Acute Appendicitis in Infancy and Childhood: A Twenty Year Study in a General Hospital *

JOHN H. FOSTER, M.D., WILLIAM H. EDWARDS, M.D.

From the Department of Surgery, Vanderbilt University School of Medicine, and the Surgical Service, Vanderbilt University Hospital, Nashville, Tennessee

IN THE PAST several decades the mortality rate for acute appendicitis has decreased significantly. In 1937 Kirtley and Daniel reported on one thousand consecutive patients of all ages with acute appendicitis at Vanderbilt University Hospital. Since that time the management of acute appendicitis in children has presented the greatest challenge. This is a report of the experience with childhood appendicitis at Vanderbilt University Hospital from 1936 through 1955. Children under the age of 13 operated upon for acute appendicitis have been studied. Only those cases substantiated by operation or autopsy are included. Children having appendectomy for reasons other than acute appendicitis were omitted.

During the 20 year period of the study, 489 children were operated upon for acute appendicitis. The operative findings are tabulated in Table 1. It is the continuing policy of this clinic to perform appendectomy in children with abdominal tenderness in the right lower quadrant which is not otherwise explainable. This necessarily results in the removal of a normal appendix in a significant number of cases, but it is believed that such a policy carries the least risk for the patient.

Most reported series of appendicitis reveal a predominant incidence in males. In this study 60 per cent of the patients were male and 40 per cent were female. One hundred and four surgeons participated in the series. Private patients comprised 37 per cent of the group and 63 per cent of the cases were ward patients.

The percentage of cases of acute appendicitis resulting in perforation of the appendix is traced through the years in Table 2. There has been a small decrease in the incidence of ruptured appendicitis. The extent of the decline still leaves much to be desired as shown in the five year period ending with 1955, for a perforated appendix was found in over one-third of the cases of childhood appendicitis.

Scott and Ware [3] and others have expressed the view that perforation of the acutely inflamed appendix tends to occur earlier in infancy than thereafter. The findings in Figure 1 would seem to support this view. More than 75 per cent of the children under the age of four were found to have ruptured appendicitis in contrast to less than 25 per cent incidence of perforated appendicitis in children aged nine through 12. That this concept may be erroneous is indicated in Figure 2 which reveals the relationship between duration of symptoms and the age of the patient. This graph is almost identical to the findings recorded in Figure 1 which plots the relation of the incidence of perforation to the age of the patient. Thus the higher incidence of perforated appendicitis in infants parallels the greater duration of their disease process. In Table 3 the relationship between the duration of symptoms and type of appendicitis is shown. When appendectomy was performed in the first 24 hours, perforation

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TABLE 1. *Disease Process in 489 Children Operated upon for Acute Appendicitis, Vanderbilt University Hospital, 1936–1955*

Acute appendicitis, unruptured	224	46%
Acute appendicitis, ruptured with local peritonitis	51	10%
Acute appendicitis, ruptured with generalized peritonitis	28	6%
Acute appendicitis, ruptured with abscess formation	55	11%
	358	
No disease demonstrated	63	
Mesenteric adenitis	58	
Meckel's diverticulitis	2	
Primary peritonitis	2	
Chronic appendicitis	5	
Omental infarct	1	
	131	27%

was encountered in only 7 per cent of the cases whereas after 96 hours perforation had occurred in 91 per cent of the patients. All children with ruptured appendicitis were tabulated as to duration of symptoms by age group in Table 4. In these children duration of symptoms ranged from 75 to 114 hours in the various age groups. There was no evidence that perforation of the appendix tended to occur earlier in the course of acute appendicitis in infants than in the older age groups. All children through the age of four had symptoms for at least 90 hours prior to the laparotomy revealing a ruptured appendix. There was no significant difference in the duration of symptoms from one age group to the next. These findings seem to indicate that perforation of the acutely inflamed appendix is not related to the age of the patient but of the duration of the disease process. The much higher incidence of perforated appendicitis in infants would then be explicable on the basis of the greater difficulty in arriving at the proper diagnosis early in the course of the disease.

In excess of 50 per cent of the children in this series resided outside of Nashville and its suburbs. The incidence of perforated appendicitis in Nashville children was 24 per cent whereas for those children residing outside of suburban Nashville a perforated appendix was found in 49 per cent of the cases.

