Ann R Coll Surg Engl 1995; 77: 358–363

Acute appendicitis: does removal of a normal appendix matter, what is the value of diagnostic accuracy and is surgical delay important?

S J Walker MD FRCS[1]
Senior Registrar in Surgery

C R West MA[2]
Principal Experimental Officer

M R Colmer MChir FRCS[1]
Consultant Surgeon

[1]Department of Surgery, Whiston and St Helen's Hospitals, Merseyside
[2]Department of Public Health, University of Liverpool

Key words: Acute appendicitis; Appendicectomy; Postoperative complications; Diagnostic accuracy; Delaying surgery

A prospective study with long-term follow-up was undertaken of 248 patients (137 males), median age 18 years (range 6–81 years), undergoing emergency appendicectomy during a 12-month period. Acute inflammation was present in 182 patients (73.4%) (males 86.1%, females 57.8%; $P < 0.001$). Before surgery, the positive predictive value of diagnostic accuracy was 82.0% (males 91.2%, females 67.7%). Delaying surgery did not significantly increase the proportion of perforated appendices (22.0%), hospital stay, or frequency of postoperative complications (overall 49.6%). Hospital complications were significantly more common among patients with a perforated appendix. There was no significant difference in the complication rate between patients with or without appendicitis while in hospital, during the first 18 months after operation or 8 years after operation. At 18 months, 17 of 238 patients (7.1%) continued to experience their original pain. After 8 years the original pain was still present in 10 of 155 patients (6.5%). Continued pain was more likely in patients having undergone removal of a normal appendix ($P < 0.001$).

Present appointment and correspondence to: Mr S J Walker, Consultant Surgeon, Department of Surgery, Blackpool Victoria Hospital, Whinney Hey Road, Blackpool, Lancashire FY3 8NR

Current management of patients with suspected appendicitis is directed at making the diagnosis promptly and treating the condition rapidly *(1)*. This aggressive policy has reduced the overall mortality from appendicitis to less than 1%, but at the cost of 20–25% of patients undergoing an unnecessary operation *(2)*. A period of observation, scoring systems, special blood tests and radiological investigations have all been advocated to improve the diagnostic accuracy in patients with suspected appendicitis *(3–7)*. Most surgeons continue to base their decision to operate on clinical grounds. Justification of this approach depends on confirmation that the true postoperative morbidity, including all problems causing patient distress, in those undergoing removal of a non-inflamed appendix is minimal and that fewer disease-related complications occur in those with appendicitis.

In patients with suspected appendicitis in whom the decision has been made to operate, the surgeon will usually have formed an opinion as to the likelihood of the diagnosis being correct. Whether such diagnostic accuracy has any clinical value has not been investigated.

In a retrospective study of children referred to a specialist centre it has been reported that appendicectomy can safely be postponed overnight *(8)*. Whether delaying surgery increases the perforation rate, frequency of early and late postoperative complications or hospital stay in a mixed group of adults and children is unknown. The purpose of this investigation was to examine the

diagnosis, treatment and follow-up of patients undergoing emergency appendicectomy during a 12-month period in one Merseyside Health District by means of a prospective study with long-term follow-up.

Patients and methods

All patients undergoing emergency appendicectomy in one Merseyside Health District (Knowsley and St Helen's, population approximately 330 000) served by two hospitals (Whiston and St Helen's Hospitals) during a 12-month period were entered into this study. Patients were managed according to a fixed protocol. Before surgery, patients underwent a full blood count and were required to provide a midstream urine specimen for ward testing, microscopy, culture and sensitivity. After deciding to operate, the surgeon was required to record details of the history, physical examination and make a judgement based on the information available as to likelihood of the final diagnosis being appendicitis ('diagnostic accuracy'). The only responses allowed were 'clinically certain' or 'clinically uncertain'.

Before surgery, all subjects received a metronidazole suppository (children, 500 mg; adults, 1 g). Postoperative antibiotics were prescribed at the discretion of the surgeon. The operative findings were recorded immediately after surgery.

