Cost-effectiveness of routine imaging of suspected appendicitis

N D'Souza¹, M Marsden^{1,2}, S Bottomley¹, N Nagarajah¹, F Scutt¹, S Toh¹

¹Department of General Surgery, Queen Alexandra Hospital, Portsmouth, UK

²Academic Department of Military Surgery and Trauma, Royal Centre for Defence Medicine, London, UK

ABSTRACT

INTRODUCTION The misdiagnosis of appendicitis and consequent removal of a normal appendix occurs in one in five patients in the UK. On the contrary, in healthcare systems with routine cross-sectional imaging of suspected appendicitis, the negative appendectomy rate is around 5%. If we could reduce the rate in the UK to similar numbers, would this be cost effective? This study aimed to calculate the financial impact of negative appendectomy at the Queen Alexandra Hospital and to explore whether a policy of routine imaging of such patients could reduce hospital costs.

MATERIALS AND METHODS We performed a retrospective analysis of all appendectomies over a 1-year period at our institution. Data were extracted on outcomes including appendix histology, operative time and length of stay to calculate the negative appendectomy rate and to analyse costs.

RESULTS A total of 531 patients over 5 years of age had an appendectomy. The negative appendectomy rate was 22% (115/531). The additional financial costs of negative appendectomy to the hospital during this period were £270,861. Universal imaging of all patients with right iliac fossa pain that could result in a 5% negative appendectomy rate would cost between £67,200 and £165,600 per year but could save £33,896 (magnetic resonance imaging), £105,896 (computed tomography) or £132,296 (ultrasound) depending on imaging modality used.

CONCLUSIONS Negative appendectomy is still too frequent and results in additional financial burden to the health service. Routine imaging of patients with suspected appendicitis would not only reduce the negative appendectomy rate but could lead to cost savings and a better service for our patients.

KEYWORDS

Appendectomy – Appendicitis – Diagnostic imaging – Outcome assessment

Accepted 5 June 2017

CORRESPONDENCE TO

Nigel D'Souza, E: mrnigeldsouza@gmail.com

Introduction

Acute appendicitis should be a clinical diagnosis. In the UK, however, the diagnosis of appendicitis is incorrect in one in five patients. At 21%, the UK negative appendectomy rate is higher than expected in a developed healthcare system.¹ The practice of selective rather than universal preoperative imaging may contribute to the high rate in the UK. Established imaging techniques such as ultrasound, computed tomography (CT) and magnetic resonance imaging (MRI) are diagnostic adjuncts that are correlated with a reduced negative appendectomy rate in other developed healthcare systems. In the US and the Netherlands, routine imaging is associated with a reduction in the negative appendectomy rate to 4.5% and 3.3%, respectively.^{1,2} The immediate costs of imaging studies can be a barrier to their routine use in the investigation of patients with suspected appendicitis. On the other hand, we often underestimate the costs of a negative appendectomy. It is therefore possible that

considerable healthcare savings could be made within the NHS if the negative appendectomy rate is reduced. In this study, we aimed to determine the incidence and the associated financial impact of negative appendectomy at Queen Alexandra Hospital using NHS tariffs. We sought to determine whether routine cross-sectional imaging of patients with suspected appendicitis could reduce the costs and remain safe for our patients.

Materials and Methods

We performed a retrospective analysis of appendectomies between 1 October 2013 and 30 September 2014. Patients were identified from the electronic theatre record and matched to their hospital *International Statistical Classification of Diseases and Related Health Problems* coding data and an electronic pathology database. Patient data included demographic details, preoperative blood results, type of operation (open or laparoscopic), operative time (minutes),

Table 1 Patients who underwent appendicectomy

	Patients <i>n</i> (%)
Total	531
Female sex	251 (47)
Age, median (IQR) years	28.5 (18–45)
Under 18 years ^a	110 (23)
Preoperative ultrasound	228 (43)
Preoperative computed tomography	22 (4)

^a Data from 484 patients.

appendix histology and length of stay (days). The number of patients seen with suspected appendicitis was derived from a previous departmental audit (Dabare *et al.*, unpublished data) on all patients presenting with right iliac fossa pain to our hospital and was estimated at 1200 patients per year.

