Ulster Med J 2019;**88(3):**25-28

Clinical Paper

Pre-Operative Imaging can Reduce Negative Appendectomy Rate in Acute Appendicitis

Jeremy Chan[1], Ka Siu Fan[2], Tsz Lun Allenis Mak[2], Sook Yin Loh[1], Stephanie Wai Yee Ng[1], Ravi Adapala[1]

Accepted: 30th May 2019
Provenance: externally peer reviewed.

Keywords: Acute appendicitis, Routine Imaging, Negative appendectomy rate

ABSTRACT

Introduction: Acute appendicitis is a common surgical emergency, with a prevalence of 112 per 100,000 people per year in Europe. Negative appendicectomy is defined as a pathologically normal appendix removed from patient suspected with appendicitis. Negative appendectomy rate (NAR) has been reported to be around 15-25%. We aimed to evaluate our unit's negative appendectomy rate and the effect of pre-operative imaging on NAR.

Method: A retrospective study including all patients who underwent both open and laparoscopic emergency appendicectomy in a single district general hospital from 2017-2018. Clinical information including cost was calculated based on the 2017/18 national tariff payment system. Patients under 18 years old were excluded from this study.

Results: Two hundred thirty-two patients were included in this study, of which 69 (29.74%) had a pre-operative CT scan. The mean length of stay was 2.57 days. The sensitivity, specificity, positive predictive value and negative predictive value for CT were 77.8%, 100%, 87.5% and 100%. The negative appendicectomy rate with and without pre-operative CT scan were 7.25% and 22.09% respectively. Based on the 2017/18 national tariff payment system, a CT abdomen and pelvis with contrast and emergency appendicectomy with CC score of 0 cost 92 and 2370 pounds respectively. The total cost of patients who underwent appendicectomy without imaging was £ 322,320. If all patients undergo pre-operative CT, with a reduction of 15% in negative appendicectomy rate, the overall total cost would significantly lower to £ 36,212.

Conclusion: Our study demonstrated that the negative appendicectomy rate could be improved by preoperative imaging. The study also showed that implementation of preoperative imaging for suspected appendicitis cases could save costs, allowing better allocation of resources.

INTRODUCTION

Acute appendicitis is a common surgical emergency, with a prevalence of 112 per 100,000 people per year in Europe[1]. In England alone, it accounts for more than 40,000 hospital admissions annually.[2] Appendicitis is defined by the presence and spreading of inflammation within the inner lining of the vermiform appendix. Its presentation varies with severity but typically includes anorexia, nausea, vomiting and migration of central abdominal pain to the right iliac fossa.[3] Early diagnosis and prompt appendicectomy are crucial to prevent significant increases in morbidity and mortality.[3,4]

Appendicitis is typically diagnosed through clinical presentation and physical examination. It is also important to note that patients at extremes of age can present with atypical and non-specific symptoms, thus, requiring a high index of suspicion.[4] Nonspecific abdominal pain and gynaecological causes in young females can present with similar symptoms. When assessing cases, it is essential to consider potential benefits in implementing imaging: the theorised benefits can be evaluated by measuring negative appendicectomy rate (NAR). NAR is defined as the incidence of pathologically normal appendices removed from patients suspected of having appendicitis.[5] NAR has been reported to be 15-25% previously and evidence suggests that it can be lowered through preoperative imaging.[5] This can, in turn, prevent unnecessary postoperative complications and costs.

The current diagnostic accuracy for appendicitis lies between 76% and 80%, translating to approximately 20% NAR in the UK without preoperative imaging.[6,7] The UK rate of NAR is significantly higher than in the US and Netherlands where imaging, including Ultrasound sonography (USS) and computed tomography (CT) are used routinely.[8,9] Through preoperative imaging, NAR can be lowered to reduce surgical complications, hasten discharge and healthcare costs.[8,10] We evaluated the use of liberal diagnostic imaging to improve

1. Department of Radiology, Wrexham Maelor Hospital, Wrexham, UK
2. St. George's, University of London, London, UK

Corresponding Author: Dr Jeremy Chan

E-mail: chanchunyu12@gmail.com

NAR and to investigate the cost-effectiveness of routine preoperative imaging in patients with suspected appendicitis in our institution.

METHOD

All patients who underwent both open and laparoscopic emergency appendicectomy in a single district general hospital from 2017-2018 were extracted from the theatre system. Information including Preoperative imaging, Inflammatory markers, post-operative appendix histology, length of stay and readmission (if applicable) are collected. The cost of hospital stay was calculated based on the 2017/18 national tariff payment system. Patients under 18 years old were excluded from this study.

