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Increased use of pre-operative imaging and laparoscopy has no impact on clinical outcomes in patients undergoing appendicectomy

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ABSTRACT

INTRODUCTION The aim of this study was to review changes in the management of acute appendicitis in a ten-year period at a large university teaching hospital in London.

METHODS This was a retrospective cohort study reviewing the medical records of patients who underwent an appendicectomy over a period of 12 months either in 1999 or 2009. Data collected included use of radiological investigations (ultrasonography, computed tomography [CT]), technique of appendicectomy (open [OA] or laparoscopic [LA]), operative time, histopathology and post-operative complications. Univariate and multivariate analysis was performed to assess the influence of variables on the incidence of negative appendicectomy, appendiceal perforation and post-operative complications.

RESULTS All of the patients operated on in 1999 (n=109) had OA. Of the patients operated on in 2009 (n=164), 67 had OA, 91 had LA and 6 had LA converted to OA.

None of the patients in 1999 had CT whereas in 2009 26% of patients had CT (sensitivity 94.7%, specificity 75.0%). This increased use of pre-operative imaging had no effect on negative appendicectomy (25.7% vs 12.8%, p=0.445), perforation (30.0% vs 21.3%, p=0.308) or complication rates (9.2% vs 10.4%). The complication rate was also similar regardless of whether patients had OA or LA (11.9% vs 9.9%). Multivariate analysis revealed that age was the only predictor of negative appendicectomy (p=0.029) or perforation (p=0.014).

CONCLUSIONS This study shows that significant increase in the use of pre-operative imaging and laparoscopy in the management of patients with acute appendicitis failed to reduce negative appendicectomy, perforation and complications rates. The patient's age was the only predictor of negative appendicectomy and perforation.

KEYWORDS

Appendicitis – Ultrasonography – Computed tomography – Laparoscopy

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Acute appendicitis is the most common abdominal emergency and accounts for roughly 40,000 hospital admissions in England per year.[1] In the past, acute appendicitis was solely a 'bedside diagnosis' based on the patient's medical history and physical examination, with laboratory investigations only helping with the interpretation of clinical findings.[2]

The main attraction of ultrasonography (US) is that it is a safe, inexpensive and readily available imaging modality. It is particularly useful for visualising pelvic anatomy and ruling out gynaecological causes of lower abdominal pain in female patients. The disadvantages of US include its inability to provide adequate information in obese patients and the operator dependent nature of its results.[3] This is reflected in the significant heterogeneity in reported rates of sensitivity and specificity of US in diagnosing acute appendicitis.[3–5]

Computed tomography (CT) has been shown to have both a high sensitivity and specificity in diagnosing acute appendicitis, leading to a further reduction in the negative appendicectomy rate.[4,6,7] Laparoscopy provides a method to accurately visualise the appendix and other abdominal contents that may be the cause of acute lower abdominal pain. Laparoscopic appendicectomy (LA) has been shown to reduce wound morbidity (odds ratio [OR]: 0.45, 95% confidence interval [CI]: 0.35–0.58), post-operative pain (reduced by 9mm on a 100mm visual analogue pain scale) and length of hospital stay (shortened by 1.1 days, 95% CI: 0.6–1.5) compared to traditional open appendicectomy (OA).[8]

The aim of this study was to document changes in the diagnostic and therapeutic processes of patients who underwent surgery for suspected acute appendicitis and evaluate the impact of these processes on clinical outcomes during two twelve-month periods separated by ten years.

Methods

This study was conducted through retrospective review of appendicectomies performed over two separate twelve-month periods, ten years apart (1 January – 31 December 1999 and 1 January – 31 December 2009). All patients over the age of ten who had an emergency appendicectomy within these two timeframes were included. Patients who had an appendicectomy but for whom no post-operative histopathology report was available and those who underwent an interval appendicectomy in a non-emergency setting were excluded.

Pre-operative data collected included patient age, sex and use of pre-operative radiological investigations. US and CT findings were classified as normal or indicative of acute appendicitis. Intra-operative data collected consisted of surgical technique (LA or OA) whereas post-operative data collected included complications (defined as a surgical complication occurring within one month of surgery and requiring treatment) and histopathological evidence of a normal appendix, acute appendicitis or a perforation. Two independent observers (JC and CB) were involved in the data collection.

Statistical analysis

All *p*-values are two-sided and a significance level of $p=0.05$ was used. Sensitivity and specificity in diagnosing acute appendicitis and negative appendicectomy rates were calculated independently for CT and US for both 1999 and 2009 cohorts. To evaluate the influence of radiological investigations on the incidence of negative appendicectomy, negative appendicectomy rates were calculated for subgroups of patients who had undergone US, CT or no radiological investigations.

