Original

Determinants of the Sub-Types of Appendicitis and Postoperative Outcomes in Children: A Single Institution Experience

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Abstract

Background: The diagnosis of appendicitis has remained clinical. Available scoring systems do not differentiate the sub-types of the diagnoses and prognosticate the outcome. This study assessed the determinants of the sub-types of appendicitis and post-operative outcome.

Method: A retrospective study of all cases of appendectomies in children aged 1 -18 years, from January 2012 to December 2020. Data was collected in a proforma, analysed with SPSS and presented in tables.

Result: There are 100 cases of appendicitis with 57% males and 43% females. The mean age was 12.4(+3.35) years. The symptom onset- presentation interval ranged from 6 hours to 6years (median 5.5 days). Commonest symptoms were right iliac fossa pain - 80%, vomiting - 58%, fever – 52%, nausea – 39%, and anorexia - 35%. Commonest diagnosis and procedure were acute appendicitis-59% and emergency appendectomy-71.4%, respectively. The median presentation-surgery interval was 23hours. Complication rate was 18% with SSI accounting for 11%. There is a relationship between absence of fever and simple appendicitis ($P < .001$). There is also a relationship between absence fever and absence of post-op complications ($P = .019$). However, absence of fever is not a determinant of the sub-diagnosis of appendicitis or post-operative complication. Symptom duration of >48hrs is a determinant of post-operative complication (OR 18.4, $P = 0.013$, CI = 1.84 – 184.5).

Conclusion: Normal temperature may suggest a simple appendicitis. Symptoms duration of >48hrs has at least 18-fold chance of post-operative complications.

Keywords: abscess, outcome, fever, acute appendicitis, complicated appendicitis.

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Introduction

Appendicitis is one of the most common causes of abdominal surgical emergency, occurring in 11 cases per 10,000 populations.[1,2,3] The practice in this environment is that most appendicitis is managed in the private hospitals, leaving complicated cases for the government-owned secondary and tertiary centres. The experience with conservative management of acute appendicitis in the past has made appendectomy the accepted treatment.[4,5] Diagnosis of appendicitis and its sub-types has remained largely clinical.[1] The use of Alvarado score has become quite inconsistent and unreliable in diagnosing appendicitis and its sub-types.[1,6] It has a sensitivity of 54%, specificity of 75%, positive predictive value of 89%, and accuracy rate of 58% to 92%.[1,6] Its use and reliance is being questioned among clinicians.[1] Appendicitis has varied presentations, sub-diagnoses and management depending on the sub-type or stage of its sequel/progression at presentation.[3,7] It could be a simple acute appendicitis (catarrhal or obstructive), gangrenous appendicitis, ruptured appendicitis, appendix mass and appendix abscess. Also, a ruptured appendix can be with a contained abscess or a generalized peritonitis with or without a dominant abscess with resultant intestinal ileus and adhesions mimicking intestinal obstruction.[8] These varied diagnoses come with varied presentations. These various presentations of appendicitis present a challenge to the clinicians as correct diagnosis leads to a correct decision on management, surgical technique and ultimately impact on the outcome.

The clinical presentations of the subtypes of appendicitis can mimic each other, especially in children. The management of each of the subtypes of appendicitis varies, as well as the prognosis.[3] It will require different resuscitative measure, pre-operative investigations, pre-operative preparation such as provisions for blood transfusion, different abdominal incision, different operative instruments, and different post-operative interventions. Therefore, accurate diagnosis of the subtype of appendicitis is important at diagnosis, for instituting a correct treatment and in predicting the expected outcome. Alvarado score and Paediatric appendicitis score (PAS) have been used to differentiate appendicitis from its differentials.[3] However, they do not clarify the diagnosis of the subtypes. This is still left at clinician's judgment. It is therefore necessary to find out the likely clinical factors that correlate with or predict the subtypes of appendicitis. This will aid in management and/or in the development of scoring system for the subtypes of appendicitis. Also factors that correlate with or predicts outcome will help in prognosis.

The aim of this study was to review the presentations and management of cases of appendicitis and to determine factors that correlate with and/or predict subtypes of the diagnosis of appendicitis. It also aims to determine the determinants of the management-outcome of appendicitis in children.

