

Open appendectomy for pediatric ruptured appendicitis: a historical clinical review of the prophylaxis of wound infection and postoperative intra-abdominal abscess

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Background: We conducted a 3-decade clinical review of prophylaxis for wound infection and postoperative intra-abdominal abscess after open appendectomy for pediatric ruptured appendicitis.

Methods: We reviewed the charts of patients with ruptured appendicitis who underwent open appendectomy performed by the same pediatric surgeon at the Hospital for Sick Children, Toronto, Canada between 1969 and 2003, inclusive. We evaluated 3 types of prophylaxis: subcutaneous (SC) antibiotic powder, peritoneal wound drain and intravenous (IV) antibiotics. We divided the sample into 4 treatment groups: peritoneal wound drain alone (group 1); peritoneal wound drain, SC antibiotic powder and IV antibiotics (group 2); SC antibiotic powder and IV antibiotics (group 3); and IV antibiotics alone (group 4). We used the χ^2 test with Bonferroni correction for multiple comparisons.

Results: There were 496 patients: 348 (70%) boys and 148 (30%) girls, with a mean age of 7 (range newborn to 17) years. There were 90 (18%) wound infections. Compared with the current standard of practice, IV antibiotics alone (group 4), peritoneal wound drain (group 1) was associated with the lowest number of wound infections (7 [7%], $p = 0.023$). There were 43 (9%) postoperative intra-abdominal abscesses. Compared with IV antibiotics alone, SC antibiotic powder with IV antibiotics (group 3) was associated with the lowest number of postoperative intra-abdominal abscesses (14 [6%], $p = 0.06$).

Conclusion: Over a 35-year period of open appendectomy for pediatric ruptured appendicitis, wound infection was least frequent in patients who received prophylactic peritoneal wound drain, and postoperative intra-abdominal abscess was least frequent in those who received prophylactic SC antibiotic powder and IV antibiotics.

Contexte : Nous avons procédé à une revue clinique sur 3 décennies de la prophylaxie des infections de plaies et des abcès intra-abdominaux consécutifs à l'appendicectomie ouverte pour rupture de l'appendice en pédiatrie.

Méthodes : Nous avons passé en revue les dossiers de patients admis pour rupture de l'appendice qui ont subi une appendicectomie ouverte exécutée par le même pédochirurgien à l'Hôpital pour enfants malades (SickKids) de Toronto, au Canada, de 1969 à 2003 inclusivement. Nous avons évalué 3 types de prophylaxie : poudre antibiotique sous-cutanée (s.-c.), drain péritonéal de la plaie et antibiothérapie intraveineuse (i.v.). Nous avons divisé l'échantillon en 4 groupes selon les traitements administrés : drain péritonéal seul (groupe 1); drain péritonéal, poudre antibiotique s.-c. et antibiothérapie i.v. (groupe 2); poudre antibiotique s.-c. et antibiothérapie i.v. (groupe 3); antibiothérapie i.v. seule (groupe 4). Nous avons utilisé un test de χ^2 avec correction de Bonferroni pour comparaisons multiples.

Résultats : L'échantillon regroupait 496 patients : 348 garçons (70 %) et 148 filles (30 %) âgés en moyenne de 7 ans (de nourrisson à 17 ans). On a dénombré 90 cas (18 %) d'infection de plaie. Comparativement à la norme actuelle de pratique, soit l'antibiothérapie i.v. seule (groupe 4), le drain péritonéal (groupe 1) a été associé au nombre le plus faible d'infections de plaies (7 [7 %], $p = 0,023$). On a dénombré 43 cas (9 %) d'abcès intra-abdominaux postopératoires. Comparativement à l'antibiothérapie i.v. seule, la poudre antibiotique s.-c. avec antibiothérapie i.v. (groupe 3) a été associée au plus faible nombre d'abcès intra-abdominaux postopératoires (14 [6 %], $p = 0,06$).

Conclusion : Dans les appendicectomies ouvertes pour rupture de l'appendice pratiquées chez des enfants sur une période de 35 ans, l'infection de plaie a été la moins fréquente chez les patients traités par drain péritonéal prophylactique et l'abcès intra-abdominal postopératoire a été le moins fréquent chez ceux qui avaient reçu de la poudre antibiotique s.-c. et une antibiothérapie i.v. prophylactiques.

Wound infection and postoperative intra-abdominal abscess following open appendectomy for ruptured appendicitis in infants and children have been ongoing problems, with much discussion in the literature.¹⁻⁷⁰ This paper is a 3-decade clinical review of open appendectomy for pediatric ruptured appendicitis that addresses these 2 predefined specific adverse events.

