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ORIGINAL ARTICLE

The evaluation level of acute trauma pathologies by the emergency medicine physician assistant in abdominal computed tomography images of the trauma patients

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Abstract

Abdominal injury is the third leading cause of death due to trauma. In this study, it is aimed to investigate the level of detection of acute trauma pathologies by the emergency medicine physician assistant in abdominal tomography images taken in trauma patients. Contrast-enhanced abdominal tomography images of 207 patients who applied with trauma between 12.15.2020 and 12.15.2021 were included in this study. In order to evaluate the images of the patients, the evaluation of the emergency medicine physician assistant was compared with the radiology official report. Patients' age, gender, current complaints, symptoms, trauma classification, injury sites accompanying abdominal injury, hospitalization status and mortality rates were analyzed. The statistical distribution of the patients' demographic and clinical information was calculated. The reports of the patients whose radiology official report was issued and the emergency medicine assistant forms were transferred to the SPSS program as "pathology exists" or "no pathology". In the study, 79.2% (n=164) were male and 20.8% (n=43) were female. The median age was 33 years. In terms of interpretation of abdominal tomography, a statistically significant correlation was found between the radiologist and the emergency medicine physician assistant in the evaluation of liver, spleen and kidney; intra-abdominal and retroperitoneal hemorrhage, muscle and fascia injury of abdominal wall; vertebral, iliac, ischiatic, pubic bone, sacrum and femoral neck fracture. It was determined that 12.1% (n=25) of the patients were admitted to the intensive care unit and 5.3% (n=11) were died. High sensitivity, specificity, positive and negative predictive values were found in the evaluation of abdominal contrast-enhanced tomography imaging of patients admitted to the emergency department due to trauma by the emergency medicine assistant. We think that these high accuracy values are due to emergency medicine physician assistant's evaluation of the patient's history, physical examination and imaging studies as a whole.

Keywords: Trauma, abdominal computed tomography, emergency medicine physician assistant, emergency department

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Introduction

Trauma causes 10% of deaths worldwide. Trauma is among the leading causes of death between the ages of 1-45 in the United States [1]. Abdominal injury, it ranks third among the causes of death due to trauma after head, neck and thorax injuries [2]. Causes of abdominal injury include in-vehicle and out-vehicle traffic accidents, sharps and stab wounds, work accidents, assault and falling from a height [1]. Computed tomography (CT) is the most accurate non-surgical diagnostic method of the extent and anatomy of the injury in trauma patients [3]. It is life-saving for the patient when the emergency medicine assistant (EMPA), who sees the patient for the first time, evaluates the abdominal CT and makes the necessary intervention by clinical correlation. Because knowing the clinical correlation is much more helpful when interpreting CT images [4]. Although evaluating abdominal CT images is critical, there are not enough studies on the comparison of abdominal CT evaluation of emergency medicine workers with the radiology official report. In this study, we aimed to investigate the correct diagnosis rate of the EMPA in the evaluation of acute trauma pathologies in abdominal CT and to see how compatible it is with the official radiology reports, thus avoiding incomplete or misinterpretations.

Materials and Methods

Ethical aspect of the research

This study was approved by the Ethical Committee of Afyonkarahisar Health Science University (2020/554). Written informed consent was obtained from the patients/relatives evaluated within the scope of the study, by informing them about the subject of the study.

