Impact of the Increased Use of Preoperative Imaging and Laparoscopy on Appendicectomy Outcomes

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Abstract The diagnosis of appendicitis is based on clinical picture. The aim of this retrospective study was to analyse variation of outcomes and impact of increasing use of radiological investigations and laparoscopy over a 5-year period. A retrospective audit of appendicectomies over the last 5 years (01 January 2007–31 December 2011) was conducted. The negative appendicectomy rate (NAR), perforation rate and complication rate were used as outcome endpoints. A statistical analysis was performed to evaluate the difference in outcomes with surgical approach and use of radiology. One thousand fifty-five appendicectomies were performed in this period. The NAR was 22.65 % (21 % for open and 28 % for laparoscopic) and perforation rate was 14 %. There was no statistically significant difference in NAR with the use of ultrasound (P 0.3814) but there was a significant reduction in NAR with the use of computed tomography (CT) (P <0.0001). Intra-abdominal abscess (2.3 %) and wound infection (1.4 %) were the common complications with the former being higher with laparoscopy and the latter with open appendicectomy. Over 5 years, there were no significant changes in appendicectomy outcomes. The impact of diagnostic imaging on NAR varies with age, gender and the use of CT. CT can significantly reduce the negative appendicectomy rate in equivocal presentations. Complication rates vary with surgical approach.

Keywords Appendicectomy · Treatment outcome · Ultrasound · Computed tomography · Laparoscopy

Introduction

The inflamed appendix is both a surgical emergency, as well as a diagnostic dilemma for the operating surgeon. It accounts for roughly 40,000 hospital admissions per year in England [1]. The diagnosis is based on clinical grounds on the patient's medical history and the physical examination, with laboratory and radiological investigation supporting the diagnosis [2]. The decision to operate is predominantly a clinical one involving a delicate balance between ruling out false-positive cases (low negative appendicectomy rate) and reducing the incidence of perforations due to delayed decision to operate.

An average negative appendicectomy rate of 26 % (16–47 %) has been reported when the diagnosis is based on clinical and laboratory findings alone. However, the addition of radiological investigations reduces the rate to 6–10 % [3]. Radiological investigations include ultrasound, computed tomography and magnetic resonance imaging. Appropriate use of these imaging techniques helps to avoid delay in treatment, prolonged hospitalisation and unnecessary surgery.

Ultrasound is a relatively safe, inexpensive and widely available imaging modality. The accuracy of ultrasound in diagnosing appendicitis is highly variable (sensitivity 36–88 %, specificity 83–99 %) [3]. Ultrasound is limited because it is operator dependant and usually fails to provide adequate radiological information in obese patients. It is particularly useful for ruling out gynaecological causes of lower abdominal pain in women within the reproductive age, by visualising pelvic structures such as the ovaries (torsion, haemorrhage), fallopian tube (ectopic), etc. Magnetic resonance imaging scan can be used if ultrasound fails

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to diagnose the condition and the patient cannot be put through a computed tomography (CT) scanner because of renal failure/adverse effects of radiation (pregnancy) [4].

CT has been shown to be highly accurate in diagnosing acute appendicitis (sensitivity 91–100 %, specificity 83–99 %) [3]. Limitations include exposure to radiation and intolerance to intravenous dye. Most institutions use ultrasound as the initial imaging modality, followed by CT if sonographic diagnosis is uncertain. This approach seems to have excellent accuracy, with reported sensitivity of 94–99 % and specificity of 94–95 % [4].

Laparoscopy provides a method of direct visualisation of the appendix and other intra-abdominal structures that may be the cause of acute lower abdominal pain. It also enables operative intervention, if required. Laparoscopic appendectomy has improved diagnostic accuracy and wound complication rate compared with the open procedure. Controversy still exists regarding the advantages of this approach in hastening postoperative recovery and in the management of complicated appendicitis [5].

The aims of this study were to observe the pattern of variation in the diagnostic and therapeutic practice of appendectomy over the past 5 years and to assess the utility of various radiological investigations as well as laparoscopy in the management of appendicitis.

