

Original Article

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A survey of preoperative diagnosis and management of complicated appendicitis

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ABSTRACT

INTRODUCTION. Complicated appendicitis is a severe condition, requiring early diagnosis and intervention to prevent complications. We aimed to investigate how resident surgeons distinguish and manage complicated appendicitis and their perspectives on preoperative diagnostic markers.

METHODS. The electronic survey was face validated. It contained questions about demographics, resident surgeons' considerations on the preoperative diagnosis of complicated appendicitis, and views on the need for and relevance of preoperative diagnostic markers. It was sent to all resident surgeons in the Eastern part of Denmark.

RESULTS. Seven hospitals and their 92 resident surgeons received the survey, and 90% responded. Most resident surgeons used symptoms and signs of pain to diagnose suspected complicated appendicitis. Half of the surgeons used computed tomographies, and 95% used routine blood tests. Most surgeons (83%) would change the management of patients with preoperatively diagnosed complicated appendicitis in comparison to uncomplicated appendicitis. However, only 17% felt the need for a preoperative diagnostic marker.

CONCLUSIONS. Resident surgeons in Eastern Denmark use non-specific diagnostic techniques to distinguish complicated from uncomplicated appendicitis and would change treatment if appendicitis was diagnosed preoperatively. However, despite limited interest, our results suggest a need for new diagnostic markers to differentiate between the severity of appendicitis, thus enhancing education and training in managing such cases.

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Appendicitis is a common cause of acute abdominal pain [1]. Despite its high incidence, preoperative diagnosis remains challenging as no diagnostic method exists to effectively confirm the suspicion [2]. Furthermore, complicated appendicitis is a severe condition that requires early recognition to manage patients better and avoid post-operative complications [3]. The definition of complicated appendicitis varies between the clinical setting and research. In the clinical setting, perforation of the appendix is considered important to identify as perforation requires a post-operative antibiotic course [4, 5]. In research, complicated appendicitis is often defined as either a perforated appendix, gangrenous appendix, or abscess formation [6]. A similar definition is used by the European Association of Emergency Surgery and the World Society of Emergency Surgery, but no

gold standard exists. Meta-analyses support the non-operative management of uncomplicated appendicitis with antibiotics in selected cases [7, 8]. Therefore, it may have implications for the patient's treatment and risk of complications if surgeons can discriminate preoperatively between complicated and uncomplicated appendicitis.

This survey aimed to assess and explore how Danish surgeons differentiate complicated appendicitis from uncomplicated appendicitis and if this affects the management of patients. An additional aim was to record surgeons' perspectives on implementing new methods for better preoperative discrimination of complicated appendicitis.

METHODS

This study was reported according to the Strengthening the Reporting of Observational studies in Epidemiology (STROBE) statement [9]. Resident surgeons from public hospitals in Eastern Denmark, covering approximately half of the country's population, were surveyed. We recruited a resident surgeon at each department to identify eligible participants according to our eligibility criteria and to distribute the questionnaire among resident surgeons. Resident surgeons working in Eastern Denmark who could decide if a patient needed a diagnostic laparoscopy for suspected acute appendicitis were eligible for participation. The questionnaire was developed within the author group. A pilot test of the questionnaire was initially completed by two persons checking its design. Face validation was assessed by a resident surgeon who was not included in the survey to evaluate the interpretation of each question [10]. The comments provided were discussed within the author group. This produced only minor changes to the questionnaire.

The survey reported on three different sections. The term complicated appendicitis was defined at the very beginning of the questionnaire: "Complicated appendicitis refers to either gangrenous or perforated appendix (with or without peritonitis) or abscess formation. Thus, this term is broader than perforated appendix, which is often used in the clinical setting". The first section comprised demographics and resident surgeon-specific details including name, e-mail, phone number, working hospital, and job position. The aforementioned information was anonymised in the data analysis and only used to ensure that all the responses were complete and unique. The second section contained questions about the resident surgeons' considerations on the preoperative diagnosis and management of complicated appendicitis. The third section focused on the resident surgeons' current use of blood biomarkers and their possible future application in the preoperative discrimination of the severity of appendicitis. Residents had the opportunity to provide free-text responses and select pre-defined answer options. These responses were either organised into similar answer options or presented individually with quotation marks in the results, tables, and figures.

