Eur Radiol (2015) 25:1464–1470
DOI 10.1007/s00330-014-3531-0

EMERGENCY RADIOLOGY

Mandatory imaging cuts costs and reduces the rate of unnecessary surgeries in the diagnostic work-up of patients suspected of having appendicitis

M. J. Lahaye · D. M. J. Lambregts · E. Mutsaers · B. A. B. Essers · S. Breukink · V. C. Cappendijk · G. L. Beets · R. G. H. Beets-Tan

Received: 5 June 2014 / Revised: 7 October 2014 / Accepted: 19 November 2014 / Published online: 16 January 2015

Abstract
Objective To evaluate whether mandatory imaging is an effective strategy in suspected appendicitis for reducing unnecessary surgery and costs.
Methods In 2010, guidelines were implemented in The Netherlands recommending the mandatory use of preoperative imaging to confirm/refute clinically suspected appendicitis. This retrospective study included 1,556 consecutive patients with clinically suspected appendicitis in 2008–2009 (756 patients/group I) and 2011–2012 (800 patients/group II). Imaging use (none/US/CT and/or MRI) was recorded. Additional parameters were: complications, medical costs, surgical and histopathological findings. The primary study endpoint was the number of unnecessary surgeries before and after guideline implementation.
Results After clinical examination by a surgeon, 509/756 patients in group I and 540/800 patients in group II were still suspected of having appendicitis. In group I, 58.5% received preoperative imaging (42% US/12.8% CT/3.7% both), compared with 98.7% after the guidelines (61.6% US/4.4% CT/ 32.6% both). The percentage of unnecessary surgeries before the guidelines was 22.9%. After implementation, it dropped significantly to 6.2% ($p<0.001$). The surgical complication rate dropped from 19.9% to 14.2%. The average cost-per-patient decreased by 594 € from 2,482 to 1,888 € (CL:−1081; −143).
Conclusion Increased use of imaging in the diagnostic work-up of patients with clinically suspected appendicitis reduced the rate of negative appendectomies, surgical complications and costs.
Key Points
- *The 2010 Dutch guidelines recommend mandatory imaging in the work-up of appendicitis.*
- *This led to a considerable increase in the use of preoperative imaging.*
- *Mandatory imaging led to reduction in unnecessary surgeries and surgical complications.*
- *Use of mandatory imaging seems to reduce health care costs.*

Keywords Imaging · Diagnosis · Appendicitis · Health-care costs · Operative surgical procedures

Abbreviations

CT	Computed Tomography
IRB	Institutional Review Board
MRI	Magnetic Resonance Imaging
NPV	Negative Predictive Value
PPV	Positive Predictive Value
US	Ultrasound

M. J. Lahaye · D. M. J. Lambregts · E. Mutsaers · R. G. H. Beets-Tan (✉)
Department of Radiology, Maastricht University Medical Centre, P. Debyelaan 25, 6229 HX Maastricht, The Netherlands
e-mail: r.beets.tan@mumc.nl

B. A. B. Essers
Department of Epidemiology and Medical Technology, Maastricht University Medical Centre, Maastricht, The Netherlands