RESULTS

Two hundred thirty-two patients were included in this study, of which 69 (29.74%) had a pre-operative CT scan. The mean length of stay was 2.57 days. The sensitivity, specificity, positive predictive value and negative predictive value for CT were 77.8%, 100%, 87.5% and 100%. The negative appendicectomy rate with and without pre-operative CT scan were 7.25% and 22.09% respectively. Based on the 2017/18 national tariff payment system, a CT abdomen and pelvis with contrast and emergency appendicectomy with CC score of 0 cost 92 and 2370 pounds respectively. The total cost of patients who underwent appendicectomy without imaging was £ 322,320. If all patients undergo pre-operative CT, with a reduction of 15% in negative appendicectomy rate, the overall total cost would significantly lower to £ 36,212.

DISCUSSION

Appendicitis is a common cause of abdominal pain, with a lifetime risk of up to 7-8%.[11] While many present with the classic signs, those with atypical presentation present diagnostic uncertainty. Furthermore, routine laboratory markers such as C-reactive protein (CRP) and polymorphonuclear cells (WCC), are not 100% specific or sensitive.[12] The emergency general surgery guide produced by Association of Surgeons of Great Britain and Ireland (ASGBI) recommends that patients with suspected appendicitis, raised WCC or CRP should be sent for imaging or diagnostic laparoscopy.[11] Patients with normal WCC and CRP are considered unlikely to need appendicectomy and are managed conservatively or sent for additional imaging to rule out appendicitis.[11]

While acute appendicitis is an emergency, not all patients undergoing intervention have appendicitis. The hospital costs associated with negative appendicectomies include the operation, surgical consumables, hospital stays and postoperative recovery. A cost analysis of laparoscopic appendicectomy at a UK institution in 2009 revealed that the equipment costs ranged from £111 - £451 and theatre costs of £273 - £1333, producing a total median operative cost of £906.[13] With the addition of £220 per night in ward, this rises to a median total inpatient cost of £1632. This is similar to the 2017/18 national tariff payment system in which emergency appendectomy in patients without significant co-morbidity were coded as £2370. As these merely reflect the costs of the average stay 2.6 to 3.9 days, these figures would increase with complications.[14,15] Furthermore, complication rates of appendicectomies remained around 10% and were remarkably similar between positive and negative cases. Common complications include wound infection, abscesses, or hospital-acquired infections- these can be reduced by avoiding unnecessary surgery.[16,17]

Diagnostic imaging is increasingly used in investigation of right iliac fossa pain and has had success reducing NAR and complication rates.[11,18-20] This includes the most commonly used USS, CT and, less commonly, magnetic resonance imaging (MRI).[21] Mandatory preoperative imaging has been implemented with great success in the Netherlands and in a large multinational trial: NAR dropped from 15% to 3.3% across 62 Dutch hospitals (1975 patients), and NAR reduced to 5.4% in the US group (19327 patients).[22,23] The odds for negative appendicectomy without preoperative imaging was 3.7 (CI 3.0-4.4), even after adjusting for age, sex and white cell count.[23] These results are promising and warrant a review of the evidence to evaluate its implementation.

USS is widely accessible and is often the first line imaging modality used in investigating acute abdominal pain, with the diagnostic criteria being a non-compressible and non-peristaltic structure >6 mm in diameter.[4] A meta-analysis, of 2643 patients across 22 studies, calculated that USS offers a sensitivity of 86.7% (CI 85.4-88.0) and specificity of 90.0% (CI 88.9-91.2) and is generally considered useful, especially in younger populations and complex cases.[21,24,25] Efficacy of USS remains debatable as its specificity can be as low as 74% in other studies.[24] Yu et al. also calculated that the overall NAR with USS is 10.7%, compared to rates of 10%-20% without imaging.[25] The authors identified that preoperative USS might be useful for diagnosis, particularly effective in young, male sex and those with suggestive presentations. The primary limitation of USS is that it is heavily user-dependent; reliability and accuracy are limited by intra-observer variability, user experience and patient anatomy.[26]

Despite these drawbacks, a study of 228 cases on USS with optional CT use, found that preoperative imaging improved patient selection for surgery and effectively reduced NAR from 19% to 5%.[7] A similar study on the use of USS and/or CT reduced NAR from 13% to 7%.[24] While diagnostic performances were similar between USS and CT, CT was associated with a higher perforation rate: perforation rate for only surgery is 29%, 54% with CT (CI 8%-44%) and 71% with both USS and CT (CI 25%-67%). These differences may be attributed to the temporal delays but remain inconclusive as many clinical parameters were not accounted for. While the effects of USS on NAR are yet to be established, USS shows potential in reducing NAR without affecting perforation risk, but more investigation is needed to account for other variables.