Designing of the research

We evaluated 207 patients who applied to Afyonkarahisar Health Sciences University Medical Faculty of ED with trauma and underwent abdominal CT between 15.12.2020 and 15.12.2021 were evaluated prospectively. Trauma patients who underwent non-contract abdominal CT and patients over 90 years of age were not included in our study. To evaluate the images of the patients, EMPA who completed three years and completed the radiology rotation was selected. Contrast-enhanced abdominal CT was evaluated by EMPA and compared with the radiology official report. The correct diagnosis rate of EMPA was examined. EMPA was blind to the radiology report when interpreting the images. The Picture Archiving and Communication Systems (PACS) system in the emergency department (ED) was used for evaluating abdominal CT images. Radiology report was followed from Nucleus hospital information management system. All of the CT images were evaluated by the same 15-year experienced specialist abdominal radiologist. The radiologist's report was accepted as the gold standard. In addition, patients' age, gender, current complaint, symptoms, trauma classification (such as in-vehicle and/or out-of-vehicle traffic accident, falling from a height, beating, gunshot wounds, stab wounds), injury areas accompanying abdominal injury, hospitalization status and mortality rates were examined. The statistical distribution of the patients' demographic and clinical information was calculated. The reports and EMPA forms of the patients whose radiology official report was issued were transferred to the Statistical Package for the Social Sciences (SPSS) program as "pathology exists" or "no pathology". The evaluations made by EMPA and the official radiology report as "pathology exists" or "no pathology" were accepted as valid and compatible. Differently, "pathology exists" or "no pathology" in the EMPA and the official radiology report was accepted as incompatible.

CT protocol

Abdominal MDCT examinations were performed by a CT scanner (Toshiba Aquilion (80x2), Otawara, Japan). The patients were given 1-2 ml/kg iodinated nonionic contrast agent with an iodine concentration of 300 mg/cc. CT images were obtained during patient breath holding using the following parameters: slice thickness 2 mm, reconstruction index 1 mm, tube voltage 120 kVp, pitch 0.75. Slices were extended from diaphragmatic dome to the end of pelvis. Coronal and sagittal multiplanar reconstructed (MPR) images were obtained from axial CT images.

Statistical analysis method

In the analysis of the data, categorical variables were presented as percent (%) and frequencies. Age, which was a continuous variable, was expressed as the median (minimum-maximum value). Chi-square test was used for comparison of categorical variables between groups. The compatibility between the evaluations of the radiologist and EMPA was evaluated with the Cohen kappa correlation. Kappa coefficient (Ƙ) was obtained to examine the level of concurrence. The results of Kappa concordance analysis were presented as significance level p and concordance power Ƙ. Statistical analyzes were done with SPSS 26.0 package program. All the *p* values presented were bidirectional and the values with $p<0.05$ were expressed as statistically significant.

Results

Of the 207 patients in the study group, 79.2% (n=164) were male and 20.8% (n=43) were female. The median age of the patients was 33 years (1-89).

Trauma mechanisms were; 58.5% (n= 121) in-vehicle traffic accident, 15.5% (n= 32) out-vehicle traffic accident, 15.5% (n=32) falling, 3.9% (n=8) penetrating injury, and 0.5% (n=1) blunt injury. However, 6.3% (n=13) of the patients were injured by other mechanisms (explosive material, heat and barotrauma injuries).

In addition, when evaluated, it was determined that 38.6% (n=80) of trauma patients who underwent abdominal CT had no additional abdominal injury. However, 10.6% (n=22) of the patients had limb fracture, 10.1% (n=21) cranial injury (including intracranial fractures, intracranial hemorrhages and contusions), 7.7%

Table 1. Pathological lesion evaluation of the emergency medicine physician assistant and the radiologist.

Pathological Lesion	Lesions that EMPA and Radiologist jointly detected pathology		Lesions that EMPA and Radiologist detected pathologies differently		*p*	Ƙ
	Number of patients jointly detected as Pathology Exists	Number of patients jointly detected as No Pathology	Number of patients in whom Pathology Exists and EMPA detected No Pathology	Number of patients No Pathology and in whom EMPA detected Pathology Exists		
Liver injury	6	192	6	3	**<0.001**	0.549
Spleen injury	4	198	2	3	**<0.001**	0.603
Kidney injury	2	204	1	0	**<0.001**	0.798
Adrenal injury	0	202	3	2	**0.863**	-0.012
Pancreatic injury	0	206	1	0	**1.000**	0.001
Intraabdominal hemorrhage	17	186	3	1	**<0.001**	0.884
Retroperitoneal hemorrhage	3	204	0	0	**<0.001**	1.000
Muscle injury of the anterior-posterior wall of the abdomen	4	201	1	1	**<0.001**	0.795
Fascia injury of the anterior-posterior abdominal wall	4	202	0	1	**<0.001**	0.886
Vertebral fracture	26	175	4	2	**<0.001**	0.880
İliac fracture	8	199	0	0	**<0.001**	1.000
Ischiatic fracture	9	197	1	0	**<0.001**	0.945
Pubic bone fracture	13	193	0	1	**<0.001**	0.960
Sacrum fracture	3	203	1	0	**<0.001**	0.855
Femoral neck fracture	3	204	0	200	**<0.001**	1.000

