Ann Med Res 2020;27(10):2523-8

Annals of Medical Research

DOI: 10.5455/annalsmedres.2020.07.784

Original Article

Emergency medicine residents' interpretation of computed tomography scans in patients presenting with suspected acute appendicitis improve after training

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Abstract

Aim: Abdominal computed tomography (CT) is considered as the best imaging tool in the diagnosis of acute appendicitis (AA) in adults. Since most medical centers do not have access to immediate radiological assessment, emergency physicians (EPs) may have to interpret CTs when they need to make immediate clinical decisions. Therefore, it has become a necessity for EPs to achieve a certain level of imaging experience. The aim of our study was to evaluate the effect of a short educational intervention on the ability of emergency medicine residents (EMRs) to interpret AA criteria and diagnose AA using abdominal CT.

Material and Methods: Our study was an intervention study evaluating the effectiveness of education. The EMRs were given a 2-hour didactic session on "abdominal CT interpretation in the diagnosis of AA" by an experienced radiologist. Abdominal CTs of 39 patients with a final diagnosis of AA and 8 patients with other diagnoses were interpreted by four senior EMRs (3rd- and 4th-year residents) and three junior EMRs (1st- and 2nd-year residents) before and 2 weeks after the didactic session. Interpretations by the EMRs were compared with the radiologist's interpretations and classified as agreement or disagreement.

Results: Interpretation skills of senior EMRs before and after educational intervention showed considerable improvement in the rate of agreement (before vs after % agreement) didactic teaching as follows: enlargement of the appendix (72.3% vs. 86.2%), appendiceal wall thickening (69.7% vs. 81.9%), heterogeneous wall enhancement (46.8% vs. 61.2%), periappendiceal inflammation (63.8% vs. 79.8%), and AA diagnosis (73.4% vs. 88.8%), but not for appendicolith (79.8% vs. 77.7%). Junior EMRs showed no changes following the intervention.

Conclusion: After a short educational intervention, the senior EMRs showed significant improvement in interpreting AA diagnoses and abdominal CT criteria compared to junior EMRs.

Keywords: Appendicitis; computer-assisted; education; image interpretation

INTRODUCTION

Acute appendicitis (AA) is the most common cause of acute abdominal pain. Imaging plays a very important role when clinical presentation is atypical and it is necessary to exclude differential diagnoses mimicking appendicitis (1,2). Furthermore, most centers do not have radiologists available around the clock (3,4).

Although ultrasonography is the first choice of imaging in the evaluation of patients with suspected AA, due to its high sensitivity (87-100%) and specificity (83-97%) in cases where ultrasonography cannot be performed or cannot contribute to differential diagnosis, the use of computed tomography (CT) has recently become popular (5-11). However, accurate and rapid interpretation of CT images is needed to ensure optimal care in patient management. Interpretation of abdominal CT scans can be challenging. Although early radiological evaluation is ideal, emergency physicians (EPs) may have difficulty especially during the night shift and at the weekend. Since most medical centers do not have access to immediate radiological assessment, EPs may have to interpret CT scans when they need to make immediate clinical decisions. Despite all these difficulties, EPs are expected to provide the best possible patient management and achieve a certain level of imaging experience. Therefore, it has become a necessity for EPs to achieve a certain level of imaging experience.

Although there may be differences between academic hospitals, most ED training programs do not include radiological interpretation, and therefore it is difficult for

Received: 27.07.2020 **Accepted:** 28.09.2020 **Available online:** 21.10.2020
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emergency medicine residents (EMRs) to learn systematic radiological interpretation. Instead, they gradually gain experience in CT interpretation either by comparing it with radiology interpretation or by learning from senior EMRs or EPs.

