Evaluation of the appendix during diagnostic laparoscopy, the laparoscopic appendicitis score: a pilot study

Jenneke T. H. Hamminga · H. Sijbrand Hofker · Paul M. A. Broens · Philip M. Kluin · Erik Heineman · Jan Willem Haveman

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Abstract

Background Diagnostic laparoscopy is the ultimate diagnostic tool to evaluate the appendix. Still, according to the literature, this strategy results in a negative appendectomy rate of approximately 12–18 % and associated morbidity. Laparoscopic criteria for determining appendicitis are lacking. The goal of this study is to define clear and reliable criteria for appendicitis during diagnostic laparoscopy that eventually may safely reduce the negative appendectomy rate.

Methods From December 2009 through April 2011, 134 patients were included and analysed in a single-centre prospective pilot study. Intraoperatively, the appendix was evaluated by the surgeon according to nine criteria for appendicitis. The operating surgeon decided whether it should be removed or not. Immediately after the operation the surgeon had to complete a questionnaire on nine criteria for appendicitis. All removed appendices were examined by a pathologist. In case the appendix was not removed, the clinical postoperative course was decisive for the (missed) presence of appendicitis.

Results In 109 cases an inflamed appendix was removed; in 25 patients the appendix was normal, 3 of which had been removed. After univariate analysis and clinical judgement six variables were included in the Laparoscopic APPendicitis score (LAPP score). In this study, use of the LAPP score would have led to a positive predictive value of 99 % and a negative predictive value of 100 %.

Conclusions This study presents the LAPP score. The LAPP score is an easily applicable score that can be used by surgeons to evaluate the appendix during diagnostic laparoscopy. The score has high positive and negative predictive value. The LAPP score needs to be validated in a multicentre validation study.

Keywords Appendicitis · Appendectomy · Laparoscopy · Evaluation

During the last decade, a laparoscopic approach for a suspicion of appendicitis has become more common in surgical practice. Contrary to an open technique using a muscle split incision in the right lower abdominal quadrant, it is controversial at laparoscopy to remove a normal-looking appendix in case no other intra-abdominal explanation is found for the abdominal complaints. The morbidity of removing a normal appendix is 6 % [1]. In view of this side-effect it would be preferable to minimise the negative appendectomy rate, yet without risking leaving behind an inflamed appendix. For this reason the guidelines of the Dutch Society of Surgeons state that a normal-looking appendix at laparoscopy should not be removed [2]. However, evidence-based laparoscopic criteria for determining appendicitis are not defined. If there is any doubt about the presence of an abnormal appendix, it is usually removed. According to the literature, this
strategy results in a negative appendectomy rate of approximately 15% [3, 4]. The identification of well-described laparoscopic criteria may support the clinical decision that the appendix is not inflamed and that it should not be removed.

The goal of the current pilot study is to define clear and reliable criteria for appendicitis during a diagnostic laparoscopy and to come to a Laparoscopic APPendicitis (LAPP) score. Ideally, this score should be easy in use and lead to a lower rate of normal appendectomies and close to zero chance of leaving an inflamed appendix in the abdominal cavity. The LAPP score defined in this single-centre study should be validated in a multicentre validation study.

**Patients and methods**

**Patients**

From December 2009 through April 2011, all patients who were operated on with the clinical suspicion of appendicitis were asked to participate in this study (www.clinicaltrials.gov; study identifier NCT01054417). Exclusion criteria were: interval or elective appendectomy, and if the patient was not able to give informed consent. The study was approved by our institutional ethical committee. All data were prospectively collected in a database after written informed consent. The decision to operate on a patient with suspicion of appendicitis was made by the clinicians. In all patients, a thorough history, clinical examination, standard blood tests with white blood cell count, C-reactive protein and urinary analysis was performed. If necessary an abdominal ultrasound or computed tomography (CT) scan was undertaken.

