Management of Perforated Appendicitis in Children

The Controversy Continues

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A specific treatment plan for management of perforated appendix in children, initiated at the Children's Hospital in Boston, and later utilized at the Child Health Center in Galveston, has been applied to 143 patients by many surgical housestaff and faculty. The protocol consists of appendectomy, routine use of systemic gentamicin, ampicillin and clindamycin, antibiotic peritoneal irrigation, and transperitoneal drainage through the incision. The average age of the children in this series was 9.1 years (range 14 months to 21 years). The average length of hospitalization was 12.1 days. The use of this protocol resulted in only 11 patients (7.7%) developing significant complications. Complications related to infection occurred in only six of the eleven patients (4.2%). There were no deaths. This protocol of intensive primary therapy can significantly decrease the sequelae from perforated appendicitis in children.

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ALTHOUGH medical advances have been significant over the past several decades, none has greatly reduced the incidence of appendiceal perforation. Recent studies have reported that perforation occurs in 30 to 45% of cases of appendicitis,[1-3] and in fact, some investigators have stated that the incidence of perforation has increased over the past ten to twenty years.[1,3] In a study of children with perforated appendix, Savrin and Clatworthy found that perforation had occurred in 55% before medical evaluation was sought, and the remaining 45% had been seen by a physician who failed to diagnose appendicitis.[1] They suggested that a decrease in the incidence of perforated appendix will depend on an increase in parental awareness of the risk of delay in seeking medical attention for persistent abdominal pain and upon more astute diagnosis by primary physicians.

The management of perforated appendix remains a matter of controversy. This report describes the authors' protocol for the management of perforated appendix in children, explains the rationale for each aspect of the protocol, and discusses the results that were achieved.

Methods and Patient Population

In 1976, a specific treatment plan for the management of perforated appendix was instituted at the Children's Hospital Medical Center in Boston (Table 1). When a child is admitted to the hospital with a tentative diagnosis of a perforated appendix, the protocol calls for fluid resuscitation, control of hyperthermia, initiation of antibiotics, and surgical exploration. The right lower quadrant is explored through a transverse skin incision, followed by splitting of the muscle layers. An appendectomy is done in all cases. If perforation is not suspected before operation, but is discovered intraoperatively, administration of parenteral antibiotics is begun in the operating room. The antibiotics that are used are gentamicin (5 mg/kg/24 h), ampicillin (100 mg/kg/24 h), and clindamycin (40 mg/kg/24 h).

After the appendix is removed, limited debridement of the area surrounding the perforation is done to remove the loose fibrin and debris. The entire peritoneal cavity is then irrigated copiously with saline solution containing cephalothin (4 g/l). Irrigation is continued until the effluent is clear (usually after 1000–1500 ml of fluid is used). An attempt is made to aspirate as much of the irrigation fluid as possible before the wound is closed. One Penrose drain is placed in the pelvis, and another is placed along the right pericolic space. The drains exit through the lateral margin of the wound. The muscle layers, Scarpa's fascia, and skin are closed around the drains with absorbable suture.

Parenteral antibiotics are continued for a least nine days, regardless of the patient's clinical course. The

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TABLE 1. *Protocol for Management of Perforated Appendix in Children*

1. Administer fluids, control hyperthermia, and administer antibiotics (gentamicin 5 mg/kg/24 h, ampicillin 100 mg/kg/24 h, clindamycin 40 mg/kg/24 h) on admission.
2. Explore peritoneal cavity via right lower quadrant incision.
3. Perform appendectomy in all cases.
4. Perform limited peritoneal debridement.
5. Irrigate peritoneal cavity with cephalothin solution (4 g/l).
6. Place penrose drains in pelvis and right pericolic space, which exit through the lateral margin of the wound.
7. Close the muscle layers, Scarpa's fascia, and skin around the drains with absorbable suture.
8. Encourage postoperative activity and position at will.
9. Continue parenteral antibiotics for nine days.
10. Remove transperitoneal drains from the 7th to the 9th postoperative days.
11. Discharge patient generally on 10th postoperative day.

drains are advanced on the seventh and eighth postoperative days and are removed on the ninth postoperative day. No attempt is made to keep the patient in a specific position after the operation. To prevent pooling of intraperitoneal secretions in the pelvis, the authors prefer not to keep the patient in a semiupright (Fowler's) position. If the patient remains afebrile for 24 hours after the antibiotics are discontinued, the patient is discharged (usually on the tenth postoperative day).