S. Breukink · G. L. Beets
Department of Surgery, Maastricht University Medical Centre, Maastricht, The Netherlands

V. C. Cappendijk
Department of Radiology, Jeroen Bosch Hospital, 's Hertogenbosch, The Netherlands

Introduction

Acute appendicitis is one of the most common surgical emergencies. It is also the most common disorder associated with lawsuits against emergency physicians. The surgical procedure is plagued by negative appendectomies [1]. A negative appendectomy, but also a delay in treatment, can result in unnecessary prolonged hospitalization and morbidity, especially in the elderly [2, 3]. One of the major problems is that multiple disorders can mimic the clinical presentation of appendicitis, especially in women. Traditionally, clinical examination has been used to diagnose appendicitis. However, based on clinical examination only, negative appendectomy rates of 20 % have been reported [4, 5]. It has been suggested that the negative appendectomy rate can drop to as low as 2 % if imaging is added to the diagnostic work-up [1]. Based on these reports, in 2010 the Dutch College of Surgeons published new evidence-based national guidelines concerning the diagnostic work-up of patients suspected of having appendicitis, which stated that an appendectomy should not be carried out without proper preoperative imaging [6]. Ultrasound and computed tomography (CT) have a negative predictive value (NPV) of 72 % and 100 %, respectively, for diagnosing appendicitis [7–9]. Therefore the guidelines stated that a CT scan was compulsory not only after an inconclusive ultrasound, but also after a negative result with ultrasound. However, implementation of these guidelines led to discussion amongst clinicians about whether the extra mandatory imaging would be a cost-effective strategy in reducing the number of unnecessary surgeries.

Therefore the purpose of this study was to evaluate whether the mandatory use of imaging in the diagnostic work-up is an effective strategy in reducing the rate of unnecessary laparotomies in patients with suspected appendicitis. A secondary endpoint of this study was to evaluate in which way this strategy affects the average costs in these patients.

Material and methods

This study was conducted retrospectively. In our country institutional review board (IRB) approval is not required for these types of retrospective studies and patient consent was therefore waived. In our University Hospital all patients are informed that their anonymised data can be used for research purposes. No patient in this study raised an objection to the use of his/her anonymised data.

Patients

The electronic patient databases of the Maastricht University Medical Center were searched for all patients presenting to the surgeon with a suspected acute appendicitis in the differential diagnosis between 1/1/2008 and 12/31/2009 (group I: before guideline implementation) and between 1/1/2011 and 12/31/2012 (group II: after guideline implementation). Patients from the transition period (2010) were not included. Inclusion criteria were: (1) referral by a general practitioner with the suspicion of appendicitis or (2) patients presenting to the emergency department or outpatient clinic with acute pain in the right lower abdomen. Exclusion criteria were: (1) clear alternative clinical diagnosis (e.g., cholecystitis), (2) recent abdominal trauma, and (3) previous appendectomy (which was unknown at the time of patient referral).

Diagnostic work-up before and after guideline implementation

Before implementation of the guidelines there was no standard protocol in our hospital for the diagnostic work-up of patients suspected of having appendicitis. The surgeon on call arbitrarily used clinical (re-)evaluation, diagnostic laparoscopic surgery, CT and/or US for their diagnostic work-up.

The patient routing as described in the national guidelines proposed by The Dutch College of Surgeons in 2010 is displayed in Fig. 1. After implementation of the guidelines the patient routing was as follows: when a patient presents with appendicitis in the differential diagnosis, a surgeon first evaluates the patient. If after clinical and laboratory examination, the surgeon still suspects appendicitis, the patient should proceed to imaging. Ultrasound is recommended as the first-choice imaging technique in patients with suspected appendicitis due to its availability and low costs. Alternatively, CT may also be used as the primary diagnostic tool. In case of a negative or inconclusive ultrasound, the patient should proceed to additional CT examination.

Imaging procedures

All ultrasound examinations were performed using an ultrasound machine (Philips Medical Systems, Best, The Netherlands). Ultrasound was performed and evaluated by either a resident (> 1.5 years' experience in abdominal ultrasound and authorised to perform ultrasound without senior supervision) or a senior radiologist (> 4 years' experience) on call. CT examinations were performed using multislice CT devices. The standard CT protocol for appendicitis in our institution consisted of a portal venous CT examination through the entire abdomen, performed with a 70-s delay after intravenous administration of 110 cc of Ultravist 300 (Bayer Schering Pharma, Berlin, Germany). Slice thickness was 3 mm and 3-mm coronal