**Operation and questionnaire**

Before skin incision all patients received 1 g cefazoline and 500 mg metronidazol intravenously. After introduction of a sub-umbilical trocar for the camera and two additional trocars in the lower abdomen, the appendix was evaluated by the operating surgeon. The mesentery of the appendix was grasped with an atraumatic laparoscopic instrument, and the appendix was carefully manipulated in order to assess its stiffness and to evaluate it for any predefined signs of appendicitis. In case of necrosis of the appendix, presence of an appendiceal perforation or if the manipulation might induce perforation or rupture of the appendix, grasping the appendix and its mesentery was avoided. The decision of whether to remove the appendix or not was made by the operating surgeon.

Immediately after the operation the surgeons had to complete a short questionnaire consisting of 11 questions to evaluate the appendix. Eight questions were on the presence or absence of criteria for appendicitis, and additionally one question was to evaluate the stiffness of the appendix. Finally, two concluding questions (10 and 11) were asked of the surgeon (Fig. 1).

**Endpoint**

The endpoint of the study was the presence or absence of histopathology-proven appendicitis. In all cases where the appendix was removed, a pathologist reviewed the appendix macroscopically [5] for the presence of the following features: thickness and consistency of the appendix, induration of the periappendicular fat, abnormalities of the serosal membrane (purulent depositions, fibrin, matting), vascular injection, perforation, and after cutting: necrosis, perforation, luminal widening, ulceration/empyema and the presence of faecoliths. Upon macroscopic evaluation, a minimum of three slices were made through the appendix, two transverse transections, one at the base and one approximately halfway, then a longitudinal transection was made through the top of the appendix. At the histological level, appendicitis was defined by the presence of at least (local) ulceration with infiltration of polymorphonuclear neutrophils into the mucosa and submucosa (endo-appendicitis), either or not in combination with transmural inflammation, necrosis, perforation and periappendicular inflammation. In case inflammation without mucosal ulceration was found, the contralateral part of the appendix and more transverse slices were examined. In all cases histological examination formed the diagnostic endpoint.

When the appendix was not removed, the postoperative clinical course was considered to be decisive for the presence of appendicitis. The patients were prospectively followed till discharge. A follow-up appointment was made in the outpatient clinic after 2 weeks, and a telephone interview was performed after 2–3 months. After an uneventful postoperative course in a patient in whom the appendix was not removed, the appendix was considered normal at the time of the operation.

**Statistics**

Data are presented as median (interquartile range). In case of categorical data, the number of patients is presented. Differences between categorical variables were tested with Fisher’s exact test. The Mann–Whitney U test was performed to calculate differences in continuous variables. To analyse the criteria to evaluate the appendix by the surgeon, a multivariate logistic regression analysis was planned.
Results

Patients

During the study period, 170 patients were operated for the suspicion of acute appendicitis. Twenty patients were not included in the study for several reasons (Fig. 2). In 150 patients we obtained informed consent; 9 patients were excluded from further analysis due to missing data, and in 7 patients there was no clear view of the appendix. Of the remaining 134 patients, 109 underwent appendectomy for histologically proven appendicitis. Three additional patients had a histologically proven negative appendectomy. In addition, 22 patients had a normal appendix that was not removed. None of these 22 developed symptoms of appendicitis during follow-up. Baseline characteristics are presented in Table 1.

Laparoscopic appendicitis score

The operations were performed by a total of 41 different surgeons or surgical registrars. Table 2 presents the results of the evaluation of the appendix by the surgeon who performed the operation. Questions 10 and 11 were excluded from the analysis. All criteria had a highly statistically significant difference between the patients with a normal appendix and those with an inflamed appendix. Of the 25 patients with a normal appendix, none had “thickened mesentery”, “thickened appendix”, “injected vessels on the serosa of the appendix”, “fibrin on the appendix”, “perforation” or “necrosis”. Two patients (8 %) with a normal appendix scored ≥4 on the scale of “stiffness of the appendix”, and one (4 %) had an adhesion around the appendix. In six (24 %) of the patients with a normal appendix, pus or dirty fluid was present around the appendix.