METHODS

We retrospectively reviewed the charts of pediatric patients with ruptured appendicitis who had an open appendectomy performed by the same surgeon (S.H.E.) at the Hospital for Sick Children (SickKids), Toronto, Canada, between 1969 and 2003, inclusive. Patients who underwent delayed (interval, secondary) appendectomy for ruptured appendicitis were excluded from this study. We evaluated 3 types of prophylaxis for wound infection and postoperative intra-abdominal abscess: subcutaneous (SC) antibiotic powder, peritoneal wound drain and intravenous (IV) antibiotics. We divided the sample into 4 treatment groups:

- peritoneal wound drain alone (group 1);
- peritoneal wound drain, SC antibiotic powder and IV antibiotics (group 2);
- SC antibiotic powder and IV antibiotics (group 3); and
- IV antibiotics alone (group 4).

This study received SickKids Research Ethics Board approval (1000009774).

Procedure

All operations involved a Rockey–Davis modification of a McBurney incision under general anesthesia.¹ Cautery and chromic catgut sutures were used throughout for hemostasis. The appendiceal stump was cauterized and not inverted.² Gross peritoneal contamination (pus) was removed by suction. Irrigation and intraperitoneal antibiotics were not used. In patients treated between 1969 and 1998, wound closure was with chromic catgut. In those treated between 1999 and 2003, external oblique and Scarpa fascia were closed with polyglactin 910 absorbable suture (Vicryl, Ethicon Inc.). In patients treated between 1969 and 1985, skin closure was done with silk sutures, and in those treated between 1968 and 2003 it was done with staples.

From 1969 to 1975, a peritoneal drain was brought from the pelvis out through the wound. From 1976 to 1980, the peritoneal wound drain above the external oblique fascia was brought out through a skin stab wound below the incision. The peritoneal wound drain was dis-

continued after 1980. Prophylaxis with SC antibiotic powder³ involved placing the powder in the SC space (ampicillin 1976–1981, cefoxitin 1982–2003). If the infant or child was allergic to penicillin, no antibiotic powder was used in the wound. When systemic antibiotics were used, they were all given intravenously: either cefoxitin or triple antibiotics (ampicillin, clindamycin or metronidazole, gentamicin) preoperatively, and triple antibiotics postoperatively for 5–14 days, depending upon the patient's clinical course. If the infant or child was allergic to penicillin, cefoxitin and/or ampicillin were not used. No patient was given oral antibiotics in hospital or after discharge.

The definition of a wound infection was pus draining from between the stitches or staples. A postoperative intra-abdominal abscess was diagnosed based on the presence of fever, abdominal pain and/or gastrointestinal dysfunction and confirmed by radiological evidence of an intra-abdominal fluid collection.⁴

Postoperative care was the same for all patients. Follow-up continued until the patient was back to normal in all respects.

Statistical analysis

We compared the current standard of practice, IV antibiotics alone (group 4) with all other prophylaxis (groups 1–3) using the χ^2 test with Bonferroni correction for multiple comparisons.

RESULTS

Study sample

Our sample included 496 patients: 348 (70%) boys and 148 (30%) girls, with a mean age of 7 (range newborn to 17) years. Each of the 4 groups included 67–254 patients and covered 5–17 years of the study period (Table 1).

Wound infection

There were 90 (18%) wound infections, which occurred between 1 and 2 weeks postoperatively (Tables 1 and 2). No organism was cultured in 80% of these infections; *Escherichia coli* was the most common (12%). Compared with IV antibiotics (group 4), peritoneal wound drain alone (group 1) was associated with the lowest number of wound infections (7 [7%], $p = 0.023$; Table 2).

Of all 175 children who had a peritoneal wound drain (groups 1 and 2), regardless of other specific wound and

peritoneal treatment and/or IV antibiotics, a wound infection developed in 17 (10%; Table 3). By comparison, of the 321 children who had no peritoneal wound drain (groups 3 and 4), regardless of other specific wound treatment and/or IV antibiotics, a wound infection developed in 73 (23%; Table 1).

Postoperative intra-abdominal abscess

There were 43 (9%) postoperative intra-abdominal abscesses, which occurred between 2 and 4 weeks postoperatively (Tables 1 and 2). Most abscesses contained no organism; however, of those that did, *E. coli* was the most common, followed by *Staphylococcus (epidermidis, aureus)*, streptococcus (enteric, nonhemolytic, viridans), bacteroides and *Klebsiella aerogenes*. Compared with IV antibiotics alone (group 4), prophylaxis with SC antibiotic powder

and IV antibiotics (group 3) was associated with the lowest number of postoperative intra-abdominal abscesses (14 [6%], $p = 0.06$; Table 2).