This study is limited by its retrospective nature. This does not allow for a more robust and unbiased study of the predictors of outcome.

Method

This is a retrospective study of all cases of appendicitis in children operated on and managed at Nnamdi Azikiwe University Teaching Hospital (NAUTH) Nnewi Nigeria from January 2012 to December 2020. An ethical approval for the study was obtained from the institutional ethical review board (NAUTH/CS/66/Vol. 14/Ver3/174/2021/047).

Inclusion and exclusion criteria

The inclusion criteria included all cases of appendicitis in children that had an appendectomy and managed by the paediatric surgery team. The exclusion criteria were all cases of incidental appendectomies, all cases aged above 18 years, and cases not managed by the paediatric surgery team. Also excluded were cases thought to be appendicitis but intra-operatively had other pathologies like ovarian torsion or ruptured cyst. Any case that its full record could not be found was excluded.

All children who underwent appendectomy for appendicitis were chosen from the paediatric surgery operation register. The medical records department retrieved the case notes. Relevant data were collected on a proforma. Data collected were on demographics, presenting symptoms and signs, duration of symptoms, diagnosis, investigations, and their result, pre-operative care, appendectomy done and findings, post-operative cares, complications and follow-up.

Diagnosis and management of appendicitis

In NAUTH, it is the practice to make diagnosis of appendicitis in children with clinical features. Laboratory investigations are supportive. A clinical feature of migratory abdominal pain or right iliac fossa pain, anorexia, nausea, vomiting, fever and right iliac fossa tenderness suggests the diagnosis of acute appendicitis. When the above features start initially and then followed by generalized abdominal pain/tenderness, diagnosis of perforated appendicitis with generalized peritonitis is suggested and will warrant imaging investigations and then emergency laparotomy for appendectomy and peritoneal lavage is done. Recurrence of the clinical features of acute appendicitis that is usually not severe in intensity necessitates a diagnosis of sub-acute appendicitis and urgent appendectomy. In this instance, oral antibiotics and analgesia are commenced until date of surgery. Severe features of acute appendicitis and high-grade fever suggests gangrenous appendicitis or perforated

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appendicitis with a localized abscess. This is treated by emergency appendectomy with a Lanz incision that may be extended intra-operatively. In gangrenous appendicitis affecting the base of the appendix, a limited right hemicolectomy is done. A patient booked for appendectomy is admitted, placed on nil per oral, commenced on broad spectrum intravenous antibiotics and intravenous fluid. These are continued in the post-operative period. Oral intake is usually resumed 24 to 48 hours. Antibiotics is converted to orals and patient discharged with it. The follow-up usually does not exceed one week due to patient non-compliance except those who had laparotomy.

The definition of intra-operative findings is dependent on the individual managing team or surgeon's description in the operation note. An intact appendix with hypervascularity on its serosa and/or turgidity and/or edema is considered an acute appendicitis. When an acute appendix has a portion or all of its wall gangrenous, it is considered a gangrenous appendicitis. An inflamed appendix with its lumen communicating with the peritoneal cavity with or without localized abscess is a perforated appendicitis. When a perforated appendicitis has pus localized or spread in the peritoneal cavity, this is an appendicitis with localized or generalized abscess. All these, except acute appendicitis were aggregated together as complicated appendicitis. Post-operative complications are defined as surgical site infection, enterocutaneous fistula, post-operative adhesions or any other condition described by the managing team as post-operative complications.

These data were entered into the spreadsheet and analyzed with SPSS (IBM Inc) version 23. Continuous data were analysed for central tendencies and association assessed using T-test. Categorical data were analysed for frequency and association assessed using Chi-square. Multivariate logistic analysis was done for determinants of subtypes of diagnosis and outcome. Significant factors were further subjected to bivariate logistic regression. Significance was set at P-value < 0.05. Results were presented in tables.

Operational definitions:

1. ***Category of surgeon***: A consultant is a fully qualified specialist surgeon. A senior registrar is the most senior surgeon in specialist training. A registrar is a junior doctor in specialist training.
2. ***(symptom) Onset-presentation interval:*** is the time from when the symptoms started to when the patient presented to the hospital.
3. ***Presentation-surgery interval:*** is the time from when patient came to hospital to when he/she was operated on.