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Patient’s name, date of birth, identification number

Surgeon and assistant/supervisor 1. __________________ 2. __________________

1. Was the mesentery of the appendix thickened? Yes No
2. Was the appendix thickened? Yes No

3. On a scale of 0 to 10 how did you quantify the stiffness of the appendix (whole appendix or segment of it)? (mark with a line below)

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Not stiff at all</td>
</tr>
<tr>
<td>10</td>
<td>Maximal</td>
</tr>
</tbody>
</table>

4. Were there injected blood vessels on the serosa of the appendix? Yes No
5. Was there an adhesion? Yes No
6. Was there fibrin on or around the appendix? Yes No
7. Was there pus or dirty fluid around the appendix? Yes No
8. Was the appendix perforated? Yes No
9. Was there necrosis of the appendix? Yes No
10. Did you think the appendix was inflamed? Yes No In doubt
11. Did you remove the appendix? Yes No

Fig. 1 The questionnaire the surgeon had to answer after the laparoscopy
appendix. As discussed in “Patient and methods” section, we initially planned to do a multivariate logistic regression analysis. However, after evaluation of the results, almost all variables were very strong predictors. Because of this very high statistically significant predictive capacity of all variables, a multivariate logistic regression analysis was not appropriate for defining a simple and easy-to-use LAPP score. We analysed the variables on their clinically relevant outcome and ease of use in daily clinical practice. Based on the univariate results, “pus or dirty fluid around the appendix” (present in 24% in case of a normal appendix) and “fibrin around the appendix” (not present in 34% in case of appendicitis) were excluded from the LAPP score. As there was a strong correlation between “perforation” and “necrosis” of the appendix and also because both clinical entities are easy recognizable, these two variables were grouped as one. A positive answer to either one of these questions was considered as a “yes”. In case we used the remaining seven laparoscopic variables in the LAPP score, three patients would have an appendectomy of a normal appendix. By additionally removing the item “stiffness of the appendix ≥4”, only one normal appendix would have been removed. Removing more items from the score or changing the cutoff point to ≥2 answers with “yes” would have led to leaving inflamed appendices inside the abdomen (false-negative results).

The final LAPP score is presented in Fig. 3; it contains five questions on six laparoscopic variables. The potential result of the LAPP score in this cohort is presented in Table 3. Application of this score would lead to sensitivity.
of 100 % and specificity of 96 % with positive and negative predictive value of 99 and 100 %, respectively.

Discussion

This single-centre prospective pilot study presents the Laparoscopic APPendicitis (LAPP) score. The score consists of five questions on six laparoscopic variables about

Table 1 Patient characteristics, clinical presentation and intra-operative data

<table>
<thead>
<tr>
<th></th>
<th>Normal appendix</th>
<th>Inflamed appendix</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>25</td>
<td>109</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>28 (16–39)</td>
<td>30 (18–43)</td>
<td>0.29</td>
</tr>
<tr>
<td>Male</td>
<td>6 (24 %)</td>
<td>65 (60 %)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Preoperative imaging</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abdominal ultrasound</td>
<td>18 (72 %)</td>
<td>63 (58 %)</td>
<td>0.26</td>
</tr>
<tr>
<td>CT abdomen</td>
<td>1 (4 %)</td>
<td>12 (11 %)</td>
<td>0.46</td>
</tr>
<tr>
<td>Intraoperative data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appendectomy performed</td>
<td>3 (12 %)</td>
<td>109 (100 %)</td>
<td></td>
</tr>
<tr>
<td>Conversion to open</td>
<td>1 (4 %)</td>
<td>11 (10 %)</td>
<td></td>
</tr>
<tr>
<td>Intraoperative complica</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Data presented as median (interquartile range) or number (%)

Table 2 Intraoperative evaluation of the appendix by the surgeon

<table>
<thead>
<tr>
<th></th>
<th>Normal appendix</th>
<th>Inflamed appendix</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>25</td>
<td>109</td>
<td></td>
</tr>
<tr>
<td>Stiffness of the appendix</td>
<td>2 (1–2)</td>
<td>7 (6–9)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Thickened mesentery</td>
<td>0</td>
<td>92 (85 %)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Thickened appendix</td>
<td>0</td>
<td>102 (94%)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Injection of the appendix</td>
<td>0</td>
<td>102 (94 %)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Adhesion</td>
<td>1 (4%)</td>
<td>81 (74 %)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Fibrin</td>
<td>0</td>
<td>72 (66 %)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Pus or dirty fluid</td>
<td>6 (24 %)</td>
<td>58 (53 %)</td>
<td>0.01</td>
</tr>
<tr>
<td>Perforation</td>
<td>0</td>
<td>21 (19 %)</td>
<td>0.01</td>
</tr>
<tr>
<td>Necrosis</td>
<td>0</td>
<td>31 (28 %)</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