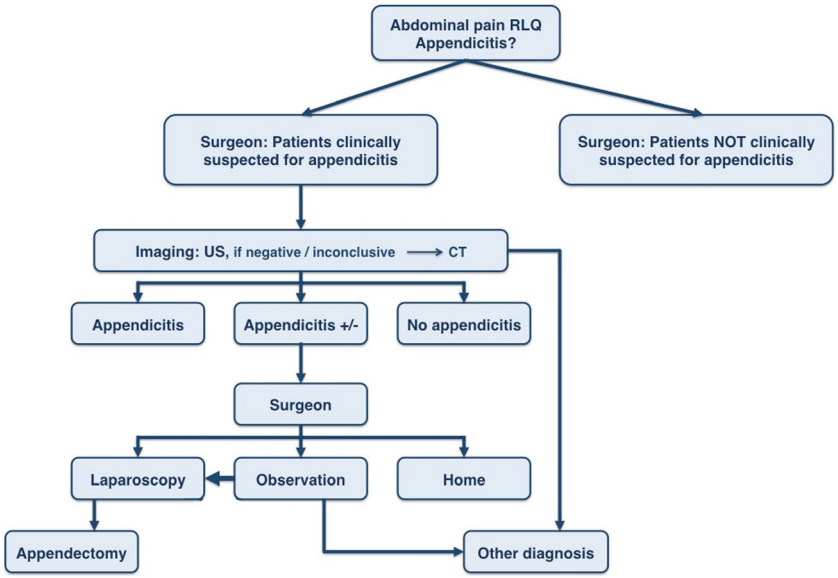

Fig. 1 Flowchart showing patient routing derived from the guidelines proposed by the Dutch College of Surgeons. *RLQ* right lower quadrant

reconstructions were routinely constructed. Oral contrast was not standard in the CT protocol for appendicitis. The resident or radiologist on call performed the image evaluation.

Surgical procedures

The standard surgical approach was a laparoscopic appendectomy. When there were complications during the laparoscopic procedure an 'open' appendectomy was performed. In case of a normal appendix, the appendix was not routinely removed. The surgeon on call performed the surgery.

Outcome variables and reference standard

A single reviewer (E.M.) analysed each study patient and recorded whether the national guidelines were followed. Additionally, for each patient the reviewer recorded the following parameters: sex, age, type/number of imaging/surgeries, laboratory tests, duration of hospital admission, number of outpatient clinic and emergency room visits, re-admissions, imaging-guided drainage, surgical outcome (normal appendix/appendicitis) and complications during a follow-up of 12 months. Complications were defined as any negative deviation from the normal postoperative course, e.g., abscess, fistula and wound infection. When an appendectomy was performed, histology of the resection specimen served as the reference standard for appendicitis versus a normal appendix. In case of a diagnostic laparoscopy without appendectomy, the surgical assessment of a normal appendix combined with a clinical follow-up of at least 12 months was the standard reference. When no surgery was performed a clinical follow-up of at least 12 months without any further evidence of appendicitis served as the reference standard to confirm the absence of appendicitis.

Cost analysis

Information regarding resource use was collected from the hospital information system for all 1,556 patients during the periods before and after implementation of the guidelines. Cost prices were obtained from the hospital financial department and the Dutch manual for cost research [10].

Since cost data are generally skewed and not normally distributed, a non-parametric bootstrap analysis with 1,000 replications was performed to estimate the confidence intervals surrounding the mean difference in costs [11].

Results

Patients

Baseline patient characteristics are presented in Table 1. In total, 1,556 patients were identified who presented to the emergency department with acute pain in the right lower abdomen and/or who were referred by a general practitioner with a clinical suspicion of appendicitis in the differential diagnosis: 756 before implementation of the guidelines (group I) and 800 after implementation of the guidelines (group II). After clinical examination by a surgeon, 509 (67.3 %) patients in group I and 540 (67.5 %) patients in group II were still suspected of having appendicitis. These patients constituted the final study population for the diagnostic work-up, surgical outcome and

Table 1 Patient characteristics

	Before guidelines	After guidelines
Total no. of patients	756	800
Men	307 (40.6 %)	317 (39.6 %)
Women	449 (59.4 %)	483 (60.4 %)
Age, y	31.6 (2–89 years)	31.6 (0–98 years)
Mean age, y	31.6 (2–89 years)	31.6 (0–98 years)
< 18 years	209 (27.6 %)	218 (27.3 %)
18–60 years	473 (62.6 %)	492 (61.5 %)
> /= 60 years	74 (9.8 %)	90 (11.3 %)
No. of patients suspected of having appendicitis after clinical evaluation by surgeon	509 (67.3 %)	540 (67.5 %)
No. of patients with proven appendicitis	254 (33.6 %)	257 (32.1 %)

assessment of complications. All patients were evaluated for the cost analysis..