Patients were examined daily on the ward. The first 18 months after discharge was considered to be the early follow-up period. Patients were examined at 1 month, 3 months, 6 months and 1 year in a special 'Appendix Clinic' and assessed again at 18 months by means of a questionnaire. Late assessment at 8 years was again by questionnaire. Missing patients were traced through hospital records, their general practitioner and the network of Family Health Service Authorities.

Complications such as wound infection or deep vein thrombosis were defined using standard criteria *(9)*. Events and subjective problems, for example bowel disturbance or menstrual irregularities, occurring for the first time after appendicectomy and considered by the patient to be both distressing and related to this disease event, have also been included under complications. When occurring during the first year, the nature and onset of any such symptoms was clarified by the doctor reviewing the patient in clinic. No attempts have been made to grade the severity of the complications encountered in this study.

Statistical analysis was performed using the Mann–Whitney and χ^2 tests with Yates' correction being computed for 2×2 tables and Fisher's exact test for small numbers. Continuous variables were examined at multiple levels.

Results

During a 12-month period, 248 patients underwent an emergency appendicectomy at Whiston and St Helen's Hospitals (Table I). Diagnosis and treatment was undertaken by a surgeon of registrar (1st or 2nd year level) or senior registrar grade in 244 cases (98.4%) and a consultant in 4 (1.6%) cases.

Table I. Patient details

	Overall	*Adults*	*Children < 16*
Males	137 (55.2%)	79 (49.7%)	58 (65.2%)
Females	111 (44.8%)	80 (50.3%)	31 (34.8%)
Total	248 (100%)	159 (100%)	89 (100%)
Appendicitis			
Males	118 (86.1%)	67 (84.8%)	51 (87.9%)
Females	64 (57.8%)	48 (60.0%)	16 (51.6%)
Total	182 (73.4%)	115 (72.3%)	67 (75.3%)
Normal appendix			
Males	19 (13.9%)	12 (15.2%)	7 (12.1%)
Females	47 (42.3%)	32 (40.0%)	15 (48.4%)
Total	66 (26.6%)	44 (27.7%)	22 (24.7%)

Median age, 18 years (range 6–81 years)

Operative and histological findings

An acutely inflamed appendix, confirmed histologically, was removed in 182 patients (73.4%) (Table I). The appendix was found to be perforated in 40 of 182 patients (22.0%). The percentage of inflamed to normal appendices was greater in males than females ($P < 0.001$; adults *versus* children NS). There was no histological evidence of acute inflammation in 66 patients (26.6%). In two patients an appendix abscess was drained initially followed at a later date by appendicectomy. In three patients, histological examination suggested that the source of the inflammation was extra-appendicular (diverticulitis, 2; salpingitis, 1). One patient developed acute appendicitis 8 days after anterior resection for a Dukes' C carcinoma of the rectum.

Disagreement between surgeon and pathologist occurred in 8.9% of cases. In 14 patients (5.6%) the appendix was considered to be inflamed by the operating surgeon but not by the pathologist reporting the specimen. Conversely, in eight patients (3.2%) the appendix appeared normal, yet histological examination demonstrated acute inflammation. Additional findings in those with or without acute appendicitis are shown in Table II.

Preoperative findings in patients with appendicitis

Six factors were most likely to be present in patients with appendicitis ($P < 0.05$): central pain moving to the right iliac fossa, duration of symptoms < 20 h, presence of rebound tenderness, pulse > 90 beats/min, white blood count $> 10 \times 10^9$/l and temperature > 37.5°C ($P = 0.053$). Right iliac fossa pain and tenderness occurred frequently, being present in 87.1% and 96.4% of patients, respectively. Neither these, nor the presence of any of the following variables, were found to be of value in differentiating between those with or without appendici-

Table II. Additional operative and histological findings in patients with or without acute appendicitis (expressed as a percentage)