EMPA: Emergency Medicine Physician Assistant, Ƙ: Kappa coefficient

(n=16) vertebral injury, 3.4% (n=7) had thoracic injuries, 2.9% (n=6) pelvis and femur neck fractures, 4.3% (n=9) other sites (genital, scrotum, scalp lacerations and facial bone fractures) injuries were found. In addition, 22.2% of our patients (n=46) had additional injuries in more than one region. Abdominal injury was detected in 6.25% of the patients (n=46) without additional injury. 60% of patients with abdominal injuries had abdominal pain.

In this study, intra-abdominal injury was determined in 33 (15.9%). Intra-abdominal injury was detected in 2 (25%) of 8 patients with penetrating injuries, 7 (21.9%) of 32 patients with out-vehicle traffic accidents, 6 (18.8%) of 32 patients with fall injuries, 18 (14.9%) of 121 patients with in-vehicle traffic accident. There was no difference between injury mechanisms and intra-abdominal injury rates (p=0.51).

It was determined that 77.8% (n=161) of 207 patients could not describe their abdominal pain. While 11.1% (n=23) of the patients had abdominal pain, it was determined that the abdominal pain was uncertain in 11.1% (n=23) of the remaining patients due to reasons such as the patient's inability to express himself/herself due to his/her age and not being evaluated due to intubation.

In the study, no agreement was found between the radiologist and EMPA in the evaluation of adrenal and pancreatic injuries of the patients. A statistically significant agreement was found between the radiologist and EMPA in liver, spleen, kidney injury, intra-abdominal, and retroperitoneal hemorrhage detection, detection of muscle and fascia injury in the anterior and posterior abdominal wall, vertebral, iliac, ischiatic, pubic bones, sacrum fracture and femoral neck fracture evaluations (Table 1).

The findings of the study showed that EMPA was able to detect the highest rate of pathological lesions with 100% sensitivity for retroperitoneal hemorrhage, fascia injury in the anterior and posterior abdominal wall, iliac, ischiatic, pubic bone and femoral neck. EMPA estimated with 100% specificity for kidney and pancreatic injury, retroperitoneal hemorrhage, fracture of iliac, ischiatic bone, sacrum and femoral neck. There was no case where the specificity of EMPA to detect pathological lesions was low (lowest specificity was detected for liver injuries with 97%). In this study, the highest positive predictive value (PPV) of EMPA with 100% was determined for kidney injury, retroperitoneal hemorrhage, fracture of iliac, ischiatic bone, sacrum and femoral neck. The lowest PPV was 0% for adrenal and pancreatic injuries. While the highest negative predictive value (NPV) was found for 100% retroperitoneal hemorrhage,

Table 2. The sensitivity, specificity, positive predictive value and negative predictive value of emergency medicine physician assistant to detect lesions by pathology types.

Pathological Lesion	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Liver injury	50	97	66.6	96.9
Spleen injury	66.7	99	57.1	99
Kidney injury	66.7	100	100	99.5
Adrenal injury	0	99	0	98.5
Pancreatic injury	0	100	0	99.5
Intraabdominal hemorrhage	85	99.5	94.4	98.4
Retroperitoneal hemorrhage	100	100	100	100
Muscle injury of the anterior-posterior wall of the abdomen	80	99.5	80	99.5
Fascia injury of the anterior-posterior abdominal wall	100	99.5	80	100
Vertebral fracture	86.7	98.9	92.9	97.8
Iliac bone fracture	100	100	100	100
Ischiatic bone fracture	100	100	100	100
Pubic bone fracture	100	99.5	92.9	100
Sacrum fracture	75	100	100	99.5
Femoral neck fracture	100	100	100	100

PPV: positive predictive value, NPV: negative predictive value

fascia injury in the anterior and posterior abdominal wall, fracture of iliac, ischiatic, pubic bones and femoral neck, there was no pathological lesion with low NPV of EMPA (the lowest NPV was 96.9% belonged to the detection of liver injury), (Table 2).