An e-mail was sent to all eligible resident surgeons containing an individual link to an electronic questionnaire developed in Research Electronic Data Capture (REDCap) [11], which is a web-based application for collecting and managing data in research studies. Three subsequent reminders were sent to participants who failed to complete the questionnaire. Data collection was performed during January 2023. No resident surgeons changed job positions during this period. This study was approved by the Danish Data Protection Agency (P-2022-880) and the head of each participating department. Approval from the Ethics Committee was not required according to Danish legislation [12]. All survey participants were informed of the study by e-mail and consented to participate in the survey. The population size of the study was decided by the number of eligible resident surgeons in the seven departments participating in the survey.

Data were analysed in Microsoft Excel (Microsoft Corp., Redmond, WA) and SPSS (SPSS Inc., Chicago, USA). Categorical results are displayed as numbers and/or percentages. Qualitative answers from the surgeons

explaining their choices in the questionnaire were grouped and represented as bar diagrams. The participants needed to provide an answer to every question to complete a section; and if one or two of the three sections were completed, their response was included.

Trial registration: none.

RESULTS

The questionnaire was distributed to 92 resident surgeons at seven hospitals that were eligible for inclusion. A total of 83 (90%) surgeons completed all three sections of the questionnaire, and their affiliation and education level are presented in **Table 1**. Non-responders were equally distributed among the departments (data not shown).

TABLE 1 Characteristics of surgeons: affiliation for the 83 resident surgeons who participated in the survey and their education levels.

Demographics of surgeons	n (%)
<i>Capital Region</i>	
Hvidovre Hospital	16 (19)
Herlev Hospital	15 (18)
North Zealand Hospital	9 (11)
Bispebjerg Hospital	8 (10)
<i>Region Zealand</i>	
Zealand University Hospital	19 (23)
Slagelse Hospital	9 (11)
Holbæk Hospital	7 (8)
<i>Education level</i>	
PGY 1	9 (12)
PGY 2	31 (37)
PGY 3	30 (36)
PGY 4	5 (6)
PGY 5	1 (1)
Other ^a	7 (8)

PGY = postgraduate year: years of experience after both graduation and basic clinical training.

a) Surgeons from gynecology/obstetrics doing part of their residency at a general surgical department.

The resident surgeons were asked to identify the three most important 1) symptoms, 2) findings of the physical examination, 3) diagnostic imaging, 4) blood tests, and 5) other clinical measures that assisted their diagnosis of complicated appendicitis, see **Table 2**. Regarding the symptoms, most surgeons found the duration of pain (82%), worsening of pain with cough or movement (40%), pain character (22%), and “fever” (22%) to be important. In the physical examination, the surgeons weighed muscular defence (59%), rebound tenderness (48%), and percussion tenderness (48%) as important findings in patients with complicated appendicitis. For diagnostic imaging, 54% of surgeons used computed tomographies (CTs) to discriminate complicated from

uncomplicated appendicitis, whereas 37% never used any imaging modalities for this purpose. Approximately 95% of the resident surgeons reported using routine blood tests when considering if a patient suffered from complicated appendicitis. Particularly, C-reactive protein (93%), leukocytes (80%), and neutrophils (45%) were rated as important by the surgeons. The remaining 5% of surgeons elaborated that “blood tests have low sensitivity and specificity”, “it is a clinical diagnosis” and “CTs are more helpful in diagnosing complicated appendicitis”.

TABLE 2 Discriminating complicated and uncomplicated appendicitis. The surgeons were asked to identify the three most important signs for discrimination between complicated and uncomplicated appendicitis regarding symptoms, findings of the physical examination, imaging and blood tests. Free-text responses are presented in quotation marks.