	Acute appendicitis (n=182)	*Non-inflamed appendix (n=66)*
No other abnormality	157 (86.3%)	26 (39.4%)
Enlarged nodes	14 (7.7%)	13 (19.7%)
Ovarian cysts (all types)	5 (2.7%)	10 (15.2%) 3 ruptured 1 twisted
Salpingitis	3 (1.6%)	3 (4.5%)
Diverticulitis	2 (1.1%)	—
Non-inflamed Meckel's diverticulum	1 (0.5%)	2 (3.0%)
Cholecystitis	—	1 (1.5%)
Faecolith in appendix	5 (2.7%)	5 (7.6%)
Fibrosis of appendix	—	3 (4.5%)
Local ulceration (without inflammation)	—	1 (1.5%)
Pinworms in appendix	1 (0.5%)	3 (4.5%)
Carcinoid tumour of appendix	—	1 (1.5%)
Endometriosis of appendix	—	1 (1.5%)

tis: nausea, anorexia, vomiting, a change in bowel function, urinary disturbance, generalised pain, diffuse tenderness, guarding, altered bowel sounds, rectal tenderness, or the finding of an abdominal mass. Patients with red blood cells in their urine were more likely to have a diagnosis other than appendicitis.

Value of diagnostic accuracy

Diagnostic accuracy was of value in predicting which patients were suffering from appendicitis. The overall positive predictive value was 82%, being superior in males (91.2%) compared with females (67.7%) (Table III). By comparison, lack of clinical certainty was a poor predictor of normality, reducing the overall correct classification rate to 69.8%. Diagnostic accuracy decreased with lengthening preoperative interval ($P<0.01$). Though not statistically significant, diagnostic accuracy and the proportion of inflamed appendices removed were greatest in patients being operated on between 6 h and 12 h after admission.

Effects of delaying surgery

Surgical delay was caused by logistic problems and/or clinical uncertainty. The proportion of perforated to inflamed appendices increased with the length of time between admission and surgery, but this did not reach statistical significance (0–6 h, 16/88 (18.2%); >6–12 h, 13/58 (22.4%); >12–24 h, 4/17 (23.5%); >24 h, 6/18 (33.3%); unclassified, 1 ($P=0.16$).

Neither the length of hospital stay, nor the frequency of postoperative complications occurring in hospital and during the early follow-up period increased significantly with the interval between admission and surgery ($P>0.05$).

Hospital stay and follow-up

The median hospital stay was 5 days (adults 5 days, children 4 days), range 3–99 days.

During the first 18 months, satisfactory follow-up was possible in 239 of 248 patients (96.4%). At 8 years, 155 patients (62.5%) replied to our questionnaire. Of the remainder, five were known to have died (not related to their appendicectomy), five were living abroad, two refused to co-operate and 81 could not be traced.

Postoperative complications

There were no perioperative deaths. Follow-up demonstrated that nearly half our patients (49.6%) suffered one or more postoperative complication (Table IV and Table V). Most complications were mild and transient.

Complications in hospital and during early follow-up

No significant difference could be demonstrated in the overall hospital complication rate (21.4%) for those with (39/182 (21.4%)) or without appendicitis (14/66 (21.2%)). Complications occurring in hospital were more common

Table III. Value of diagnostic certainty in patients undergoing emergency appendicectomy

	Sensitivity	*Specificity*	*Positive predictive rate*	*Correct classification rate*
Total (248)	75.3%	54.5%	82.0%	69.8%
Males (137)	78.8%	52.6%	91.2%	56.5%
Females (111)	68.8%	55.3%	67.7%	63.1%
Adults (159)	73.0%	56.8%	81.6%	68.6%
Males (79)	80.6%	58.3%	91.5%	77.2%
Females (80)	62.5%	56.3%	68.2%	60.0%
Children (89)	79.1%	50.0%	82.8%	71.9%
Males (58)	76.5%	42.9%	90.7%	72.4%
Females (31)	87.5%	53.3%	66.7%	71.0%

Table IV. Complications occurring for the first time in hospital after emergency appendicectomy ($n=248$)