Considering the final status of the trauma patients who underwent abdominal CT, 58.9% (n=122) were discharged, 21.3% (n=44) were admitted to the service, 12.1% (n=25) were admitted to intensive care, 5.3% (n=11) died, 1.4% (n=3) were discharged with rejection of the treatment, and 1% (n=2) were referred to another institution. CT

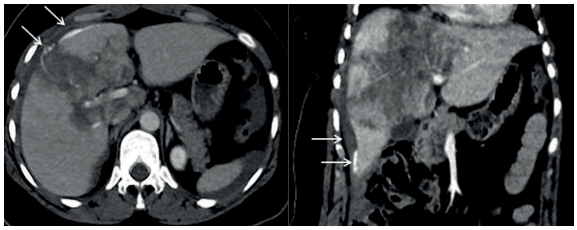

Figure 1. Liver injury. In contrast-enhanced axial and coronal CT, laceration and vascular injury covering more than 75% of the lobe, contrast medium extravasation consistent with active bleeding, and perihepatic hemorrhagic free fluid (arrows) are

Figure 2. Spleen and kidney injury. In contrast-enhanced axial CT, a laceration area (white arrow) is observed in the spleen parenchyma. In addition, left kidney injury and accompanying perirenal hematoma (dashed arrow) are seen.

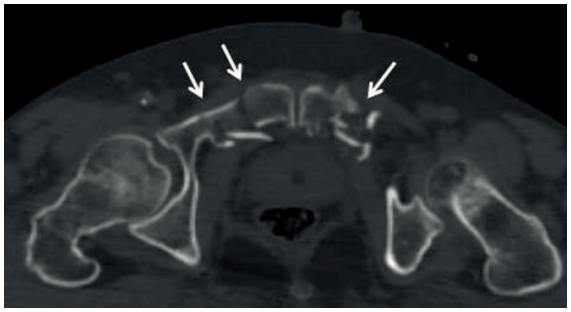

Figure 3. Pubic bone injury. At bone dose, axial CT

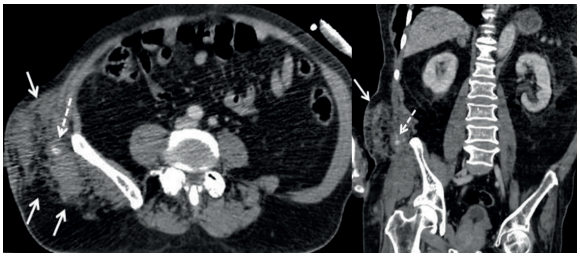

Figure 4. Muscle injury of the posterior-lateral wall of the abdomen. Axial (A) and coronal (B) CT images with IV contrast show hemorrhage in the right abdominal lateral wall and gluteal muscles (arrows)

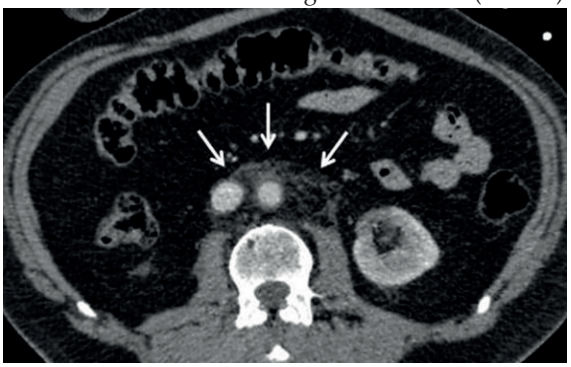

Figure 5. Retroperitoneal injury. In the axial CT image with IV contrast, density increases consistent with retroperitoneal hemorrhage in the paraaortic area were seen (arrow).