From July 1976 to June 1979, 487 patients underwent emergency appendectomy at the Children's Hospital Medical Center in Boston. Of the 125 patients who had a perforated appendix (27%), 104 patients were managed according to this protocol. In January 1979 this protocol was initiated by one of the authors (MZS) at the Child Health Center, The University of Texas Medical Branch, Galveston, Texas. From January 1979 to June 1982, 39 patients with perforated appendix were treated.

The surgical procedures, and the adherence to this protocol, were carried out by many different surgical residents and faculty members during the six-year period. All patients in this series were determined to have a perforated appendix, with peritoneal contamination by both intraoperative observation and histologic examination. The protocol was applied to all patients with perforated appendix regardless of whether the intraperitoneal contamination was contained in an abscess cavity or was diffuse. Many patients with gangrenous but nonperforated appendices were also treated according to this protocol, but they are not included in this series. The average age among the patients in this series was 9.1 years (range, 14 months to 21 years); 56 of the patients were girls, and 87 were boys. The average length of hospitalization was 12.1 days (range, 9.5 to 42 days). Antibiotic therapy was given for an average of 9.8 days.

TABLE 2. *Postoperative Complications in 143 Patients After Perforated Appendix*

Complication	Number of Patients	Frequency of Occurrence (%)
Pneumonia	1	0.7
Upper GI bleeding	1	0.7
Small bowel obstruction	1	0.7
Ascites	1	0.7
Wound infection	2	1.4
Pelvic phlegmon	4	2.8
Persistent fever (reoperation-no infection found)	1	0.7
Pelvic abscess	0	0
Subphrenic abscess	0	0
Other intra-abdominal abscesses	0	0
Death	0	0
Total	11	7.7

Results

A total of 143 patients have been treated according to this protocol, and none have died. Eleven patients had significant complications yielding an overall complication rate of 7.7% (Table 2). Six of the 11 patients (4.2%) had complications that can be attributed to infection. In this group were four patients with pelvic phlegmons who were treated successfully with antibiotics. There were no intraperitoneal abscesses. No wound infections were observed during the hospitalization, although two patients developed wound infections after discharge necessitating drainage in the outpatient clinic.

One 3-year-old patient required blood transfusions three days after the appendectomy because of an upper gastrointestinal tract hemorrhage; fortunately, the bleeding stopped spontaneously. One patient developed symptoms of a small bowel obstruction and was readmitted three days after discharge. The obstruction resolved after two days of nasogastric decompression and has not recurred in the following 28 months.

An 8-year-old boy who had fever, hypotension, and a tense abdomen on admission developed significant serous ascites after the appendectomy. He recovered completely after a lengthy hospitalization (36 days). One patient developed pneumonia and was treated successfully with antibiotics and respiratory therapy. The only reoperation in this entire patient series was done on a 7-year-old girl with juvenile rheumatoid arthritis. In this case, the diagnosis of perforated appendix was made after some delay. The patient underwent appendectomy and treatment according to the protocol. Because her fever persisted for 18 days after the operation, an intraperitoneal abscess was suspected. She underwent exploratory surgery but no infection was found.

The effectiveness of this protocol is indicated by the decreased morbidity when compared with other series (Table 3).

