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Clinical Research

Evaluation of the Use of Computerized Tomography to Diagnose Children with Acute Abdominal Complaint

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Abstract

Objective: *Computed tomography is frequently used in children despite radiation. The aim of the study is to determine the reasons for requesting computed tomography in children presenting to the emergency clinic.*

Methods: *Between 2021 January and 2022 January, 319 children who applied for non traumatic reasons and underwent computed tomography were included in the retrospective study. The patients' lower and upper abdominal computed tomography report results, demographic characteristics, symptoms, physical examination and laboratory findings were scanned and recorded from the electronic data system.*

Results: *Of the patients, 166 (52%) were male and 153 (48%) were female. The mean age was 11.80 ± 4.13 years. While no findings were detected in 110 (34%) patients, findings of acute surgical abdomen were detected in 85 (27%). Findings suggestive of acute appendicitis were detected in 79 of the 85 patients. Male gender, constipation complaint, tenderness in the right lower quadrant and defence on physical examination were significantly higher in children with acute surgical abdominal findings compared to children without findings (p<0.001, p=0.026, p<0.001 and p<0.020 respectively) .In patients with suspected acute surgical pathology, ANC (p<0.001) and NLR cut-off value (p<0.001) were found to be significantly higher according to age.*

Conclusion*: The study revealed that computed tomography is frequently used in pediatric emergency services, especially to exclude the diagnosis of acute appendicitis. The use of computed tomography can be reduced by using detailed history, physical examination, laboratory tests and radiation-free imaging studies according to the suspected preliminary diagnosis.*

Key words*: Children, Computed Tomography, Pediatric Emergency,*

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Introduction

Acute abdominal pain (AAP) is one of the most common causes of referral to pediatric emergency clinics, with a prevalence estimated at 5.1-5.5% (1). In the clinical evaluation of children with AAP, it is important to determine the possible etiological cause and to determine whether surgical intervention is required (2, 3). Especially in young children, it is difficult to determine the etiology due to the nonspecificity of most signs and symptoms, and the problems experienced during history taking and examination (4). Considering that inflammatory markers such as white blood cell (WBC) count and C reactive protein (CRP) are not diagnostic, imaging studies are frequently used to distinguish conditions requiring acute surgical intervention from others (5).

In children with acute AAP, direct abdominal radiography (DAR), ultrasonography (USG), magnetic resonance (MR) and computerized tomography (CT) are generally used as imaging methods (6). However, the decision on which method to use is made according to the patient's age, the presumptive diagnosis, clinical condition and the availability of imaging methods in the hospital. The high accuracy, easy access, short imaging time, especially in young children, and the inadequacy of classical imaging methods such as standing direct DAR and USG in revealing etiological causes, as well as concerns about malpractice, have led emergency physicians to use CT more widely (7, 8). However, caution should be exercised when choosing it over other imaging methods due to reasons such as radiation, allergy or nephrotoxicity risk due to the contrast agent used (3, 9).

This study aimed to determine the indications for diagnostic CT use in children admitted to a tertiary hospital in Ankara with acute abdominal pain between 2020 and 2021.

Materials and Methods

This cross-sectional study included 319 children who presented to the Pediatric Emergency Clinic of the University of Health Sciences Ankara Keçiören Training and Research Hospital with abdominal pain and underwent abdominal CT between 2020 and 2021.

The patients' symptoms at the time of presentation to the pediatric emergency clinic, physical examination findings, laboratory findings, imaging examination reports, whether or not they had consulted with the relevant department, CT scan time, and follow-up periods were recorded. Then, the patients were divided into two groups as those with and without findings on abdominal CT. Patients with pathological findings on CT scan were divided into two subgroups as those with and without acute surgical abdomen findings (acute appendicitis, intussusception, ileus, ovarian torsion). The groups were compared with each other according to their complaints at presentation, physical examination findings, laboratory findings and imaging tests performed, CT scan times, follow-up periods, and whether or not they had requested consultation with the relevant department.