*Complication**	*Acute appendicitis (n=182)*	*Non-inflamed appendix (n=66)*
Chest infection	10 (5.5%)	1 (1.5%)
Deep vein thrombosis	3 (1.6%)	—
Pulmonary embolism	3 (1.6%)	—
Wound infection	21 (11.5%)	8 (12.1%)
Haematoma	3 (1.6%)	—
Urinary tract infection	—	3 (4.5%)
Persistent vomiting	2 (1.1%)	—
Intra-abdominal abscess	5 (2.7%)	1 (1.5%)
Bowel obstruction	6 (3.3%)	1 (1.5%)
Wound disruption	7 (3.8%)	1 (1.5%)
Enterocutaneous fistula	1 (0.5%)	—
Prolapsed piles	1 (0.5%)	—
Persistent high pyrexia	7 (3.8%)	1 (1.5%)
Severe skin rash	1 (0.5%)	—
Severe asthma attack	1 (0.5%)	—
Scoline apnoea	1 (0.5%)	—
Other complications	2 (1.1%)	3 (4.5%)
Reoperation required	5 (2.7%)	1 (1.5%)
ITU care needed	3 (1.6%)	—

* Complications starting in hospital but continuing after discharge are recorded once only under 'In hospital'

among patients with a perforated appendix (16 of 40 (40.0%)) compared with those with an inflamed but intact organ (23 of 142 (16.2%)) ($P<0.01$).

Despite all subjects receiving a preoperative metronidazole suppository, 29 of 248 patients (11.7%) developed a wound infection in hospital compared with 26 of 239 (10.9%) first occurring after discharge (Table IV and Table V).

The proportion of complications occurring in the early postoperative period was greater among patients who had undergone removal of a non-inflamed appendix (34 of 65 (52.3%)) compared with an inflamed appendix (67 of 174 (38.5%)), but this did not reach statistical significance ($P=0.076$).

Complications after 8 years of follow-up

At 8 years 39 patients (25.2%) still had symptoms which they considered to be related to their original disease episode (Table V). The proportion of complications present in the late postoperative period was greater among patients who had undergone removal of a non-inflamed appendix (15 of 41 (36.5%)) compared with an inflamed appendix (24 of 114 (21.1%)), but this did not reach statistical significance ($P=0.079$). In a minority of patients, their original presentation heralded the start of a chronic bowel, urological or gynaecological history.

Did appendicectomy cure the patient's original pain?

At 18 months after operation, 17 of 238 patients (7.1%) claimed that appendicectomy had not cured their original pain, while at 8 years pain was still present in 10 of 155 patients (6.5%) (Table V). At both assessment intervals the original pain was more likely to be present in patients who had undergone removal of a normal appendix ($P<0.001$).

Discussion

The proportion of normal, inflamed and perforated appendices encountered in this study was similar to that reported by other authors *(10,11)*. Our findings confirm the difficulties involved in making the correct diagnosis in females *(10)*. The appendix was found not to be inflamed in 40% of adult women and nearly 50% of the girls. Overall, nearly 40% of patients with a non-inflamed appendix had no intra-abdominal abnormality to account for their symptoms. Of those who did, emergency surgery was rarely of benefit.

Did it matter that 26.6% of patients underwent an unnecessary appendicectomy? Our findings go some way to answering this question. Complications occurred in nearly half our subjects, and their frequency did not significantly differ between those with or without appendicitis. The wound infection rate, for example, was of the order of 20% in both groups. Some complications were more serious (Table IV and Table V). Removal of a non-inflamed appendix can, therefore, not be regarded as an innocuous procedure.

Why was our complication rate so high? Why did 25% of patients still have symptoms after 8 years' follow-up? There are several possible explanations. The first is that this represents the typical experience after emergency appendicectomy. The second is that we have been over-

Table V. Complications encountered at early and late assessment after discharge after emergency appendicectomy*

