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Less negative appendectomies due to imaging in patients with suspected appendicitis

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Abstract
Background The optimal diagnostics and treatment of acute appendicitis continues to be a challenge. We evaluated the implementation of the guideline "diagnostics and treatment in acute appendicitis" in 2010. This guideline states that, in every patient with clinically suspected acute appendicitis, an ultrasonography or CT scan is advised to confirm the diagnosis before surgery.
Patients and methods We selected all consecutive patients with acute appendicitis in our hospital in the years 2008 and 2011. We compared the use of imaging and the operation results in both years.
Results In 2008, 228 patients were treated for acute appendicitis. In 43 %, imaging was performed. In 2011, 238 patients were treated; in 99 % of the cases, imaging was performed. A decrease in patients with negative appendectomy was seen from 19 % in 2008 to 5 % in 2011. Financial analysis showed a reduction in costs favoring 2011.
Conclusions The increased use of pre-operative imaging in patients with suspected acute appendicitis resulted in a cost-effective way to decrease the number of patients with negative appendectomies.

Keywords Appendicitis · Imaging · Guideline

Appendicitis is the most common cause of acute abdominal pain requiring surgery in adults and children [1–3]. There are more than 16,000 new cases of acute appendicitis in the Netherlands every year [4]. Males and females have a lifetime appendicitis risk of 8.6 and 6.7 %, respectively [5]. This rapidly progressing inflammatory process requires prompt removal of the appendix to prevent life-threatening complications such as ruptured appendix and peritonitis. Because abdominal pain is a common complaint, accurate and quick diagnosis of acute appendicitis is essential to minimize morbidity. Traditionally, the diagnosis of appendicitis has been based on clinical features and physical examination [6]. Diagnostic accuracy without pre-operative imaging is about 76–80 % for combined groups of male and female patients [7, 8]. Unnecessary surgery in patients with suspected appendicitis results in increased morbidity and expense. Over the past two decades, the use of dedicated pre-operative ultrasonography (US) and computed tomography (CT) techniques for the evaluation of patients clinically suspected of acute appendicitis has led to improved diagnostic accuracy [7]. In light of this, in 2010 the Dutch College of Surgeons introduced a guideline entitled "diagnostics and treatment in acute appendicitis" with recommendations concerning pre-operative imaging in the diagnosis and treatment of acute appendicitis. The guideline states that in every patient with clinically suspected acute appendicitis an ultrasonography or CT scan is advised to confirm diagnosis before surgery (Fig. 1).

The aim of this study is to investigate whether the introduction of the 2010 guideline has led to an increase of pre-operative imaging and a decrease of negative appendectomies in our clinic. As a secondary outcome, we evaluated the rate of perforation in patients with acute appendicitis and determined the difference in costs between negative appendectomies and the increased use of imaging.

