Risk scoring systems in patients with suspected acute appendicitis scheduled to laparoscopy—a single centre retrospective analysis

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Background: The ideal assessment of patients with suspected appendicitis remains a matter of debate, with no national guidelines currently available in Denmark to direct clinical care. We investigated the potential benefit of validated risk scoring systems in patients with suspected appendicitis.

Methods: Patients aged 16–45 years old undergoing diagnostic laparoscopy for suspected appendicitis at a single institution from 01/01/2019 to 31/12/2019 were included. The primary endpoint was the negative appendicectomy rate (NAR). Secondary endpoints included the false negative rate (FNR) and specificity of the Appendicitis Inflammatory Response Score (AIRS) and the Adult Appendicitis Score (AAS).

Results: A total of 361 patients were included, of whom 188 (52.1%) were female. Appendicectomy was performed in 287 patients (79.5%). The NAR was 6.6%. Alternative diagnoses at laparoscopy were more common in females, who were less likely to proceed to appendicectomy than males (67.6% versus 92.4%, P<0.001). Pre-operative imaging was performed in 62 patients (17.2%), most commonly with computed tomography, which had an FNR and specificity of 12.6% and 83.3%. In males, the AIRS had an FNR and specificity of 7.3% and 44.4%. In females, the AAS had an FNR and specificity of 35.7% and 66.7%.

Conclusions: Stratification of patients with suspected appendicitis using clinical judgement was associated with a low NAR but high rates of unnecessary laparoscopy. Risk scoring appears unhelpful in young females, in whom routine pre-operative imaging may be considered.

Keywords: Appendicitis; imaging; laparoscopy

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Introduction

Despite being the most common general surgical emergency worldwide, the optimal strategy to diagnose patients with acute appendicitis continues to be debated (1). Although the textbook presentation of migratory abdominal pain settling in the right iliac fossa is well known, diagnosis of appendicitis in clinical practice is complicated by atypical presentations and a range of differential diagnoses (2). Diagnostic approaches vary on both regional and national levels and range from mandatory radiological confirmation of appendicitis prior to surgery, to the use of laparoscopy as both a diagnostic and therapeutic tool in patients with high clinical suspicion of disease (3-5). Neither strategy is free

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from criticism. Computed tomography (CT) scanning is the most commonly employed imaging modality, and whilst current guidelines recommend its use in patients aged >40 years, due to the increased incidence of malignancies and diverticulitis, concerns remain regarding the long-term consequences of exposing younger patients to ionising radiation (6,7). The use of laparoscopy as a diagnostic tool is also associated with risks, in the form of operative complications or higher rates of negative appendicectomies, where a histologically normal appendix is removed (8,9).

Various scoring systems for appendicitis have been developed, with the aim of standardizing diagnostic pathways and reducing the number of young patients undergoing unnecessary scans or operations. However, given the sheer number of different scoring systems that exist, it is unclear which, if any, is superior and what role these systems have in routine clinical practice (10). A recent multicentre study including over 5,000 patients aged <45 years with suspected appendicitis analysed 15 different scoring systems, finding the Adult Appendicitis Score (AAS) performs best in women and the Appendicitis Inflammatory Response Score (AIRS) performs best in men (4). These scores formed the basis of a sex-specific flowchart, recommending CT scanning prior to operation in women with an AAS score ≤8 and men with an AIRS score ≤2.

In Denmark at present, no national guidelines exist for the management of patients with suspected appendicitis. Whilst the strategies of routine pre-operative imaging or the stratification of patients to imaging based on scoring systems appear reasonable, their potential benefit in a Danish patient population remains unknown. This study sought to determine the outcomes of patients undergoing diagnostic laparoscopy for suspected appendicitis and to evaluate the utility of the AAS and AIRS scores. We present the following article in accordance with the STROBE reporting checklist (available at https://ls.amegroups.com/article/view/10.21037/ls-22-7/rc) (11).