There are several studies in the literature evaluating EPs' ability to interpret abdominal CT images. Generally, these studies compare interpretation skills of EPs with those of radiologists or surgical physicians (3, 12-14). Only two studies have been found on the effect of radiographic training on the ability of EPs to interpret abdominal CT scans in AA (14,15). To the best of our knowledge, there is not yet sufficient information about the effectiveness of training given to EMRs for interpreting AA criteria and diagnosis of AA in abdominal CT. In addition, it is unknown to what extent senior and junior residents benefit from the given didactic training. The results of this topic may help achieve the goal of improving interpretation of abdominal CT of patients with suspected AA. Also It may be use as basic data to establish CT imaging education guidelines for EMRs in academic teaching medical centers. Therefore, the aim of our study was to investigate the effect of training EMRs in the interpretation of abdominal CT scans in patients with suspected AA.

MATERIAL and METHODS

Study Design

This study is an intervention study evaluating the effectiveness of education. It was approved by the Ethical Committee of our hospital.

Study Setting and Population

This study was conducted in a teaching and research hospital that has ≥190.000 patients annually and a residency training program.

We performed a retrospective review of the medical records of consecutive adult patients (age ≥18 years) referred for contrast-enhanced abdominal CT scan in whom the diagnosis of AA was suspected between January 1 and May 1, 2018. Abdominal CT scans of the patients included in the study were used as training material for interpretation by EMRs before and after educational intervention. Trauma patients and <18 years old patients were excluded from the study.

Study Protocol

To minimize the effects of any previous radiology trainings, the 7 EMRs chosen to be studied had not undertaken the radiology rotation available in our hospital. To determine the effect of duration of ED training and clinical experience, two groups were formed consisting of senior EMRs (3rd- and 4th-year residents) and junior EMRs (1st- and 2nd-year residents).

Each resident assessed the abdominal CT scans of patients included in the study in the axial-coronal-sagittal plane blindly, alone, independently, and under supervision. All of the assessments were accomplished without time limitation in a quiet room in the ED. The EMRs were then given 2 hours of teaching on "abdominal CT interpretation in the diagnosis of AA" by a radiologist with more than 20 years of experience. The images used in the training session were different from the abdominal CTs included in the study. Standardized data collection forms were used before and 15 days after the training. CT findings of AA (Table 1) were marked on the data forms as present or absent by each resident (2,14,16).

Table 1. Computed tomography findings of acute appendicitis (2,14,16)

Criterion 1. Enlargement of the appendix to >6 mm in transverse diameter
Criterion 2. Thickening of the wall of the appendix >3 mm
Criterion 3. Abnormal and heterogeneous enhancement of the wall (visual assessment comparing with quadratus lumborum muscle)
Criterion 4. Appendicolith
Criterion 5. Periappendiceal inflammation (fat stranding, periappendiceal fluid, abscess, phlegmon)

Then, according to the preliminary interpretations of the criteria in Table 1, the diagnosis of AA was recorded as either present or absent by the EMRs. Reports of a non-visualized appendix and no secondary signs of inflammation were considered negativein terms of AA (17). The CT findings regarding presence or absence of AA were recorded by one radiologist (not the radiologist giving the training) blinded to the final diagnosis in the patients. The interpretations provided before and after the training by the EMRs were compared with the radiologist's interpretations and classified according to agreement or disagreement. False negative and false positive interpretations of the EMRs compared to the radiology report were regarded as disagreement. The radiologist's reports were considered as the gold standard and reference for comparison.

C T protocol

The computed tomography scans were obtained with a 128-Row multidetector CT machine, (SOMATOM Definition AS, Siemens Healthcare, Erlangen, Germany). All of the CT examinations were performed with intravenous non-ionic contrast material (Biemexol; 300mg Iohexol; Biem İlaç, Ankara, Turkey) given via 20G needle in an antecubital vein. No rectal or oral contrast media were given. All abdominopelvic scans were performed under breath-hold, preferably under full inspiration where available in order to reduce motion artifacts. Using 0.6mm slice thickness and 5mm reconstruction, a routine whole abdomen CT protocol was applied to all of the individuals starting a the lower thoracic cage and ending at the proximal thigh. Images then were transferred to work stations [Aquarius Workstation, version 4.4.13; TeraRecon Inc., San Mateo, CA or Siemens Syngo.via (version VB30A_HF03; Siemens AG Healthcare Sector, Erlangen, Germany)] for multiplanar reformatting and detailed analysis.