Methods

Macclesfield District General Hospital is a medium-sized district general hospital with around 48,000 accident and emergency attendances a year, leading to around 23 % of patients admitted to various specialties. Appendicitis is one of the leading causes for surgical admissions along with bowel obstruction. The management of appendicitis follows standard practice with the diagnosis being a clinical one and laparoscopy and diagnostic imaging used to aid diagnosis in equivocal presentations. Open appendectomy is still the major surgical approach, with laparoscopy used in certain equivocal cases (most commonly women of child bearing age), as well as only in the presence of experienced surgeons. There has been an increased use of diagnostic imaging and laparoscopy over the years.

A retrospective audit of appendectomies performed over the last 5 years was conducted (1 January 2007–31 December 2011). Preoperative data collected included patients' demographics and use of preoperative radiological investigations. Ultrasound and CT findings were classified as normal, indicative of acute appendicitis or other diagnoses. Intra-operative data included surgical technique (laparoscopic or open). Post-operative data included complications (defined as a surgical complication, which urged the patient to reattend the hospital, requiring treatment) and histopathological findings of

abnormal appendix, acute appendicitis, perforation or miscellaneous conditions of the appendix mimicking appendicitis. Patients undergoing an appendectomy were stratified by age, sex and surgical approach (open or laparoscopic) in order to measure the association between the use of ultrasound, CT and laparoscopy and the outcome of appendectomy. The negative appendectomy rate, perforation rate and complication rate were used as outcome endpoints. The data collection was divided among four investigators (AS, MA, LC, CA) and verified by two independent investigators (AS, MA).

Statistical Analysis

The data were segregated based on age, sex, use of ultrasound, CT and surgical approach. The negative appendectomy rate and perforation rates were calculated for each group.

Using GraphPad software, the Chi square test with two-tailed *P* values was used to investigate if there was a significant difference in negative appendectomy rates between

1. Patients who underwent ultrasound compared with those in whom no radiological investigation was used (in equivocal presentations).
2. Patients in whom CT was performed compared with those in whom CT was not performed (in equivocal presentations).

A *P* value of <0.05 was used to denote significance. Sensitivity and positive predictive value of the pathological and radiological tests were also computed. Specificity was not considered, as true negatives were not known because only patients who underwent appendectomy were considered. No statistical analysis could be performed comparing negative appendectomy rate (NAR) for open vs laparoscopic appendectomy, as all appendices were removed laparoscopically if no other intra-abdominal pathology was found irrespective of macroscopic appearance.

Results

The study comprised 1,055 patients over the 5 years. The male to female ratio was 1:1.2. The patients' characteristics are as described in Table 1.

The overall negative appendectomy rate was 22.56 % (21 % for open and 28 % for laparoscopic appendectomy). Appendectomy rate according to age and sex is shown in Table 1. The overall perforation rate was 14 %. On retrospective review, 481 patients had an equivocal presentation as shown (older age of presentation, 304; modified Alvarado score <7, 257). Ultrasound scan was used in 348

Table 1 Demographic characteristics of patients

Sex	Age	Total number	Operative approach		Histopathology			Negative appendectomy rate (%)
			Open	Laparoscopic	Inflamed	Normal	Misc.	
Female	>60	54	47	7	45	6	3	11.11
	16–60	349	306	43	236	113	0	32.37
	<16	152	142	10	101	42	9	19.7
Males	>60	41	33	8	33	6	2	14.63
	16–60	307	292	15	263	42	2	13.68
	<16	152	145	7	115	30	7	19.73

patients and 86 of them proceeded to have a CT scan of the abdomen. Seventy patients underwent CT scan directly without awaiting ultrasound. One hundred and forty-three patients underwent laparoscopy with 90 of them proceeding to appendectomy. The remaining (965) underwent an open approach. All patients who had laparoscopy and where no other cause intra-abdominal pathology was found underwent an appendectomy irrespective of the macroscopic appearance of the appendix. The laparoscopic approach was used more in women in the age group of 16–60 years. The variation of the negative appendectomy rate and perforation rates with regard to the use of radiological imaging and laparoscopy over the years can be seen in Fig. 1. It was interesting to note that the negative appendectomy rate was significantly reduced in patients who presented with an equivocal picture and who underwent CT scanning (2.5 %, $P=0.0001$).