To calculate the associated financial costs, we analysed length of stay and operative time. Operative time was costed using a previously published estimate of £16 per minute.³ The costs of consumables, including laparoscopic equipment, were not estimated. The financial costs of length of stay were approximated from *NHS Reference Costs 2014–2015* for non-elective bed days for patients post-appendicectomy.⁴ To keep our estimations conservative, we used the cheapest daily bed stay tariff for adult and paediatric patients with no comorbidities, which are £298.76 and £510.41, respectively. We assumed that the negative appendicectomy rate would only decrease to approximately 5%, consistent with Dutch and American results.^{1,2}

The study was conducted at Queen Alexandra Hospital NHS Trust, a 1250-bed acute District General Hospital in Portsmouth, UK. All patients were seen by the emergency general surgery team following referral from the emergency department or a general practitioner. The decision to operate was made by a consultant general surgeon or surgical

registrar based on clinical findings, serum white cell count, serum C-reactive protein and selective ultrasound. Continuous data were expressed as mean (standard deviation) if normally distributed data or as median (25th percentile, 75th percentile) if not normally distributed. Comparisons were made between groups with Mann-Whitney U test or independent samples T-test as appropriate. Categorical data were expressed as numbers (percentages). Statistical significance was accepted at *P* less than 0.05. All calculations were performed with IBM SPSS Statistics version 22.0.

Results

Five hundred and thirty-one patients, aged 5-years and above, had an appendicectomy during the year and were included in this study. The demographics of these patients are summarised in Table 1. The negative appendicectomy rate was 22% (115/531) in all patients and 15% (14/108) in the paediatric cohort (age 6–17 years). Of the total, 85% of patients underwent laparoscopic surgery, 2% patients had laparoscopic surgery converted to open and 6% patients underwent open surgery. The mode of access was unknown in the remaining 7%. The median white cell count and C-reactive protein were significantly higher in the appendicitis group. Median theatre time (door to door) and operating time (skin to skin) were also significantly longer for patients with appendicitis compared with patients in whom histologically normal appendices were removed but anaesthetic time and hospital stay were not significantly different between the two groups (Table 2).

If the negative appendicectomy rate was reduced from 22% to 5%, the estimated total hospital costs for these patients would be reduced from £262,581 to £63,085 per year in our institution (Table 3). Despite the additional costs of routine imaging of the estimated 1200 patients per year who present with right iliac fossa pain in our institution (so as to achieve the 5% negative appendicectomy rate), there will still be total hospital cost savings using any of the three modalities (ultrasound, CT or MRI) between £33,896 to £132,296 (Table 4).

Table 2 Comparison of patient undergoing surgery with or without appendicitis

	Appendicitis median (IQR)		P value
	Yes	No	
Preoperative inflammatory markers:			
White cell count (x 10 ⁹ /l)	13.6 (10.4–17.0)	9 (7.0–12.3)	< 0.01
C-reactive protein (mg/l)	54 (15–116)	10 (3–59)	< 0.01
Operative time: (minutes)			
Theatre	113 (90–132)	92 (77–103)	< 0.01
Skin–skin	68 (50–90)	51 (43–70)	< 0.01
Anaesthesia	25 (21–29)	23 (20–27)	ns
Length of stay (days)	2 (2–3)	2 (1–3)	ns

Table 3 Negative appendectomy costs

Costs	Negative appendectomy rate	
	Current (n = 115)	5% (n = 27)
Operation (92 minutes at £16/minute) (n)	115	27
Hospital stay:		
Adult (2.5 nights at £298.76/night) (n)	101	21
Paediatric (2.5 nights at £510.41/night) (n)	14	6
Total (£)	262,581	63,085

Discussion

This study postulates there may be financial savings to be made by routinely imaging all patients with suspected appendicitis. A negative appendectomy incurs costs to the hospital, including the costs of bed occupancy and operating theatre time. This study attempts to quantify both of those variables for a year's worth of appendectomies in our institution. We recognise that our analysis overestimates the need for imaging for all patients. In some patients clinical diagnosis alone is sufficient; for example, patients who are peritonitic need surgery often without imaging. The costs we have estimated are therefore likely to be excessive and the savings to be too conservative. Other costs are more difficult to capture. The costs of consumables, including laparoscopic equipment, were not calculated but would likely be less than £100 per patient and would incur additional savings if surgery was avoided. There are costs related to the treatment of postoperative complications both in hospital and in primary care. Postoperative complications for the removal of a histologically normal appendix are around 5–10%.⁵ Costs to the economy include the loss of earnings of a patient or their carers during their recovery following surgery.

In 2010, the negative appendectomy rate in the Netherlands was 15%. Consequently, guidelines that mandated imaging of all patients with suspected appendicitis prior to surgery were introduced.⁶ After implementation of the guidelines in 2014, Van Rossem *et al.*² audited the management of appendicitis at 62 Dutch hospitals. They demonstrated that the negative appendectomy rate had reduced to 3.5%.² These results are similar to the results of the Surgical Care and Outcomes Assessment Program (SCOAP)

study in the USA, where the negative appendectomy rate was reduced to 5.4% in 19,327 patients who underwent mandatory imaging.¹