	Early follow-up (n=239)		*Late follow-up (n=155)*	
Complication	*A (n=174)*	*N (n=65)*	*A (n=114)*	*N (n=41)*
Deep vein thrombosis	1 (0.6%)	—	—	—
Pulmonary embolism	1 (0.6%)	—	—	—
Wound infection	19 (10.9%)	7 (10.8%)	—	—
Urinary tract infection	1 (0.6%)	1 (1.5%)	—	—
Micturition difficult	8 (4.6%)	2 (3.1%)	4 (3.5%)	2 (4.9%)
Persistent vomiting	4 (2.3%)	3 (4.6%)	—	—
Intra-abdominal abscess	3 (1.7%)	—	—	—
Bowel obstruction	3 (1.7%)	1 (1.5%)	—	—
Wound disruption	7 (4.0%)	4 (6.2%)	—	—
Pancreatitis	1 (0.6%)	—	—	—
Prolapsed piles	1 (0.6%)	—	—	—
Bowel disturbance	12 (6.9%)	10 (15.4%)	7 (6.1%)	8 (19.5%)
Abdominal pain	21 (12.1%)	24 (36.9%)	10 (8.8%)	10 (24.4%)
Wound pain	11 (6.3%)	13 (20.0%)	4 (3.5%)	1 (2.4%)
Wound hernia	5 (2.9%)	1 (1.5%)	2 (1.8%)	—
Appetite loss	1 (0.6%)	3 (4.6%)	—	—
Weight loss	2 (1.1%)	—	—	1 (2.4%)
Caecal carcinoma	1 (0.6%)	—	—	—
Other complications	5 (2.9%)	1 (1.5%)	—	3 (7.3%)
Reoperation required	5 (2.9%)	—	—	—
Further investigations	10 (5.7%)	7 (10.8%)	—	—
Further admissions	10 (5.7%)	5 (7.7%)	—	—
Pain not cured	5 (2.9%)	12 (18.5%)	2 (1.8%)	8 (19.5%)
Gynaecology problems	*Females (n=107)*		*Females (n=73)*	
	A (n=60)	*N (n=47)*	*A (n=39)*	*N (n=34)*
Discharge	1 (1.7%)	4 (8.5%)	—	3 (8.8%)
Menstrual problems	5 (8.5%)	2 (4.3%)	2 (5.1%)	3 (8.8%)
Pelvic inflammatory disease	1 (1.7%)	2 (4.3%)	1 (2.6%)	2 (5.9%)
Ovarian cysts	1 (1.7%)	1 (2.1%)	2 (5.1%)	3 (8.8%)
Carcinoma	2 (3.3%)	—	1 (2.6%)	1 (2.9%)
Conception problems	—	—	—	1 (2.9%)
Other	—	—	5 (12.8%)	1 (2.9%)

* Complications starting in hospital but continuing after discharge are recorded once under 'In hospital'

enthusiastic in our collection of data on complications. Third, the high complication rate might have occurred because of factors such as the relative inexperience of the operating surgeon and the lack of a postoperative antibiotic policy. Finally, follow-up of most patients after appendicectomy is usually brief. A review of the literature suggests that very little is known about the long-term morbidity of this condition. In the conduct of this study we acknowledge one omission, the inclusion of a control group. For most complications, especially during early follow-up, this does not matter as it is reasonable to assume that they would not have occurred if the patient had been left untouched. Conversely, for more subjective symptoms, such as altered bowel function or abdominal pain, we have no information on the frequency of such complaints in the general population and how they alter with time.

Could the number of negative appendicectomies have been reduced? A review of the preoperative signs and symptoms failed to identify one factor that was universally present or absent in all those with appendicitis. Six preoperative factors were found to be of value: central pain moving to the right iliac fossa, duration of symptoms < 20 h, presence of rebound tenderness, pulse > 90 beats/min, white blood count $> 10 \times 10^9$/l and temperature > 37.5°C. Interestingly, right iliac fossa pain or tenderness, though frequently present, was of no differentiating value.

Several authors have attempted to improve diagnostic accuracy by means of a symptom/physical findings score *(4,12)*. Among the limitations of the currently available methods are their complexity and rigidity. Generally they have not found favour. Our results indicate that determining simple clinical accuracy, representing a summation of different preoperative factors with the surgeon giving each a varying degree of importance, is just as valuable (overall positive predictive value 82%). From our results, we suggest that if the surgeon is clinically certain of the diagnosis in a male then he is justified in performing an appendicectomy. In a female he, or she is advised to re-examine the evidence.