TABLE 3. *Results from Several Series of Pediatric Patients Following Appendectomy for Perforated Appendix*

Author	Number of Patients	Average Age (years)	Peritoneal Drains	Peritoneal Irrigation	Complications			Deaths
					Wound Infection	Intra-abdominal Abscess	Other	
Graham[21]	28	(0–5)†	Yes	Yes	35% (1)	4%	25%	0%
	69	(0–5)†	No	Yes				
Haller[22]	24	7.5	Yes	No	(2)	13%	4%	8%
	19	8.4	No	No	(2)	16%	5%	0%
Janik[26]	525	10	Yes	No	(3)	21%	?	0.2%
	48		No	No	(3)	15%	?	6%
Marchildon[3]	89	7.5	Yes	21%	8%	3%	6%	0%
Othersen[20]	60	8.4	Yes	Yes	(4)	(4)	?	21%
	25		No	?	(4)	(4)	?	4%
Stone[2]	359	10.2	No	No	26%	9%	?	0%
Bower[9]	20	11	Yes	Yes	8%	2%	11%	1%
	77		No	Yes				
Schwartz*	143	9	Yes	Yes	1.4%	0%	6.3%	0%

? Not reported in publication.
† Indicates age range.
* Present study.
(1) Twenty infections occurred in 58 patients who had wound closure.
(2) No infections, but all patients had subcutaneous drains.
(3) Thirty-two per cent infection with primary closure and 7% with delayed closure.
(4) Wound and intra-abdominal infection rate 22% in drained and 52% in undrained patients.

Discussion

Fifty years ago, the mortality rate for patients with perforated appendix was 10 to 20%.[4,5] The risk of death from a perforated appendix has now decreased dramatically, but the morbidity rate remains high. Much controversy exists about the optimum way to reduce this morbidity. The areas of controversy include when to operate, whether to remove the appendix during the first operation, whether to use intraperitoneal or wound drainage or both, whether systemic antibiotics should be used, whether wound closure should be delayed, and whether the patient should be kept in a specific position after surgery. A great number of protocols have been promoted in the literature, and they may represent only a fraction of the routines that are in use.

The protocol described in this report was designed to diminish the incidence of wound and intra-abdominal infections. Several aspects of the protocol, however, are controversial and their merit can be challenged. For example, an appendectomy is performed in all cases to eliminate the source of intraperitoneal contamination and the possibility of "recurrent" appendicitis. Other authors have chosen a different approach. Powers et al.[6] demonstrated that in some patients with perforated appendix, intravenous fluids and antibiotics eliminated the need for immediate surgical intervention, although an "elective" appendectomy had to be performed four to six weeks later. In their series, however, 16 of the 48 patients (25%) required early surgery because of persistent or worsening symptoms. Moreover, the 32 patients that were discharged after receiving antibiotic therapy only were requested to be seen weekly as outpatients, until they were readmitted for appendectomy. In the authors' opinion, such weekly visits to the physician placed too great a burden on the patient and the family.

Many authors have suggested that patients who have a well defined mass in the right lower quadrant should have only abscess drainage initially with abdominal exploration and appendectomy deferred until a later time. This approach to treatment assumes that the examining surgeon can differentiate before operation between a phlegmon and an abscess. In a retrospective study, Jordan et al.[7] identified 45 patients who had an appendiceal mass out of 806 patients who were treated for appendicitis. Of the patients with an abdominal mass, 45% were found to have a phlegmon at surgery, 26% had less than 50 ml of pus in an abscess cavity, and only 28% had an abscess cavity that contained more than 50 ml of pus. The evidence from this study indicated that only about one or two in four patients would be a candidate for drainage as described, and of course, all would have to be readmitted later for an interval appendectomy.

One of the least controversial issues in the management of perforated appendix involves the use of parenteral antibiotics. Although the specific antibiotic to use may be debated, most authors agree that broad-spectrum antibiotics for gram-negative and anaerobic organisms are beneficial. Shandling et al. reported a high complication rate (46%) among their pediatric patients

with perforated appendix who did not receive antibiotics.[8] In a group of patients who were treated at Grady Memorial Hospital in Atlanta, Stone et al. decreased the rate of intra-abdominal abscess from 20.9% to 8.7% by using parenteral antibiotics.[2]

Recently, most authors have recommended that gentamicin and clindamycin be used.[7,9] In addition to clinical evidence that supports the use of these parenteral antibiotics, data from experimental studies indicate that broad-spectrum antibiotics are effective in cases of feces-induced peritonitis.[10,11] The authors chose to add ampicillin to the gentamicin and clindamycin regimen because ampicillin is effective against nonhospital-acquired *Escherichia coli*, and high concentrations of the drug in the blood will produce little toxicity. Ampicillin is used also because Enterococcus is often cultured at the time of exploration of the peritoneal cavity[9,12] and this organism is sensitive to ampicillin but resistant to gentamicin. Perhaps the new tertiary cephalosporins (such as moxalactam) may eliminate the need for multidrug therapy in cases of perforated appendix.