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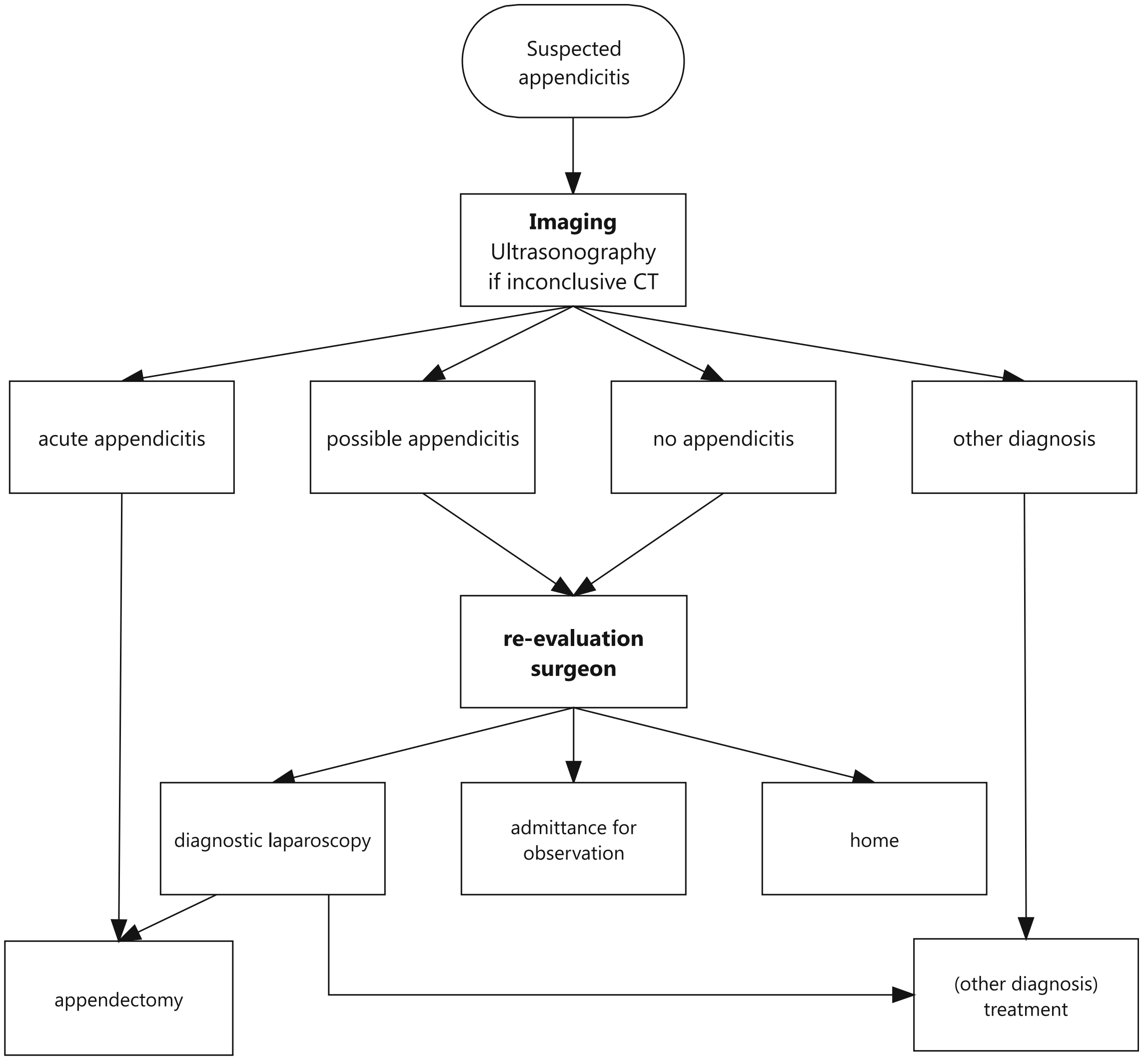

Fig. 1 Flow chart treatment and diagnosis in patients with suspected acute appendicitis

Materials and methods

Patients

In this retrospective study, all consecutive patients with suspected appendicitis attending the Kennemer Gasthuis Haarlem in the years 2008 and 2011 were included. They were selected from the digital hospital registration system, surgery registration system, and pathology department database. These databases contained all patients who underwent surgery with post-operative specimen evaluations. Diagnostic laparoscopies in patients with suspected acute appendicitis were also included. The collected data included: gender, age, temperature, leukocyte count, CRP, days of illness, ultrasound reports, CT scans, diagnostic laparoscopy reports, pathology reports, complications, and duration of hospital stay. Patients with incidental appendectomy were not included. Patients were divided in two groups based on year of treatment, 2008 and 2011, respectively. Patients who received pre-operative imaging, including patients who underwent US and/or a CT scan, were registered in both years. Negative appendectomy was defined as removal of a histological normal appendix or negative diagnostic laparoscopy. Primary outcome was the rate of negative appendectomy and the secondary outcome was the rate of perforated appendicitis, furthermore, a financial analysis was performed to evaluate the cost-effectiveness of the increased use of imaging in patients with suspected appendicitis

Definitions

Ultrasonographic appendicitis involves a compressed diameter of the appendix of more than 6–7 mm, with or without inflammatory changes in the fat surrounding the appendix. CT diagnosis of acute appendicitis is based on the appearance of a thickened (6–7 mm) appendix with surrounding fat infiltration. [9, 10]. All specimens were routinely examined morphologically. Patients with a histological gangrenous inflamed appendix were placed in the phlegmonous inflamed appendix group. The diagnosis of perforated appendicitis was made according to intra operative findings by the surgeon. Patients were treated with open appendectomy or laparoscopic appendectomy, following the preferences of the attending surgeon. Calculation was based on public data of hospitalization costs. The average cost of negative appendectomy (i.e., diagnostic laparoscopy) is $1,700 [11]. Costs of abdominal ultrasound and CT scanning are estimated at $250 and $550, respectively.