The use of USS does not always offer a definite diagnosis of appendicitis and hence requires additional, complementary modalities such as CT or MRI. CT offers higher sensitivity and specificity, of 84% and 99% respectively, as well as reducing NAR from 13% to 5%.[24] The Surgical Care Outcomes and Assessment Program (SCOAP) collaborative in the US analysed a dataset of 20,000 patients across 60 hospitals and identified that preoperative imaging substantially improved NAR, where CT achieved statistically significant ($P < 0.001$) reduction in comparison to USS.[23] NAR with CT and USS in young adults were 4.6% vs 12% respectively, whereas it was 3.8% vs 8.6% for middle-aged populations. Another multi-centre study on preoperative CT saw significantly lower NAR compared to non-imaged groups (6.6% vs 20.6%, $P < 0.05$).[27] They also observed the vastly different CT utilisation (86.9%, 66.4% and 13.3%) across the centres which provided a statistically significant inverse correlation, rho= -1 ($P < 0.05$), between CT use and NAR. While in the UK, Stephenson et al has introduced a trial by performing a low dose contrast CT in raised inflammatory markers/ inconclusive USS group. They reported a significantly low NAR (4%) with no missed cases of appendicitis.[6]

Regardless of the benefits in reducing NAR, we should also consider the limitations, namely surgical delay and radiation. A UK cohort study of 2510 patients investigated the safety of in-hospital delays in acute appendicitis cases and did not find an association between timing of operation and risk of complicated appendicitis.[2,28] All the calculated ORs were statistically insignificant ($P > 0.30$): 12-24 hours OR 0.98; 24-48 hours OR 0.88; 48+ hours OR 0.82. Another study of 9048 adult appendicectomies, found the mean time from presentation to surgery to be 8.6 hours which was not a predictor of perforation risk (OR 1.0, CI 0.99-1.01).[2] These findings also agree with a meta-analysis of 11 non-randomised studies of 8858 patients; delay of 12-24 hours is not associated with increased complicated appendicitis (OR 0.97; $P = 0.750$).[29] However, delays of >48 hours were associated with increased wound infection and 30-days adverse events, with adjusted OR of 2.24 ($P = 0.039$) and 1.71 ($P = 0.024$) respectively.[28] As these diagnostic scans can be performed almost immediately, additional imaging is unlikely to subject patients to such risks.

Conversely, concerns with CT lies in its use of radiation and its limitation in specific patient groups such as children and pregnant women. This is important as appendicectomy is commonly performed on these groups who are particularly vulnerable to radiation. Appendicitis is both the most common non-obstetric surgical emergency and paediatric surgical emergency, affecting up to 2.1 per 1000 pregnancies and 23.3 per 10,000 10-19-year-olds.[4,24] Radiation dosage delivered by abdominal CT can range up to 10-20 mSv, equivalent to 500-1000 chest radiographs. With a higher portion of dividing cells, children are more radiosensitive and have longer for radiation-induced cancers to develop. An abdominal CT, at 240 mAs, on a patient at age 10 gives a 0.09-lifetime attributable risk of cancer, whereas the same radiation dose at age 35 would be 0.02.[30] Furthermore, a study attributed 1.5-2% of cancers in the US to CT radiation, highlighting the importance of reducing dosage during routine use.

Radiation doses can vary between institutions and countries. A study investigating CT doses, from 151 institutions across seven countries, revealed the median effective dose for abdominal CT to range between 5-32 mSV, where the UK mean was 7.9 mSv.[31] The findings suggest that dose variation is primarily attributed to protocol and machine parameters instead of clinical circumstances, hence, implementation of standardised doses may reduce radiation while maintaining sufficient diagnostic accuracy. In a study comparing high and low appendicitis CT doses (5.2 mSv vs 1.4 mSv in males and 7.1 mSv vs 2.2 mSv in females) no significant difference was found ($P>0.05$).[32] Promising results are achieved by reducing radiation dose using lower tube current, but it also increases image noise and can lower diagnostic accuracy.[33] Up to 22% of emergency abdominal CT resulted in the need for additional diagnostics due to incidental pathologies, including potential malignant adnexal, pulmonary and colorectal lesions.[34] In short, the lack of standardised CT dosage across institutions presents a barrier towards balancing radiation dose and diagnostic performance.