Of all 391 children who had IV antibiotics (groups 2–4), regardless of other specific wound and peritoneal treatment, postoperative intra-abdominal abscesses developed in 21 (5%; Table 3). By comparison, of the 105 children who had no IV antibiotics (group 1), regardless of other specific wound and peritoneal treatment, postoperative intra-abdominal abscesses developed in 12 (11%; Table 2).

All patients recovered well; there were no deaths.

DISCUSSION

This series includes only pediatric patients with ruptured appendices who underwent open appendectomy immediately after resuscitation. Although laparoscopic removal of

Table 1. Three types of prophylaxis for postoperative wound infection and intra-abdominal abscess in children with ruptured appendicitis

Treatment group	Prophylaxis			Details of treatment group			Postoperative result; no. (%)	
	Subcutaneous antibiotic powder	Peritoneal wound drain	IV antibiotics	Years included	No. years	No. patients	Wound infection	Intra-abdominal abscess
1		√		1969–75	7	105	7 (7)	12 (11)
2	√	√	√	1976–80	5	70	10 (14)	10 (14)
3	√		√	1981–86 1993–2003	17	254	57 (22)	14 (6)
4*			√	1987–92	6	67	16 (24)	7 (10)
Total				1969–2003	35	496	90 (18)	43 (9)

IV = intravenous.
*Current standard of practice.

Table 2. Comparison of the rate of postoperative complications associated with the current standard of practice, IV antibiotic prophylaxis (group 4), and that associated with all other prophylaxis (groups 1–3)

Treatment group	Wound infection			Intra-abdominal abscess		
	No. (%)	Group comparison	p value	No. (%)	Group comparison	p value
1. Peritoneal wound drain, $n = 105$	7 (7)	Group 1 v. group 4	0.023	12 (11)	Group 1 v. group 4	0.84
2. Peritoneal wound drain, SC antibiotic powder, IV antibiotics, $n = 70$	10 (14)	Group 2 v. group 4	0.22	10 (14)	Group 2 v. group 4	0.67
3. SC antibiotic powder, IV antibiotics, $n = 254$	57 (22)	Group 3 v. group 4	0.93	14 (6)	Group 3 v. group 4	0.06
4. IV antibiotics, $n = 67$	16 (24)	Group 4	—	7 (10)	Group 4	—
Total, $n = 496$	90 (18)			43 (9)		

IV = intravenous; SC = subcutaneous.
* χ^2 test with Bonferroni correction for multiple comparisons.

Table 3. Combination of treatment groups with 3 types of prophylaxis for postoperative wound infections and intra-abdominal abscess in children with ruptured appendicitis

Combination of treatment groups	Prophylaxis			No. patients	Postoperative result; no. (%)	
	SC antibiotic powder	Peritoneal wound drain	IV antibiotics		Wound infection	Intra-abdominal abscess
1,2		√		175	17 (10)	22 (13)
2,3	√			324	67 (21)	24 (7)
2,3,4			√	391	83 (21)	21 (5)

IV = intravenous; SC = subcutaneous.

the ruptured appendix has become increasingly common in children, this was not done at SickKids until 1994. Moreover, there are still open appendectomies being done in both adult and pediatric populations throughout the world.⁵⁻⁸

Since the 1950s, reports of the incidence of wound infection and postoperative intra-abdominal abscess after open appendectomy in children with a ruptured appendix have ranged from 0% to 84% (Tables 4 and 5).^{5,9-12,14-35} Most authors have reported rates of about 5% for wound infection and 10% for postoperative intra-abdominal abscess.^{5,9-12,14-18,20-40} Although some reports (both adult and pediatric, often combined) indicate that some form of antibiotic prophylaxis will diminish the incidence of both complications,^{35,37-50} others claim it makes no difference.^{5,23,24,27-33,36,51-54}

In our series, each ruptured appendix at operation had an obvious perforation confirmed by histopathological examination. The amount of peritoneal contamination varied between a small localized area in the right lower quadrant (15%) and gross contamination throughout the peritoneal cavity (85%). However, it was difficult correlating the preoperative presentation, intraoperative contamination and postoperative course. Patients with a gangrenous appendix with no obvious perforation were not included in this study. We are aware of only 2 pediatric studies^{13,35} that distinguished between localized and diffuse perforations, but only 1 of these studies excluded patients with gangrenous appendicitis unless there was also a perforation.¹³ There was a significant improvement in both the wound infection and postoperative intra-abdominal abscess rates when patients with unruptured gangrenous appendicitis were included in the study.³⁵