Exclusion Criteria

Patients who presented to the emergency department due to trauma were not included in the study.

Statistical Analysis

Statistical analysis was performed with SPSS 22.0 (Statistical Programme Social Sciences) package program. Kolmogrow Smirrov test was applied to determine normally distributed data. Chi square test or Fisher exact test was used to compare qualitative data between groups. Student t test was applied for data consisting of two groups and showing normal distribution, and Mann Whitney U test was applied for data not showing normal distribution. Univariate and multivariate logistic regression analysis was applied to determine possible factors thought to be effective in those with acute surgical abdomen detected on CT. Variables with $p<0.25$ in univariate logistic regression analysis were included in multivariate logistic regression analysis. Enter model was used in multivariate logistic regression analysis. Roc curve analysis was applied to determine the cut-off values of CRP, WBC count, absolute neutrophil count (ANC), neutrophil lymphocyte ratio (NLR) and Mean Platelet Volume (MPV) values for those with findings on CT and those with acute surgical abdomen detected in those with findings. It was evaluated at $p<0.05$ significance level.

This study received ethics committee approval dated 27.04.2021 and numbered 2012-KAEK-15/2267

Results

Of the 319 patients included in the study, 166 (52%) were male and 153 (48%) were female. Their ages ranged from 1 to 18 years, and the mean age was 11.80 ± 4.13 years (Table 1). No findings were detected in 110 (34%) of the patients. Findings that did not cause acute surgical abdomen were detected in 124 (39%), and findings suggesting acute surgical pathology were detected in 85 (26%).

Table 1. Comparison of demographic characteristics of all cases with abdominal CT.

	Computed Tomography			p	(n:209)	CT Pathological Findings Delected		p
	Finding Delected (n:209)	**No Finding Delected (n:110)**	**Total (n:319)**			**Acute Surgical Abdomen Delected (n:85)**	**Acute Surgical Abdomen Untedected (n:124)**	
Gender					**Gender**			
Female	111(53,1%)	55(50,0%)	166(52,0%)	0,597*	**Female**	28(32,9%)	83(66,90%)	<0,001*
Male	98(46,9%)	55(50,0%)	153(48,0%)		**Male**	57(67,1%)	41(33,10%)	
Age, years	12,28±4,34	10,88±4,34	11,80±4,34	$0,004^{\beta}$	**Age, years**	11,95±3,39	12,50±4,27	$0,300^{\beta}$
Under 2 years old	1(0,50%)	1(0,9%)	2(0,60%)	0,004*	**Under 2 years old**	-	1(0,80%)	0,089*
2-5 years old	11(5,30%)	10(9,1%)	21(6,60%)		**2-5 years old**	2(2,4%)	9(7,30%)	
5-12 years old	72(34,4%)	55(50%)	127(39,80%)		**5-12 years old**	36(42,4%)	36(29%)	
Over 12 years old	125(59,8%)	44(40%)	169(53%)		**Over 12 years old**	47(55,3%)	78(62,9%)	

The mean age of all children with symptoms in the study was 12.28 ± 4.34 years, while the mean age of children with no symptoms was 10.88 ± 4.34 years, and while most cases were over the age of 12 in those with symptoms, most cases were between the ages of 5-12 in those with no symptoms. A statistically significant difference was found between the groups in terms of age grouping (p: 0.004). The mean age of children with acute surgical abdomen findings was 11.95 ± 3.39 years, while the mean age of those without was 12.56 ± 4.40 years. The most cases were over the age of 12 in both groups. No statistically significant difference was found between the groups in terms of age grouping (p:>0.089).

Among the cases with acute surgical abdomen, 28 (32.9%) were girls and 57 (67.1%) were boys, while 83 (66.9%) were girls and 41 (33.1%) were boys in cases without acute surgical abdomen. The rate of boys in children with acute surgical abdomen was found to be statistically significantly higher than in those without (p:<0.001).