Statistical analysis

All statistical analyses were performed using SPSS for windows (version 17.0, SPSS Inc, Chicago, USA). The Chi-square test was used for categorical data, independent samples T test for numeric variables and the Mann–Whitney test for numerical variables with a non-normal distribution. All statistical tests were conducted two-sided and p values of 0.05 or less were considered significant.

A subgroup analysis between male and female patients was conducted. The relation between phlegmonous and perforated appendicitis was also calculated.

Results

In 2008, 228 patients were treated for a suspected appendicitis with a mean age of 33 years and a male/female ratio of 1:1.17. During the year 2011, 238 patients were treated with a mean age of 33 years and a male/female ratio of 1:1.14. The baseline characteristics are listed in Table 1 and do not indicate any significant difference. Laboratory tests that were carried out when patients were admitted to the medical center showed equal results in leukocyte counts and CRP levels ($p = 0.556$ and $p = 0.372$) for both years.

In 2011, the pre-operative imaging in patients with suspected appendicitis increased to 99 % compared to 43 % in 2008 ($p < 0.001$) (Fig. 2). In 98 % of the pre-operative imaging cases, ultrasonography was conducted. The increased use of pre-operative imaging resulted in a decrease in patients with a normal appendix from 19 to 5 % ($p < 0.001$). In 2008, there was no difference between the imaging and non-imaging group in patients with negative appendectomy (respectively, 21 out of 98 and 23 out of 130, $p = 0.479$).

The amount of diagnostic laparoscopies decreased from 69 in 2008 to 9 in 2011 ($p < 0.001$) (Table 2).

In 2008, imaging was not performed in 16 patients with a normal appendix diagnosed during laparoscopy. In all other patients in the laparoscopy subgroup who were diagnosed with a negative appendicitis, the imaging modalities were inconclusive. In 2011, imaging was performed in all nine patients who underwent diagnostic laparoscopy of which two patients had no appendicitis. This denotes a significant difference regarding the use of imaging. However, the increase in imaging did not significantly reduce the amount of negative appendicitis in the diagnostic laparoscopy group (Table 3).

The gender subgroup analysis, shown in Table 4, revealed an increase in imaging for both male and female patients ($p < 0.001$). A decrease in diagnostic laparoscopy from 66 to 9 was seen in the female group ($p < 0.001$). For both genders, a reduction was observed in negative appendectomies in 2011 compared to 2008.

A slight increase was noted in patients with a perforated appendicitis between 2008 (22 %, 39 out of 181) and 2011 (26 %, 57 out of 223), yet there was no statistical significant difference ($p = 0.346$).

Other diagnoses made as result of the pathology report were: melanoma, adenocarcinoma, and carcinoid tumors.

The complication rate overall for both years was not significantly different ($p = 0.378$), respectively, 31 out of 228 in 2008 and 31 out of 238 in 2011. In 2008, there was no difference in complication rate in patients with or without imaging.