CONCLUSION

In conclusion, our study demonstrates that negative appendicectomy rate can be reduced significantly with the use of preoperative imaging. The clinical potential of various imaging modalities has been demonstrated by successful implementation in the Netherlands and offers a solution to unnecessary operations and expenditure. This study also showed that implementation of preoperative imaging for suspected appendicitis cases would be cost saving, allowing better allocation of resources. Further studies should focus on a standardised CT protocols to minimise the risk of radiation, especially in young adult and females.

Funding Statement: No funding obtained for this study

Disclosure: None

REFERENCES

1. Ferris M, Quan S, Kaplan BS, Molodecky N, Ball CG, Chernoff GW, *et al*. The global incidence of appendicitis: A systematic review of population-based studies. *Ann Surg*. 2017;**266(2)**:237-41.
2. Drake FT, Mottey NE, Farrokhi ET, Florence MG, Johnson MG, Mock C, *et al*. Time to appendectomy and risk of perforation in acute appendicitis. *JAMA Surg*. 2014;**149(8)**:837-44.
3. Baird DLH, Simillis C, Kontovounisios C, Rasheed S, Tekkis PP. Acute appendicitis. *BMJ*. 2017;**357**:j1703.
4. Humes DJ, Simpson J. Acute appendicitis. *BMJ*. 2006;**333(7567)**:530-4.
5. Raja AS, Wright C, Sodickson AD, Zane RD, Schiff GD, Hanson R, *et al*. Negative appendectomy rate in the era of CT: An 18-year perspective. *Radiology*. 2010;**256(2)**:460-5.
6. Stephenson J, Al-Nowfal A, Khatiwada AS, Lim Z, Norwood M, Verma R. Can imaging have a beneficial effect on reducing negative appendicectomy rates. *Clinical Radiology*. 2018;**73(Suppl 1)**:e21.
7. Boonstra PA, van Veen RN, Stockmann, HB. Less negative appendectomies due to imaging in patients with suspected appendicitis. *Surg Endosc*. 2015;**29(8)**:2365-70.

8. D'Souza N, Marsden M, Bottomley S, Nagarajah N, Scutt F, Toh S. Cost-effectiveness of routine imaging of suspected appendicitis. *Ann R Coll Surg Engl*. 2018;**100(1)**:47-51.

9. Lahaye MJ, Lambregts DM, Mutsaers E, Essers BA, Breukink S, Cappendijk VC, *et al*. Mandatory imaging cuts costs and reduces the rate of unnecessary surgeries in the diagnostic work-up of patients suspected of having appendicitis. *Eur Radiol*. 2015;**25(5)**:1464-70.

10. Lehtimäki TT, Valtonen H, Miettinen P, Juvonen P, Paajanen H, Vanninen R. A randomised clinical trial of routine versus selective CT imaging in acute abdomen: Impact of patient age on treatment costs and hospital resource use. *Eur J Radiol*. 2017;**87**:1-7.

11. Association of Surgeons of Great Britain and Ireland. Royal College of surgeons Advancing Surgical Standards. Commissioning Guide: Emergency general surgery (acute abdominal pain). London: Association of Surgeons of Great Britain and Ireland; 2014.

12. Mostbeck G, Adam E, Nielsen M, Claudon M, Clevert D, Nicolau C, *et al*. How to diagnose acute appendicitis: ultrasound first. *Insights Imaging*. 2016;**7(2)**:255-63.

13. Needham PJ, Laughlan KA, Botterill ID, Ambrose NS. Laparoscopic appendicectomy: calculating the cost. *Ann R Coll Surg Engl*. 2009;**91(7)**:606-8.

14. Minutolo V, Licciardello A, Di Stefano B, Arena M, Arena G, Antonacci V. Outcomes and cost analysis of laparoscopic versus open appendectomy for treatment of acute appendicitis: 4-years experience in a district hospital. *BMC Surg*. 2014;**14**:14.

15. Costa-Navarro D, Jiménez-Fuertes M, Illán-Riquelme A. Laparoscopic appendectomy: quality care and cost-effectiveness for today's economy. *World J Emerg Surg*. 2013;**8(1)**:45.

16. National Surgical Research Collaborative. Multicentre observational study of performance variation in provision and outcome of emergency appendicectomy. *Br J Surg*. 2013;**100(9)**:1240-52.

