Original article

Intra-operative culture in appendicitis: traditional practice challenged

Marc A Gladman, Charles H Knowles, Lucy J Gladman, John G Payne

Department of Surgery, Queen Mary's Hospital, Sidcup, Kent, UK

Introduction: Traditionally, microbiological swabs are taken for culture during appendicectomy. However, the pathogens encountered are largely predictable, and sensitive to broad-spectrum antibiotics. Thus, we aimed to examine the clinical value of this practice, by determining the influence of microbiological results on postoperative outcome in patients undergoing appendicectomy.

Patients and Methods: The study population comprised 721 consecutive patients undergoing appendicectomy for suspected acute appendicitis in a single district general hospital. Microbiological culture results and sensitivities of isolates were recorded in relation to histopathological findings and infective morbidity, to establish whether they influenced postoperative outcome.

Results: Swabs were taken during 463 (64%) appendicectomies. Only 113 (24%) yielded positive cultures ('coliforms', anaerobes and *Streptococcus milleri* were most frequently isolated). Organisms resistant to broad-spectrum antibiotics were encountered in only 11 of 463 patients (2%) where swabs were taken. Overall, 39 patients (5%) developed significant infective complications postoperatively. Neither the presence of a positive intra-operative culture, nor the isolation of resistant organisms were significant in predicting infective complications ($P = 0.11$ and 0.17 , respectively).

Conclusions: In the population studied, the results of intra-operative culture did not influence clinical outcome in patients undergoing appendicectomy. The practice of taking routine microbiological swabs for culture must be seriously questioned.

Key words: Appendicectomy – Microbiological swabs – Intra-operative culture – Postoperative outcome

Despite reductions in the overall mortality and morbidity associated with appendicectomy in recent years,¹ infective complications continue to contribute significantly to morbidity. The demonstration of polymicrobial flora within the peritoneal cavity in cases of acute appendicitis² has led to routine microbiological swabbing for culture during appendicectomy. This is in the expectation that identification of organisms and knowledge of their sensitivities will guide selection of the

most suitable antibiotic regimen and reduce infective morbidity.

The pathogens encountered in acute appendicitis are well characterised^{3,4} and comprise normal aerobic and anaerobic enteric organisms,⁵ with 'coliforms' and Gram-negative anaerobes most common.⁶ The selection of appropriate peri-operative antibiotic agents is made on an empirical basis and numerous studies have demonstrated that the use of broad-spectrum antibiotics against aerobic

Correspondence to: Mr Marc A Gladman, Academic Department of Surgery, 4th Floor Alexandra Wing, The Royal London Hospital, Whitechapel, London E1 1BB, UK. E-mail: m.a.gladman@qmul.ac.uk

and anaerobic organisms is effective in acute appendicitis.⁷⁻⁹ Thus, the need for intra-operative cultures might be questioned. Indeed, it has been suggested that the practice of obtaining intra-operative swabs for culture should be abandoned in appendicitis.¹⁰⁻¹³

The aim of this retrospective observational study was to examine the clinical value of intra-operative cultures, by determining the influence of microbiological results on post-operative outcome in patients undergoing appendicectomy.

Patients and Methods

The study population

In a 4-year period (1997–2000), 808 consecutive patients underwent appendicectomy for suspected acute appendicitis in a single district general hospital. Of these, 721 patients (358 [50%] male; median age, 24 years; range, 1–88 years), with fully comprehensive clinical, microbiological and histopathological data were included in the study.

Methods

Data were acquired using computerised database systems (Patient Administration System [PAS] and APEX system), and notes review in selected cases. Basic demographic data, median length of hospital stay (days), histopathological findings of excised appendices, results of intra-operative cultures, and postoperative complications were recorded.

Histopathology

The histopathological examination findings of the excised appendices were recorded. Patients were stratified according to the following pathological groups:¹⁴ (i) non-inflamed appendix; (ii) suppurative appendicitis (neutrophilic infiltration); (iii) gangrenous appendicitis (definite necrosis of the appendicular wall); and (iv) perforated appendicitis $\pm$ abscess formation (obvious microscopic evidence of perforation of the appendicular wall $\pm$ evidence of intramural abscess formation).