Diagnostic work-up and guideline compliance

Details on imaging and guideline compliance are presented in Table 2. In group I, before the guidelines, 289/509 (58.5 %) patients underwent imaging (42 % ultrasound, 12.8 % CT, 3.7 % ultrasound + CT) as part of their diagnostic work-up. In group II, after implementation of the guidelines, 533/540 (98.7 %) of the patients underwent imaging (61.7 % ultrasound, 4.4 % CT, 32.6 % ultrasound + CT, 0.7 % magnetic resonance imaging (MRI)), during their diagnostic work-up. Four MRIs were carried out in group II after implementation of the guidelines (in two pregnant women and two children). No MRI was performed in group I. In 340 of these 540 patients (63 %), the imaging procedures were fully compliant with the guidelines; of the other 190 patients seven patients received no preoperative imaging and in 183 patients additional CT was omitted after an inconclusive (109) or negative (74) ultrasound examination.

Surgical procedure and outcome

Details on surgical procedures are presented in Table 2. Follow-up of the patients who did not have their appendix removed after surgery showed that none of these patients in either group developed appendicitis. Before the guidelines, 332/509 (65.2 %) patients in group I received surgery, of whom 76 (22.9 %) turned out to have a normal appendix. Fifty-nine of the 76 (78 %) patients with a normal appendix received no preoperative imaging. In group 1, four out of these seventeen patients received a diagnostic work-up similar to the guidelines that were implemented in 2010. After implementation of the guidelines, 274/540 (50.7 %) of the patients in group II received surgery, of whom seventeen (6.2 %) had a normal appendix. Four of these seventeen patients (24 %) did not receive the diagnostic

Table 2 Overview of surgery and imaging

	Before guidelines	After guidelines
Total no. of surgeries	65.2 % (332/509)	50.7 % (274/540)
Laparoscopic	44.0 % (224/509)	40.9 % (221/540)
Open surgery	14.1 % (72/509)	6.1 % (33/540)
Both (conversion)	7.1 % (36/509)	3.7 % (20/540)
Unnecessary surgeries	22.9 % (76/332)	6.2 % (17/274)
No imaging and direct surgery	63.6 % (211/332)	2.6 % (7/274)
Imaging (US and/or CT)	58.5 % (298/509)	98.7 % (533/540)
US only	42.0 % (214/509)	61.7 % (333/540)
CT only	12.8 % (65/509)	4.4 % (24/540)
Both US and CT	3.7 % (19/509)	32.6 % (176/540)
MRI	0 % (0/509)	0.7 % (4/540)
Guidelines followed or similar imaging strategy before guidelines	55.3 % (418/756)	76.3 % (610/800)

US ultrasound, *CT* computed tomography, *MRI* magnetic resonance imaging

Table 3 Overview of the average number and costs on a patient basis

	Before guideline (n=756)		After guideline (n=800)		Cost difference (€)	Confidence levels (€)
	No. (pp patient)	Average costs (€)	No. (pp patient)	Average costs (€)		
Laboratory testing	2.26	88.31	2.15	84.09	-4.22	n.s.
Imaging:						
US	0.43	12.30	0.76	21.48	9.18	(6;12)
CT	0.19	15.57	0.32	26.84	11.27	(3;19)
Plain film	0.16	1.49	0.10	0.92	-0.57	n.s
Hospital visits:						
Polyclinic	0.84	115.07	0.64	87.17	-27.90	(-48;-7)
ER	1.22	195.98	1.18	188.00	-7.98	n.s.
Surgeries	0.45	715.26	0.35	551.04	-164.22	(-289;-30)
Hospital stay (days)	2.75	1335.03	1.91	926.35	-408.68	(-763;-67)
CT/US drainage	0.01	2.53	0.01	1.67	-0.86	n.s.
Total	2481.55		1887.56		594	(-1.081;-143)