The 3 types of prophylaxis for wound infection and postoperative intra-abdominal abscess after open appendectomy in children with ruptured appendicitis have all been tried at SickKids since the 1960s (Table 1). In the 1960s and 1970s, antibiotics were not routinely used at SickKids, and the rationale for this was supported by the literature,^{5,20-29,55-63} including a 1974 study⁵⁴ conducted at SickKids that reported a wound infection rate of 19% and a postoperative intra-abdominal abscess rate of 14%, which were the norm of the time. However, in 1982, David and colleagues³⁵

reported the results of a 5-year retrospective review involving 270 patients at SickKids with ruptured appendicitis; the authors found a wound infection rate of 6% and a postoperative intra-abdominal abscess rate of 5%. They concluded that using triple IV antibiotics (ampicillin, clindamycin or metronidazole, gentamycin) and not using a peritoneal wound drain decreased the incidence of both wound infection and postoperative intra-abdominal abscess; this finding was also supported by their review of the literature at that time.^{5,31,64,65} The authors also focused on the specific antibiotic treatment of anaerobic bacteria, especially *Bacteroides fragilis*.^{27,32,40,66,67} However, the drawback of their paper was that patients with unruptured gangrenous appendicitis were also included in their study of ruptured appendicitis, and including those patients improved their results.

In 1969, 2 parallel studies were conducted at SickKids to examine

1. prophylaxis for wound infection after open appendectomy in patients with acute appendicitis, and
2. prophylaxis for wound infection and postoperative intra-abdominal abscess after open appendectomy in patients with ruptured appendicitis.

After 25 years (in 1995), the results of the first study were published,³ reporting that prophylactic SC cefoxitin powder and preoperative IV antibiotics was significantly better (wound infection rate 2.5%, $p = 0.003$) than the other treatment groups in the study. The results from the second study were tabulated and evaluated in January 2004 and are presented here. We found that patients who received a peritoneal wound drain had the lowest wound infection rate (7%; Table 2) and that patients treated with SC antibiotic powder and IV antibiotics had the lowest postoperative intra-abdominal abscess rate (6%; Table 2). Although 2 previous studies^{9,11} concluded that immediate appendectomy, antibiotic irrigations of the peritoneal cavity, transperitoneal drainage through the wound and 10-day treatment with intravenous ampicillin, clindamycin and gentamycin was the “gold standard” for treatment of perforated appendicitis, peritoneal drainage for the treatment

Table 4. Pediatric ruptured appendicitis papers reporting on peritoneal drain with postoperative wound infections and intra-abdominal abscess results

Study	Publication year (no. years)	No. patients	Postoperative result; % (range)	
			Wound infection	Intra-abdominal abscess
Schwartz et al. ⁹	1983	143	1.4	0
Curran et al. ¹⁰	1993	167	0	3.0
Lund et al. ¹¹	1994	373	1.3	1.3
Oka et al. ¹²	2003	114	5.0	9.0
Narci et al. ¹³	2007	109	28.4	12.8
Total, $n = 5$	(24)	906	(0-28)	(0-12)

Table 5. Pediatric ruptured appendicitis papers reporting no peritoneal drain with postoperative wound infections and intra-abdominal abscess results

Study	Publication year (no. years)	No. patients	Postoperative result; % (range)	
			Wound infection	Intra-abdominal abscess
Karp et al. ¹⁴	1986	88	3.4	1.1
Samelson and Reyes ¹⁵	1987	170	2.4	1.8
Elmore et al. ¹⁶	1987	102	0	1.3
Neilson et al. ¹⁷	1990	117	1.7	1.7
Emil et al. ¹⁸	2003	125	4.0	8.0
Narci et al. ¹³	2007	117	16.2	3.4
Total, $n = 6$	(21)	719	(0-16)	(1.1-8)

of ruptured appendicitis in infants and children has become less popular over the last 20 years despite reported wound infection and postoperative intra-abdominal abscess rates ranging from 0% to 12% (Table 4). During the same period, the results of similar series that did not use peritoneal drain indicated wound infection rates ranging from 0% to 16% and postoperative intra-abdominal abscess rates ranging from 1.1% to 8% (Table 5).

CONCLUSION

The best results from our clinical review show no major variations from these other large series.

Competing interests: None declared.

Contributors: S.H. Ein and A. Nasr designed the study and analyzed the data. S.H. Ein and A. Ein acquired the data. S.H. Ein wrote the article. All authors reviewed the article and approved its publication.

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