Results

There were 194 cases of appendectomies within of nine (9) years. A total of 85 appendectomies were excluded because they were incidental appendectomies from bowel resection in gangrenous intussusceptions, midgut volvulus and other pathologies. Nine (9) case files could not be retrieved and were excluded. One hundred (100) cases of appendectomies from appendicitis were, therefore, included and analyzed.

The age of the patients ranged from 2 to 17 years. The mean age and weight were 12.4 (±3.35) years and 42.4(±13.80) Kg, respectively. The sex distribution shows that 57% were males and 43% were females. Almost half (49%) came from a distance more than 30Km. Their packed cell volume ranged from 18% to 49%.

The commonest symptoms were right –sided abdominal pain in 80 children (80%) and vomiting in 58 patients (58%) of patients. Migratory abdominal pain was reported in 25 children (25%) of the patients. The commonest signs were localized abdominal tenderness, 81 patients (81%) and elevated temperature, 34 patients (34%). (Table 1)

Table 1: Clinical Features of patients with appendicitis

Clinical Features	Yes (%)	No (%)
Migratory abdominal pain	25 (25%)	75 (75%)
Right-sided abdominal pain	80 (80%)	20 (20%)
Generalized abdominal pain	21 (21%)	79 (79%)
Fever	52 (52%)	48 (48%)
Anorexia	35 (35%)	65 (65%)
Nausea	39 (39%)	61 (61%)
Vomiting	58 (58%)	42 (42%)
Diarrhea	9 (9%)	91 (91%)
Constipation	5 (5%)	95 (95%)
Urinary frequency	14 (14%)	86 (86%)
Elevated temperature	34 (34%)	66 (66%)
Localized tenderness	81 (81%)	19 (19%)
Generalized tenderness	25 (25%)	75 (75%)
Mass per abdomen	3 (3%)	97 (97%)

The diagnoses were made mainly on clinical basis, as 90% of the clinical diagnoses were upheld after laboratory investigation. Sixty-one patients (61%) had an abdominal ultrasound done, 18 (18%) had an abdominopelvic plain radiograph, and 22(22%) had full blood count (FBC) before operative intervention. The most clinical diagnosis made was simple acute appendicitis in 59(59%) of the cases. (Table 2) These diagnoses were made by the consultants, the senior registrars, and registrars in 56(56%), 34(34%) and 10(10%) of cases, respectively.

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Table 2: Laboratory utilisation and clinical diagnosis of the appendicitis patients

Laboratory Utilization	Distribution	Frequency (Percentage)
Full blood count done	Yes	22 (22%)
	No	78 (78%)
Leukocytosis	Yes	6 (6%)
	No	16 (16%)
	Not applicable	78 (78%)
Leukocytosis with shift to left	Yes	3 (3%)
	No	3 (3%)
	not applicable	94 (94%)
Abdominal ultrasound	Yes	61 (61%)
	No	39 (39%)
Abdominal ultrasound report	Normal appendix	26 (26%)
	Inflamed appendix	19 (19%)
	Abscess	10 (10%)
	Mass	2 (2%)
	Intestinal obstruction	4 (4%)
	Not applicable	39 (39%)
Abdominal X-ray findings	Features of intestinal obstruction	9 (9%)
	Air in peritoneal cavity	3 (3%)
	No essential findings	6 (6%)
	Not applicable	82 (82%)
Diagnosis		
Clinical diagnosis made	Acute appendicitis	59 (59%)
	Sub-acute appendicitis	17 (17%)
	Ruptured appendicitis	16 (16%)
	Appendix abscess	1 (1%)
	Other acute abdomen	7 (7%)
Diagnosis after laboratory investigation tallying with clinical diagnosis	Yes	90 (90%)
	No	10 (10%)