Table 1 Baseline characteristics and complication rate

Characteristics	N	2008 mean	Std.	n	2011 mean	Std.	p value
Total	228			238			
Age		32.77	20		32.96	18.5	0.622*
Male	105	–	–	111	–	–	0.899†
Female	123	–	–	127	–	–	0.899†
Days before admittance	172	1.63	1.05	237	1.66	1.16	0.819*
Leucocytes	225	14.51	4.84	238	14.24	4.83	0.556‡
CRP	225	55.49	65.2	238	63.71	75.3	0.372*
Complication rate	31			31			0.378†

† Chi-square test, ‡ Independent samples T test, * Mann–Whitney test

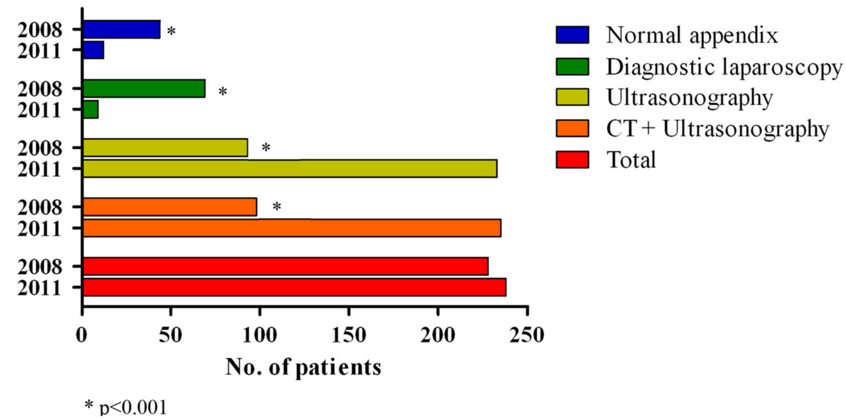

Fig. 2 The use of imaging compared between 2008 and 2011

Table 2 Results

Appendices	2008	2011	p value
Total appendices	228	238	
Normal appendices (with imaging)	44 (21)	12 (12)	0.001†
Inflamed appendices	181	223	<0.001†
Other diagnosis	3	2	0.618

† Chi-square test

Table 3 Results from the diagnostic laparoscopy group

Diagnostic laparoscopy	2008	2011	p value
Total	69	9	<0.001†
Visualization	18	9	<0.001†
Ultrasonography	18	9	<0.001†
Additional CT	2	1	0.228†
Normal appendix (PA)	25	2	0.406†

† Chi-square

Table 4 Subgroup analysis male/female population

Male/female	2008	2011	p value
Total			
Male	105	111	0.899†
Female	123	127	
Visualization			
Male	42	108	<0.001†
Female	56	127	<0.001†
Ultrasound			
Male	38	107	<0.001†
Female	55	126	<0.001†
Diagnostic laparoscopy			
Male	3	0	0.07†
Female	66	9	<0.001†
Normal appendix			
Male	13	4	<0.05†
Female	31	8	<0.001†

† Chi-square test

Cost analysis

The economic aspects of the present study are described in Table 5. Thirty six patients were spared from negative appendectomy in 2011 compared to 2008, but the use of imaging increased. There is a clear reduction of $15.200 favoring 2011.

Discussion

In this retrospective cohort study, the increased use of preoperative imaging in a general community teaching hospital led to an improved treatment outcome in patients with suspected appendicitis. The rate of negative appendectomy decreased from 19 % in 2008 to 5 % in 2011 due to a better patient selection before surgery. To our knowledge, this study is the first to evaluate the importation of the guideline 'diagnosis and treatment in acute appendicitis' by the Dutch college of surgeons in 2010.

In accordance with our results, Körner et al. showed the diagnostic accuracy in patients with a suspected appendicitis without the use of imaging around 76 % with a significant higher percentage of accurate diagnosis in males compared to females: 82 and 68 %, respectively ($p < 0.001$) [7]. A meta-analysis including 22 articles with 2,643 patients performed by Yu et al. in 2005 showed a negative appendectomy rate of 10.7 % in patients with suspected appendicitis when using US; in patients who did not get US, the rate was between 10 and 20 % [12]. Guss et al. reported a decrease in negative appendectomy rate from 15.5 to 7.9 % since the introduction of CT scanning in patients with suspected appendicitis.