Microbiology

All intra-operative microbiological swabs of the appendix fossa, intra-abdominal fluid or purulent exudate/discrete abscesses were taken using a single microbiological swab in transport medium (Medical Wire and Equipment Co. (Bath) Ltd, Wiltshire, UK), refrigerated out-of-hours, and then plated onto blood and MacConkey agar (aerobic and anaerobic culture). All were cultured on site in the same laboratory and organisms were identified and sensitivities performed using standard methods. Data

Table 1 Histological findings and median length of hospital stay

Histology	Number (percent)	Length of stay (range)
Non-inflamed	220 (31%)	3 (1–24) days
Suppurative	432 (60%)	3 (1–34) days
Gangrenous	23 (3%)	5 (2–19) days
Perforation/abscess	46 (6%)	5 (2–16) days
Total	721 (100%)	3 (1–34) days

concerning individual species of bacteria were recorded in all cases. For the purposes of the study, they were collectively analysed as 'coliforms', 'pseudomonads', 'anaerobes', *etc.* The frequency with which swabs were taken in each of the histopathological groups was established, and the culture results and sensitivities were recorded.

Postoperative complications

Postoperative complications were defined as those occurring within 30 days of operation. Criteria used to employ detailed notes review were any re-attendance or re-admission and/or prolonged postoperative hospital stay (≥ 7 days). Attention was focused on clinically significant infective complications, which for the purposes of the study were defined as purulent wound infection/superficial (abdominal wall) collections and intra-abdominal abscesses. Culture results and sensitivities of these patients were examined in detail (when performed) to establish whether microbiological laboratory results influenced clinical outcome.

Specific details relating to the operative procedure (*e.g.* method of skin closure, use of drains, *etc.*) were not recorded, as the influence of such factors was not under evaluation. According to departmental protocol, all patients with suspected appendicitis should have received a minimum of three prophylactic doses of intravenous double-agent antibiotic therapy (cefuroxime and metronidazole) peri-operatively. In cases of cephalosporin allergy, this agent was generally substituted with gentamycin or ciprofloxacin. The specific postoperative antibiotic regimen in terms of timing and duration of therapy was dictated according to the intra-operative findings, and clinical progress postoperatively, and was again based on broad-spectrum cover with intravenous cefuroxime and metronidazole.

Statistical analysis

Fisher's exact test was used to analyse contingencies where appropriate. The descriptive nature of this retrospective study means that it was not appropriate to apply more complex predictive models using a multivariate approach. Analyses were performed using a commercially available

Table 2 Positive bacterial culture as related to histological diagnosis

Histology	Total swabbed	Positive culture	No. of organisms cultured (median)
Non-inflamed	102 (46%)	9 (9%)	1
Suppurative	302 (70%)	75 (25%)	2
Gangrenous	21 (91%)	7 (33%)	2
Perforation/abscess	38 (83%)	22 (42%)	3
Total	463 (64%)	113 (24%)	2

statistical software package. (Prism 3.0®, GraphPad Software, Inc., San Diego, CA, USA). A *P* value of < 0.05 was considered to be statistically significant.

Results

The median interval to operation time was 0 days (range, 0–31 days) and median hospital stay 3 days (range, 1–34 days).

Histopathology

The number of patients in each histopathological group and lengths of hospital stay are shown in Table 1. The majority of excised specimens demonstrated 'uncomplicated' suppurative appendicitis (60%). Normal appendices were removed in 31% of cases. The median length of stay increased with severity of appendicitis, although small numbers of patients with prolonged stays were observed in all groups. In addition, uncommon associated histopathological findings included 5 cases (0.7%) of carcinoid tumours, and 1 case each (0.1%) of mucinous cystadenoma and adenocarcinoma, respectively. The presence of thread-worms was noted in 16 (2%) appendices.

Microbiology

Overall, an intra-operative swab was taken in 463 of 721 (64%) patients, including those with normal appendices,

although swabs were taken more frequently in patients with 'complicated' appendicitis (Table 2). Only 113 of the 463 swabs taken yielded a positive culture (24%). The proportion of patients with a positive culture, and number of organisms cultured increased with severity of histological diagnosis (Table 2).

The most frequently cultured organisms were 'coliforms', anaerobes and *Streptococcus milleri* (Table 3). The sensitivities of the commonly cultured organisms to cefuroxime are shown in Table 4. Resistance to cefuroxime was only encountered in 12 out of 118 isolates. All anaerobic organisms were sensitive to metronidazole.

Postoperative complications

There were no peri-operative deaths. In-patient stay was ≥ 7 days in 46 patients. Forty-one patients re-attended or were re-admitted within 30 days. Of these 87 patients, 39 (45%) had infective complications (5% of total [39/721]). Nineteen patients (2.6%) had intra-abdominal abscesses and 20 (2.7%), wound infections/superficial collections.