For univariate analysis, dichotomous data were analysed using the Fisher's exact or chi-square tests; parametric continuous data were analysed using the Student's t-test and non-parametric continuous data were analysed with the Mann–Whitney U test. To exclude confounding effects of demographic and other variables, multivariate analysis was performed using a binary logistic regression analysis. A forward variable selection procedure was used, incorporating variables significant in univariate analysis. Inclusion in the model required a significance level of $p \leq 0.1$. The threshold for statistical significance was set at $p \leq 0.05$. Analyses were performed using PASW® Statistics version 18.0 (SPSS Inc, Chicago, IL, US).

Results

The study comprised 273 patients of which 109 underwent appendicectomy in 1999 and 164 in 2009. Patients in both groups were similar in regard to their age (1999: mean age 27 years, standard deviation [SD] 12 years; 2009: mean age 28.5 years, SD 15.2 years; $p=0.445$) and the female-to-male ratio (1:1.18 in 1999 vs 1:1.87 in 2009, $p=0.903$).

Operative details

Of the 109 patients who were operated on in 1999, none had LA. Of the 164 appendicectomies performed in 2009, 67 (40.9%) were OA, 91 (55.5%) were LA and 6 (3.7%) were LA that converted to open operations. The rise in numbers of LA performed in 2009 was significant ($p<0.0001$).

In 2009 the negative appendicectomy rate for the laparoscopic group was 25.8% (25/97), compared to 16.5% (11/67) for the open group. The increased negative appendicectomy rate in the laparoscopic group may be explained by the increased use of laparoscopy as a diagnostic tool and the removal of normal appendices to prevent future complications. In 2009 the rate of perforation was 14.4% (14/97) in the LA group compared with 20.9% (14/67) in the OA group.

Ultrasonography

The mean age and female-to-male ratio of patients undergoing pre-operative US in both groups was similar (28.0 years [SD: 8.1 years] and 1:0.16 in 1999 vs 23.9 years [SD: 9.8 years] and 1:0.25 in 2009).

In 1999 US was performed for 22 patients. Six of these cases indicated the presence of acute appendicitis. US sensitivity was 35.7% and the specificity was 85.7%. The negative appendicectomy rate was not significantly different for patients who did or did not have pre-operative US (36.4% [8/22] vs 24.1% [21/87] respectively).

In 2009 US was performed for 49 patients. Almost half ($n=21$) of these cases indicated the presence of acute appendicitis. The sensitivity was 51.4% and the specificity was 78.6%. The negative appendicectomy rate was again similar regardless of whether the patients had or had not had pre-operative US (32.7% [16/49] vs 24.7% [28/115] respectively).

There was no significant difference in the overall use of US between 1999 and 2009 ($p=0.074$) but in both years US was used significantly more frequently ($p=0.028$) in those patients with a negative appendicectomy (possibly due to US being used as an investigation of choice in women or those with an equivocal diagnosis).

Computed tomography

There was no pre-operative CT performed in 1999. In 2009 42 patients received CT (mean patient age: 40.8 years, SD: 16.4 years), of which 39 (92.8%) demonstrated evidence of acute appendicitis. The sensitivity and specificity of CT in 2009 was 94.7% and 75.0% respectively. The negative appendicectomy rate in patients with pre-operative CT was 7.1% (3/42). CT was used significantly more in patients with histology proven appendicitis ($p=0.05$).

Histology

In 1999 post-operative histology revealed positive appendicitis in 73.4% of patients (80/109), no evidence of appendicitis in 25.7% of patients (negative appendicectomy rate in 28/109) and other significant pathology in 0.9% of patients (1/109). Almost a third of patients with acute appendicitis (30%, 24/80) had histological evidence of a perforation.

For the 2009 cohort, post-operative histology revealed positive appendicitis in 77.4% of patients (127/164) and no appendicitis in 12.8% of patients (negative appendicectomy rate in 21/164), with other significant pathology noted in 9.8% of patients (16/164).

The negative appendicectomy rate in 2009 was lower than that in 1999 although this difference failed to reach statistical significance (*p*=0.445). Twenty-seven patients with acute appendicitis revealed histological evidence of perforation, giving a perforation rate of 21.3% in 2009 compared to 30% (24/80) in 1999. Again, this difference was not statistically significant (*p*=0.308).

Univariate analysis revealed that the only variables predictive of negative appendicectomy were age and sex. Patients with a negative appendicectomy were significantly older in both cohorts (mean age: 29.4 years [SD: 14.1 years] vs 23.8 years [SD: 12.8 years], *p*=0.004). More male patients had positive appendicitis histology (*p*=0.046). Older age was associated with perforated appendicitis histology (mean age: 33.2 years [SD: 17.8 years] vs 26.9 years [SD: 12.7 years], *p*=0.018). The use of US and CT, and sex were not associated with a significant difference in the rate of perforated appendicitis histology (*p*=0.06, *p*=0.393 and *p*=0.263 respectively).

In multivariate analysis across both 1999 and 2009 cohorts, patient age was the only independent predictor of negative appendicectomy (OR: 1.031, 95% CI: 1.003–1.059, *p*=0.029) and perforated appendicitis (OR: 1.028, 95% CI: 1.006–1.051, *p*=0.014). The following variables were not significant: sex, pre-operative US and pre-operative CT.