There is another aspect of childhood appendicitis which does seem to be related to the child's age. This is the ability of the child to localize the infection once perforation has occurred (Table 5). In children through the age of four years perforation of the appendix resulted in generalized peritonitis in 34 per cent of the cases. Age

TABLE 2. *Types of Appendicitis in Relation to Year*

	Acute Appendicitis, Unruptured Number of Children	Acute Appendicitis, Ruptured Number of Children	Percentage Ruptured
1936–40	51	40	44%
1940–45	53	27	34%
1945–50	59	31	34%
1950–55	61	36	37%
	224	134	38%

TABLE 3. *Relation of Duration of Symptoms to Type Appendicitis*

Duration Symptoms, Hours	Acute Appendicitis, Unruptured Number of Children	Acute Appendicitis, Ruptured Number of Children	Percentage Ruptured
0–24	120	8	7%
24–48	73	25	25%
48–72	20	27	59%
72–96	6	15	68%
Over 96	5	59	91%

TABLE 4. *Acute Appendicitis, Ruptured: Relation of Age to Duration of Symptoms*

Age	Number of Children	Duration of Symptoms, Hours
0–2	15	114
3–4	20	90
5–6	22	80
7–8	25	75
9–10	28	86
11–12	24	92

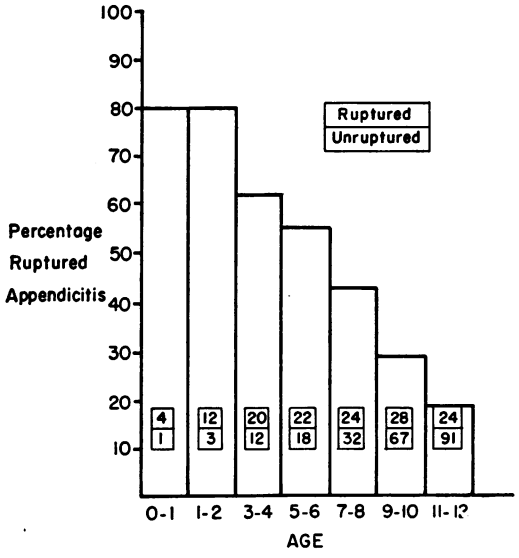

FIG. 1. Relationship between age and type of appendicitis in 358 children.

FIG. 2. Relationship between age and duration of symptoms at time of admission to hospital in 358 children with appendicitis, Vanderbilt University Hospital, 1936–1955.

groups five through 12 revealed that only 16 per cent of the patients with ruptured appendicitis developed generalized peritonitis. Thus in the infant two factors contribute to the gravity of acute appendicitis: on the one hand the diagnosis is more difficult and treatment often delayed, and on the other hand once rupture occurs there is a greater risk of generalized peritonitis.

TABLE 5. *Localization of Infection from Ruptured Appendix in Relation to Age*

Age	Local Peritonitis or Abscess Number of Children	Generalized Peritonitis Number of Children	Percentage not Localized
0–4	23	12	34%
5–12	83	16	16%
	106	28	25%

The delay in diagnosis and treatment increases the likelihood of perforation of the appendix from which there is a greater risk of generalized peritonitis.

Some of the features of the clinical history in each type of appendicitis are listed in Table 6. The most important feature of this table is the number of children who failed to display the listed historical facts; for instance, 12 per cent of the children with unruptured appendicitis did not have right lower quadrant abdominal pain. The extremely high incidence of cathartics administered to children when the diagnosis was still in doubt must also have contributed to the incidence of perforated appendicitis. The current liberal use of antibiotics in children may serve to mask appendicitis and lead to further delay in diagnosis and definitive treatment.

The physical findings recorded in Table 7 once again reveal significant percentages in which each of the classical findings is absent. The presence of maximal abdominal tenderness in the right lower quadrant was the most constant finding. As stated earlier, any child with tenderness in the right lower quadrant, otherwise unexplainable, receives the benefit of an appendectomy.