Data Analysis

Statistical analysis was performed using SPSS 20.0 for Windows (SPSS, Chicago, IL, USA). Categorical data were expressed as numbers and percentages. Pre-and post-training assessments of the senior and junior EMRs for AA diagnosis and criteria were compared by the McNemar Test. The analyses were performed within 95% confidence intervals and P <0.05 was considered statistically significant.

RESULTS

Fifty-one patients were identified who met the inclusion criteria for the study. Forty-seven patients were included in the study as four patients voluntarily left the ED before the end of the treatment. The radiologists' interpretations of the CT findings were in 100% agreement with the surgical and pathological results in the 39 patients with a definite diagnosis of AA made after surgical exploration. Eight patients with other diagnoses were contacted by telephone, and it was confirmed that they did not require any surgical intervention in the month following their emergency admissions. The contrast-enhanced abdominal CT scans of 39 patients with a final diagnosis of AA and 8 patients with other diagnoses were interpreted before and after EMR training. In 39 patients with final diagnosis of AA, the abdominal CT interpretation revealed enlargement of the appendix in 74.5% (n=29) of them, appendiceal wall thickening in 70.2% (n=27), abnormal and heterogeneous enhancement of the wall in 78.7% (n=30), appendicolith in 29.8% (n=12), and peri-appendiceal inflammation in 70.2% (n=27). Table 2 presents the pre- and post-training disagreement rates of the EMRs for the diagnosis of AA.

Table 2. The disagreement rates of emergency medicine residents for the diagnosis of acute appendicitis

	Pre-training n (%)	Post-training n (%)
Total disagreement	79 (24.0)	51 (15.5)
False negative report	66 (20.0)	38 (11.5)
False positive report	13 (4.0)	13 (4.0)
Agreement	250 (76.0)	278 (84.5)

Table 3. Evaluation of acute appendicitis and criteria by all emergency medicine residents according to pre- and post-training radiological interpretation

	Pre-training Agreement n(%)	Post-training Agreement n(%)	95% CI	P
Criterion 1	243 (73.9)	271 (82.4)	0.026 – 0.144	0.005
Criterion 2	232 (70.5)	260 (79.0)	0.025 –0.145	0.006
Criterion 3	152 (46.2)	172 (52.3)	0.007– 0 .115	0.027
Criterion 4	257 (78.1)	237 (72.0)	(-) 0.114–(-) 0.008	0.025
Criterion 5	224 (68.1)	259 (78.7)	0.045 – 0.168	0.001
Appendicitis	250 (76.0)	278 (84.5)	0.028 – 0.142	0.003

The comparison of the CT interpretations of the senior radiologist with that made by EMRs before and after the radiological training is presented in Table 3, 4, and 5. In this study it was found that the EMRs benefited from the training for the diagnosis of AA and three of the specific criteria (Table 3). In the senior EMR cohort, there was a significant increase in the rate of agreement after training for AA diagnosis in all criteria, except for appendicolith. The agreement rates of the senior EMRs for all criteria and the diagnosis of AA before and after educational intervention were higher than those of the junior EMRs. In senior EMRs high agreement rates were observed after training in AA diagnostic criteria 1,2, and 5 (72.3%, 69.7%, and 63.8% before educational intervention vs. 86.2%, 81.9%, and 79.8% after educational intervention, respectively) (Table 4). Junior EMRs however, did not benefit from the training for all the criteria and AA diagnosis, especially criterion 4 (Table 5).