Fig. 3 The Laparoscopic APPendicitis (LAPP) score

1. Perforation or necrosis of the appendix?
2. Thickened appendix?
3. Thickened mesentery of the appendix?
4. Injection of the vessels on the serosa of the appendix?
5. Adhesion around the appendix?

If ≥ 1 question is answered with yes, then proceed to appendectomy
that states not to remove a normal-looking appendix, we did not find it ethical to remove all appendices for the purpose of this study. In such a scenario we would be absolutely sure that a normal-looking appendix is indeed a histologically proven normal appendix and not a mild appendicitis that is sometimes a self-limiting disease.

During the last decades, attempts have been made to reduce the normal appendectomy rate by, for example, clinical scoring systems such as the Alvarado score [17]. In addition, more and more centres will perform preoperative diagnostic imaging such as ultrasound and CT scan, although these modalities have their disadvantages such as operator dependency and availability after hours for ultrasound and for CT scans side-effects of radiation especially in children and young adults. It is known that standard imaging can lead to a reduction of negative appendectomies to approximately 4–8 % in prospective studies [18–22], although in “real life”, considering for example availability in the emergency setting and after hours, there is no doubt that the negative appendectomy rate will be higher. We performed preoperative imaging in 65 % of our patients (Table 1). Therefore, in our opinion the LAPP score would add to current practice as it requires no extra costs or delay and is always available. Without a laparoscopic appendicitis score, it requires courage on the part of the surgeon performing a laparoscopy on a patient with suspicion of appendicitis not to remove a normal-looking appendix in the absence of other pathology. As far as the authors are aware, nobody has ever studied the laparoscopic appearance of appendicitis, nor given solid recommendations on when it is safe to declare an appendix as being normal and not to remove it. The LAPP score might lead to a further reduction of the normal appendectomy rate and its associated costs and morbidity.

This study has its limitations. During the operation, the surgeon was the only person who evaluated the appendix, made the decision of whether or not the appendix should be removed and completed the evaluation form after the operation. Therefore, the LAPP score might be self-affirming, as the surgeon might tend to answer positive on the questions after the appendix was removed and complete a negative answer if the appendix was not removed. Although, we feel that it is the best reflection of today’s clinical practice and after analysis, there are several important differences between the questions answered on the form. Furthermore, in this study the operations were performed by 41 different surgeons or surgical registrars, reflecting the diversity of our clinic. As this study is a single-centre study, the results may not be applicable to other centres. The high positive and negative predictive value of the LAPP score should be reproduced in a large multicentre validation study that we are setting up. One might argue that the clinical impact of using the LAPP score is minute, as in this cohort the normal appendectomy rate could be reduced from 4 patients to 1 (out of 134 diagnostic laparoscopies). Non-published retrospective data from our own hospital show that the normal appendectomy rate already reduced from 11 to 5 % (2008 vs. 2009). We believe that the only explanation for this reduction is that in 2009 we were setting up this study and there was a lot of discussion in our hospital on normal appendectomies, therefore the clinical impact of using this score is probably higher.

In conclusion, the LAPP score is a simple and easily applicable score for assessing the appendix during diagnostic laparoscopy. In our cohort of patients, the score would have led to the absence of any missed case of appendicitis and a false-positive appendectomy rate of 4 %. The LAPP score needs to be validated in a multicentre validation study.

Disclosures Authors Jenneke T. H., Hamminga, H. Sijsbrand Hofker, Paul M. A. Broens, Philip M. Kluin, Erik Heineeman and Jan Willem Haveman have no conflicts of interest or financial ties to disclose.

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