Finally in Table 8 are the laboratory findings according to the type of appendicitis. The range of values listed for each of the determinations indicates that any of these tests may be unreliable in any given case. The combination of nausea, vomiting, abdominal pain and tenderness in the right

TABLE 6. *Clinical History in Relation to Type of Appendicitis*

Type of Appendicitis	Duration Symptoms	Nausea	Vomiting	RLQ Pain	Previous Similar Episodes	Previous Therapy	
						Cathartics	Antibiotic
Acute appendicitis, unruptured	27 hrs.	80%	72%	88%	31%	12%	1%
Acute appendicitis, ruptured with local peritonitis	52 hrs.	98%	94%	74%	18%	27%	10%
Acute appendicitis, ruptured with general peritonitis	78 hrs.	96%	96%	60%	13%	40%	8%
Acute appendicitis, ruptured with abscess	136 hrs.	88%	86%	71%	18%	43%	8%

TABLE 7. *Physical Findings in Relation to Type of Appendicitis*

Type of Appendicitis	Maximal Abdominal Tenderness RLQ	Maximal Rectal Tenderness Right Side	Maximal Muscle Spasm RLQ	Palpable Mass Present
Acute appendicitis, unruptured	96%	68%	62%	3%
Acute appendicitis, ruptured with local peritonitis	94%	81%	59%	12%
Acute appendicitis, ruptured with general peritonitis	80%	44%	25%	20%
Acute appendicitis, ruptured with abscess	94%	78%	58%	59%

TABLE 8. *Laboratory Findings in Relation to Type of Appendicitis*

Type of Appendicitis	Temperature °F. Oral		Leukocyte Count Thousands		Polymorphs Count Percentage	
	Average	Range	Average	Range	Average	Range
Acute appendicitis, unruptured	100.3	97.8–100.4	17.0	4.0–34.0	78%	32–91
Acute appendicitis, ruptured with local peritonitis	101.8	98.8–103.6	18.3	6.9–42.0	76%	36–93
Acute appendicitis, ruptured with general peritonitis	102.0	99.8–103.4	17.9	8.2–28.0	80%	56–91
Acute appendicitis, ruptured with abscess	101.4	99.4–104.0	18.9	1.7–37.0	77%	56–90

lower quadrant, elevated temperature and a high white blood count is the one most often reproduced in the child with appendicitis. However, not one of these features is constant.

Operative treatment was carried out in 98.5 per cent of the 358 children with acute appendicitis. Three of the five cases treated by non-operative methods were children with appendical abscess who returned later for an interval appendectomy and did well. The remaining two children had perforated appendicitis with generalized peritonitis. One of these died during the course of delayed treatment; death occurred the night prior to the proposed day of operation. The other child in the nonoperative group developed perforated appendicitis and generalized peritonitis four days following cleft palate repair. The correct diag-

nosis was not apparent until postmortem examination. Immediate operative therapy, within the first 24 hours of hospitalization, was carried out in 92 per cent of the cases. The delayed operative group was made up of those in which appendical abscess was thought to be present and in those cases where the diagnosis of appendicitis was uncertain.

Most authors seem to agree that a child with the diagnosis of acute appendicitis should have some preoperative preparation with intravenous fluids, antibiotics and gastric suction if indicated. This is imperative in the extremely ill child who is dehydrated and acidotic. In this series 9 per cent of the children with unruptured appendicitis and 45 per cent of those with ruptured appendicitis received preoperative treatment primarily in the form of intravenous fluids. It was not possible to verify the virtues of preoperative treatment by comparing the results in the groups receiving and not receiving such therapy. The children receiving preoperative treatment were those with the gravest illness at the time of admission to the hospital.

A McBurney incision was used in 86 per cent of the cases and a right rectus incision in 13 per cent of the patients. In 70 per cent of the cases of ruptured appendicitis peritoneal drainage was utilized. It is the current practice in this hospital to employ peritoneal drainage along with appendectomy in children with ruptured appendicitis and peritonitis. Drainage alone was most commonly used in cases of appendical abscess; there were 30 such instances. In 15, or 50 per cent, of these cases there was no record of interval appendectomy ever being performed. The number of these that have had appendectomy elsewhere is unknown. Also of interest is the finding that 25 per cent of the cases treated with drainage alone had an acute exacerbation before interval appendectomy was performed. These acute exacerbations occurred one to eight weeks following discharge from the hospital.

A study of the postoperative therapy administered revealed that 45 per cent of patients with unruptured appendicitis and 73 per cent of those with ruptured appendicitis received antibiotics. Intravenous fluids were administered for one or more days in about 95 per cent of the patients. Children with ruptured appendicitis received blood, plasma or albumin in one-third of the cases. Gastric suction was used in 40 per cent of the patients with perforated appendicitis during the postoperative period. In 44 per cent of the cases of ruptured appendicitis Fowler's or semi-Fowler's position was utilized in the postoperative period. Peritoneal fluid was cultured for bacteria in 81 per cent of the cases of ruptured appendicitis and 86 per cent of the cultures revealed bacterial growth. E. Coli was the most commonly encountered bacterium. Fecaliths were recorded as being present in 25 per cent of both unruptured and ruptured appendicitis.