By contrast, Flum and colleagues reported no significant decline in the rate of negative appendectomies despite

Table 5 Economic aspects

	Costs		2008 No. of patients	Costs	2011 No. of patients	Costs
	Ultrasound	$250,00	93	$23,250,00	233	$58,250,00
	CT scan	$550,00	18	$9,900,00	38	$20,900,00
				$33,150,00		$79,150,00
Total imaging costs + extra negative appendectomies performed in 2008	Negative appendectomy costs (2011–2008)	$1,700	36	$61,200,00		
		Total		$94,350,00		$79,150,00

increased use of CT and US over between 1980 and 1999 [13, 14]. Flum and colleagues' explanation for this stagnation is the low sensitivity of CT and US. The discrepancy with the present study is most likely a result of the use of modern imaging techniques with an increased sensitivity and could explain the equality of patients with negative appendectomies in both groups (imaging vs. non-imaging) in 2008.

In the conducted study, the increase of imaging did not result in a decline in patients with perforated appendicitis, which corresponds with the pertinent literature [15, 16]. Even though some studies report a slight increase in patients with perforated appendicitis due to in hospital delay caused by the imaging examination [17], we did not investigate intervals from presentation to imaging to surgery, so it proved impossible, given the data to establish such a correlation. Results of previous studies [8, 18] suggest that most of the delay in diagnosis that leads to perforation is due to patient delay in consulting a physician. Anderson et al. suggest that perforated appendicitis is distinct from non-perforated appendicitis [19, 20]. The use of imaging did not affect complication rates for both groups and years. They were not significantly different, 13–14 % in both years which is slightly lower as reported in other studies [21].

According to our results, diagnosis of acute appendicitis is more difficult in female patients, as a number of gynaecologic conditions (e.g., pelvic inflammatory disease, ruptured Graafian follicles, endometriosis, ovarian torsion) may simulate the clinical presentation of acute appendicitis, reducing the accuracy of clinical work-up [1, 22].

Also, a decline was observed in the amount of performed diagnostic laparoscopies. This may be due to more adequate diagnostics; in fact the percentage of normal appendectomies in the diagnostic laparoscopy group is higher than the overall group. This can be explained by selection bias. That is to say, patients undergoing laparoscopic appendectomy may be at higher risk for misdiagnosis.

Since we analyzed 1 year before and 1 year after the implementation of the guideline in our hospital, a convincing comparison could be made to demonstrate the effects of the increased use of imaging. A clear limitation of the present study is the lack of inclusion of patients who presented at our emergency department with suspected appendicitis and had negative test results (e.g., laboratory tests or ultrasonography) and consequently did not undergo surgery. For this reason, we could not calculate how many patients were spared from negative appendectomy due to the change in pre-operative workup. This study, however, does clearly point out how to improve the diagnostic process and treatment outcome in patients with suspected appendicitis.

We have shown the use of imaging improves the treatment outcome in patients with suspected appendicitis. Notwithstanding there is ample controversy about the modality of imaging. Studies have been published regarding the better diagnostic performance of CT scanning in contrast with ultrasonography. In contrast, the lack of radiation exposure and the limited costs is a major advantage of ultrasonography [23–26]. The most cost-effective method, according to Wan et al., would be to start with ultrasonography and to follow-up with CT scanning when the former proved negative [27]. This is according to the implemented dutch guideline.

Cost analysis showed a clear reduction in costs in 2011, yet it is not an exact calculation of total expenditures. The used rates are estimated from public data, real costs could be higher for both diagnostic laparoscopies and imaging depending on treatment center and days of hospital admission. A negative appendectomy will prevent patients from future episodes of appendicitis and diagnostic costs in patients with nonspecific recurrent abdominal pain, these factors were outside the scope of the performed study but are relevant and could be the focus in future studies.

In conclusion, appendicitis is the most common cause of acute abdominal pain in the lower right quadrant. Diagnosis is sometimes difficult and without adequate imaging, 20 % of the patients are misdiagnosed. This study demonstrates the use of pre-operative imaging is cost-effective and does improve the adequacy of the diagnosis of acute appendicitis before a surgical treatment is initiated. As a result of the introduction of the guideline *"diagnosis and treatment of acute appendicitis"* from the Dutch College of Surgeons, our hospital registered an increase in pre-operative imaging resulting in a decrease in patients with a negative appendectomy.

Disclosures P. A. Boonstra, R. N. van Veen, H. B. A. C. Stockmann have no conflict of interest.

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