Methods

Patients aged 16–45 years undergoing laparoscopic surgery for suspected or radiologically confirmed acute appendicitis at our institution between 01/01/2019 and 31/12/2019 were identified using electronic records. Relevant clinicopathological variables were extracted from electronic patient records. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the institutional review board of Bispebjerg Hospital. The study was approved by the hospital management of Bispebjerg Hospital, Copenhagen, Denmark as a quality assurance project and thus informed consent was not needed from the patients.

During the study period, patients were managed according to the clinical judgement of the admitting surgeon. Pre-operative imaging was not performed routinely, though was considered in the case of atypical or delayed presentations. Furthermore, no appendicitis scoring systems were in routine use. The use of a laparoscopic surgery for suspected appendicitis is standard approach at our institution. Open surgery is only typically performed when a pre-operative diagnosis of an appendiceal malignancy has been made and this patient group was not thought to be relevant to the study's aim. As such patients undergoing a laparoscopic operation with or without conversion were included, whereas those undergoing a purely open operation were excluded.

The primary endpoint of this study was the negative appendicectomy rate (NAR), defined as a histological diagnosis other than acute appendicitis or appendiceal neoplasia after appendicectomy. Secondary endpoints included the performance of pre-operative imaging and the AIRS and AAS systems, and 30-day morbidity and mortality rates. The ideal risk assessment for appendicitis would identify as many patients without disease as low risk (true negatives) whilst minimising the misdiagnosis of patients with appendicitis (false negatives). We therefore reported the performance of pre-operative imaging and the AIRS and AAS systems in terms of their false negative rate (FNR) [false negatives/(false negatives + true positives)] and specificity [true negatives/(true negatives + false positives)]. The grade of appendicitis was determined from the operation note, with inflamed or gangrenous appendicitis defined as uncomplicated and the presence of perforation, abscess or peritonitis defined as complicated. For all analyses, patients were stratified into two groups based on sex. AAS and AIRS were calculated retrospectively for females and males, respectively.

Statistical analysis

All statistical analyses were performed using IBM SPSS statistics for Macintosh, version 27.0. The Chi-squared test was used for the comparison of categorical variables, whereas the Kruskal-Wallis test was used for the comparison of continuous variables. All tests were 2-tailed and a P value of <0.05 was considered statistically significant.

Table 1 Operative demographics of patients undergoing diagnostic laparoscopy due to suspected appendicitis

Variable	Male	Female	P value
Number of patients	173 (47.9)	188 (52.1)	–
Number undergoing appendicectomy	160 (92.4)	127 (67.6)	<0.001
Grade of appendicitis			0.236
Uncomplicated	126 (78.8)	107 (84.3)	
Complicated	34 (21.2)	20 (15.7)	
Number of negative appendicectomies	9 (5.6)	12 (9.4)	0.217
Pathological diagnosis			0.202
Appendicitis	148 (92.5)	113 (89.0)	
Normal appendix	8 (5.0)	12 (9.4)	
Neoplasia	3 (1.9)	2 (1.6)	
IBD	1 (0.6)	0 (0)	

Numbers in parentheses are percentages. IBD, inflammatory bowel disease.

Table 2 The use of imaging in patients with suspected appendicitis

Variable	Male	Female	P value
Pre-operative imaging	38 (22.0)	$24^{§}$ (12.8)	0.021*
Imaging modality			0.262
Contrast CT	30 (78.9)	16 (66.7)	
Non-contrast CT	1 (2.6)	4 (16.7)	
Ultrasound	6 (15.8)	4 (16.7)	
MRI	1 (2.6)	1 (4.2)	
Conclusion from imaging			0.046*
Appendicitis	31 (81.6)	14 (58.3)	
Inconclusive	7 (18.4)	10 (41.7)	

Numbers in parentheses are percentages. §, one patient underwent CT, ultrasound and MRI scanning; *, statistically significant results. CT, computed tomography.

