ACUTE APPENDICITIS IN CHILDREN*

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THE PURPOSE OF THIS PAPER is to evaluate the role of chemotherapeutic drugs and antibiotic agents in the surgical treatment of acute appendicitis in children. The study is based upon 777 consecutive cases of acute appendicitis in children 14 years of age and under. The youngest child in this series was 18 months of age.

The diagnosis and treatment of appendicitis has been on a sound and established basis since 1886, when Reginald Fitz[4] published his epochal paper "Perforating Ulcer of the Vermiform Appendix With Special Reference to Diagnosis and Treatment." Appendicitis is the most common lesion of the abdomen requiring surgical intervention in childhood. Many writers on this subject believe that appendicitis in children is quite different from appendicitis in adults. With this contention, I must disagree. The chain of pathologic events in children is essentially the same as that in adults. The progress of the disease is often more rapid in children than in adults and there is less chance of localization in children. As the disease develops, the symptoms and signs are similar in children and in adults. The difference between children and adults does not lie in a difference of pathology, signs and symptoms, but in the greater difficulties of making a diagnosis in children.

All writers agree that the mortality from appendicitis has decreased in the past two decades. An article in a Statistical Bulletin of the Metropolitan Life Insurance Company[5] entitled "Appendicitis Mortality Near Vanishing Point" states: "The mortality from appendicitis has been cut by more than one half in the past five years and by almost three-fourths in the past decade, among the industrial policyholders of the Metropolitan Life Insurance Company. The age-adjusted death rate in 1946 was 3.2 per 100,000, as compared with a rate of 7.1 in 1941. The improvement in mortality has extended to the entire range of ages in each sex. Marked advances in the medical care and the surgical treatment of patients have also played a large part in reducing the death toll from appendicitis. In very recent years, chemotherapy has probably been the outstanding factor in further reducing the mortality from the disease. There appears to be no evidence that the incidence of appendicitis is decreasing; in fact, the figures available seem to point the other way."

The Commission on Acute Appendicitis Mortality of the Medical Society of the State of Pennsylvania[2] has reported on the continuing decrease in mortality from 1937 till the present time. In 1937 the mortality reported was 3.39 per cent, and in 1947 it was .076 per cent.

Following the introduction of the chemotherapeutic drugs, numerous reports appeared in the literature discussing their use in appendicitis. Most of these reports advocated their use and stated that they had decreased the mortality in appendiceal peritonitis. Ravdin, Rhoads and Lock-

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wood[10] in 1940, reported: "The mortality in a series of 809 consecutive cases of acute appendicitis has been reduced from 1.5 per cent in the first 552 cases to 0.4 per cent in the last 257 cases. The improvement is, we believe, the result of the employment of sulfanilamide in all severe cases in the latter group. No other known factor was changed." Penberthy, Benson and Weller,[9] in 1942, stated: "Chemotherapy has proved of definite benefit in the treatment of appendicitis in infants and children." W. J. Norris,[7] in 1946, stated: "the introduction of sulfa drugs has done more than any other single factor to reduce the mortality rate."

Likewise, following the introduction of penicillin and later the other antibiotic agents, articles appeared in the literature reporting lowered mortality in appendiceal peritonitis. Ochsner and Johnston[8] in 1945 reported 50 cases of spreading peritonitis treated with penicillin in which there was but one death. All masses resolved. In no case was it necessary to drain an intra-abdominal abscess and there was no spontaneous drainage into the bowel. Abel and Allen[1] likewise feel penicillin is a valuable adjunct in the treatment of appendicitis in children.

In 1940, we instituted the routine use of sulfanilamide in the treatment of appendiceal peritonitis. Since 1945, we have been using penicillin and the other antibiotics in all appendiceal peritonitis cases. We were anxious to determine as accurately as possible what part the chemotherapeutic drugs and antibiotic agents played in the reduction of mortality in appendicitis in infants and children. Therefore, we reviewed all the cases of acute appendicitis at the Children's Hospital of the Mary J. Drexel Home from 1930 to August 20, 1951, a total of 777 consecutive cases (Table I). There was no mortality in the non-perforated group. The mortality for the entire series was 1.8 per cent. The mortality among patients in whom the appendix had perforated is also shown in Table I. The perforated cases were divided into only two classifications, (a) perforated with peritonitis and (b) perforated with localized abscess. Tables II and III show the same statistics for patients five years and under, and three years and under, respectively. It may be significant that the mortality rate in the patients three years and under is twice that of the group of patients five years and under.