Of the 85 patients with acute surgical pathology, 79 had acute appendicitis, 4 had intestinal obstuction, 1 had ovarian torsion, and 1 had findings suggesting intussusception (Table 2).

Table 2. Ages and presumed diagnoses of patients with acute surgical abdomen findings on CT.

n:85		Age groups			
		Under 2 years old	**2-5 years old**	**5-12 years old**	**Over 12 years old**
Acute Appendicitis	79 (92%)	-	1 (1,17%)	33 (38%)	45 (52%)
Ovarian Torsion	1 (1,17%)	-	-	1(1,17%)	-
Ileus	4 (4,70%)	-	1 (1,17%)	2 (2,35%)	1(1,17%)
Invagination	1 (1,17%)	-	-	-	1(1,17%)

In patients with findings on CT but not requiring acute surgical intervention, the most common findings were mesenteric lymphadenitis, acute gastroenteritis findings, ovarian cysts, and urinary pathology.

The most common complaint in all patients included in the study was abdominal pain. It was observed that abdominal pain was accompanied by vomiting, fever and diarrhea. In children with acute surgical abdomen, male gender (p:<0.001), constipation (p:0.024), tenderness in the right lower quadrant of the abdomen on physical examination (p:<0.001) and defense (p:0.020) were significantly higher compared to those without acute surgical abdomen. In those without acute surgical abdomen, the rate of those with widespread abdominal tenderness (p:0.039) and in those without any findings, the rate of those with normal abdominal examination was significantly higher (p:<0.001) (Table 3).

Table 3. Physical examination results of patients with and without acute surgical abdomen detected on CT.

(n:209)	CT Pathological Findings Detected		p
	Acute Surgical Abdomen Diagnosed (n:85)	Acute Surgical Abdomen Undetected (n:124)	
	n(%)	n(%)	
Abdomen comfortable	6 (7,10%)	34(27,40%)	<0,001*
Lower right quadrant sensitivitiy	54 (63,50%)	31 (25%)	<0,001*
Widespread abdominal tenderness	13 (15,30%)	34(27,40%)	0,039*
Defense in the lower right quadrant	14 (16,50%)	8(6,50%)	0,020*
Rebaund in lower right quadrant	7 (8,20%)	5 (4,00%)	0,234*
Suprapubic tendernes	1 (1,20%)	5 (4,00%)	0,404*
Epigastric tenderness	5 (5,90%)	4 (3,20%)	0,491*
Costavertebral angle tenderness	1 (1,20%)	8 (6,50%)	0,086*
Oropharynx hyperemic,tonsils hypertrophic	3 (3,50%)	5 (4,00%)	0,999*
Increased bowel sounds	2 (2,40%)	2 (1,60%)	0,999*
Tenderness in testicles	-	1 (0,80%)	0,999*
Sensitivity in the lower left quadrant	2 (2,40%)	4 (3,20%)	0,999*
Periumbilical tenderness	2 (2,40%)	3 (2,40%)	0,999*
Tenderness in the right upper quadrant of the abdomen	3 (3,50%)	3 (2,40%)	0,689*
Chi square test*			

In patients with acute surgical pathology on CT, WBC count, ANC, and NLR were found to be statistically significantly higher than in those without acute surgical pathology, while no significant difference was found in CRP and MPV values (Table 4).