Results

A total of 361 patients underwent laparoscopy for suspected appendicitis during the study period, of whom 188 (52.1%) were female. Operative demographics stratified by sex are shown in *Table 1*. A macroscopic diagnosis of appendicitis, made at the time of surgery by the operating surgeon, was made in 287 patients (79.5%), in whom an appendicectomy was performed. Alternative diagnoses were more commonly identified at the time of laparoscopy in females, with a significantly smaller proportion undergoing appendicectomy when compared with males (67.6% versus 92.4%, P<0.001). A summary of these alternative diagnoses is given in Table S1. If such alternative diagnoses had been made pre-operatively, we estimate that only 3 of these 74 patients (4.1%) would have required operative intervention. In those patients diagnosed with appendicitis, no difference in the grade of disease was noted between sexes. In those patients undergoing appendicectomy, a pathological diagnosis of appendicitis was confirmed in 263 patients (91.6%) with appendiceal neoplasms found in a further 5 patients (1.7%). This gave an overall NAR of 6.6%, with a greater proportion of females undergoing removal of a normal appendix than males (9.4% versus 3.5%).

Pre-operative imaging was performed in 62 patients (17.2%) and was performed in a significantly greater proportion of males (22.0% versus 12.8%, P=0.021) (*Table 2*). Computed tomography (CT) with intravenous contrast was the most commonly used imaging modality and was performed in 30 males (78.9%) and 16 females (66.7%). Conclusive evidence of appendicitis was reported in 45 patients (72.6%), with pre-operative imaging more likely to be reported as inconclusive in females (41.7% versus 18.4%, P=0.046). Of the 46 patients undergoing CT scanning with intravenous contrast, 38 (82.6%) had conclusive evidence of appendicitis, which correlated with a pathological diagnosis of appendicitis in 36 (94.7%). Of the 2 remaining patients, one had an appendiceal neoplasm and the other had Crohn's disease affecting the terminal ileum and caecum. In the 8 patients with inconclusive CT

Table 3 Performance of the AIRS system in males aged <45 years

Variable	High-risk	Low-risk	P value
Number of patients	156 (90.2)	17 (9.8)	–
Pre-operative imaging	32 (20.5)	6 (35.3)	0.162
N° undergoing appendicectomy	145 (92.9)	15 (88.2)	0.484
Grade of appendicitis			0.431
Uncomplicated	113 (77.9)	13 (86.7)	
Complicated	32 (22.1)	2 (13.3)	
Negative appendicectomy rate	3.4%	26.7%	<0.001*
Pathological diagnosis			–
Appendicitis	137 (94.5)	11 (73.3)	
Normal appendix	5 (3.4)	3 (20.0)	
Neoplasia	3 (2.1)	0 (0)	
IBD	0 (0)	1 (6.7)	

Numbers in parentheses are percentages. *, statistically significant results. IBD, inflammatory bowel disease. AIRS, Appendicitis Inflammatory Response Score.

Table 4 Performance of the Adult Appendicitis Score (AAS) in females aged <45 years

Variable	High-risk	Low-risk	P value
Number of patients	108 (57.4)	80 (42.6)	–
Pre-operative imaging	10 (9.3)	14 (17.5)	0.094
N° undergoing appendicectomy	78 (72.2)	49 (61.3)	0.112
Grade of appendicitis			0.390
Uncomplicated	64 (82.1)	43 (87.8)	
Complicated	14 (17.9)	6 (12.2)	
Negative appendicectomy rate	5.1%	16.3%	0.032*
Pathological diagnosis			–
Appendicitis	72 (92.3)	41 (83.7)	
Normal appendix	4 (5.1)	8 (16.3)	
Neoplasia	2 (2.6)	0 (0)	

Numbers in parentheses are percentages. *, statistically significant results.

scanning, only 3 (37.5%) had a pathological diagnosis of appendicitis, with a normal appendix removed in 2 patients and a macroscopically normal appendix found and left *in situ* in the remaining 3. The FNR and specificity of CT scanning with intravenous contrast were 12.6% and 83.3%, respectively.