US ultrasound, *CT* computed tomography, *ER* emergency room, *n.s.* not significant

work-up according to the guidelines: in two patients laparoscopy was performed without any preoperative imaging and the other two patients had an inconclusive ultrasound with no additional CT examination. Of the patients with signs of appendicitis on CT images, 3.3 % had no appendicitis at histology. The decrease in the rate of unnecessary surgeries after guideline implementation was significant ($p < 0.00001$). The surgical complication rate dropped from 19.9 % (66/332) in group I to 14.2 % (17/274) in group II.

Cost analysis

For the cost analysis all 1,556 patients were evaluated (see Table 3). After implementation of the guidelines, the costs of imaging increased significantly on a patient basis from an average of 29 € to 49 €. Conversely, the average duration of hospital stay and costs per patient decreased significantly from 2.75 to 1.91 days, resulting in a drop in costs from 1,335 € to 926 € (confidence level (CL): −763;−67). Average surgical costs decreased from 715 to 551 € per patient (CL: −289;−30). In total, the average costs per patient decreased by 594 € (from 2,482 to 1,888 € (CL: −1081;−143)) after implementation of the guidelines. The average costs per patient with an uncomplicated laparoscopy were 3,939 € in group I and 3,900 € in group II. The average costs per patient with complications were 8,910 € in group I and 8,988 € in group II.

Discussion

The results of our study show that the implementation of the Dutch national clinical practice guidelines for the management of patients with suspected appendicitis recommending mandatory use of imaging led to a significant increase in the use of preoperative imaging. This resulted in a significant reduction in the rate of unnecessary appendectomies from 22.9 % to 6.2 %. Additionally, the overall complication rate after surgery dropped significantly from 19.9 % to 14.4 %. The average costs per patient dropped significantly by 594 € from an average of 2,482 € to an average of 1,888 € per patient, despite a significant increase in the number of imaging examinations.

In patients clinically diagnosed with acute appendicitis, the reported overall negative appendectomy rate (with no routine use of imaging in the diagnostic work-up) is about 15–20 %: 10 % in men and 25–45 % in women of childbearing age [5, 12–14]. This is consistent with the rate of unnecessary laparotomies prior to the guidelines in our hospital (22.9 %) in which almost two-thirds of the patients received no preoperative imaging. Another reason for the relatively high rate of unnecessary laparotomies prior to the guidelines was the common practice in our hospital of performing a diagnostic laparoscopy in cases where there was a strong clinical suspicion of appendicitis.

Overall accuracy of clinical examination for the diagnosis of acute appendicitis is known to be approximately 80 % [15], indicating that in up to 20 % the patients are misdiagnosed. Ultrasound has a positive predictive value (PPV) of 97 % [7]. The PPV of CT is comparable (97 %) with an overall accuracy of (unenhanced) CT up to 98.2 % [16]. This means that theoretically the number of unnecessary laparotomies should be very low with the use of CT in the diagnostic work-up. This was also reported in recent literature, in which very low negative appendectomy rates of 1.7 % were described with the use of preoperative CT imaging [17]. Our data confirm these findings: only 3.3 % of the patients with signs of appendicitis on CT images had a normal appendix and had thus received an