The accuracy of the ultrasound and CT scan in patients presenting with an equivocal presentation is shown in Table 2. Comparison of the NAR between patients undergoing ultrasound and those who did not have any radiological investigation, and between those who had CT against those who did not have CT, is shown in Table 3. The various

histopathological conditions that mimicked appendicitis are shown in Table 4.

Wound infection and intra-abdominal abscess were the most common complications post-appendectomy in our study (Table 5). Other miscellaneous complications included wound dehiscence (two patients) and stump appendicitis (one patient).

Discussion

Although several studies have demonstrated the benefits of both ultrasound and CT in the diagnosis of appendicitis, only few comment on their impact on the negative appendectomy rate with increasing use over time. This study has looked at a relatively large number of patients undergoing appendectomy (1,055) and analysed the clinical outcomes over a 5-year period. In our centre, the present study has enabled us to provide evidence to change the practice from increasing use of ultrasound and diagnostic laparoscopy (in patients other than women of reproductive age) to the use of CT for the diagnosis of appendicitis in equivocal cases.

Fig. 1 Variation in practice over the years. Values in the y-axis are in percentage

Table 2 Accuracy of the various pathological and radiological tests

Sample no.	Test	Sensitivity (%)	Positive predictive value
1	Ultrasound	32.6	0.28
2	CT	97	0.97

Our study showed that CT significantly reduced the negative appendectomy rate. A recently conducted meta-analysis by Krajewski et al. [6] echoed this. CT was used more commonly in elderly patients (both male and female). Negative appendectomy rate was significantly lower in patients who underwent CT. This indicates the benefit of the use of CT in equivocal cases, and the potential benefit in reducing the overall negative appendectomy rate. On the basis of the data acquired, around five CT scans could potentially prevent one additional negative appendectomy. Although this may mean more exposure to radiation and an increased cost, it needs to be weighed against the effect of a negative appendectomy.

Ultrasound was used more commonly in women (more between 16 and 60). Although the accuracy to diagnose appendicitis was more in males, it did not vary with age in either sex. Ultrasound as a diagnostic modality is not as sensitive as CT, since more cases of appendicitis are missed if the decision is only based only on ultrasound findings. However, the false-positive rate of ultrasound is similar to CT. In addition, the results showed that the negative appendectomy rate was not significantly lower in patients who underwent ultrasound, compared with those who did not undergo any radiological investigation. This reflects the practice of using ultrasound to rule out gynaecological conditions rather than to diagnose appendicitis by surgeons.

Although the proportion of patients undergoing radiological investigations increased over the 5-year period, this did not reflect an overall significant decrease in negative appendectomy rate. This could be due to the fact that in our hospital the percentage of people undergoing a CT scan (<12 %) and an ultrasound scan (32.3 %) was still quite low compared to larger number in other studies.

The negative appendectomy rate was on average 22.65 %. This is similar to the rates mentioned in literature [7–10]. The rate was higher in women of reproductive age

Table 3 Chi square and *P* values for comparison of NAR in equivocal presentations

Parameters	Chi square value	<i>P</i> value
Patients with ultrasound and without any radiological investigation	2.575	0.1086
Patients with and without CT	22.932	0.0001

Table 4 Conditions mimicking appendicitis

Sample no.	Condition	Number
1	Carcinoid tumour	5
2	Adenocarcinoma	4
3	Pin worm infection	8
4	Faecalith	6

(32.8 % in this age group vs 18.9 % in the remainder of the population; $P=0.023$), as reflected in other studies [8]. This can be attributed to the difficulty in clinically differentiating the cause for lower abdominal pain in this group of patients. Even with a normal ultrasound scan, gynaecological conditions cannot be ruled out and further radiological/laparoscopic investigation is warranted.

Laparoscopic appendectomy has been shown to have lower postoperative pain and earlier return to work, but slightly longer operative times in uncomplicated appendicitis [5]. Complication rates were comparable, except that wound infections were slightly lower after laparoscopic appendectomy. However, deep pelvic abscesses were twice as frequent in the laparoscopic approach, which was similar to the findings in our study. Although laparoscopy enables direct visualisation of the appendix with minimal access, controversies exist regarding whether a normal looking appendix should be removed without any other pathology in the abdomen. As all such appendices were removed, this, in the author's opinion, contributed to the higher NAR in patients undergoing laparoscopy. Guidelines need to be designed to guide surgeons on the use of diagnostic laparoscopy for appendicitis.

