

Emergency computed tomography for the diagnosis of acute appendicitis: How effectively we use it?

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ABSTRACT

BACKGROUND: Technological developments support using ultrasonography (US) in all patients, if available, and advanced diagnostic methods such as abdominal computed tomography (CT) in case of clinical suspicion during diagnostic process of acute appendicitis. We aimed to investigate whether CT was appropriately and efficiently used in the diagnosis of acute appendicitis.

METHODS: Between May 2013 and February 2016, 811 patients who underwent appendectomy were retrospectively reviewed from an IRB-approved database, and those who underwent a preoperative CT were enrolled into the study. Results of Alvarado scores and US were recorded in addition to which clinic requested the CT (general surgery or emergency department).

RESULTS: The frequency of CT use in the diagnostic process was 25% (n=208/811). Ultrasound was negative for appendicitis in 53% of these patients. The mean Alvarado score was 5 ± 1.5 (range: 3–8). General surgeons requested 57% of CTs. Alvarado scores were significantly higher in patients whose CT was requested by general surgery than in those whose CT was requested by the emergency clinic (5.6 vs. 4.7, $p=0.013$). Regarding histopathological results, age and Alvarado scores were significantly lower ($p=0.015$ and 0.037 , respectively), whereas the frequency of negative CT was significantly higher ($p=0.042$) in those with negative appendectomy (n=29, 14%).

CONCLUSION: Most patients who underwent CT in the diagnostic process had an Alvarado score between 5 and 8 and negative ultrasound for appendicitis preoperatively. These findings may provide efficient use of CT in the diagnosis of appendicitis with an acceptable rate of 25% compared with the findings in current literature. However, further research is needed to ensure more efficient use of CT because negative appendectomy has been a concern in our series despite promising results of this study.

Keywords: Acute abdomen; acute appendicitis; Alvarado score; computed tomography.

INTRODUCTION

Acute appendicitis is usually diagnosed on the basis of a patient's clinical history in conjunction with physical examination and laboratory and radiological studies. In early times, the main aim was to perform surgery as early as possible to prevent any appendiceal rupture or severe peritonitis; hence, patients underwent immediate surgery in case of typical findings without radiological evaluation. However, in the current era, where radiology has become surgeon's main helper, almost all patients are examined using ultrasonography (US)

prior to making a surgical decision. In addition, computed tomography (CT) remains the next preferred diagnostic test to determine the problem in patients with a clinical suspicion of appendicitis because it is the most accurate imaging study for the evaluation of appendicitis and differential diagnosis of acute right lower quadrant pain.

Advanced imaging is advisable in patients with atypical symptoms, which can occur in infants, small children, elderly, and young women. Many gynecologic conditions can mimic acute appendicitis, making the diagnosis unclear. Alvarado scoring

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system has been established for use in patients with suspected appendicitis and used since it was first reported in 1986.^[1] This score helps clinicians to determine the better candidate for further diagnostic imaging (mostly CT). In case of an Alvarado score between 5 and 7, CT is indicated.

In recent years, CT has become more widespread, accessible, and affordable in addition to being performed quickly. Its use has also expanded for appendicitis, and this can sometimes be unnecessary. One of the highest rated causes of increasing use of advanced radiological studies is clinicians' intolerance for uncertainty which is related to growing clinical indications.^[2] Whether clinicians use it appropriately and efficiently for suspicion of appendicitis is still questionable. We aimed to investigate the role of CT in our emergency practice and whether we apply it correctly in a tertiary health care center in Istanbul.

MATERIALS AND METHODS

Patient Selection

The local ethical committee of Sisli Hamidiye Etfal Training and Research Hospital approved this study. Informed consent was waived from all patients. Between May 2013 and February 2016, 811 consecutive adult patients (aged >18 years) with a history of appendectomy were reviewed. Among these patients, we only selected patients who underwent abdominal CT during preoperative assessment. A total of 208 patients (25%) met this criterion. Data collection included patients' demographic features, radiological (US and CT) findings, and histopathological examinations. Patients were evaluated by comprehensive history, clinicopathological examination, and Modified Alvarado Score.^[3] In addition, information about which clinic (general surgery or emergency service) requested the CT scan was recorded.