The operations were emergency simple appendectomies 67 patients (67%), urgent appendectomies 6(6%), drainage & appendectomy 26(26%) and bowel resection 1(1%) respectively. The senior registrars, consultants and registrars performed 52 (52%), 40 (40%) and 10 (10%) of these procedures respectively. The anaesthesia used for the procedures were: general anaesthesia with facemask 37 (37%) cases, general anaesthesia with endotracheal intubation 34 (34%) cases and spinal anaesthesia 29 (29%) cases. The intra-operative diagnoses were appendicitis 69 (69%) cases, gangrenous/perforated appendix 17 (17%) cases, and appendix abscess 14(14%) cases respectively. Sixty eight (68%) of the surgeries were done in the evening-night period (5pm to 5am), 20 (20%) cases were done in the afternoon period (12pm to 4pm) and 11 (11%) cases were done in the morning period (6am -11am).

The median symptom onset-presentation interval was 5.5 days (range was 0.25 to 2190 days). The modal presentation-surgery interval was 24 hours (range was 4 to 868 hours). The minimum and maximum surgery duration were 33 minutes and 205 minutes (3 hours & 25 minutes) respectively. The mean post-operative nil per oral (NPO) duration, median post-operative admission duration, and mean post-operative oral antibiotics duration were 2.4($\pm$1.28), 6.8($\pm$13.02) and 7.5($\pm$3.84) days respectively. (Table 3).

Table 3: Management of appendicitis patients

	Minimum	**Maximum**	**Median (mode)**	**Mean**
Onset-presentation interval (days)	0.25	2190	5.5 (2)	-
Presentation-surgery interval (hours)	4	868	23 (24)	-

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Duration of surgery (minutes)	33	205	-	75.8 (±32.44)
Post-operative Nil per oral interval (days)	1	6	-	2.4 (±1.28)
Duration intravenous antibiotic post-operative (days)	1	120	3 (2)	-
Duration of post-operative admission (days)	1	120	3 (3)	-
Duration of post-operative oral antibiotics	4	28	-	7.5 (±3.84)
Follow-up duration (days)	0	330	7 (7)	-

The post-operative complications rate was 18%. The severest were one case (1%) each of enterocutaneous fistula and intestinal perforation. There were 11 cases (11%) of surgical site infection (SSI), 2 cases (2%) of wound breakdown, and 1 case (1%) each of paralytic ileus, post-operative nausea/vomiting (PONV) and adhesive intestinal obstruction. Of the 100 specimens, 30% were sent for histology, 11(11% of all cases) of which were retrieved. Five (5) of the retrieved histology report noted neutrophil infiltration of the submucosal layer and six (6) noted lymphoid follicle enlargement.

There was a positive association between the absence of fever and intra-operative diagnosis of simple appendicitis, (X^2 = 14.77, P <0.001). There is a positive association between fever and post-operative complications, (X^2 = 5.82, P < 0.019). Also, there is a positive association between fever and surgical site infection (X^2 = 4.403, P = .036). (Table 4).

Table 4: Relationship between fever and intra-operative diagnosis

		Simple appendicitis	**Complicated appendicitis**	**Total**	**Pearson Chi-square**	**P-value**
Fever	yes	27	25	52	14.77	<0.001
	no	42	6	48		
Total		69	31	100		
Relationship between fever and post-operative complications						
		Nil complication	complications			
Fever	yes	38	14	52	5.82	0.019
	no	44	4	48		
Total		82	18	100		

In a multivariate analysis, none of the symptoms and signs is a determinant of intra-operative diagnosis, (see Table 5). However, symptoms duration of >48 hours is a determinant of post-operative complications and constitute an 18-fold increase in the likelihood of post-operative complications (OR 18.4, P = 0.013, CI = 1.84 – 184.5); (see Table 5). Specifically, absence of generalized abdominal tenderness predicts in 89% of cases absence of surgical site infection (SSI) as a post-operative complication (OR = .114 P = .041, CI = .014 – .919)

Table 5: Multivariate determinants of intra-operative diagnosis* of appendicitis and post-operative complications in appendectomy