There are a few limitations to the study. The study was retrospective in nature. The diagnosis of appendicitis and indications for investigation/treatment (or approach) were hence not standardised. The statistical conclusions (accuracy, statistical difference) are reflective of previous practice in an “uncontrolled” environment and may not reflect the exact values as would be obtained by a controlled prospective trial. However, day-to-day clinical practice is not in a controlled environment, and hence these results potentially

Table 5 Complications following appendectomy

Operative approach	Age	Abscess formation (%)	Wound infection (%)
Open	<16	0	1.2
	>16	1.6	1.3
Laparoscopic	<16	0	0.6
	>16	4.5	0.5

give a more realistic reflection of the utility of these diagnostic modalities. Complication rates were considered based on re-attendance to hospital, which potentially misses out minor complications (such as minor wound infections). However, the major complications have been accounted for. As mentioned in the “Methods” section, no statistical analysis could be performed comparing NAR for open vs laparoscopic appendectomy, as all appendices were removed laparoscopically if no other intra-abdominal pathology was found irrespective of macroscopic appearance.

Conclusion

The negative appendectomy rates and perforation rates in our hospital for over 5 years (1055 patients) were 22.56 % (21 % for open and 28 % for laparoscopic appendectomy) and 14 %, respectively, similar to those reported in other studies even though the use of CT and laparoscopy is quite low compared with other centres. The negative appendectomy rate varied significantly with age and sex of the patient, but did not vary overall with the increased use of imaging or laparoscopy. The rate was, however, significantly reduced in patients undergoing CT scan for suspected appendicitis, whereas the use of ultrasound did not alter the diagnosis significantly. Intra-abdominal abscesses were more common in the laparoscopic approach and wound infections were more common in the open approach. Increased use of CT scan may be warranted over the increased use of ultrasound or diagnostic laparoscopy in order to

diagnose appendicitis more accurately and to avoid unnecessary surgery.

References

1. Main procedures and interventions: summary. Hospital Episode Statistics. <http://www.hesonline.nhs.uk/Ease/servlet/ContentServer?siteID=1937&categoryID=204> Accessed 24 Jan 2013
2. Birchley D (2006) Patients with clinical acute appendicitis should have pre-operative full blood count and C-reactive protein assays. *Ann R Coll Surg Engl* 88:27–32
3. Gaitini D (2011) Imaging acute appendicitis: state of the art. *J Clin Imaging Sci* 1:49, Epub 2011 Oct 7
4. Rybkin AV, Thoeni RF (2007) Current concepts in imaging of appendicitis. *Radiol Clin North Am* 45:411–422
5. Korndorffer JR Jr, Fellingner E, Reed W (2010) SAGES guideline for laparoscopic appendectomy. *Surg Endosc* 24(4):757–761, Epub 2009 Sep 29
6. Krajewski S, Brown J, Phang PT, Raval M, Brown CJ (2011) Impact of computed tomography of the abdomen on clinical outcomes in patients with acute right lower quadrant pain: a meta-analysis. *Can J Surg* 54(1):43–53
7. Flum DR, Morris A, Koepsell T, Dellinger EP (2001) Has misdiagnosis of appendicitis decreased over time? A population-based analysis. *JAMA* 286(14):1748–1753
8. Flum DR, Koepsell T (2002) The clinical and economic correlates of misdiagnosed appendicitis: nationwide analysis. *Arch Surg* 137(7):799–804
9. Sauerland S, Jaschinski T, Neugebauer EA (2010) Laparoscopic versus open surgery for suspected appendicitis. *Cochrane Database Syst Rev* 6(10), CD001546
10. Aziz O, Athanasiou T, Tekkis PP, Purkayastha S, Haddow J, Malinowski V, Paraskeva P, Darzi A (2006) Laparoscopic versus open appendectomy in children: a meta-analysis. *Ann Surg* 243(1):17–27