The cases have been divided into four groups, namely:

Group I	1930 – 1932
Group II	1932 – 1936
Group III	1937 – 1944
Group IV	1945 – 1950

The mortality in perforated cases, according to these groups, is shown in Table IV. Each group contains roughly the same number of cases. Group I represents an era in which fluid electrolyte therapy was not well understood. Group II represents an era in which (a) parenteral fluid administration was more frequently used and carefully controlled. (b) Intestinal decompression was used routinely in all peritonitis cases. (c) There was a marked increase in the use of the McBurney incision. Group III represents an era in which the chemotherapeutic drugs, especially sulfanilamide, were used, both locally in the abdomen and by hyperdermoclysis. Group IV represents the antibiotic era. All peritonitis cases received penicillin, streptomycin and various

TABLE I.—*Acute Appendicitis in Children, Mary J. Drexel Hospital, 1930 to August 20, 1951.*

	Cases	Deaths	Mortality
Non-perforated, 599 (77.1%)	599	0	0
Perforated, 178 (22.9%)	...	14	8.0 %
Perforations with abscess	48	1	2.08
Perforations with peritonitis	126	13	10.32
Perforations on removal	4	0	0
Total	777	14	1.8 %

Eleven of the patients who died were operated upon and three were non-operative deaths.

combinations of other antibiotic agents. Table V shows the same division into groups with mortality in patients five years and under. The reduction in mortality shows the same trend in both the entire group and the group of patients five years and under.

TABLE II.—*Acute Appendicitis in Children, Mary J. Drexel Hospital, 1930 to August 20, 1951.*

	Patients Five Years and Under		
	Cases	Deaths	Mortality
Non-perforated, 30 (37.04%)	30	0	0
Perforated, 51 (62.96%)	..	10	19.6 %
Perforations with abscess	13	0	0
Perforations with peritonitis	38	10	26.31
Total	81	10	12.34%

Seven of the patients who died were operated upon and three were non-operative deaths.

In our series the most striking improvement in mortality occurred in Group II. (Fig. 1.)

DIAGNOSIS

As stated previously, I believe the symptoms and signs of appendicitis in children are essentially the same as in adults, the main difference being a greater difficulty in making the diagnosis in children. A general rule applicable for diagnosis: abdominal pain, vomiting and slight fever should always be considered as due to acute appendicitis unless proved otherwise. I have never been able to differentiate with any accuracy between acute appendicitis and mesenteric adenitis. Rectal examination deserves special mention. Since the pelvis of a child is smaller than in an adult, the area covered by rectal examination is correspondingly greater. Frequently, such an examination will provide the diagnosis in an otherwise obscure clinical picture. I agree with a statement by Morton and Kilby[6]: "A laparotomy is mandatory if, after 24 hours' observation of a child with abdominal pain, there is any reasonable doubt in the mind of the clinician that one of these systemic diseases rather than acute appendicitis is the cause."

TREATMENT

Once the diagnosis of acute appendicitis has been made, early operation is the procedure of choice. In cases of acute appendicitis and acute appendicitis with peritonitis, operation is delayed no longer than necessary to restore hydration and electrolyte balance. Delayed operation for appendiceal peritonitis was practiced in only a few cases in this series. These cases were in the early groups, that is, before 1940. We feel that delayed operation in appendiceal peritonitis in children is definitely contraindicated. The appendix should always be removed. The only cases in which this rule is not followed is in the localized abscess group. Merely to drain in cases of appendiceal peritonitis is not logical, for what will prevent the continued pouring out of septic material from the diseased organ into the free peritoneal cavity? There is only one case in this series in which the appendix was not removed in the presence of peritonitis; this patient died, as is usually the case (Table VI).

TABLE III.—*Acute Appendicitis in Children, Mary J. Drexel Hospital, 1930 to August 20, 1951.*

	Patients Three Years and Under		
	Cases	Deaths	Mortality
Non-perforated, 8 (28.53%)	8	0	0
Perforated, 20 (71.47%)	..	7	35. %
Perforations with abscess	4	0	0
Perforations with peritonitis	16	7	43.75
Total	28	7	25. %

Five of the patients who died were operated upon and two were non-operative deaths.