Table 4. Comparison of cases with and without acute surgical pathology detected on CT according to laboratory results.

n:209	Findings Detected in Computerized Tomography				
	Those Diagnosed With Acute Surgical Abdomen (n:85)		**Those Without Acute Surgical Abdomen (n:124)**		**p**
	X±SS	Med(Q_3-Q_1)	X±SS	Med(Q_3-Q_1)	
CRP	43,58±76,36	8,7 (1,66-48,2)	25,58±43,17	5,5 (0,62-24,9)	0,079$^{\Phi}$
WBC	13843,53 ± 4708,94	14200 (10500-17100)	10795,16±4448,84	10150 (7450-12400)	**<0,001** $^{\Phi}$
ANC	1096,82 ± 4598,19	11480 (7750-14260)	7690,65±4200,07	6630 (4590-9035)	**<0,001** $^{\Phi}$
NLR	7,67± 6,30	6,32 (3,32-9,21)	4,84±4,99	3,33 (1,76-6,15)	**<0,001** $^{\Phi}$
MPV	8,90 ± 0,88	-	9,15±1,05	-	0,071 $^{\beta}$
Bağımsız örneklem t test $^{\beta}$ **Mann Whitney U testi** $^{\Phi}$					

CRP: C Reactive Protein (mg/L), WBC: White Blood Cell (/µL) ANC: Absolute Neutrophil Count (/µL)
NLR: , Neutrophil Lymphocyte Ratio, MPV: Mean Platelet Volume (Fl)

The ROC curve analysis was carried out to determine the diagnostic value of WBC and other markers like ANC, NLR, CRP and MPV in differentiating between patients with and without signs of acute surgical abdomen. The optimal cut-off levels for WBC, ANC, NLR, CRP and MPV were 12450 (/µL) (sensitivity 62.4%, specificity 75.6%, and AUC: 0.701), 9240 (/µL) (sensitivity 64.7 %, specifity 76.4 %, and AUC: 0.685), 5.095 (sensitivity 62.4%, specificity 71.5%, and AUC: 0,680) respectively. CRP and MPV are not sufficient to distinguish between patients with acute surgical abdomen and those without findings on CT (p:>0.05) (Table 5, Figure1).

Table 5. Results of ROC curve analysis of CRP, WBC, ANS, NLR and MPV measurements in distinguishing between patients with and without acute surgical abdomen findings in CT.

	AUCROC (%95 CI)	Std. Err.	P	Cut Off	Sens.	Spec.
CRP	0,572 (0,492-0,651)	0,040	0,079	-	-	-
WBC	0,701 (0,627-0,775)	0,038	<0,001	12450	62,40%	75,60 %
ANC	0,711 (0,638-0,784)	0,037	<0,001	9290	64,70%	76,40 %
NLR	0,680 (0,606-0,753)	0,038	<0,001	5,095	62,40%	71,50 %
MPV	0,436 (0,358-0,514)	0,040	0,118	-	-	

AUCROC: Area under the Roc curve, CRP: C Reactive Protein (normal values < 5 mg/L)
WBC: White Blood Cell (/µL), ANC: Absolute Neutrophil Count (/µL)
NLR: Neutrophil Lymphocyte Ratio, MPV: Mean Platelet Volume (fL), CI: Confidence Interval, Std. Err. Standard Error, Cut Off: Cut-off Value, Sensitivite: Sensitivity, Spesifite: Sensitivity,
Normal ranges of WBC and ANS values vary by age