The length of hospitalization with childhood appendicitis decreased over the 20 year period. Cases of unruptured appendicitis remained in the hospital seven days during the years 1936–1945, and since that time five days has been the average figure. In the ruptured appendicitis group the decrease has been from 19 to 12 days.

The variety of postoperative complications encountered is listed in Table 9. Since 1936 there has been a gradual decrease in the yearly incidence of postoperative complications of acute appendicitis. From a figure of 20 per cent during the years 1936 through 1940 the incidence of such complications was reduced to 12 per cent in the years 1951 through 1955. Abscess formation in the postoperative period was the most common complication; this occurred 41 times. Operative treatment of postoperative abscess was carried out in 26 cases, and 15 cases responded to non-operative methods. Intestinal obstruction occurred in the postoperative period in 9 instances. Operative intervention was re-

TABLE 9. *Postoperative Complications in Relation to Type of Appendicitis*

Type of Complication	Acute Appendicitis Unruptured	Acute Appendicitis Ruptured
Wound abscess	12	15
Pelvic abscess	1	9
Subphrenic abscess	0	4
Intestinal obstruction	2	7
Bronchopneumonia	1	4
Septicemia	0	6
Ventral hernia	0	2
Rheumatic fever exacerbation	0	1
Febrile convulsions	0	2
Lower nephron nephrosis	0	2
Death, cause unknown	0	2
Fecal fistula	0	2
Hemorrhagic diathesis	0	1
Empyema	0	2
	16	59

quired in four of the patients, two of whom died, one in 1939 and another in 1954. The other five patients with intestinal obstruction responded to gastric suction and conservative management.

The value of drainage of the peritoneal cavity in perforated appendicitis is difficult to assess which probably accounts for the differences of opinion on the subject that exist among surgeons. In this series peritoneal drainage was used in 94 per cent of the cases of appendical abscess and in 80 per cent of the cases of generalized peritonitis following rupture of the appendix. In the cases of ruptured appendicitis with localized peritonitis a comparison of the value of drainage was possible as about half of the cases were treated each way (Table 10). Twenty-six of the patients had appendectomy without drainage while 25 patients had an appendectomy with drainage. Both groups received antibiotics. There were nine cases which were not drained that developed postoperative abscess, while four patients that were drained developed an abscess. It is not possible to draw any conclusions from this small group of patients, but results would seem to support the advocates of peritoneal drainage in ruptured appendicitis with localized peritonitis. Abscess formation was twice as frequent following appendectomy without drainage.

TABLE 10. *The Influence of Peritoneal Drainage in Acute Appendicitis, Ruptured, with Localized Peritonitis*

	Number of Patients	Postoperative Abscess
Appendectomy without drain	26	9
Appendectomy with drain	25	4

An attempt was made to evaluate the effect of antibiotics in the treatment of acute appendicitis (Table 11). There were 224 children with unruptured acute appendicitis of which 120, or 52 per cent, did not receive any antibiotic therapy. The postoperative morbidity was no different from that encountered in the 104 children receiving antibiotic therapy. In those children with ruptured appendicitis who received antibiotics, the mortality decreased from 20 per cent to 7 per cent. It should be noted that this comparison does not take into account the other improvements in therapy that developed coincidentally with the advent of antibiotics. Improved anesthesia and fluid therapy must have exerted some influence.

TABLE 11. *Postoperative Morbidity* and Mortality as Related to Antibiotic Therapy*

Postoperative Therapy	Acute Appendicitis		Unruptured Mortality	Acute Appendicitis		Ruptured Mortality
	Number	Morbidity		Number	Morbidity	
Antibiotics	104	8.1%	0	100	32%	7.0%
No antibiotics	120	6.7%	0	34	41%	20.0%

* Postoperative morbidity represents incidence of complications.