Answer	n (%)
<i>Symptoms</i>	
Duration of pain	68 (82)
Worsening of pain due to cough or movement	33 (40)
Pain character	18 (22)
“Fever”	18 (22)
Lower right quadrant pain	17 (21)
Nausea/vomiting	12 (15)
Migration of pain	8 (10)
Other ^a	3 (4)
Loss of appetite	1 (1)
Diarrhoea	-
Urogenital symptoms	-
<i>Physical examination</i>	
Muscular defence	48 (59)
Rebound tenderness	40 (48)
Percussion tenderness	40 (48)
Indirect pain	24 (29)
Tenderness other areas than lower right quadrant	15 (18)
Direct pain in the lower right quadrant	13 (16)
Other ^b	10 (12)
Palpable mass in the lower right quadrant	9 (11)
Walking with a limp	9 (11)
Positive Rovsing's sign	4 (5)
Positive psoas sign	2 (2)
Positive obturator sign	-
<i>Imaging</i>	
CT	45 (54)
I do not use imaging	31 (37)
Other ^c	4 (5)
Abdominal ultrasound	3 (4)
MRI	-
Conventional X-ray	-
<i>Blood tests</i>	
C-reactive protein	77 (93)
Leukocytes	66 (80)
Neutrophils	37 (45)
Bilirubin	8 (10)
Other ^d	4 (5)
Haemoglobin	-
Creatinine	-
Calprotectin	-

a) “Grade of pain” (n = 2), and “sepsis” (n = 1).

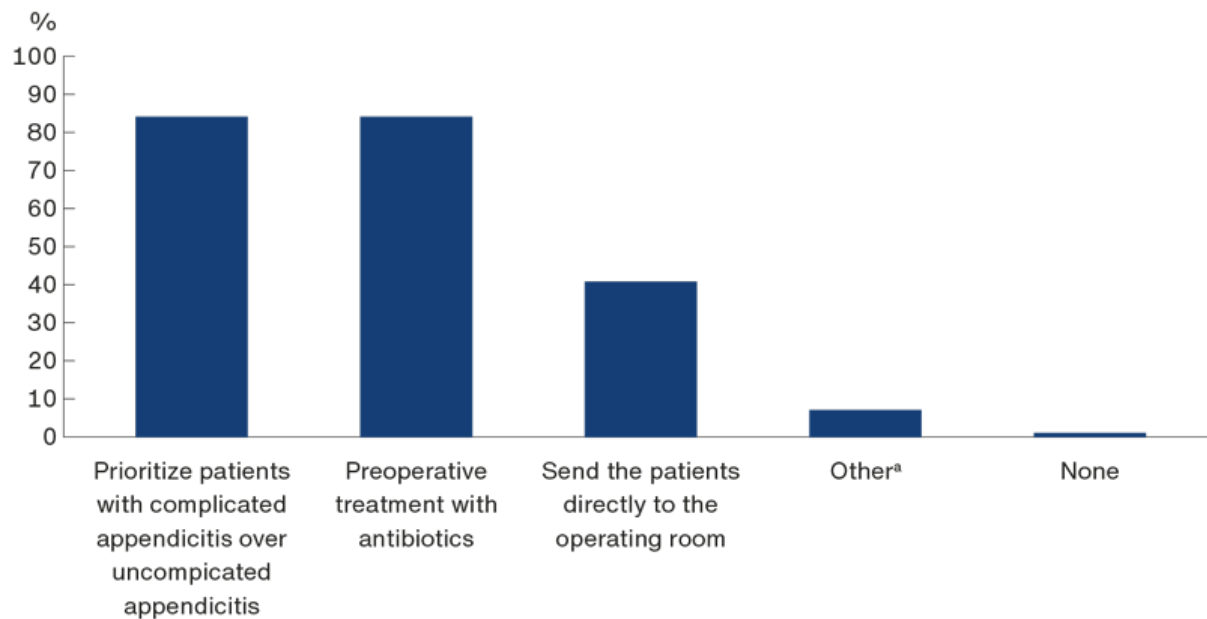
b) “The general condition of the patients” (n = 10).

c) “CT for adults and ultrasound for children” (n = 4).

d) “Blood tests have low sensitivity and specificity” (n = 1), “it is a clinical diagnosis” (n = 2), and “that CTs are more helpful in diagnosing complicated appendicitis” (n = 1).

The management of patients with complicated appendicitis was explored and is depicted in **Figure 1**. Almost all surgeons would act differently if a patient was preoperatively diagnosed with complicated appendicitis. Many surgeons would prioritise these patients over uncomplicated cases (84%) and/or would start preoperative treatment with antibiotics (84%), and 41% would send these patients directly to the operating room.

FIGURE 1 A bar diagram representing variation in surgeons' responses for the course of treatment for complicated appendicitis. Surgeons were asked to choose up to three steps. Thus, percentages equal > 100%.