Studies have shown that mandatory imaging can save costs.^{7,8} While clinicians may reserve the right to scan patients selectively based on their own clinical judgement, robust evidence demonstrates this approach results in a higher negative appendectomy rate compared with mandatory imaging (13.9% vs. 2.6%).⁹ The SCOAP study showed the odds ratio of negative appendectomy in non-imaged patients was 3.7. This mandatory imaging approach improves the service to patients with suspected appendicitis as it enables an early diagnosis which, in most patients, facilitates early surgery or discharge. This reduces the need for prolonged inpatient observation or repeat attendances.^{10,11}

Selection of an appropriate imaging modality can be challenging. CT is the first line investigation in the US. However, in the UK, the costs and perceived risks of radiation exposure from CT is a barrier to its routine use. This is particularly true in younger patients, where the cumulative risk is believed to be greater. The link between radiation dose of CT and risk of cancer was established in part based on data from the Biologic Effects of Ionizing Radiation VII report.¹² Estimates on cancer incidence from CT have been derived from follow up data on survivors of Hiroshima and Chernobyl. Other authors have made the point that extrapolating the carcinogenic effects from a nuclear disaster to a CT scan is contentious,¹³ although all clinicians agree that radiation is likely to be harmful and should be limited wherever possible. Similar concerns are held in Holland with regards to the radiation dose of CT² and, consequently, ultrasound is the first-line investigation

Table 4 Cost implications of routine imaging of all patients with right iliac fossa pain per year

Costs	Ultrasound	CT	MRI
Routine imaging (1200 patients)	£67,200	£93,600	£165,600
Routine imaging + 5% NAR	£130,285	£156,685	£228,685
Total savings in comparison to current practice (22% NAR)	£132,296	£105,896	£33,896

CT, computed tomography; MRI, magnetic resonance imaging; NAR, negative appendectomy rate.

for suspected appendicitis.⁶ Published studies of ultrasound for appendicitis have high experimental diagnostic accuracy¹⁴ but the same is not true in UK clinical practice,¹⁵ where ultrasound has been the first-line test in patients under the age of 40 years presenting with suspected appendicitis. Radiographers are involved in providing ultrasound for suspected appendicitis in the UK, while in the Netherlands this service is provided exclusively by radiologists. Given that ultrasound for appendicitis is an advanced skill, this may explain the poor diagnostic results in the UK versus the Netherlands. Within our study cohort, 231 patients underwent an ultrasound scan preoperatively. Ultrasound had a sensitivity of 77% and specificity of 61%, although the appendix was not visualised in 36% of cases. The sensitivity rose to 81% and appendix non-visualisation rate decreased to 11% with a specialist gastrointestinal consultant-provided service.¹⁶ We therefore believe that advanced training in and audit of gastrointestinal sonography is required to improve UK results.

MRI is an imaging technique that holds promise and is under review.¹⁷ It has a diagnostic accuracy equivalent to CT, without the radiation exposure. New MRI protocols have reduced on-table scan time to less than 3 minutes in children.¹⁸ However, MRI requires gastrointestinal radiology expertise to report, which is currently a scarce resource, particularly out of hours.

There are therefore challenges to implementing a mandatory imaging policy based on ultrasound (poor sensitivity), CT (radiation exposure) and MRI (lack of expertise and availability). The most feasible approach would be an adoption of the Dutch pathway: ultrasound as a first line test, followed by low-dose CT (in adults) or MRI (in paediatric or pregnant patients) if the ultrasound is negative or inconclusive.

Competing departmental priorities and complex reimbursement tariffs within the NHS currently inhibit the establishment of a mandatory imaging service. Provision of routine imaging slots may incur costs to a radiology department whose budget is not compensated with savings from emergency theatre provision or reduced inpatient stay. Reimbursement tariffs also mean that costs are not always clear. In other words, it may appear cheaper to a surgical departmental budget holder to remove a normal appendix than to avoid surgery with imaging, even if the hospital costs may be greater. An inadequately resourced policy of mandatory imaging may result in delays to theatre and, consequently, a longer length of stay or possibly more morbidity.

There are some rarely discussed and controversial benefits to a negative appendectomy. It can eliminate appendicitis as a cause of right iliac fossa pain and can enable early and safe discharge of patients following uncomplicated surgery. Anecdotally, some patients with right iliac fossa pain feel better following appendectomy, despite negative appendix histology. Whether this is due to a placebo effect or the mooted 'neuroimmune appendicitis' is unclear.¹⁹ Finally, laparoscopic excision of a normal appendix is frequently regarded as an ideal training case for our junior surgical trainees. We would contend that this reason

is no longer justifiable in modern surgical practice where patient safety is paramount and, thus, any imaging that avoids unnecessary surgery should be considered instead.