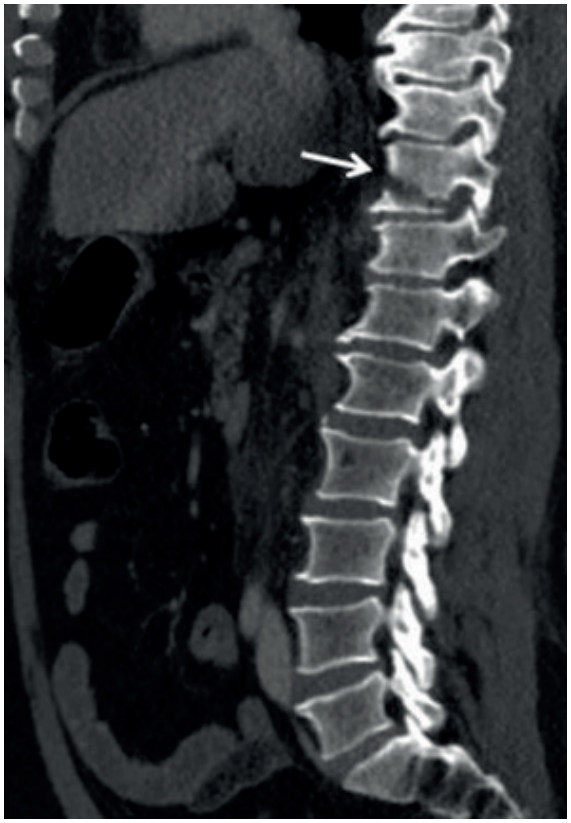

Figure 6. Vertebral injury. A vertical fracture line is observed in the T10 vertebral body in the sagittal CT image (arrow).

Discussion

In order to reduce mortality in stable trauma patients, it is essential to quickly detect acute pathologies with CT and perform the necessary intervention. Since hemorrhagic shock can develop within minutes in trauma patients, it is vital for the emergency physician to see the acute pathology in the CT before the radiology interpretation and take the necessary intervention [5].

In a study, it was reported that 77% of trauma patients were male, 23% were female, and the median age was 39 (26-54) [6]. In another study, it was reported that the incidence of abdominal trauma was higher in young men [7]. Similarly, in our study, abdominal CT was performed in a total of 207 patients, of whom 79.2% (n= 164) were male and 20.8% (n= 43) were female. However, the median age of the patients was 33 years (1-89) in our study. Also, this median age of trauma correlates with American data. Because it is the leading cause of death in trauma between the ages of 1-45 [1].

In a study conducted by Güven et al. including patients of falling from a height (49.1%) and traffic accidents (43.5%) were the most common reasons for trauma patients to apply to the ED, followed by stabbing (2.9%), firearm injuries (2.3%) and other injuries (2.3%) [6]. In our study, similar to the literature, it was determined that of the trauma patients who applied to the ED and required abdominal CT, 58.5% had an in-vehicle and 15.5% had an out-vehicle traffic accident. These data were in accordance with the Turkish Statistical Institute's data on all in-vehicle (50.4%) and out-of-vehicle traffic (motorcycle accident-18.8%) accidents in Türkiye [8]. In addition, according to the data of the World Health Organization, men involved in traffic accidents were found to be three times higher than women, as in our study, and this was in conformity with our study [9]. In our study, all of them were categorized separately without generalization, and no significant difference was found between injury mechanisms and intra-abdominal injury rates. The reason for this was predicted as the severity of the injury rather than the mechanism of the injury and the insufficient number of cases.

Abdominal pain was not present in 40% of patients with abdominal injuries without additional injuries. This showed us that patients can have abdominal injury without no additional injury and abdominal pain. In order to determine this, it is vital for the emergency physician to evaluate the patient with clinical correlation, anamnesis and physical examination [10].