	Intra-operative diagnosis of appendicitis		**Post-operative complications**	
Determinants	**Odd ratio (CI)**	**P-value**	**Odd ratio (CI)**	**P-value**
Right-sided abdominal pain	.311 (.054 - 1.78)	.190	.777 (.161-3.75)	.754
Generalized abdominal pain	1.81 (.279 – 11.7)	.534	3.32 (.630-17.5)	.157
Fever	1.19 (.263 – 5.39)	.821	2.83 (.523 – 15.3)	.227
Vomiting	1.85 (.496 – 6.90)	.359	.810 (.180 – 3.65)	.784
Anorexia	.978 (.253 – 3.78)	.974	.776 (.189 – 3.19)	.725
Raised temperature	3.22 (.769 – 13.5)	.109	.806 (.177 – 3.67)	.780
Localized tenderness	.538 (.063 – 4.63)	.573	.741 (.111 – 4.96)	.757
Generalized tenderness	5.50 (.800 – 37.8)	.083	3.00 (.410 – 22.0)	.279
Symptoms duration (≤ 48 hrs & 48 hrs)	-	-	18.4 (1.84-184.5)	0.013
Presentation-surgery interval (≤24hrs and >24hrs)	-	-	1.002 (197-5.097)	.998

**diagnosis: simple appendicitis and complicated appendicitis (gangrenous, perforated appendicitis and abscess)*

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Discussion

Acute appendicitis is one of the most common reasons for emergency abdominal surgery.[1,3] The peak age incidence is between 10 and 19 years.[9,10] This is in consonance with the findings in this study, where mean age is 12.4 years. Acute appendicitis is thought to be common within this age range due to the poor drainage of the vermiform appendix lumen in this age group.[10] This is thought to be orchestrated by common viral infection in this age group that causes lymphoid hyperplasia (a very common histological finding in appendicitis specimen) with its subsequent obstruction or narrowing of the appendix lumen. This impairs luminal drainage. The dietary intake in this age group contains relatively less fibre, which is a risk factor implicated in acute appendicitis.[10]

The male to female ratio of 1.3:1 in this study is like the findings of Addiss et al [10] in the USA of 1.4:1. The subjects in this study had no comorbidities apart from the diagnosis of appendicitis. This is reflected in a relatively good mean hematocrit of >35% and a mean weight of 42.4Kg. These were appropriate for the mean age. No chronic disease condition has been associated with appendicitis or known to increase the lifetime risk of appendicitis on an individual.[10]

The classical presenting features of appendicitis are no longer common from this study, just like other recent studies.[5] The migratory abdominal pain, nausea, vomiting, and anorexia were more likely to be absent than present. The dominant clinical features were right sided lower abdominal pain and tenderness. These are so, as patients take over-the-counter self-medication as a first line of care before presenting to the hospital. Oral antibiotics and analgesia are usually taken, and when symptoms do not reduce, they now present to the hospital. This is buttressed by a median symptom onset-presentation interval of 5.5 days. By this time, the clinical features have been attenuated by the medications and time-lag. Again, children may not be able, under stress, to recall the progression of their clinical symptoms. The symptoms alone or in combination do not always give out the diagnosis. Quite a number of patients with generalized abdominal pain do not have complicated appendicitis in this study.

The diagnosis of appendicitis and appendix pathology has remained clinical.[11] The usage of laboratory support in this series was poor. Abdominal ultrasound was used in 61% of the subjects, and in about 19% was appendix reported as inflamed. This does not relate to the clinical diagnosis or to the intra-operative findings/diagnosis, which was as high as 69%. This buttresses the fact that surgeons in this part of the world are relying on their clinical acumen rather than on laboratory results for the diagnosis of appendix pathologies.[11] It is also important to note the variation in ultrasound report of abscess and the eventual intra-operative findings (10% vs 14%). One can attribute this to the operator-dependability of ultrasound. However, there was no use of computed tomography scan in this series which is far more sensitive and specific for the diagnosis of appendix pathology, compared to ultrasound.[12] However, current thinking is to use radiological investigations for unclear diagnosis, while clear cut appendicitis is based on clinical acumen.[11] Complete blood count which is a necessary component of Alvarado scoring system, Appendicitis inflammatory score (AIR), and Paediatric appendicitis score (PAS), were poorly utilized. It shows the less emphasis placed on the scoring system for appendicitis diagnosis by the managers of these cases.[5] These scoring systems are now used for assessing risks and making for accuracy of diagnosis.[11] The scoring system is recommended for use in children.[13] It is known that these scoring systems are most sensitive with severe inflammation or complicated appendicitis. Hence, they are untenable with mildly and moderately inflamed appendix. However, this raises the question: which of the appendicitis could be managed conservatively or operatively? This opens a new vista for research on the review of usage of the various scoring systems and tailoring them to predict the appropriate management of appendicitis.[3,9]