Sonography and CT

All sonographic examinations were performed with an ultrasound (US) system equipped with a 2–5-MHz convex, 5–8-MHz curved, or a 5–12-MHz linear transducer (Siemens S2000, Siemens Healthcare, Erlangen, Germany). Abdominal radiologists with 2–6 years of experience performed the sonographic studies. For normal appendix definition, the entire length of the appendix is required to be visualized with a transverse outer diameter of ≤ 6 mm. US criteria for acute appendicitis is defined as an incompressible appendix with a diameter of ≥ 6 mm and a mural thickness of >2 mm and having periappendiceal hyperechoic fat and free fluid.^[4,5]

Computed tomography was performed using a 16- or 64-slice multidetector CT scanner (Somatom Sensation Open; Siemens, Germany) only with IV contrast. Acute appendicitis was defined as an enlarged appendix (≥ 7 mm in outer diameter), peri-appendiceal fatty infiltration, and a thickened appendiceal wall with enhancement.^[6]

Data Analysis

The sonographic and CT examinations from 208 patients were retrospectively reviewed by the consensus of two radiologists with 6 and 10 years of abdominal imaging experience. During both review sessions, the radiologists were asked to classify each appendix as normal or perforated appendicitis. The other possible causes of right lower quadrant pain other than appendicitis were also recorded.

Statistical Analysis

IBM SPSS version 20 (IBM, Chicago) was used for analysis. Continuous variables were represented as mean \pm standard deviation or median and range. Categorical variables were represented as percentages. Continuous and categorical parameters were analyzed using independent sample t-tests or Mann–Whitney U-test and chi-square tests, respectively. Kruskal–Wallis test was used for multiple comparisons. P values <0.05 were considered statistically significant.

RESULTS

There were 63 female and 145 male patients with a mean age of 36.6 ± 12 years (range, 18–79 years). Indications for CT after sonography were as follows: (1) radiologist's recommendation for additional CT because of equivocal sonographic findings or evaluation of the inflammatory extension ($n=49$); (2) clinician's recommendation due to atypical abdominal pain or a discrepancy between sonographic and laboratory results ($n=68$); and (3) emergency clinician's decision for a differential diagnosis of suspected pathology of appendicitis that could not be detected by US ($n=91$).

Table 1. Demographic and radiological features of the patients ($n=208$, 25%)

Age, years (Mean \pm SD)	36.6 \pm 12
Gender (Male/Female)*	145/63
Alvarado score (Mean \pm SD)	5 \pm 1.5
Alvarado score	
1–4	59
5–8	149, 71.6%
9, 10	0
Ultrasonography	
(+)	47
(–)	112
Equivocal	49
Computed tomography request	
Emergency clinician	91 (43.7%)
General surgeon	117 (56%)

*Alvarado score was significantly higher in females who underwent CT preoperatively (5.6 ± 1.4 vs 4.8 ± 1.6 , $p<0.001$). SD: Standard deviation.

Table 2. Radiological findings and Alvarado scores on the basis of which clinic requested

Variables	No of patients	p
Ultrasonography (+/- /0 [†])	47/112/49	
Computed tomography (+/-)	175/33 (15%)	
Distribution of Alvarado scores**		
General surgery (57%)	5.6±0.6	0.013
Emergency medicine (42%)	4.7±1.2	

[†]Can not be visualized; ^{**}Regarding the clinics requested the computed tomography.

Most of the patients (66%) had an Alvarado score between 5 and 8 (Table 1). US findings were negative for appendicitis in 112 (53%) patients; however, other reports recommended abdominal CT in case of suspicion of appendicitis. General surgeons requested most of the abdominal CTs (53%). Alvarado score was significantly higher in patients with CT ordered by general surgeons (5.6 vs 4.7, p=0.013) (Table 2). CT was negative for appendicitis in 33 cases.