Validated scoring systems were retrospectively applied to all patients (*Tables 3,4*). Using the AIRS system, 156 males (90.2%) were identified as high-risk, of whom 145 (92.9%) had macroscopic evidence of appendicitis at operation. Whilst there was no difference in the proportion of patients undergoing appendicectomy, the NAR was higher in those with a low-risk AIRS (26.7% versus 3.4%, P<0.001). The FNR and specificity of the AIRS system in males were 7.3% and 44.4%, respectively. Using the AAS system, 108 females (57.4%) were identified as high-risk, of whom 72.2% had macroscopic evidence of appendicitis at operation. Again, no difference in the proportion of patients undergoing appendicectomy was noted between the high- and low-risk groups, although the NAR was higher in those with a low-risk AAS (16.3% versus 5.1%, P=0.032). The FNR and specificity of the AAS system in females were 35.7% and 66.7%, respectively. Appendiceal neoplasms were only identified in patients identified as high-risk by the AIRS or AAS systems. Complicated appendicitis was found in 8 (8.2%) of patients identified as low risk by these scoring systems.

A total of 29 patients developed complications, giving an overall 30-day morbidity rate of 8.0%. Of the 74 patients who underwent laparoscopy without subsequent appendicectomy, 3 (4.1%) developed complications, none of which were > Clavien Dindo grade 2. Of the 21 patients who underwent a negative appendicectomy, 2 (9.5%) developed complications, one requiring re-operation due to intra-abdominal bleeding. No patients died within 30 days of operation.

Discussion

The ideal management of patients presenting with suspected appendicitis remains controversial and at present no national guidelines are available to direct clinical decision making. Over a 12-month period where patients were managed without the use of scoring systems or mandatory verification of the diagnosis with imaging prior to surgery, we found that a NAR of 6.6% was achieved. However, an alternative diagnosis was identified in over 20% of patients undergoing laparoscopy, the overwhelming majority of whom could have been spared an operation. The majority of alternative diagnoses were identified in females, of whom only 2/3 were found to have a macroscopic diagnosis of appendicitis. Whilst the 30-day morbidity associated with diagnostic laparoscopy was low, these results raise the question as to whether stratifying the management of patients, in particular females, with suspected appendicitis by clinical judgement alone is a sufficiently robust strategy in the present day.

The routine use of pre-operative imaging is one potential strategy that may reduce the number of patients undergoing both unnecessary laparoscopy and negative appendicectomy. Such a strategy was introduced in The Netherlands in 2010 with guidelines recommending ultrasound as a first line investigation, which may be supplemented by CT scanning if necessary (3). Strict adherence to these guidelines resulted in a sharp decrease in the number of negative appendicectomies, falling from 16% prior to their publication to just over 3% thereafter (12,13). Furthermore, the reported rate of negative laparoscopies, where a normal appendix or alternative diagnosis was found, was similar at just over 3% (13). These rates contrast sharply with the experience from a multicentre study from the United Kingdom, where pre-operative imaging was performed in only 30% of patients and 20% of patients underwent a negative appendicectomy (5). It is of interest that although pre-operative imaging was used even less frequently in the current study, our NAR was markedly lower than that of the British study and more in keeping with those reported from other European nations (4). A possible explanation for this may be variations in the management of a macroscopically normal appendix, which was as a rule left *in situ* at our institution. The removal of a macroscopically normal appendix is associated with increased risks of both complications and prolonged admission when compared with diagnostic laparoscopy alone for no apparent clinical benefit (8,9).

Whilst the Dutch data provide a compelling argument for the use of routine pre-operative imaging in patients with suspected appendicitis, the optimal imaging modality remains a matter of debate. Whilst cheap, safe, and widely available, reports on the accuracy of ultrasound vary, which is perhaps a reflection of its user-dependent nature (14). The accuracy of CT scanning in diagnosing appendicitis is well established, although concerns remain about the associated radiation exposure, particularly in young patients (15). A recent population-based study from South Korea including over 300,000 patients who had undergone CT due to suspected appendicitis reported an increased incidence of haematological malignancies in these patients (16). Although CT scanning was the commonly used modality in the current study, it was still only performed in a minority of patients and least frequently in females. This may represent a reluctance to expose young patients to the potential risks of radiation, in particular young women. Low dose CT scanning has been shown to be non-inferior to normal CT scanning for the diagnosis of appendicitis and may counter concerns regarding radiation exposure (17). With these scans, patients are exposed to just 2 mSv, the equivalent of a year's background radiation in Europe, as opposed to the 8 mSv associated with normal CT scans. Given that the omission of intravenous contrast appears to have little detrimental impact on the accuracy of CT scanning, an argument could be made for the use of non-contrast low dose CT scanning as the most appropriate initial imaging modality in this patient group (18,19). Magnetic resonance imaging (MRI) is an alternative that allows radiation exposure to be avoided altogether (20). However, this modality may be less accessible than CT scanning, particularly during out-of-hours periods.