Other relatively frequent causes of morbidity were: paralytic ileus (*n* = 6), persistent postoperative pain (with no obvious abnormality; *n* = 6), urinary tract infection (*n* = 5), wound haematoma (*n* = 4), respiratory tract infection (*n* = 4), and deep venous thrombosis (*n* = 1).

Data analysis

Significant infective complications occurred more frequently in patients with 'complicated' (gangrenous/perforated) appendicitis (Table 5). Intra-operative swabs were taken at appendectomy in 29 of 39 patients (74%) who developed postoperative infective collections. Overall, 11 (38%) of these had a positive culture, but this proportion was similar to the positive culture rate in patients without infective complications (102 of 434 patients [24%]; *P* = 0.11). Organisms resistant to cefuroxime were cultured in only 2 of 29 patients (7%) who had intra-operative swabs taken and subsequently

Table 3 Organisms isolated according to histological diagnosis

Organism	Non-inflamed	Suppurative	Gangrenous	Perforated/abscess	Total
'Coliforms'	5	52	5	13	75
'Pseudomonads'	1	1	1	3	6
Skin-type ^a	7	13	1	5	26
<i>Streptococcus milleri</i>	1	17	2	7	27
Non-haemolytic streptococci	1	6	1	2	10
Anaerobes	3	23	3	14	43
'Mixed growth' ^b	9	4	1	4	18
Total	27	116	14	48	205

^aIncludes diphtheroids, *Staphylococcus aureus*, and *Staphylococcus epidermidis*.

^bRepresents 'scanty' growth of mixed faecal organisms. In such cases, no sensitivities were reported by the laboratory.

Table 4 Sensitivities of significant aerobic organisms to cefuroxime

Organism	Number of isolates	Number sensitive	Number resistant
'Coliforms'	75	71	4 ^a
'Pseudomonads'	6	0	6 ^a
<i>Streptococcus milleri</i>	27	27	0
Non-haemolytic streptococci	10	8	2 ^b
Total	118	106 (90%)	12 (10%)

^aAll 10 organisms isolated were sensitive to cefotaxime, ciprofloxacin or gentamycin.

^bBoth resistant organisms were enterococci.

developed postoperative collections and 10 of 434 (2%) of patients with no infective complications; these proportions did not differ significantly ($P = 0.17$).

The clinical records of the two patients in whom resistant organisms were cultured and who developed postoperative complications were reviewed. Both had undergone uneventful removal of appendices (suppurative appendicitis), on the day of admission, and had received three peri-operative doses of cefuroxime and metronidazole. The culture from the first patient, a 21-year-old male, yielded a 'coliform' that was resistant to cefuroxime (sensitive to cefotaxime, ciprofloxacin and gentamycin) and a resistant enterococcus. He developed a pelvic abscess postoperatively, and was treated with intravenous cefuroxime and metronidazole, despite the original microbiological results (indeed, there was no evidence that the original microbiological results were reviewed), prior to drainage at laparotomy. The culture from the second patient, a 74-year-old male, yielded 'coliforms' and *Pseudomonas* spp. that were resistant to cefuroxime (sensitive to ciprofloxacin and gentamycin). He developed a wound collection postoperatively, which was treated with flucloxacillin and surgical drainage.

Culture results were seemingly ignored. In both instances, postoperative cultures failed to yield significant growth and thus, no comparison could be made with the culture results obtained pre-operatively.

Discussion

This study demonstrates that, in current clinical practice in a single district general hospital, microbiological swabs are taken at 64% of appendicectomies – apparently regardless of intra-operative findings. However, only 24% of these yielded a positive culture, with common enteric organisms, with predictable sensitivities to antimicrobial agents being isolated in the vast majority. The finding of a positive intra-operative culture did not predict infective complications. Organisms resistant to standard broad-spectrum antimicrobial therapy (cefuroxime and metronidazole) were encountered in only 2% of patients where swabs were taken, and their presence was not significant in predicting infective morbidity. Moreover, such findings did not appear to influence management. When complications occurred, antimicrobial treatment was not tailored to the culture results.

The study is limited due to its retrospective design. Specific details relating to the exact peri-operative antibiotic regimen or surgical procedure were not recorded in all individual cases. Although the majority of patients received peri-operative cefuroxime and metronidazole, alternative agents may have been used in a minority of cases (e.g. patients with allergy). In addition, details of the number of doses administered prior to surgery were not examined, and might have influenced culture results. It is possible that variation in surgical procedure (e.g. relating to abdominal washout and method of skin closure) may have also influenced the development of infective complications.