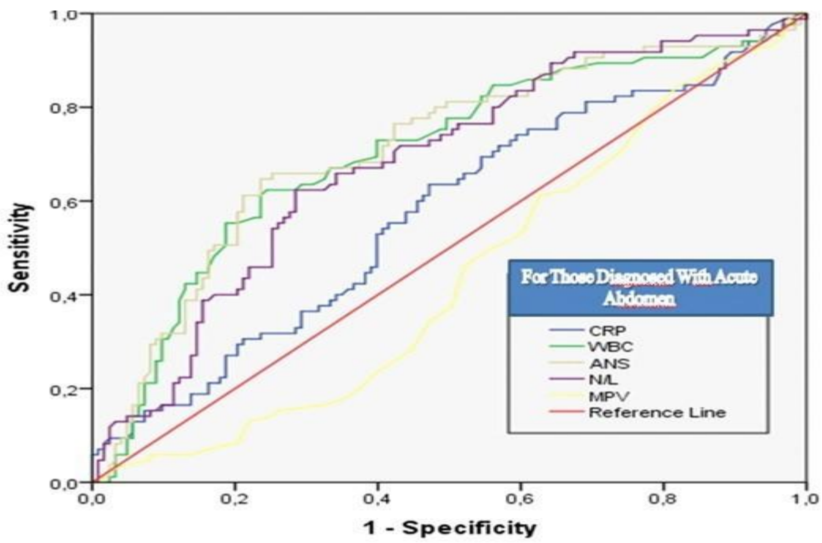

Figure 1. ROC curve of CRP, WBC, ANS, N/L, MPV, measurements in distinguishing those with acute abdomen and those without pathological findings on CT Roc curve.

Discussion

After CT was invented in the 1970s, its use has increased worldwide, especially in the pediatric population (10) and in pediatric emergency services in the last two decades (11, 12). According to the study by Callahan et al., the use of CT in children varies between 6% and 11% (19). In our study, 649 of 968 patients with suspected acute surgical abdomen underwent abdominal USG (67%), 319 underwent abdominal CT (32%), and 67 underwent both abdominal USG and abdominal CT (7%). Radiation exposure is the most important deterrent to the use of CT. It is estimated that most radiation-related malignancies will occur at least 40 years after exposure (13). Therefore, in order to minimize the radiation caused by CT, only CT of the relevant region should be obtained according to the suspected preliminary diagnosis (14, 15). In a study by Ahn et al. (16), no pathology that could explain the pain was detected in 20% of 188 patients who underwent CT, and in a study by Özkan et al. (17) with 270 patients, no pathology was detected that could explain the pain in 30% of the patients. In our study, both lower and upper abdominal CT were obtained in 319 patients who underwent abdominal CT. Of the upper abdominal CTs, 273 (85.5%) were reported as normal, and no findings requiring emergency surgery were found in any patient. Of the lower abdominal CTs, 128 (40%) were reported as normal, and findings suggestive of acute appendicitis were detected in 79 of 85 patients considered to have acute surgical pathology. Acute appendicitis is the leading disease requiring emergency surgery in children. It is diagnosed in 1-8% of children presenting to the pediatric emergency department with acute abdominal pain (18, 19). It is typically seen in children and adolescents aged 5-15 years. Diagnosis can be made with history, physical examination, laboratory tests, and imaging methods such as USG and CT. No laboratory test is 100% sensitive and 100% specific for the diagnosis of acute appendicitis. CT is very important in detecting acute appendicitis and its complications and in reducing unnecessary surgeries. The reported sensitivity of CT for the diagnosis of acute appendicitis in children ranges from 87% to 100% and specificity from 89% to 98% (20, 21).

In the study conducted by Fahimi et al., it was shown that more CT scans were performed in boys than in girls who presented with acute surgical abdominal pain (22), and in the study conducted by Shahi et al., it was shown that more CT scans were performed in girls (23). In the study conducted by Larson et al., it was shown that there was no difference between the genders (13).