Table 4. Evaluation of acute appendicitis and criteria by junior emergency medicine residents according to pre- and post-training radiological interpretation

	Pre-training Agreement n(%)	Post-training Agreement n(%)	95% CI	P
Criterion 1	107 (75.9)	109 (77.3)	0.081 – 0.110	0.769
Criterion 2	101 (71.6)	106 (75.2)	(-) 0.067 –0.138	0.494
Criterion 3	64 (45.4)	57 (40.4)	(-) 0.128– 0.280	0.210
Criterion 4	107 (75.9)	91 (64.5)	(-) 0.209 –(-) 0.018	0.020
Criterion 5	104 (73.8)	109 (77.3)	(-) 0.057– 0.128	0.448
Appendicitis	112 (79.4)	111 (78.7)	(-) 0.097 – 0.083	0.877

Table 5. Evaluation of acute appendicitis and criteria by senior emergency medicine residents according to pre- and post-training radiological interpretation

	Pre-training Agreement n(%)	Post-training Agreement n(%)	95% CI	P
Criterion 1	136 (72.3)	162 (86.2)	0.081 – 0.110	<0.001
Criterion 2	131 (69.7)	154 (81.9)	(-) 0.067 –0.138	0.001
Criterion 3	88 (46.8)	115 (61.2)	(-) 0.128– 0.28	<0.001
Criterion 4	150 (79.8)	146 (77.7)	(-) 0.209 –(-) 0.018	0.481
Criterion 5	120 (63.8)	150 (79.8)	(-) 0.057– 0.128	<0.001
Appendicitis	138 (73.4)	167 (88.8)	(-) 0.097 – 0.083	<0.001

DISCUSSION

The use of CT scans has increased recently since most EDs have access to CT scans 24 hours a day. CT scans contribute to differential diagnosis, are rapid and feasible, and do not require the presence of radiologists in the hospital (3,4). However, the intense working conditions of most EDs necessitate the preparation of preliminary reports CT scans by EPs to facilitate early patient management.

In this study, we demonstrated that senior EMRs' ability to correctly interpret AA in abdominal CT improved from 73.4% to 88.8% after a 2-hour didactic session. When the interpretation skills of the senior and junior EMRs were evaluated separately, however, it was seen that the senior EMRs benefited from the training whereas the junior EMRs did not. In a recent study published by Limon et al., the ability of four EPs to interpret AA criteria on abdominal CT was evaluated 2 weeks after a 4-hour training session given by the radiology department (14). However, in that study, pre-training evaluations were not performed and EPs were not asked whether there was a radiological diagnosis of AA. Limon et al. showed that the performance of EPs was good for criteria 1 and 2, but not for the other criteria (14). Similarly, in the present study, the senior EMRs were found to perform well in evaluating the criteria 1, 2, and 5. However, the performance of both resident groups, and particularly that of the junior resident group, was not good in evaluating criterion 4. We can explain this by the fact that appendicolith is less common than the other four criteria and that residents see fewer appendicolith findings when practicing abdominal CT interpretation. Furthermore, in comparison with non-enhanced CT, appendicolith is not easily identified on contrast-enhanced CT (18). In a study by Choi et al., the most useful criteria for the diagnosis of AA in contrast-enhanced abdominal CT were found to be enlarged appendix, appendiceal wall thickening, periappendiceal fat stranding, and appendiceal wall enhancement, respectively (16). Our study replicated these findings in senior EMRs.

In the literature, we have encountered only one study evaluating the abdominal CT imaging skills of EMRs in terms of AA both before and after training. In that study, Song et al. used a different training model and method than in our study (15). They examined the experience period and learning curve required for 1st-year EMRs to diagnose AA in abdominal CT. The EMRs completed a CT interpretation checklist, which was developed by ED personnel and used for a long time before and after the training. They were also given bedside training on abdominal CT interpretation by senior EMRs or EPs. The authors concluded that 16 to 20 checklist interpretations were required to obtain acceptable CT interpretations from abdominal CT scans in suspected AA by 1st-year EMRs. Additionally, they showed that after performing 61 to 80 CT scans, 1st-year EMRs could diagnose AA with acceptable accuracy, regardless of suspicion of AA (15).