The absence of fever is associated with a diagnosis of simple appendicitis. The presence of fever is associated with the likelihood of post-operative complications. This can be tied to complicated appendicitis (gangrene, abscess) likely to present with fever.[14,15] Surgical site infection (SSI) is the most common complication as complicated appendicitis leads to contaminated or dirty surgical wound with a higher rate of SSI. The incidence of SSI in this study, 11% is like other results from low-income countries.[16] This was irrespective of antibiotics usage for an average of 10 days in the post-operative period in this series. This is in keeping with a systematic and meta-analysis finding that the incidence of SSI after appendectomies in Low- and Medium-Income Countries (LMICs) is independent of antibiotics usage in the post-operative period.[16] However, antibiotics prophylaxis reduces SSI after appendectomies.[17]

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None of the major symptoms and signs is a determinant or predictor of intra-operative diagnosis. This supports the use of a scoring system. There is a 3-fold increase in the likelihood of an intra-operative diagnosis of complicated appendicitis with a fever at presentation, but this was not statistically significant (OR=3.22, CI=0.769-13.5, P=.109). Symptom duration of more than 48 hours has an 18-fold likelihood of post-operative complications, and this was statistically significant (OR=18.4, CI=1.84-184.5, P=0.013). This is like findings in Ethiopia by Assefa et al.[14] Late presentation may be a pointer to a progressing inflammation and likelihood of complication. Complicated appendicitis has a higher chance of post-operative complication.[14,15]

At 31%, there is a higher rate of complicated appendicitis on presentation. This could be explained by the hospital being a tertiary centre, where most cases are referred to and would have been very sick or delayed before getting to it. Also, this may be due to the late presentation common in the environment of this study. This may explain why most of the cases were done by the senior surgeons (senior registrars and consultants). This caliber of surgeons may also account for less sinister post-operative complications like enterocutaneous fistula. Most of the patients received intravenous antibiotics for 3 days post-operatively and continued oral antibiotics for 7 days. This was obviously prolonged. And no patient was exempted from the prolonged antibiotics administration. With a SSI rate of 11%, the prolonged antibiotics use does not seem to have made any difference in that regard.[17]

There is a poor utilization of histological inputs in the management of the patients in this study. This is similar to the poor use of radiological imaging in the pre-operative diagnosis. The implication is that multidisciplinary collaboration is still poor. This is no longer the norm in current patients' management.[18,19] It denies the body of literature the exact subtype of diagnosis of these patients managed. The use of histological study of the specimen will enable opportunity to tease out the patients that may have benefitted from conservative care in a retrospective review.

Conclusion

Right-sided pain and localized tenderness are the commonest clinical feature of appendicitis. Clinical diagnosis is still relevant in our environment for making the diagnosis of appendicitis. However, it is inadequate in differentiating the sub-types of appendicitis. No single clinical feature determines pre-operatively the subtypes of appendicitis. However, absence of fever predicts the subtype of simple appendicitis and absence of post-operative complications. Symptoms duration more than 48 hours predicts post-operative complications. Prolonged antibiotics usage post-operatively does not prevent SSI.

Declarations

Ethical Consideration: An ethical approval for the study was obtained from the institutional ethical review board (NAUTH/CS/66/Vol. 14/Ver3/174/2021/047).

Authors' Contribution: This manuscript has been read and approved by all the authors. All the authors met the requirements for authorship vis-à-vis: designing of the study, interpretation of data, drafting the article, revising it critically for important intellectual content; and the final approval of the version to be published. Modekwe VI developed the concept, acquired the data, and analysed the data. Each author believes that the manuscript represents honest work and is original.

Conflict of interest: We declare no conflict of interest.

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