Conclusion

In summary, the negative appendectomy rate in the our institution appears to be too high. We have postulated that, in our institution, mandatory imaging of patients with right iliac fossa pain would not only reduce unnecessary appendectomies but also reduce hospital costs and provide a better service to our patients. We therefore recommend this approach should be more widely considered within the NHS. As a result of this analysis, we have implemented a new 'right iliac fossa pain' pathway at the Queen Alexandra Hospital that emphasises the importance of early imaging in our patients. We plan to re-audit the outcomes of this pathway to confirm if it leads to both a lower negative appendectomy rate and a more cost-effective service.

Ethics and Consent

Ethics approval was not required for this study. After approval by the hospital audit department, retrospective data were acquired as part of service improvement in appendicitis.

References

1. Drake FT, Florence MG, Johnson MG *et al*. Progress in the diagnosis of appendicitis: a report from Washington State's Surgical Care and Outcomes Assessment Program. *Ann Surg* 2012; **256** (4): 586–94.
2. van Rossem CC, Bolmers MD, Schreinemacher MH *et al*. Prospective nationwide outcome audit of surgery for suspected acute appendicitis. *Br J Surg* 2016; **103** (1): 144–151.
3. Shapter SL, Paul MJ, White SM. Incidence and estimated annual cost of emergency laparotomy in England: is there a major funding shortfall? *Anaesthesia* 2012; **67** (5): 474–478.
4. Department of Health. *Reference Costs 2014–15*. London: Department of Health; 2015.
5. National Surgical Research Collaborative. Multicentre observational study of performance variation in provision and outcome of emergency appendectomy. *Br J Surg* 2013; **100** (9): 1,240–1,252.
6. Bakker OJ, Go PM, Puylaert JB *et al*. [Guideline on diagnosis and treatment of acute appendicitis: imaging prior to appendectomy is recommended]. *Ned Tijdschr Geneeskde* 2010; **154**: A303.
7. Rao PM, Rhea JT, Novelline RA *et al*. Effect of computed tomography of the appendix on treatment of patients and use of hospital resources. *N Engl J Med* 1998; **338** (3): 141–146.
8. Boonstra P, van Veen R, Stockmann H. Less negative appendectomies due to imaging in patients with suspected appendicitis. *Surg Endosc* 2015; **29** (8): 2365–2370.
9. Lee CC, Golub R, Singer AJ *et al*. Routine versus selective abdominal computed tomography scan in the evaluation of right lower quadrant pain: a randomized controlled trial. *Acad Emerg Med* 2007; **14** (2): 117–122.
10. Cobben L, Groot I, Kingma L *et al*. A simple MRI protocol in patients with clinically suspected appendicitis: results in 138 patients and effect on outcome of appendectomy. *Eur Radiol* 2009; **19** (5): 1,175–1,183.
11. Heverhagen JT, Pfestroff K, Heverhagen AE *et al*. Diagnostic accuracy of magnetic resonance imaging: a prospective evaluation of patients with suspected appendicitis (diamond). *J Magn Reson Imaging* 2012; **35** (3): 617–623.
12. Committee to Assess Health Risks from Exposure to Low Levels of Ionizing Radiation. *Health Risks from Exposure to Low Levels of Ionizing Radiation. BEIR VII Phase 2*. Washington DC: National Academies Press; 2006.

13. Hendee WR, O'Connor MK. Radiation risks of medical imaging: separating fact from fantasy. *Radiology* 2012; **264** (2): 312–321.
14. Rettenbacher T, Hollerweger A, Gritzmann N *et al*. Appendicitis: should diagnostic imaging be performed if the clinical presentation is highly suggestive of the disease? *Gastroenterology* 2002; **123** (4): 992–998.
15. D'Souza N, D'Souza C, Grant D *et al*. The value of ultrasonography in the diagnosis of appendicitis. *Int J Surg* 2015; **13**: 165–169.
16. Scutt F, Marsden MER, D'Souza N *et al*. Right iliac fossa ultrasound: seniority of ultrasonographer is related to the rate of negative appendectomy. Poster no. C-2373. European Congress of Radiology 2016. http://postereng.netkey.at/esr/viewing/index.php?module=viewing_poster&pi=133992 (accessed 27 June 2017).
17. D'Souza N, Thaventhiran A, Beable R *et al*. Magnetic resonance imaging (MRI) for diagnosis of acute appendicitis. *Cochrane Database Syst Rev* 2016; (1): CD012028.
18. Johnson AK, Filippi CG, Andrews T *et al*. Ultrafast 3-T MRI in the evaluation of children with acute lower abdominal pain for the detection of appendicitis. *AJR Am J Roentgenol* 2012; **198** (6): 1424–1430.
19. Di Sebastiano P, Fink T, di Mola FF *et al*. Neuroimmune appendicitis. *Lancet* 1999; **354** (9177): 461–466.