Many surgeons are opposed to peritoneal irrigation in any form because of fear of spreading the bacterial inoculum. It has been well documented, however, that the fluid within the peritoneal cavity has an established circulation.[13] Thus, fluid with bacterial contamination that is present in the right lower quadrant will reach the subdiaphragmatic space in minutes anyway. A greater benefit may be derived, therefore, from reducing the bacterial inoculum that is already circulating throughout the peritoneal cavity. Saline irrigation alone might be effective, but the available evidence does not support this hypothesis.[14,15] On the other hand, several studies have found that antibiotic irrigation helps to decrease the incidence of intra-abdominal abscesses.[14,16-18] A cephalothin irrigation was used because cephalothin is effective against *E. coli* and many other gram-negative rods. The cavity is irrigated until the effluent is clear, then the irrigant is aspirated as completely as possible. Cephalothin has not been found to cause significant toxicity in the peritoneal cavity.[17,18] Aminoglycoside antibiotics are not used for irrigation (for example, neomycin or kanamycin) because of the risk of respiratory complications, caused by neuromuscular blockade, and the risk of renal and auditory toxicity.

One of the most controversial issues in the management of perforated appendix is the use of transperitoneal drains. Some authors have advocated that transperitoneal drains be used in the management of all patients with perforated appendix.[3,20,21] Othersen stated that drains that are brought through the wound will also provide drainage for all layers of the abdominal wound.[20] Marchildon and Dudgeon reported that only three of 83 patients with perforated appendix (3.6%) developed an intra-abdominal or pelvic abscess when intraperitoneal drains were used.[3]

On the other hand, at least two studies have suggested that transperitoneal drainage is not beneficial. Haller et al.[22] did a prospective study of 43 patients to evaluate the use of transperitoneal drainage. The patients who did not have transperitoneal drainage had a 15.8% incidence of intra-abdominal abscess, and the patients who had transperitoneal drainage had a 12.5% incidence of intra-abdominal abscess. In a randomized study by Greenall et al.,[23] 103 patients were treated with or without drainage after appendectomy for perforated appendix. In the nondrainage group, 12 of 55 patients (21.8%), and in the drainage group, seven of 48 patients (14.6%) developed an intra-abdominal abscess. These authors concluded that transperitoneal drainage was of little benefit. It should be noted that in these two studies, the incidence of intra-abdominal infection was high in comparison with that in other series.[3,9]

As reported by Stone et al.[2] and Greenall et al.,[23] at least 80% of intraperitoneal abscesses that develop after the removal of a perforated appendix are in the right lower quadrant or pelvis. The transperitoneal drainage in this series may have helped to prevent abscesses in the right lower quadrant or pelvis, especially in patients who were not maintained in the semiupright (Fowler's) position. Before parenteral antibiotics were available, the maintenance of patients in Fowler's position after appendectomy was an important and beneficial concept.[24,25] However, if adequate levels of antibiotics are maintained in the blood, reducing the intraperitoneal inoculum rapidly may be of greater benefit. Fowler's position retards this clearing process by encouraging debris and bacteria to "puddle," and thus it may contribute to the development of a pelvic abscess.

Many aspects of this protocol are controversial, but the authors have achieved encouraging results even when many residents and faculty surgeons participated. The overall complication rate was 7.7% and the percentage of complications that involved infections was only 4.2%. It is believed that this protocol of intensive primary therapy can significantly decrease the common adverse sequelae from perforated appendix in children.

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