Table 5 Histological and microbiological results in patients with infective complications

Histology	Number of cases	Number swabbed	Positive culture	Number of organisms cultured (median)
Wound/superficial collections ($n = 20$)				
Non-inflamed	3	1 (33%)	0 (0%)	0
Suppurative	11	6 (55%)	2 (33%)	2
Gangrenous	2	2 (100%)	1 (50%)	2
Perforation/abscess	4	4 (100%)	2 (50%)	2
Subtotal	20	13 (65%)	5 (38%)	
Intra-abdominal abscesses ($n = 19$)				
Non-inflamed	1	1 (100%)	0 (0%)	0
Suppurative	6	4 (67%)	1 (25%)	2
Gangrenous	4	4 (100%)	1 (25%)	2
Perforation/abscess	8	7 (88%)	4 (57%)	3
Subtotal	19	16 (84%)	6 (38%)	
Total		39	29 (74%)	11 (38%)

The majority of patients in this study were found to have 'uncomplicated' suppurative appendicitis. The positive culture rate, and number of organisms cultured increased with severity of histological diagnosis as previously noted,^{11,15,16} although even cultures from non-inflamed appendices were positive in 9% of cases, as has formerly been described.¹¹ It is possible that, in certain patients, this positive culture result may reflect alternative underlying pathology.

There is wide variation in the positive culture rates previously reported in the literature, ranging from 18% to 95%.^{12,15,17,18} This may reflect differences related to the collection and transfer of specimens or the culture techniques employed. In particular, collection techniques and prolonged exposure to oxygen can influence the isolation of anaerobes.¹⁹ Further variation may also reflect differing inclusion/exclusion criteria; for example, exclusion of patients with a non-inflamed appendix¹⁵ or inclusion of only patients with complicated appendicitis.¹² The relatively low overall positive culture rate observed in our series may have been influenced by the ratio of a low proportion of patients with 'complicated' appendicitis, and a relatively high rate of removal of non-inflamed appendices (31%) almost half of which were swabbed. Although the removal of non-inflamed appendices was high, it is similar to the 20–30% negative appendectomy rates quoted by Jones.¹ Furthermore, the use of peri-operative antibiotic prophylaxis may have influenced the positive culture rates.

In terms of organisms cultured, enteric commensals tend to be most commonly isolated in cases of appendicitis,^{6,12} and our results concur with this, given that 'coliforms' and anaerobes were isolated most frequently. The vast majority of isolates were sensitive to standard broad-spectrum antibiotics, although predictable resistant to cefuroxime was encountered in 'pseudomonads' and enterococci. All anaerobes isolated were sensitive to metronidazole, despite a reported increase in resistance in recent years.²⁰

Overall, 5% of patients developed infection post-operatively, although the design of the study may have led to the omission of patients with 'minor' wound infections managed in the community. Infective complications continue to contribute most significantly to morbidity following appendectomy, and relate to the degree of contamination found at operation.²¹ We observed that the results of microbiological culture did not predict the occurrence of infective complications. Furthermore, such results were not acted on in clinical practice when patients developed infective complications postoperatively. Jaffers and Pollock¹⁰ have previously noted that in 608 patients with acute appendicitis, not one single patient had antibiotic therapy changed on the basis of culture results. Although we did not attempt to evaluate the influence of culture

results on antibiotic treatment formally, others have also found that only 7–16% of patients have a change of antibiotic therapy on the basis of culture findings.^{6,10,12,22} It is possible that this is because surgeons tend not to rely on the results of microbiological cultures,^{22,23} but instead rely on clinical judgement in conjunction with the proven effectiveness of antimicrobial agents that offer a broad-spectrum of cover against likely pathogens. The results of cultures must be taken in context with postoperative clinical progress. Thus, when this is uneventful, the significance of the isolation of resistant organisms might be questioned. Conversely, antibiotic therapy may well be warranted in the face of infective complications; even if the original cultures were negative.

Conclusions

In current clinical practice in a single district general hospital, the results of microbiological cultures taken during appendectomy are not predictive of infective complications, and are not acted on in clinical practice. From the data, taken in the context of other published studies, it is concluded that the traditional practice of taking microbiological swabs for culture during appendectomy is of no clinical value. In the face of resource implications, continuation of the practice should be questioned seriously. However, definitive scientific proof will only come from a suitably designed prospective study examining this practice.

Acknowledgements

This work was presented, in part, orally at the annual meeting of the Association of Surgeons of Great Britain & Ireland, Manchester, UK, in May 2003 and appears in abstract form in *Br J Surg* 2003; **90** (Suppl 1): 34.