There are several studies in the literature showing the usefulness of educational intervention studies to improve the medical skills of clinicians (19-21). Levitt et al. evaluated head CT interpretation skills of emergency medical professionals after 1 hour of training and showed that the emergency and radiology CT scan agreement rate increased from 61.3% to 88.6% (19). In a study by Perron et al., EMRs detected intracranial pain with only 60% accuracy before the educational intervention, and achieved an accuracy rate of 78% three months after the educational intervention (20). Kerwin et al. found significant improvement in the ability of EMRs and EPs to recognize abnormal wall movements on echocardiographic images after a short 30-minute training (median pre-training score 67%, median post-training score 87%) (21). In the present study, the agreement rate of the senior EMRs both before and after the educational intervention was higher than that of the junior EMRs. These results are consistent with the literature (22,23). This may be explained by different experiences and levels of training of the residents included in this study regarding abdominal CT interpretation for the diagnosis of AA. It can also be explained by the fact that senior EMRs see a greater number of abdominal CTs and develop their interpretation skills thanks to both EPs and radiology physicians during patient management. In addition, the training duration of 2 hours may not have been sufficient to transmit the desired knowledge to the junior EMRs. On the other hand, Kang et al. found no significant difference in the disagreement rates associated with the educational level of EMRs. They stated that this was due to the imaging education program, which was given in a condensed manner in the first year of EMR training at their institute (13).

Of the 47 patients included in our study, only 8 had an alternative diagnosis. As the number of cases with alternative diagnoses was very low and these were out of the scope of the present study, the residents were not asked what the other diagnoses were. In addition, clinical information, pelvic examination and laboratory data should be taken into consideration when performing CT evaluation of patients with alternative diagnoses.

Our objective was to assess the validity of an educational intervention to identify criteria for AA and diagnosis of AA on abdominal CT. This study was not conducted to reveal the ability of emergency physicians to interpret abdominal CTs without the assistance of radiologists;it was intended only as a starting point to support the imaging training of emergency physicians who have to make life-changing decisions without immediate radiological support.

At our institute, there was no a systematic radiology training program for EMRs at the time of our study. The residents were received training about imaging only as part of a training program oriented towards common and serious illnesses. A standard resident training was provided in our ED with the joint participation of junior and senior EMRs. For the last year, in order to increase the quality of training, the residents were divided into two groups as senior and junior and training programs were created according to learning objectives. In addition, CT interpretation practice is performed with the radiologist during the training hours of senior residents.

We believe that a good imaging training program initiated from the first year of residency training would be beneficial for improving the preliminary interpretation skills of EMRs and for eliminating the gap in interpretation skills between junior and senior EMRs. Also, a different training program can be created for senior and junior residents. In addition, the quality of practical training can be improved with the support of the radiology department. These studies may help establish the training curricula of EMRs on radiological interpretation.

Our study has several limitations. First, the patient selection was retrospective, uncontrolled, and nonrandomized. Therefore, when assessing the CT scans, the EMRs were blinded to patients' clinics. Second, our study included image interpretations made by a limited number of EMRs from a single institution, and we are not able to determine to what extent the results can be applied to other institutions. Third, the small number of EMRs and their separation into two subgroups can decrease the reliability of the results. However, we still believe that our results provide a perspective for training clinics regarding resident education. For instance, an intensive imaging training program can be prepared by education officers starting from the first year of residency training, or the training subjects and hours can be planned according to the residents'education year. Fourth, we did not receive feedback from the EMRs participating in the study regarding the content, duration, and effectiveness of the training. Fifth, an ideal environment could not be fully provided for the residents during their assessment and the image quality of the computers used was not very good compared to those used in the radiology department.

CONCLUSION

Overall, our results show that a 2-hour didactic educational intervention improves the ability of the senior EMRs to interpret abdominal CT scans for the diagnoses of AA and criteria, but is insufficient for the junior EMRs.

Acknowledgements: The authors thank all EMRs for their kind help and Dr Murat Anil for statistical consultation in this research study.

Competing interests: The authors declare that they have no competing interest.

Financial Disclosure: There are no financial supports.

Ethical approval: The study was approved by the University of Health Sciences, Bozyaka Teaching and Research Hospital Ethics Committee (2019/3).

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