In the localized abscess group there is no urgency. When the abscess is palpable and the mass is lateral, the extraperitoneal approach is ideal. When the mass is not lateral, the extraperitoneal approach is not feasible, and then the incision is made over the presenting mass. The appendix should not be removed unless it is accessible, and

TABLE IV.—*Acute Appendicitis in Children, Mary J. Drexel Hospital, 1930 to August 20, 1951. Mortality in Perforated Cases.*

Period	Entire Series		
	No. of Cases	Deaths	Mortality (Per cent)
1930–1932	43	7	16.3
1933–1936	46	3 (1–not op.)	6.5
1937–1944	53	2 (1–not op.)	3.78
1945–1951	36	2 (1–not op.)	5.5

appendectomy can be accomplished without danger of contaminating uninvolved peritoneum. There was one death in the abscess group. In this case the appendix was removed with considerable difficulty, which we feel was an error in operative judgment, for following the operation the child developed a generalized peritonitis and died.

TABLE V.—*Acute Appendicitis in Children Mortality in Perforated Cases, 1930 to August 20, 1951.*

Period	Patients Five Years and Under		
	No. of Cases	Deaths	Mortality (Per cent)
1930–1932	6	3	50
1933–1936	17	3	17.6
1937–1944	19	2 (1–not op.)	10.53
1945–1951	10	2 (1–not op.)	20

INCISION

Figure 2 shows the relative frequency of McBurney over right rectus incisions from year to year. There are four distinct advantages of the McBurney incision over the right rectus incision. It permits easy, direct access to the site of the disease, minimizing any soiling of uninvolved peritoneum. Drains, when necessary, can be placed laterally. A McBurney incision can be closed loosely without risk of postoperative hernia, and such closure is very important when peritonitis is present. In the drainage cases, when the McBurney incision is employed, only the peritoneum need be sutured. Postoperative wound complications, such as infection or cellulitis of the abdominal wall, are rarely seen. Lastly, when a secondary operation for obstruction is necessary, it can be easily performed by the right rectus route through uncontaminated structures if the primary operation was performed by the McBurney approach. For these reasons the McBurney incision is now used almost exclusively.

DRAINAGE

Drainage is used only when gross septic or fecal soiling is present, or when considerable exudate exists on the cecum, terminal ileum, or parietal peritoneum. The presence of fluid, even cloudy fluid, is no indication for drainage. In recent years we have used drainage less frequently. Many of the patients with early peritonitis are not drained. In these cases, after closing the peritoneum, the rest of the abdominal wall is either left open or is closed loosely. The latter method has been used most since the use of antibiotics pre- and postoperatively. Postoperatively, in addition to the usual supportive measures such as intravenous fluids, oxygen and duodenal suction are employed as indicated.

ANESTHESIA

The advances in anesthesia in the past 15 years, we feel, have contributed to a decreased morbidity attending major and minor surgical procedures upon infants and children.

TABLE VI.—*Acute Appendicitis in Children, Mary J. Drexel Hospital, 1930 to August 20, 1951. Removal of Appendix*

	Appendix Removed	Appendix Not Removed	Death
Appendiceal Peritonitis	125	1	1
Appendiceal Abscess	42	6	1

Among the changes in technics and general supportive methods can be listed:

1. The constant presence of intravenous infusions in the major cases. This not only allows immediate replacement of fluids lost, but provides quick access to the circulation

for emergency medication and blood transfusions.

2. The recognition of the role of hyperthermia and increased arterial CO_2 tension in providing a background for so-called

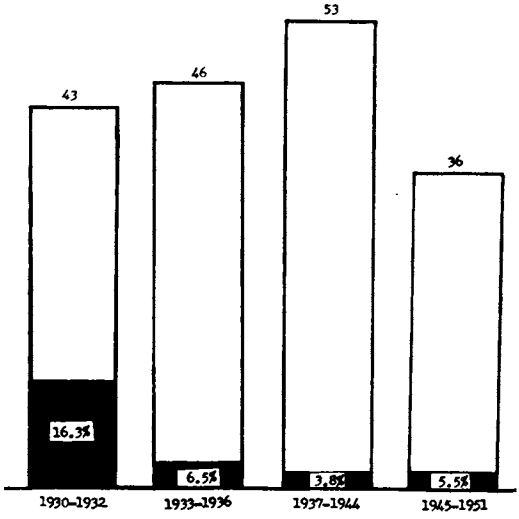

FIG. 1.—Mortality in patients with appendiceal perforation.

anesthetic convulsions. Fluid therapy plus rapidly acting intravenous barbiturate medication serve as aids in overcoming such occurrences.