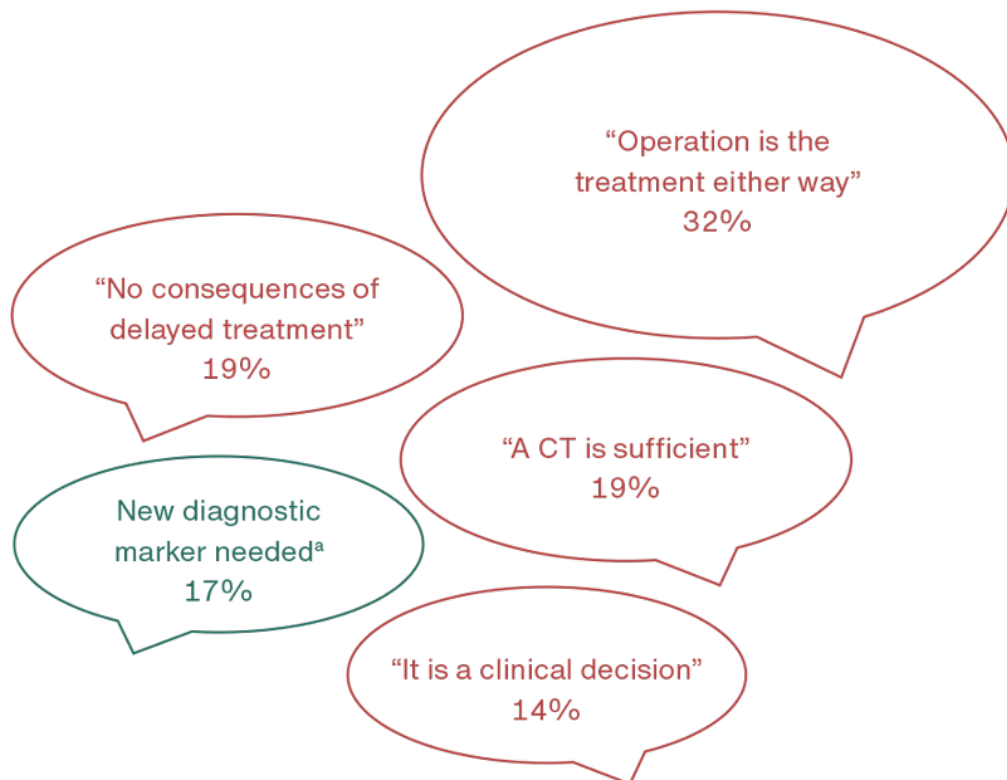


a) "ask a senior surgeon for assistance" (n = 1), "initiate sepsis regimen" (n = 1), "ultrasound-guided drainage for abscess formation" (n = 1), "inform patients regarding the risk of complications" (n = 1) and "initiate patients on preoperative antibiotics regardless of the severity of the condition" (n = 1).

Most surgeons (83%) did not feel a need for a new biomarker to discriminate between complicated and uncomplicated appendicitis. They further elaborated that there would be no consequences of a biomarker since "operation is the treatment either way" (32%), and there are "no consequences of delayed treatment" (19%) (**Figure 2**). The remaining resident surgeons (17%) reasoned that there was a need for a new biomarker and that this would affect prioritising and treatment of patients. If a new biomarker was developed, more than half of the surgeons (64%) would stress the importance of precision, whereas 33% weighted readily available results. Furthermore, surgeons would anticipate new biomarkers to be inflammatory markers (80%), bacterial or viral markers (12%), or had no opinion (8%).

FIGURE 2 Speech bubbles present the grouped responses from surgeons regarding the need for a new diagnostic marker for better discrimination of complicated and uncomplicated appendicitis. The speech bubbles are red when answers implied no need for a new biomarker and green when answers implied a need for a new diagnostic marker.

A new diagnostic marker for complicated appendicitis? Yes versus no



a) "prioritising complicated patients" (n = 5), "conservatively treat uncomplicated cases" (n = 5), "difficult to differentiate preoperatively" (n = 3) and "reduce the frequency of CT" (n = 1).

DISCUSSION

This survey found that resident surgeons in Eastern Denmark diagnose complicated appendicitis preoperatively through symptoms and signs of pain, routine inflammatory blood tests, and CTs. For patients with preoperatively diagnosed complicated appendicitis, most surgeons would initiate preoperative antibiotics and prioritise them over uncomplicated cases. Most surgeons did not think that a new diagnostic marker was necessary for distinguishing between complicated and uncomplicated appendicitis because current diagnostic methods, including CT, were considered sufficient, and the treatment would be the same anyway. However, if a

new marker were to be developed, high precision and readily available results were considered important.