All patients underwent surgery within 12 h following CT. Histopathological examinations revealed negative findings for acute appendicitis in 29 (14%) of patients. In these patients, age and Alvarado scores were significantly lower than those with positive pathological examination results (Table 3). The rate of negative CT findings in these patients was significantly higher (58% vs. 9%, p<0.001).

In 12 patients, whose CT revealed positive findings despite negative US results, histopathological results were negative for appendicitis. Sensitivity and specificity of CT were 92% and 58%, respectively.

DISCUSSION

The differential diagnosis of right lower-quadrant pain includes several disorders including gastrointestinal, gynecologic, and ureteric pathology. Imaging studies are beneficial in evaluating right lower-quadrant pain. However, growth in use and

overuse of diagnostic imaging significantly impacts the quality and costs of health care services.^[7] CT is currently popular for the differential diagnosis of right low quadrant pain, particularly in the suspicion of acute appendicitis. In our center, one-fifth of patients with suspected appendicitis underwent CT to determine the underlying etiology. More than half of the patients, who underwent CT scan, had negative or equivocal findings in US regarding appendicitis. The mean Alvarado score in our series was about 5 with a significantly higher value in female patients. This latter finding could be related to the wide range of possible disorders which resulted in right lower quadrant pain that needs differential diagnosis, particularly in female patients. In an algorithm to guide CT use for appendicitis, this difference was also noted. The score was determined as ≤8 for female patients, whereas it was 6 for male patients.^[8]

Strategies for improvement in the decision-making process include the use of diagnostic scoring systems, laboratory markers, and advanced imaging modalities including CT. Despite several disadvantages such as high cost, radiation exposure, and time-consuming, CT is proved to be the dominant imaging method given that ultrasound proved to be ineffective in the suspicion of appendicitis.^[9] Utilization of high-technology has decreased the rate of negative appendectomy.^[10,11] In the present study, the rate of negative appendectomy was quite higher when compared to our series including whole patients who underwent appendectomy with or without preoperative CT,^[12,13] but it was comparable with the literature.^[11] However, this could be attributed to the fact that the present study included patients whose clinical presentation was suspicious for appendicitis and who underwent advanced imaging method (CT). Most of the patients with negative appendectomy were younger and had significantly lower Alvarado scores. This relation could be due to the higher possibility of lymphoid hyperplasia in this population and subsequent subtle clinical findings. Therefore, initial medical management should be considered in such group of patients that may result in clinical improvement soon after a short observation period.

How clinicians use these strategies depends on many factors related to the practice setting, population served, and clinical

Table 3. Comparative analysis of clinical and radiological findings regarding pathological results

	Pathology (-) (n=29, 14%)	Pathology (+) (n=179)	p
Gender (Female/Male)	13/16	51/128	0.192
Age	29±12	38±12	0.015
Alvarado score	4.9±1.5	5.6±1.3	0.037
Ultrasonography (+/- /0 [†])	8/6/15	39/106/34	0.023
Computed tomography** (+/-)	12/17	163/16 (9%)	<0.001

[†]Can not be visualized. ^{**}The rate of negative CT was around 10%.

goals. In our study, compared with the emergency clinicians, the patients who were requested CT by general surgeons had significantly higher Alvarado scores. A plausible explanation for this includes the clinical goal of the surgeons and need for surgical decision-making process of appendicitis. Although emergency clinicians aim to determine the underlying disorder of right lower quadrant pain and refer patients to the right clinic, general surgeons mostly use CT to eliminate pitfalls and focus on the differential diagnosis of plausible acute appendicitis.