17. Lee M, Paavana T, Mazari F, Wilson TR. The morbidity of negative appendicectomy. *Ann R Coll Surg Engl*. 2014;**96(7)**:517-20.

18. Keyzer C, Zalcman M, De Maertelaer V, Coppens E, Bali MA, Gevenois PA, *et al*. Comparison of US and unenhanced multi-detector row CT in patients suspected of having acute appendicitis. *Radiology*. 2005;**236(2)**:527-34.

19. van Randen A, Bipat S, Zwinderman AH, Ubbink DT, Stoker J, Boermeester MA. Acute appendicitis: meta-analysis of diagnostic performance of CT and graded compression US related to prevalence of disease. *Radiology*. 2008;**249(1)**:97-106.

20. Doria AS, Moineddin R, Kellenberger CJ, Epelman M, Beyene J, Schuh S, *et al*. US or CT for diagnosis of appendicitis in children and adults? A meta-analysis. *Radiology*. 2006;**241(1)**:83-94.

21. Alfraih Y, Postuma R, Keijzer R. How do you diagnose appendicitis? An international evaluation of methods. *Int J Surg*. 2014;**12(5)**:67-70.

22. van Rossem CC, Bolmers MD, Schreinemacher MH, van Geloven, AA, Bemelman WA; Snapshot Appendicitis Collaborative Study Group. Prospective nationwide outcome audit of surgery for suspected acute appendicitis. *Br J Surg*. 2016;**103(1)**:144-51.

23. Drake FT, Florence MG, Johnson MG, Jurkovich GJ, Kwon S, Schmidt Z, *et al*. Progress in the diagnosis of appendicitis: report from Washington State's Surgical Care and Outcomes Assessment Program. *Ann Surg*. 2012;**256(4)**:586-94.

24. Karakas SP, Guelfguat M, Leonidas JC, Springer S, Singh SP. Acute appendicitis in children: comparison of clinical diagnosis with ultrasound and CT imaging. *Pediatr Radiol*. 2000;**30(2)**:94-8.

25. Yu SH, Kim CB, Park JW, Kim MS, Radosevich DM. Ultrasonography in the diagnosis of appendicitis: evaluation by meta-analysis. *Korean J Radiol*. 2005;**6(4)**:267-77.

26. Heverhagen JT, Pfestroff K, Heverhagen AE, Klose KJ, Kessler K, Sitter H. Diagnostic accuracy of magnetic resonance imaging: A prospective evaluation of patients with suspected appendicitis (diamond). *J Magn Reson Imaging*. 2012;**35(3)**:617-23.

27. Kim K, Lee CC, Song K, Kim W, Suh G, Singer AJ. The impact of helical computed tomography on the negative appendectomy rate: a multi-center comparison. *J Emerg Med*. 2008;**34(1)**:3-6.

28. Bhangu A. Safety of short, in-hospital delays before surgery for acute appendicitis: multicentre cohort study, systematic review, and meta-analysis. *Ann Surg*. 2014;**259(5)**:894-903.

29. United Kingdom National Surgical Research Collaborative, Bhangu A. Safety of short, in-hospital delays before surgery for acute appendicitis: multicentre cohort study, systematic review, and meta-analysis. *Ann Surg*. 2014;**259(5)**:894-903.

30. Brenner DJ, Hall EJ. Computed tomography - an increasing source of radiation exposure. *N Engl J Med*. 2007;**357(22)**:2277-84.

31. Smith-Bindman R, Wang Y, Chu P, Chung R, Einstein AJ, Balcombe J, *et al*. International variation in radiation dose for computed tomography examinations: prospective cohort study. *BMJ*. 2019;**364**:k4931.

32. Keyzer C, Tack D, de Maertelaer V, Bohy P, Gevenois PA, Van Gansbeke D. Acute appendicitis: Comparison of low-dose and standard-dose unenhanced multi-detector row CT. Radiology. 2004;232(1):**164-172. doi**: 10.1148/radiol.2321031115.

33. Seo H, Lee KH, Kim HJ, Kim K, Kang SB, Kim SY, *et al*. Diagnosis of acute appendicitis with sliding slab ray-sum interpretation of low-dose unenhanced CT and standard-dose i.v. contrast-enhanced CT scans. *AJR Am J Roentgenol*. 2009;**193(1)**:96-105.

34. Kelly ME, Heeney A, Redmond CE, Costelloe J, Nason GJ, Ryan J, *et al*. Incidental findings detected on emergency abdominal CT scans: A 1-year review. *Abdom Imaging*. 2015;**40(6)**:1853-7.