TABLE VII.—*Causes of Death.*

	No. of Cases
Peritonitis	6
Peritonitis (non-operative)	3
Secondary abscess followed by peritonitis	1
Intestinal obstruction	2
Intestinal obstruction and peritonitis	1
Pneumonia	1
Total	14

3. The use of cyclopropane (including endotracheal intubation) has found wide acceptance in pediatric anesthesia. However, open drop ether still retains a foremost place.

4. Spinal anesthesia, even in infants, has become an accepted procedure, particularly in toxic cases.

5. The use of curare to give excellent relaxation with a light plane of anesthesia has diminished the length of the post-anesthetic recovery period and its attendant pulmonary complications.

DISCUSSION OF DEATHS

There were 14 deaths, three were non-operative (Table VII). As one would expect, peritonitis was the principal cause of death, both operative and non-operative. Three deaths were due to postoperative intestinal obstruction. The obstruction in all these cases was secondary to peritonitis. There was one death from pneumonia. The deaths from obstruction and pneumonia occurred in Groups I and II, that is, before 1940. I would like to discuss further, in detail, the deaths that were theoretically avoidable.

Case 1.—In this case the appendix was not removed in the presence of perforation and peritonitis.

Case 2.—This was an appendiceal abscess and the appendix was removed with difficulty. The child died with peritonitis. We feel that this was an error in judgment. Removal of the appendix should not have been attempted in this case.

Case 3.—This was a case where a Meckel's diverticulum which was not diseased was removed in the presence of appendiceal infection. We list this as an error in judgment.

Case 4.—This was a perforated appendix with peritonitis, in 1947. The child patient was extremely ill and distended on admission; temperature 103°. He was operated upon 3 hours after admission. Preoperatively, he did not receive fluids. Intestinal decompression was not instituted, and antibiotics were not given. We feel that operation should have been delayed until proper fluid electrolyte therapy and intestinal decompression had been instituted.

Case 5.—H. J., age 2 years 7 months, was admitted to the hospital with a temperature of 104°, and was treated on the Medical Service for bronchitis and gastro-enteritis. Four days after admission, a surgical consultation was requested, and at this time a mass was felt in the right lower quadrant and a diagnosis of perforated appendix

was made. It was felt that the child was localizing his infection. At this time the child was in a state of alkalosis. In spite of chemotherapeutic measures, plus intravenous fluids, etc., the general condition did not improve and the child died on the twelfth hospital day. Following necropsy examination the cause of death was listed as a ruptured appendix with appendiceal abscess and generalized peritonitis. It is possible that this child, when seen by the surgeons nine days prior to death, had a localized abscess which later perforated. We believe this case might have been saved if incision and drainage of the abscess had been performed when first seen by the surgeon.

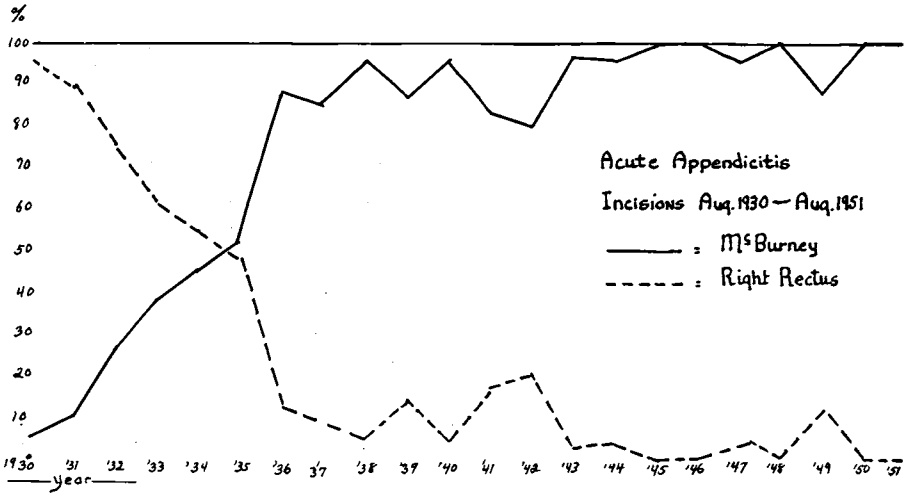

FIG. 2

We feel the following factors were responsible for the reduction in mortality in our series, in order of their importance:

1. Carefully controlled pre- and postoperative fluid electrolyte administration.
2. Increasing use of the McBurney incision.
3. Routine use of gastro-duodenal suction in all peritonitis cases both pre- and postoperatively.