A chi-square test revealed no significant difference in the negative appendicectomy rate between the 1999 and 2009 cohorts (*p*=0.445).

Post-operative complications

In 1999, 9.2% of patients (10/109) suffered from post-operative complications compared to 10.4% of patients (17/164) in 2009. Post-operative complications for OA affected 11.9% of patients (8/67) and LA post-operative complications affected 9.9% of patients (9/91) in 2009.

Discussion

Some studies have shown the benefit of US and CT in patients where the diagnosis is unclear, especially in older age groups and women.[9,10] Other authors feel that these investigations do not reduce negative appendicectomy rate[11] and may even lengthen the time to diagnosis and lead to increased perforation rates of the inflamed appendix.[11]

Diagnostic laparoscopy, especially in fertile women, can reduce the risk of negative appendicectomy.[8] In patients with complicated appendicitis, it has been shown to reduce the rate of surgical site infection without a difference in post-operative intra-abdominal abscess formation.[12] The advantages of LA in male patients are less clear with a randomised trial from 2010 demonstrating no advantages and even an increased operative time compared to OA.[13]

There was a greater reliance on radiological imaging of patients undergoing appendicectomy in 2009 compared with 1999. US was used more frequently in 2009 (29.9%) than in 1999 (20.2%) but the ability to diagnose appendicitis based on this investigation remained the same. There was no significant improvement in either the sensitivity (35.7% in 1999 vs 51.4% in 2009) or specificity (85.7% in 1999 vs 78.6% in 2009) of US for diagnosing acute appendicitis. The sensitivity and specificity of US is subject to influence from operator experience and ability. This is a factor that could unfortunately not be assessed due to the retrospective nature of this study. US may provide an added benefit in the diagnosis of other non-surgical causes of lower abdominal pain including pelvic inflammatory disease, ectopic pregnancies and ovarian cysts.

Overall, US was used more frequently in patients who had a negative appendicectomy (*p*=0.028). This may be a reflection of the popularity of US in patients with clinically equivocal signs and symptoms.

The fact that no CT was performed in the 1999 cohort and that 25% of patients suspected of having appendicitis had this investigation suggests a significant shift in surgical practice. We have to remember that patients undergoing CT are exposed to a significant dose of radiation, estimated at approximately 100–500 times those of conventional radiography, depending on the body part being imaged.[14] The risk of cancer from a single CT scan could be as high as 1 in 80 as shown in a recent study.[15]

Increased use of US and CT also has significant implications for the National Health Service in the UK, mainly because of the cost of CT itself. The argument of whether pre-operative imaging increases length of hospital stay as a result of waiting for the scan[16] or whether it reduces the time to diagnosis and therefore decreases the length of stay within the emergency department remains contentious.[17,18] Some studies in favour of CT describe the high sensitivity as a positive factor in reducing the cost associated with negative appendicectomy.[19] In our study, however, CT produced no reduction in either the negative appendicectomy rate (*p*=0.445) or the incidence of perforated appendicitis (*p*=0.393). This finding adds strength to the argument against indiscriminate use of this imaging modality. Our study therefore showed that increased use of both CT and US over this ten-year period did not improve the diagnostic accuracy of clinicians in detecting acute appendicitis.

A further interesting observation was that no LA was performed in 1999 compared with 91 procedures in 2009. Laparoscopy significantly adds to the cost of managing acute appendicitis in that it uses a number of high cost disposable instruments not employed in OA and it takes longer to perform. We have shown no statistically significant improvement in the negative appendicectomy rate between patients undergoing OA or LA (*p*=0.445). The OA post-operative complication rate was similar to that of LA (11.9% vs 9.9%). We therefore conclude that LA does not produce a diagnostic or therapeutic advantage over OA.

The total negative appendicectomy rate reduced from 26% in 1999 to 13% in 2009. However, this finding did not reach statistical significance. This may be the result of a type II statistical error that is associated with comparative studies such as the one presented here. The retrospective character of this study imposed certain limitations on the type of data available and the strength of our conclusions.

Nevertheless, we believe that its main strength is to reflect on 'real life' surgical practice and it significantly contributes to what is known about the current management of acute appendicitis. Analysing two cohorts of patients who underwent appendicectomy ten years apart showed significant increased use of US, CT and laparoscopy. In our study, however, these changes had no impact on negative appendicectomy rates or the incidence of appendiceal perforation and neither did they affect post-operative complication rates. The real benefit of radiological investigation may lie in the exclusion of appendicitis and diagnosis of other pathology.

Conclusions

This study has shown that over the past ten years there has been an increased use of expensive pre-operative investigations. However, these have failed to translate into an improvement in the diagnosis and management of acute appendicitis. Members of the medical profession must constantly evaluate the investigations readily available to them and whether they are both necessary and cost-effective in the setting of acute appendicitis.

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