In a meta-analysis of 6 prospective studies, CT demonstrated superior sensitivity (91%) and specificity (90%) compared with US (sensitivity 78%; specificity, 83%) in the diagnosis of acute appendicitis.^[14] US was beyond the scope of this study; however, 90% sensitivity of CT was compatible with the current literature, whereas a specificity of 53% was quite low. This issue can be related to these limited patient series of whose diagnosis was suspected for appendicitis. Nevertheless, in most patients, clinical decision was based on physical examination findings that integrated with laboratory and imaging study results.

Limitations of the study were its retrospective design, lack of cost analysis, and adverse effects of radiation exposure or radiopaque use. Further limitations include the lack of observer-blindness regarding disease status and CT results; this may have resulted in overestimation of the validity and reliability of this study.

In conclusion, the use of abdominal CT in case of clinical suspicion of acute appendicitis or indeterminate diagnostic scores was particularly performed for patients with inconclusive or negative appendicitis ultrasound results and an Alvarado score between 5 and 8. These promising results may support the efficient use of CT. However, the rate of negative appendectomy still remained quite high. Therefore, further studies are required to determine how CT can be more efficiently used for patients with a preliminary diagnosis of acute appendicitis.

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ORJİNAL ÇALIŞMA - ÖZET

Akut apandisit tanısında bilgisayarlı tomografi ne kadar etkili kullanılıyor?

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AMAÇ: Gelişen teknolojik imkanlar ve bunlara kolay ulaşım ile birlikte akut apandisit hastalarının tanısında hemen her hastada kullanılan ultrasonografi (USG) -özellikle klinik şüphede kalınan hastalarda- bilgisayarlı tomografi (BT) ile desteklenmektedir. Biz bu çalışmada özellikle Alvarado skorlaması ve US sonuçları göz önüne alınarak akut apandisit tanısında kullanılan BT'nin ne kadar etkin kullanıldığını araştırmayı hedefledik.

GEREÇ VE YÖNTEM: Mayıs 2013 ve Şubat 2016 tarihleri arasında acil serviste değerlendirilerek tedavisi düzenlenen akut apandisit hastaları etik kurul onaylı veriler analiz edilerek geriye dönük tarandı. Ameliyat öncesi BT kullanılan hastalar çalışmaya alındı. Hastaların demografi verileri, Alvarado skorları, USG ve BT raporları, BT istenen bölüm (acil servis-cerrahi), ameliyat notları ve patoloji sonuçları kayıt edildi.

BULGULAR: Çalışma sürecinde tedavi edilen 811 akut apandisit hastasından 208'ine (%25) BT çekildiği saptandı. Hastaların hepsine en az bir kez USG yapılmıştı ve %53'ünde (n=112) USG negatif idi. Alvarado skorları ortalama 5 ± 1.5 (dağılım: 3-8) idi. Bilgisayarlı tomografi istemlerinin %42'si acil hekimleri tarafından %57'si cerrahlar tarafından istenmişti. Acil servis ve cerrahi branşlarının BT istemi yaptıkları hastaların ortalama Alvarado skorları sırasıyla 4.7 ve 5.6 olarak bulundu ($p=0.013$). Apendiks patolojisi normal saptanan (n=29, %14) hastalarda negatif BT oranı anlamlı yüksek ($p=0.042$); yaş ve Alvarado skoru anlamlı düşük (sırasıyla, $p=0.015$ ve 0.037) saptandı.

TARTIŞMA: Alvarado skorunun BT çekilen hastaların çoğunda 5-8 arasında olması ve çoğunlukla USG negatif hastalarda olmak üzere %25 oranında uygulanması ameliyat öncesi BT'nin apandisit tanısında etkin kullanıldığı lehine yorumlanabilir. Bu sonuçlar ışığında çalışmamızdaki negatif apandektomi oranları göz önüne alındığında BT'nin daha etkin kullanımını sağlamak için ileri çalışmalara ihtiyaç vardır.

Anahtar sözcükler: Akut apandisit; akut batın; Alvarado skoru; bilgisayarlı tomografi.

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