The authors would like to thank the microbiology laboratory staff at Queen Mary's Hospital for performing culture studies, particularly Dr J Kensit, consultant microbiologist, for his additional contribution to the preparation of the manuscript.

References

1. Jones PF. Suspected acute appendicitis: trends in management over 30 years. *J Surg* 2001; **88**: 1570–7.
2. Altemeier WA. The bacterial flora of acute perforated appendicitis with peritonitis. A bacteriological study based upon one hundred cases. *Ann Surg* 1938; **107**: 517–28.
3. Bennion RS, Thompson JE, Baron EJ, Finegold SM. Gangrenous and perforated appendicitis with peritonitis: treatment and bacteriology. *Clin Ther* 1990; **12** (Suppl C):31–44.
4. Simon GL, Gorbach SL. Intestinal flora in health and disease. *Gastroenterology* 1984; **86**: 174–93.

5. Brook I. Bacterial studies of peritoneal cavity and postoperative surgical wound drainage following perforated appendix in children. *Ann Surg* 1980; **192**: 208–12.
6. Fraulin FO, Thurston OG. Value of cultures of tissue samples taken at operation for lower intestinal perforation. *Can J Surg* 1993; **36**: 261–5.
7. Andersen BR, Kallehave FL, Andersen HK. Antibiotics versus placebo for prevention of postoperative infection after appendectomy. *Cochrane Database System Rev* 2001; (3): CD001439.
8. Bauer T, Vennits B, Holm B, Hahn-Pedersen J, Lysen D, Galatius H *et al*. Antibiotic prophylaxis in acute nonperforated appendicitis. The Danish Multicenter Study Group III. *Ann Surg* 1989; **209**: 307–11.
9. Busuttill RW, Davidson RK, Fine M, Tompkins RK. Effect of prophylactic antibiotics in acute nonperforated appendicitis: a prospective, randomized, double-blind clinical study. *Ann Surg* 1981; **194**: 502–9.
10. Jaffers GJ, Pollock TW. Intraoperative culturing during surgery for acute appendicitis. *Arch Surg* 1981; **116**: 866–8.
11. McNamara MJ, Pasquale MD, Evans SR. Acute appendicitis and the use of intraperitoneal cultures. *Surg Gynecol Obstet* 1993; **177**: 393–7.
12. Mosdell DM, Morris DM, Fry DE. Peritoneal cultures and antibiotic therapy in pediatric perforated appendicitis. *Am J Surg* 1994; **167**: 313–6.
13. Dougherty SH. Antimicrobial culture and susceptibility testing has little value for routine management of secondary bacterial peritonitis. *Clin Infect Dis* 1997; **25** (Suppl 2): S258–61.
14. Carr NJ. The pathology of acute appendicitis. *Ann Diagn Pathol* 2000; **4**: 46–58.
15. Seco JL, Ojeda E, Reguilon C, Rey JM, Irurzun A, Serrano SR *et al*. Combined topical and systemic antibiotic prophylaxis in acute appendicitis. *Am J Surg* 1990; **159**: 226–30.
16. Bilik R, Burnweit C, Shandling B. Is abdominal cavity culture of any value in appendicitis? *Am J Surg* 1998; **175**: 267–70.
17. Henderson J, Forshaw MJ, Power DM, Babu Dinkara E. Should surgeons swab during appendicectomy? An audit. *J R Coll Surg Edinb* 2001; **46**: 367.
18. Pal KM, Khan A. Appendicitis: a continuing challenge. *J Pak Med Assoc* 1998; **48**: 189–92.
19. Stone HH, Kolb LD, Geheber CE. Incidence and significance of intraperitoneal anaerobic bacteria. *Ann Surg* 1975; **181**: 705–15.
20. Giamarellou H. Anaerobic infection therapy. *Int J Antimicrob Agents* 2000; **16**: 341–6.
21. Helmer KS, Robinson EK, Lally KP, Vasquez JC, Kwong KL, Liu TH *et al*. Standardized patient care guidelines reduce infectious morbidity in appendectomy patients. *Am J Surg* 2002; **183**: 608–13.
22. Kokoska ER, Silen ML, Tracy Jr TF, Dillon PA, Kennedy DJ, Craddock TV *et al*. The impact of intraoperative culture on treatment and outcome in children with perforated appendicitis. *J Pediatr Surg* 1999; **34**: 749–53.
23. Browder W, Smith JW, Vivoda LM, Nichols RL. Nonperforative appendicitis: a continuing surgical dilemma. *J Infect Dis* 1989; **159**: 1088–94.