A potential downside to the adoption of routine pre-operative imaging is the increased demands that may be placed on radiology departments. The concomitant use of scoring systems may mitigate these effects, allowing imaging to be reserved for patients with uncertain clinical diagnoses and atypical presentations. However, concerns regarding the performance and validity of these scoring systems may limit their adoption into routine clinical practice. A multicentre study of more than 5,000 patients recently identified the AIRS and AAS systems as the best performing risk prediction models in males and females, respectively (4). Despite this, the same study provided evidence that the performance of these models was not uniform across different healthcare systems. Whilst the AIRS system performed well in British males using a cut-off of ≤2, the FNR of the same system rose from 2.4% to 32% when applied to a mixed cohort of Irish, Italian, Portuguese, and Spanish patients. Similarly, the FNR of the AAS system using a cut-off of ≤8 rose from 3.7% in British females to 17.5% in the mixed cohort. These data highlight the potential problems with extrapolating the results of risk prediction models for appendicitis from one country to another. In the current study, whilst the AIRS system performed reasonably well, with a FNR in males of 7.3%, the AAS system was associated with a FNR of 35.7% in females. This would suggest that while the AIRS system may be of use in stratifying the management of male patients with suspected appendicitis in Denmark, the AAS may be of limited value in the pre-operative assessment of females.

The authors recognise the limitations of this study. Due to the study's retrospective nature, it was not possible to identify patients presenting with suspected appendicitis who did not proceed to surgery. Whilst it would be of interest to investigate what role imaging in particular had in the management of these patients, given that much of the focus on the management of appendicitis has been on the avoidance of over-treatment, the outcomes of patients proceeding to surgery may be of more relevance. An additional limitation is that, given the single centre nature of this study, caution should be applied when extrapolating these findings to a national level. Given the lack of national guidelines on the management of this patient group, it is possible that the use of pre-operative imaging and scoring systems may vary on both regional and national levels.

In summary, we have found evidence to suggest that the current management of young patients with suspected appendicitis is associated with high rates of unnecessary surgery, particular in females. Whilst internationally validated scoring systems may be of use in stratifying the management of males, they appear to be of limited value in females in a Danish patient population. Consideration should be given to a policy of routine pre-operative imaging in young women, using ultrasound, non-contrast low dose CT or MRI dependent on local expertise and resources. The AIRS system may be of value in identifying low-risk males in whom pre-operative imaging would be of benefit.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://ls.amegroups.com/article/view/10.21037/ls-22-7/rc

Data Sharing Statement: Available at https://ls.amegroups.com/article/view/10.21037/ls-22-7/dss

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://ls.amegroups.com/article/view/10.21037/ls-22-7/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the institutional review board of Bispebjerg Hospital. The study was approved by the hospital management of Bispebjerg Hospital, Copenhagen, Denmark as a quality assurance project and thus informed consent was not needed from the patients.

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Supplementary

Table S1 Differential diagnoses found at laparoscopy for suspected appendicitis

Diagnosis	Male	Female
Mesenteric adenitis	4	17
Ruptured ovarian cyst	–	15
Retrograde menstruation	–	6
Pelvic inflammatory disease	–	5
Appendagitis epiploicae	2	–
Omental torsion*	2	–
Meckel's diverticulum	1	2
Diverticulitis	1	–
Terminal ileitis	0	1
Ovarian torsion*	–	1
Purulent peritonitis	0	1
Normal	3	13

*, diagnoses assessed as still requiring operative intervention.

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