From this study, although not statistically proved, it is felt that certain factors definitely decreased our morbidity. They are:

1. Improvement in anesthesia.
2. Antibiotics. These decreased wound infection, allowed decreasing use of drainage and permitted tighter closure of wounds and reduced respiratory complications.
3. Oxygen therapy postoperatively. This controlled distention and lessened respiratory complications.

Before stating our final conclusions, I would like to turn back some 45 years and report the cases of acute appendicitis in the same Children's Hospital in the year 1904. I quote from a Treatise on Appendicitis, 1905, by the late Dr. John B. Deaver[3]: "In the year ending December 1, 1904, 77 cases of appendicitis were treated in the Children's Hospital of the Mary J. Drexel Home. Of these, two were moribund, and died without operation. Of the 75 patients operated upon, not one died. Among these there were 64 acute, and 11 of chronic appendicitis. In 36 of these acute cases the

TABLE VIII.—*Acute Appendicitis in Children, Mary J. Drexel Hospital, January 1, 1904 to December 1, 1904.*

	Cases	Deaths	Mortality
Non-perforated, 26 (40.63%)	26	0	0
Perforated, 38 (59.37%)	..	2	5.27%
Perforations with abscess	2	..	.....
Perforations with peritonitis	36	..	.....
Total	64	2	3.13%

The two patients who died were non-operative deaths.

abscess had either burst before operation, or no abscess had ever existed, the appendix perforating into the general peritoneal cavity. In two cases the abscess was still circumscribed, and was drained extra-peritoneally without removal of the appendix. In the remaining acute cases the disease was confined to the appendix, with serous peritonitis in three cases." (Table VIII). This would make the mortality of the 64 acute cases 3.13 per cent. In this series, fluid therapy was administered by hyperdermoclysis and proctoclysis. Abdominal distention was treated by frequent gastric lavage, administered by the old fashioned stomach pump. We can be sure that in this series neither chemotherapeutic nor antibiotic agents played a part in this low mortality.

COMMENT AND CONCLUSION

The primary reason for studying our cases of acute appendicitis in children over a 20-year period was to evaluate the role that chemotherapy and antibiotics played in the treatment of acute appendicitis. From the analysis of 777 consecutive cases of acute appendicitis from 1930 to 1951, the following opinion has been reached:

1. In this series there is no evidence that the mortality was lowered by the use of chemotherapeutic or antibiotic agents.

2. Though we are unable to substantiate it by any statistical analysis, we feel that the use of chemotherapeutic and antibiotic agents did bring about a lowered morbidity.

BIBLIOGRAPHY

[1] Abel, Wm. G., and P. D. Allen: Acute Appendicitis in Children. Ann. Surg., **132:** 1093, 1950.

[2] Bower, J. O.: Commission on Acute Appendicitis Mortality of the Med. Soc. of State of Pa. Personal Communication, 1951.

[3] Deaver, John B.: Appendicitis. Third Ed., p. 243. The Blakiston Co., 1905, Philadelphia.

[4] Fitz, Reginald: Perforating Ulcer of the Vermiform Appendix With Special Reference to Diagnosis and Treatment. Am. J. Med. Sci., **92:** 321, 1886.

[5] Metropolitan Life Ins. Co. Statistical Bull.: Recent Decline in Appendicitis Mortality. **28:** 7, 1947; **27:** 9, 1946.

[6] Morton, T. V., Jr., and R. A. Kilby: Appendicitis in Children. Am. J. Surg., **80:** 5, 1950.

[7] Norris, W. J.: Appendicitis in Children. West. J. of Surg., Gynec. & Obst., **54:** 183, 1946.

[8] Ochsner, A., and J. H. Johnston: Peritonitis. Surgery, **17:** 873, 1945.

[9] Penberthy, G. C., C. D. Benson and C. N. Weller: Appendicitis in Infants and Children: A Fifteen Year Study. Ann. Surg., **115:** 945, 1942.

[10] Ravdin, I. S., J. E. Rhoads and J. S. Lockwood: The Use of Sulfanilamide in Treatment of Peritonitis Associated with Appendicitis. Ann. Surg., **111:** 53, 1940.