In a study designed by Vaziri et al. the results of abdomino-pelvic CT scans of patients admitted to ED with abdomino-pelvic trauma, a high agreement value (κ= 0.881) was found between interpretation of emergency medicine physicians and radiology physicians [7]. Similarly, in our study, a statistically significant agreement was found between interpretation of EMPA and the radiologist.

In a study conducted with 156 patients with multiple injuries who were over the age of 18

who underwent CT scan, similar to our study, emergency room physicians and on-duty radiologists were compared [11]. In our study, PPD values for liver injury and spleen injury was showed similarity to the study. In a study designed by Vaziri et al. found the sensitivity, specificity, PPD and NPD values of emergency room doctor reports in terms of spleen hematoma were found to be 86.67%, 99.56%, 81.25%, 99.71% and Kappa coefficient 0.836% [7]. In our study, it was determined that the sensitivity, specificity, PPD and NPD values of EMPA to detect spleen lesions were similar to the study of Vaziri et al.

In a study conducted by Güven et al., the official report of emergency medicine physicians and radiology was compared for the interpretation of abdominal CT performed on 232 trauma patients [6]. When liver injury and spleen injury were evaluated, our study had similar sensitivity, specificity, and NPD values with the study of Güven et al. However, compared to our study of spleen and liver injury, higher PPD values were found in the study of Güven et al.

In a study conducted by Kartal et al. bleeding was not classified as intra-abdominal or retroperitoneal hemorrhage and was accepted as abdominal hemorrhage. And also, in a study designed by Güven et al. and Kartal et al. the pelvic fracture was evaluated as a whole [6,11]. In our study, EMPA had higher sensitivity, specificity, PPD and NPD values in detecting kidney injury, intra-abdominal hemorrhage, and pelvic fractures compared to the study of Güven et al. In our study, intraabdominal and retroperitoneal hemorrhage were evaluated separately.

However, in our study, unlike similar studies, the pelvis bone was evaluated in 3 parts as iliac, ischiatic and pubic bone. As a result of our study, the PPD value of the pubic bone was found to be lower than that of the iliac and ischial bones. The sensitivity, specificity, PPD, and NPD value of EMPA were found to be 100% accurate for pathology detection in iliac and ischiatic bone. Our study is a rare and valuable study in terms of dissecting and examining the pelvis bone and obtaining meaningful results. In addition, the existence of different results detected in our study was explained that there was only one EMPA in the study and the difference in the number of cases.

In our study, femoral neck fracture was evaluated by EMPA. A 100% agreement was found in terms of sensitivity, specificity, PPD, and NPD. These statistics are not available in the studies. In addition, unlike other studies, vertebral fractures were detected in 26 patients in our study, and a statistically significant agreement was found between the radiologist and EMPA in the fracture evaluations [6,11]. Also, muscle and fascia injury in the anterior and posterior abdominal wall was evaluated in our study and it was found to be statistically significant. Our study is also a rare and valuable study in this respect.

In a study designed by Bagheri et al., the effect of contrast-enhanced CT interpretation on morbidity and mortality by emergency medicine physicians was investigated. In the study, it was seen that 68.2% of the abdominal CT interpretations of emergency medicine physicians were interpreted correctly. In the study, 5 patients died, and no preventable cause was found by early CT interpretation in any patient [12]. Our study was not categorized as preventable or unavoidable causes. Compared to the study by Bagheri et al., our study had higher accuracy rate. This difference was explained by the fact that our study was conducted on a single EMPA, the lack of official radiology training in the study of Bagheri et al., and the difference in the number of cases.

In our study, whole body CT scanning was performed in 90% or more of trauma patients. In a study by Tillou et al., 284 patients with blunt trauma were evaluated and it was reported that whole body CT scan was unnecessary at a rate of 27%. It was found that the injury would have been missed in two patients who required immediate intervention had the whole-body CT scan not been performed. It was also found that potentially significant injuries would be missed in 17% of total patients [13]. Of the 207 patients included in our study, 122 were discharged. If the discharged patients are considered clinically insignificant, it is concluded that CT performed in 58% of trauma patients is unnecessary. This is

due to the increase in malpractice cases and the possibility of abdominal injury despite clinical incompatibility.