unnecessary surgical procedure. Drawbacks of CT imaging like costs and higher radiation dose are becoming less important now that multiple studies have shown that unenhanced low-dose CT can be used to accurately detect/rule out appendicitis [16, 18]. In our study, however, no low-dose CT examinations were made. An additional benefit of CT is that in patients with appendicitis CT imaging accurately demonstrates the full extent of the disease. Furthermore, an alternative cause of abdominal pain may be found with CT in almost one-third of the patients suspected of having appendicitis [19]. Nevertheless, the Dutch national guidelines do not recommend CT as the first-choice imaging modality in the standard work-up. Instead, the guidelines dictate the use of ultrasound as the primary imaging tool. The main reason for this is that, in spite of the moderate negative predictive value, ultrasound has been reported to have a similarly high PPV to that of CT [7]. This means that if appendicitis is diagnosed with ultrasound, the chance of a normal appendix is very low. Furthermore, the costs of ultrasound compared with CT are considerably lower. Ultrasound may, however, be difficult to perform in a few scenarios, such as in patients with severe abdominal pain, patients with overlying intraluminal gas and adipose patients. Furthermore, ultrasound is operator dependant. Therefore the guidelines state that – in case of a 'contraindication' for ultrasound, CT imaging can also be used as an alternative primary imaging tool.

Despite the increase in imaging procedures after implementation of the guidelines, we observed a significant decrease in the average costs of care per patient. The main reasons for this reduction in costs was a reduction in the number of laparotomies (from 11.4 % to 6.1 %). This consequently led to a reduction in the average number of hospital admission days (from 2.75 to 1.91 days) and complication rates (from 19.9 % to 14.2 %). The lower complication rate with the use of mandatory imaging may be interpreted as a result of an earlier diagnosis of appendicitis. This plays a key role in cost reduction; the literature shows that early diagnosed, uncomplicated appendicitis carries little morbidity and is relatively inexpensive to treat. However, if the appendicitis progresses, the costs rise exponentially [20]. This was also the case in our study. In addition, selected patients with early-stage appendicitis could benefit from more conservative treatments such as antibiotics [21], lowering the costs even more.

Although the costs of CT compared to a surgical procedure and associated hospital days are very low, our surgeons appeared rather reluctant to order a CT after an inconclusive and in particular after a negative ultrasound examination. Despite scientific evidence, appendicitis is still widely believed to be a 'simple' clinical diagnosis [22]. This probably resulted in a suboptimal implementation of the guidelines with consequent lower imaging costs. Theoretically, however, full adherence to the guidelines would still have been a cost-effective approach as the current cost reduction of 594 € per patient means that the addition of CT after inconclusive/negative ultrasound will still result in a reduction in overall costs. Due to the high accuracy of CT it would probably lead to even less unnecessary surgery, resulting in further cost reduction. The suboptimal implementation means that the exact impact of the guidelines could not precisely be defined in this study. Furthermore, the present study was limited due to its retrospective nature. However, the purpose of this study was to evaluate effectiveness of the new guidelines after implementation in a busy daily clinic. Further research is recommended, as a prospective cost-effectiveness study including a social perspective for economic evaluation could help to understand all costs associated with patients suspected of having appendicitis.

In conclusion, this study demonstrates that the implementation of guidelines resulted in a major increase in the use of imaging in the work-up of patients with clinically suspected appendicitis. This resulted in a reduction in negative appendectomies and surgical complications, and reduced the costs of care per patient in the daily clinical practice.

Acknowledgments The scientific guarantor of this publication is Prof. Dr. RGH Beets-Tan. The authors of this manuscript declare no relationships with any companies whose products or services may be related to the subject matter of the article. The authors state that this work has not received any funding. One of the authors has significant statistical expertise. Institutional Review Board (IRB) approval was not required because this is retrospective study, and in our country IRB approval is not required for this type of retrospective studys and patient consent was therefore waived. In our University Hospital all patients are informed that their anonymised data can be used for research purposes. No patient in this study raised an objection to the use of his/her anonymised data. Written informed consent was waived by the IRB. Methodology: retrospective, observational, performed at one institution.