Of all the investigations that have been advocated for the diagnosis of appendicitis, two are finding favour, namely ultrasound scanning *(2)* and laparoscopy *(7)*. The limitation of the first is that the findings tend not to be clear-cut in those patients in whom diagnosis is difficult. In the second, the appendix may appear macroscopically normal, tempting the surgeon to leave it *in situ*, yet the deeper layers are histologically inflamed. Inconsistency between the operative and histological diagnosis of appendicitis are not widely appreciated. Andersson *et al. (13)* reported a false-positive diagnosis of 10% (ie the surgeon considered the appendix inflamed but pathologist did not) and a false-negative diagnosis of 6%, results which are of a similar order to our own *(14)*. An example is provided by our patient with a carcinoid tumour in whom the appendix appeared normal.

Does delaying surgery matter? The traditional view of appendicitis holds that there is a progressive series of stages between early inflammation and perforation, with the latter being the inevitable outcome of delayed surgery *(1)*. Consequently, the majority of surgeons favour early operation. Such assumptions are challenged by both our results and those of Surana *et al. (8)*. Though the reasons for surgical delay varied in this non-randomised study, and it is likely that those patients who were very tender or toxic got earlier treatment, our results indicate that, in general, delaying surgery does not significantly increase the perforation rate, duration of hospital stay or frequency of postoperative complications. With regard to perforation, results from Sweden *(13)* suggest that perforating and non-perforating appendicitis may be two separate conditions and appendicitis that resolves spontaneously is common.

The clinical implications of these findings are that, depending on the condition of the patient, surgery may frequently safely be delayed overnight, or until a more senior colleague is available. Therein lies a danger, in that these conclusions may be used by surgeons, anaesthetists or hospital managers as an excuse to delay surgery when the condition of an individual patient clearly indicates otherwise.

The authors acknowledge the help of Margaret Stock, Linda Pennington (Family Health Service Authority, St Helen's and Knowsley Health Authority), Suzanne Walker and the staff of the Clinical Audit Department, Warrington District General Hospital.

References

1 Malt RA. The perforated appendix. *N Engl J Med* 1986; **315**: 1546–7.
2 Anonymous. A sound approach to the diagnosis of acute appendicitis. *Lancet* 1987; **1**: 198–200.
3 Nauta RJ, Magnant C. Observation versus operation for abdominal pain in the right lower quadrant; roles of the clinical examination and the leucocyte count. *Am J Surg* 1986; **151**: 746–68.
4 Arnbjornsson E. Scoring system for computer-aided diagnosis of acute appendicitis; the value of prospective versus retrospective studies. *Ann Chir Gynaecol* 1985; **74**: 159–66.
5 Pearson RH. Ultrasonography for diagnosing appendicitis. *Br Med J* 1988; **297**: 309–10.
6 Rajagopalan AE, Mason JH, Kennedy M, Pawlikowski J. The value of the barium enema in the diagnosis of acute appendicitis. *Arch Surg* 1977; **112**: 531–3.
7 Paterson-Brown S, Thompson JN, Eckersley JR, Ponting GA, Dudley HA. Which patients with suspected appendicitis should undergo laparoscopy? *Br Med J* 1988; **296**: 1363–4.
8 Surana R, Quinn F, Puri P. Is it necessary to perform appendicectomy in the middle of the night in children? *Br Med J* 1993; **306**: 1168.
9 Pollock A, ed. *Postoperative Complications in Surgery*. Oxford: Blackwell Scientific, 1991.
10 Gilmore OJA, Browett JP, Griffin PH *et al.* Appendicitis and mimicking conditions. *Lancet* 1975; **2** (7932): 421–4.
11 Berry J, Malt RA. Appendicitis near its centenary. *Ann Surg* 1984; **200**: 567–75.
12 Izbicki JR, Knoefel WT, Wilker DK *et al.* Accurate diagnosis of acute appendicitis: a retrospective and prospective analysis of 686 patients. *Eur J Surg* 1992; **158**: 227–31.
13 Andersson R, Hugander A, Thulin A, Nystrom PO, Olaison G. Indications for operation in suspected appendicitis and incidence of perforation. *Br Med J* 1994; **308**: 107–10.
14 Grunewald B, Keating J. Should the 'normal' appendix be removed at operation for appendicitis? *J R Coll Surg Edinb* 1993; **38**: 158–60.

Received 16 January 1995