Nearly all the surgeons reported using routine blood tests, especially C-reactive protein, leukocytes, and neutrophils to diagnose complicated appendicitis. However, routine blood tests have previously been investigated in multiple studies and were independently not accurate enough and of low predictive value [13]. Approximately half of the resident surgeons used CTs to preoperatively diagnose complicated appendicitis. CT scans demonstrated higher specificity [14] in identifying patients without complicated appendicitis but exhibited lower sensitivity, ranging between 14% and 59%, in distinguishing between complicated and uncomplicated cases [15].

The demand for a new diagnostic marker was low (17%). It was deemed irrelevant as 32% believed the treatment for any severity of appendicitis to be the same and 19% stated that there were no consequences for delaying the treatment of complicated appendicitis. Firstly, non-operative treatment of uncomplicated appendicitis with antibiotics has been employed for selected patients [7, 8]. In Scandinavia, however, this is not commonly used. Only 13% of departments surveyed in Norway and Sweden had established a non-operative treatment for uncomplicated appendicitis, whereas more than half of departments used it sporadically [16]. However, without a diagnostic marker, the ability to differentiate the severity of appendicitis preoperatively and establish an effective conservative treatment plan for uncomplicated cases would be unattainable [7]. Secondly, despite surgeons' views, delayed treatment of complicated appendicitis has various consequences. A recent multicentre study on approximately 2,000 patients found that delaying treatment for complicated appendicitis >8 hours increased the rate of sepsis, abscesses, post-operative fistulas, and reinterventions [3]. Thus, timely appendectomy, e.g., operation within eight hours [17], in complicated appendicitis is critical to reduce the risk of complications. Whether a patient with an abscess should undergo acute laparoscopic surgery, percutaneous drainage, or conservative treatment remains uncertain [17].

The strengths of this survey include sound reporting in accordance with the STROBE guideline [9] and face validation within the target group. The response rate for the survey was high, 90%, and well above the recommended 60% minimum level [18]. Thus, the findings of the survey are generalisable as the survey covers almost all resident surgeons responsible for treating half of the Danish population, allowing for comparison with countries with similar healthcare and surgical education systems. On the other hand, the limitations of this survey were that it only covers half of Denmark. Furthermore, at the outset of the questionnaire, the surgeons were presented with the research definition of "complicated appendicitis", but it is possible that surgeons primarily responded to questions in the context of a perforated appendix, which is of importance in the clinical setting. This may potentially have led to biased or inaccurate responses, which may potentially have affected the validity of the research findings. Another limitation of this study is the translation of the questions and responses from Danish into English to be presented in the article. However, the first author is a native speaker of English and ensured accurate translation. Finally, face validation of the questionnaire was conducted only once.

Our study revealed that even though complicated appendicitis is a common surgical emergency, educational programs for surgeons in training could be improved regarding the most accurate diagnostic methods and management for different severities of appendicitis. The use of routine blood tests and CTs individually as diagnostic methods is not accurate in the discrimination of complicated appendicitis [13, 14]. Nevertheless, many Danish surgeons relied on these methods in the clinical setting. To improve the accuracy of diagnosing complicated appendicitis and reduce the risk of misdiagnosis, what could be considered in the future is using a panel of biomarkers combined with clinical history, physical examination, and imaging (e.g., scoring systems) [19, 20]. Such an approach may also help identify patients with early or atypical symptoms of complicated appendicitis who may not present with blood test abnormalities [13]. Future studies should focus on accurately diagnosing patients with complicated appendicitis using diagnostic methods that have high precision and

provide readily available results.

CONCLUSIONS

Surgeons employ a range of diagnostic methods, including signs and symptoms of pain, CTs, and routine blood tests, to distinguish between cases of complicated and uncomplicated appendicitis. Patients diagnosed with complicated appendicitis preoperatively were typically managed differently than patients with uncomplicated appendicitis. However, less than half would effectuate early appendectomy. However, the diagnostic techniques utilised to discriminate have low accuracy. Our results emphasise the necessity of developing new and better methods to differentiate between complicated and uncomplicated appendicitis. This, in turn, could enhance education and training for managing complicated cases.

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