach successfully, the other patient had an attempted laparoscopic intervention but was converted to open surgery and the third patient was re-operated via an open approach. Thus an attempt to provide minimally invasive surgery even upon re-operation.

Conclusion

In this retrospective cohort study comparing the outcomes of children presenting with acute appendicitis undergoing LA or OA, there was no significant difference between the two operative methods regarding the development of intestinal ileus or number of patients being re-admitted or re-operated.

There was significantly a higher probability of developing intra-abdominal collections when undergoing LA. This is a concern internationally with LA. However, SSI was significantly reduced in the LA group. The other significant finding was that the length of hospital stay in LA group was reduced when compared to that of the OA group.

Considering that there was an increased incidence of complicated cases and operations were being performed by trainees, LA is feasible in a tertiary-level hospital in a developing country as shown by this study which was carried out at the Paediatric Surgery Department of DGMAH. Patients having LA had a better outcome in terms of intestinal ileus, SSI and length of hospital stay, however the LA group had a significantly increased risk of intra-abdominal collections. Therefore, cases of simple appendicitis can be performed laparoscopically, however with regard to complicated appendicitis there is no superiority between the two operative modalities in this study, which is consistent with international literature.

However, in this study, it can be postulated that the learning curve was a major contributory factor to the increased levels of complications, as all operations were performed by trainees. Therefore, we recommend implementation of adequate simulation practices in laparoscopy in the setting of a developing country to attain the laparoscopic expertise of our international counterparts in order to improve the standard of care.

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Conflicts of interest
There are no conflicts of interest.

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