References

1. Raja AS, Wright C, Sodickson AD et al (2010) Negative appendectomy rate in the era of CT: an 18-year perspective. Radiology 256:460–465
2. Ditillo MF, Dziura JD, Rabinovici R (2006) Is it safe to delay appendectomy in adults with acute appendicitis? Ann Surg 244: 656–660
3. Omari AH, Khammash MR, Qasaimeh GR, Shammari AK, Yaseen MK, Hammori SK (2014) Acute appendicitis in the elderly: risk factors for perforation. World J Emerg Surg 9:6
4. Andersson RE, Hugander A, Thulin AJ (1992) Diagnostic accuracy and perforation rate in appendicitis: association with age and sex of the patient and with appendicectomy rate. Eur J Surg 158:37–41
5. Berry J Jr, Malt RA (1984) Appendicitis near its centenary. Ann Surg 200:567–575
6. Bakker OJ, Go PM, Puylaert JB, Kazemier G, Heij HA, Werkgroep richtlijn Diagnostiek en behandeling van acute a (2010) [Guideline on diagnosis and treatment of acute appendicitis: imaging prior to appendectomy is recommended]. Ned Tijdschr Geneeskd 154:A303
7. Nasiri S, Mohebbi F, Sodagari N, Hedayat A (2012) Diagnostic values of ultrasound and the Modified Alvarado Scoring System in acute appendicitis. Int J Emerg Med 5:26
8. Naffaa LN, Ishak GE, Haddad MC (2005) The value of contrast-enhanced helical CT scan with rectal contrast enema in the diagnosis of acute appendicitis. Clin Imaging 29:255–258

9. Pooler BD, Lawrence EM, Pickhardt PJ (2012) MDCT for suspected appendicitis in the elderly: diagnostic performance and patient outcome. Emerg Radiol 19:27–33
10. Hakkart-van Roijen L TS, Bouwmans CA. (2010) Dutch manual for cost research. Handleiding voor kostenonderzoek, methoden en standard kostprijzen voor economische evaluaties in de gezondheidszorg. College voor zorgverzekeringen
11. Briggs AH, Wonderling DE, Mooney CZ (1997) Pulling cost-effectiveness analysis up by its bootstraps: a non-parametric approach to confidence interval estimation. Health Econ 6:327–340
12. Webster DP, Schneider CN, Cheche S, Daar AA, Miller G (1993) Differentiating acute appendicitis from pelvic inflammatory disease in women of childbearing age. Am J Emerg Med 11:569–572
13. Wen SW, Naylor CD (1995) Diagnostic accuracy and short-term surgical outcomes in cases of suspected acute appendicitis. CMAJ 152:1617–1626
14. Bongard F, Landers DV, Lewis F (1985) Differential diagnosis of appendicitis and pelvic inflammatory disease. A prospective analysis. Am J Surg 150:90–96
15. Lau WY, Fan ST, Yiu TF, Chu KW, Wong SH (1984) Negative findings at appendectomy. Am J Surg 148:375–378
16. Ege G, Akman H, Sahin A, Bugra D, Kuzucu K (2002) Diagnostic value of unenhanced helical CT in adult patients with suspected acute appendicitis. Br J Radiol 75:721–725
17. Soyer P, Dohan A, Eveno C et al (2013) Pitfalls and mimickers at 64-section helical CT that cause negative appendectomy: an analysis from 1057 appendectomies. Clin Imaging 37:895–901
18. Seo H, Lee KH, Kim HJ et al (2009) 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 193:96–105
19. Pooler BD, Lawrence EM, Pickhardt PJ (2012) Alternative diagnoses to suspected appendicitis at CT. Radiology 265:733–742
20. Kong V, Aldous C, Handley J, Clarke D (2013) The cost effectiveness of early management of acute appendicitis underlies the importance of curative surgical services to a primary healthcare programme. Ann R Coll Surg Engl 95:280–284
21. Wojciechowicz KH, Hoffkamp HJ, van Hulst RA (2010) Conservative treatment of acute appendicitis: an overview. Int Marit Health 62: 265–272
22. Kruis W, Morgenstern J, Schanz S (2013) Appendicitis/diverticulitis: diagnostics and conservative treatment. Dig Dis 31:69–75