TABLE 12. *Mortality Rate in 358 Children with Acute Appendicitis, Vanderbilt University Hospital, 1936–55*

Type of Appendicitis	Number Cases	Deaths	Mortality
Acute appendicitis, unruptured	224	0	0%
Acute appendicitis, ruptured with local peritonitis	51	3	6%
Acute appendicitis, ruptured with general peritonitis	28	8	29%
Acute appendicitis, ruptured with abscess	55	3	4%
	358	14	3.9%

TABLE 14. *Relation of Age and Mortality Rate in Acute Appendicitis, Ruptured*

Age	Number	Deaths	% Mortality	Over-all % Mortality
Under 1	4	1	25%	20%
1–2	11	1	8%	7%
3–4	20	2	10%	6%
5–6	22	2	9%	5%
7–8	25	5	20%	9%
9–10	28	1	4%	1%
11–12	24	2	8%	1.6%
	134	14	10%	3.9%

The mortality rates for the types of appendicitis are recorded in Table 12. In 224 children with unruptured appendicitis there were no deaths. One child with mesenteric adenitis died of cardiac arrest at the time of operation. In 134 children with ruptured appendicitis 14 deaths occurred; eight of these were children with generalized peritonitis. The over-all mortality of 3.9 per cent in 358 children, of which 38 per cent had ruptured acute appendicitis, is considerably greater than that reported in some other series. McLanahan [2] reported on 823 children at Union Memorial Hospital, Baltimore, covering the years 1933–1949 with 0.24 per cent mortality. However, the incidence of ruptured appendicitis was 14 per cent. Children's Hospital in Boston reported 1,232 children in the years 1939–1951 with 47 per cent perforated appendicitis and a mortality of 0.7 per cent.

An analysis of the cases by five year period reveals that the over-all mortality fell from 8.8 per cent for the period 1936–1940 to 1 per cent for the period 1951–1955. This includes all cases of acute appendicitis whereas attention should more properly be focused on the results with ruptured appendicitis. In Table 13 the cases of perforated appendicitis are broken down into five year periods. The decrease from a high of 20 per cent in the years 1936–1940 to 3 per cent in the years 1951–1955 still leaves something to be desired. The small decrease from 44 per cent to 37 per cent in the incidence of ruptured appendicitis in the same periods would seem to indicate improved treatment to be the major factor in the steadily declining mortality rate. The fact that there were no deaths in children with acute appendicitis, unruptured, is felt to justify early exploration for acute appendicitis in children with right lower quadrant abdominal tenderness not otherwise explainable. However, the Boston Children's Hospital series quoted above is ample proof that ruptured acute appendicitis in children can be treated with less than 1 per cent mortality.

TABLE 13. *Acute Appendicitis Ruptured: Mortality Rates by Five Year Periods*

Year	Number Children	Deaths	Percentage Mortality
1936–40	40	8	20%
1941–45	27	1	4%
1946–50	31	4	13%
1951–55	36	1	3%
Total	134	14	10%

A breakdown by age group in Table 14 reveals that in ruptured appendicitis there is no significant difference in the mortality rate from one age group to the next. However, the consideration of all children with appendicitis, both ruptured and unruptured, reveals a steady decline from 20 per cent in children under one year of age to

1 per cent for children nine to 12 years of age. This merely reflects the greater incidence of ruptured appendicitis in the younger age groups, where the delay in diagnosis is greatest. Thus after perforation has occurred one age group is treated as well as another, and the real improvement in the future treatment of appendicitis will probably be related to increasing the number of children having appendectomy prior to rupture of the appendix.

Although proof is difficult, it is felt that preoperative treatment in the form of antibiotics, intravenous fluids including normal saline, plasma or blood where indicated and gastric suction is extremely important in determining the ultimate result in a child acutely ill with ruptured appendicitis. Whatever delay is required to carry out these procedures and to reduce the temperature below 101° F. (38.3° C.) is not only worthwhile but seems to be essential to consistently successful results.

SUMMARY

In summary, there were 358 children under age 13 treated for acute appendicitis at the Vanderbilt University Hospital during the years 1936–1955. The over-all mortality was 3.9 per cent. For the five year period ending with 1955, the mortality rate had decreased to 1.0 per cent.

For the five year period ending in 1940 the mortality for ruptured appendicitis was 20 per cent, whereas for the five year period ending in 1955 it was 2.8 per cent. The incidence of ruptured appendicitis did not decrease in proportion to the improved mortality rates. The mortality for unruptured appendicitis throughout the entire period of the study was 0 per cent.

Perforation of the acute appendix is related to the duration of the disease and not to the age of the patient per se. Duration of symptoms prior to operation was twice as great in children under four years of age as thereafter. Once perforation of the appendix has occurred, the infants developed generalized peritonitis twice as often as the older children.

Antibiotic administration was associated with a decrease in the postoperative morbidity and mortality in children with ruptured appendicitis but not in those children with unruptured appendicitis.

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