In the study conducted by Davenport et al. and Kharbanda et al., it was determined that acute appendicitis was more common in boys (24, 25). In our study, 153 (48%) of 319 patients who underwent abdominal CT were male and 166 (52%) were female, and the rate of male children in children with acute surgical abdomen was found to be statistically significantly higher than in those without acute surgical abdomen. Different studies have found that CT use is higher in older age groups (13, 22). This is thought to be due to the ease of imaging in older patients and the decrease in concerns about radiation risk (26, 27). Shahi et al. reported a higher rate of use in younger pediatric patients in their study (23). In this case, it is thought to be due to the difficulty of obtaining a reliable physical examination and history in young infants. The patients included in our study were between 1 and 18 years old, and their mean age was 11.80 ± 4.13 years. The mean age of children with findings on CT was 12.28 ± 4.34 years, while the mean age of children without findings was 10.88 ± 4.34 years, and the ages of children with findings were statistically significantly higher. Cases with and without findings on CT were also evaluated according to age groups, and while the majority of cases with findings were over the age of 12, the majority of cases without findings were between the ages of 5-12, and there was a statistically significant difference. Studies by Davenport et al. and Kharbanda et al. found that acute appendicitis peaked at the age of 10-12 (24, 25). In our study, it was determined that the children with acute surgical abdomen findings on CT were mostly over 12 years of age, and it is thought that this is due to the high average age of the patients included in our study. Acute gastroenteritis is a common cause of abdominal pain in pediatric emergency departments, and abdominal pain is often accompanied by fever, diarrhea, and vomiting. Acute gastroenteritis can easily be misdiagnosed as acute appendicitis and is the most common diagnosis in cases of missed acute appendicitis (28, 29). In our study, it was observed that vomiting, diarrhea and fever were the most common symptoms accompanying abdominal pain in both groups between those with and without acute surgical abdomen findings on abdominal CT, and no statistically significant difference was found except for constipation.

The WBC count is the most commonly used test to support the diagnosis of acute appendicitis. Normal ranges in children vary by age (30). The presence of leukocytosis should be assessed according to these ranges. However, leukocytosis is a nonspecific reaction caused by physical stress, acute or chronic inflammation, and many other causes. It has an acceptable sensitivity (79-93%) but low specificity in many reports (31). WBC count alone is not a good predictor of acute surgical abdomen because it does not have sufficient sensitivity or specificity (32, 33). In the study by Sack et al., it was found that the white blood cell count was significantly higher in perforated or phlegmonous appendicitis. According to the data obtained in our study, it was understood that the total WBC count of 12.45 x10^3/µL is within the normal range for all age groups and therefore does not guide in predicting acute surgical abdomen. In our study, CRP, WBC count, ANC, and NLR were found to be significantly higher in patients with findings on CT compared to those without. WBC count, ANC, and NLR were found to be significantly higher in those with acute surgical abdomen compared to those without. In those with findings detected on abdominal CT, CRP values were thought to be high because they also include inflammatory causes such as urinary tract infection and acute gastroenteritis. USG is very important in the rapid and accurate diagnosis of acute appendicitis in children, with a sensitivity of 90-96%, a specificity of 94-98% and an accuracy of 94% (34, 35). It is widely used in pediatric patients because it is practical, does not involve radiation, and is noninvasive. It is the first imaging method of choice in pediatric patients when there is concern about a surgical condition (36, 37). It reduces the rate of negative laparotomy (36). In cases of intra-abdominal dense gas, obesity, scar tissue or perforation, dependence on the person performing the procedure may affect the accuracy of USG (38). In cases where definitive diagnosis cannot be made with USG, CT is preferred. In our study, it was determined that 67 out of 319 patients who underwent abdominal CT and 15 out of 85 patients who had acute surgical abdomen findings had abdominal USG before hand.

Since all patients with acute surgical abdomen findings on CT were referred to an external center for surgery, our study was limited in that we could not obtain postoperative histopathological diagnoses.

Conclusion

In our study, it was observed that abdominal CT was commonly used in the pediatric emergency department, especially to exclude the diagnosis of acute appendicitis. After a detailed history physical examination and supplementary auxiliary laboratory tests can be guiding according to the suspected preliminary diagnosis. In case imaging is needed, radiation free imaging methods such as USG should be used first. If abdominal CT is to be performed in patients who cannot be diagnosed with

USG, it should be limited to the relevant anatomical localization.

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Conflicts of Interest and Funding

There is no conflict of interest or financial support in our study.

Author Contribution

FMK: Working hypothesis, management

TCC: Data collection processing

Ethics Committee Approval

This study was approved by the ethics committee of Ankara Health Sciences University Keçiören Training and Research Hospital, dated 27.04.2021 and numbered

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