Conclusion

High sensitivity, specificity, PPV and NPV were found in the evaluation of abdominal contrast-enhanced CT imaging of patients admitted to the ED due to trauma by the EMPA. We think that these high accuracy values are due to EMPA's evaluation of the patient's history, physical examination and imaging studies as a whole.

Study limitations

In our study, abdominal CT evaluation was performed by a single EMPA. Great vessel injuries and mesenteric contusion were not included in our study. Additionally, intra-abdominal injuries were evaluated as "pathology exists" or "no pathology", and the grading the injury level of solid organs were not specified.

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Conflict of interest

There are no conflicts of interest to declare.

References

1. Centers for Disease Control and Prevention. Web-based injury statistics query and reporting system. 2020; Online at; https://www.cdc.gov/injury/wisqars/index.html
2. Novelline RA, Rhea JT, Bell T. Helical CT of abdominal trauma. Radiol Clin North Am. 1999;37:591-612. doi: 10.1016/s0033-8389(05)70113-5.
3. Soto JA, Anderson SW. Multidetector CT of blunt abdominal trauma. Radiology. 2012;265(3):678-93. doi: 10.1148/radiol.12120354.
4. Karpuz Ç. Acil servise başvuran hastalara çekilen toraks bilgisayarlı tomografilerin değerlendirilmesinde acil tıp uzmanlık öğrencilerinin tomografileri yorumlamadaki doğruluk ve güvenilirlik derecelerinin araştırılması. Specialization Thesis in Medicine, Uludağ Üniversitesi, Bursa, 2018; Online at; https://acikbilim.yok.gov.tr/handle/20.500.12812/700495.
5. Sarsılmaz A, Kocakoç E. Abdominal travma. Trd Sem. 2016;4:299-312. doi: 10.5152/trs.2016.389.
6. Guven R, Akca AH, Caltili C, Sasmaz MI, Kaykisiz EK, Baran S, et al. Comparing the interpretation of emergency department computed tomography between emergency physicians and attending radiologists: A multicenter study. Niger J Clin Pract. 2018;21(10):1323-9. doi: 10.4103/njcp.njcp_22_18.
7. Vaziri S, Mosaddegh R, Rezai M, Mohammadi F, Ashari MA. Emergency medicine service can interpret abdomino-pelvic CT scans with close to the same accuracy as radiology service. Journal of Critical Reviews. 2020;7(4):709-13. doi: 10.31838/jcr.07.04.132
8. Türkiye İstatistik Kurumu (TÜİK). Karayolu trafik kaza istatistikleri 2020. 2021; Online at; https://data.tuik.gov.tr/Bulten/Index?p=Road-Traffic-Accident-Statistics-2020-37436.
9. World Health Organization (WHO). Road traffic injuries. 2021; Online at; https://www.who.int/news-room/fact-sheets/detail/road-traffic-injuries.
10. 10. Kirkpatrick AW, Brenneman FD, McLean RF, Rapanos T, Boulanger BR. Is clinical examination an accurate indicator of raised intra-abdominal pressure in critically injured patients? Can J Surg. 2000;43(3):207-11.
11. Kartal ZA, Kozacı N, Çekiç B, Beydilli İ, Akçimen M, Güven DS, et al. CT interpretations in multiply injured patients: comparison of emergency physicians and on-call radiologists. Am J Emerg Med. 2016;34(12):2331-35. doi: 10.1016/j.ajem.2016.08.044.
12. Bagheri-Hariri S, Ayoobi-Yazdi N, Afkar M, Farahmand S, Arbab M, Shahlafar N, et al. Abdominal and pelvic CT scan interpretation of emergency medicine physicians compared with radiologists' report and its impact on patients' outcome. Emerg Radiol. 2017;24(6):675-80. doi: 10.1007/s10140-017-1542-2.
13. Tillou A, Gupta M, Baraff LJ, Schriger DL, Hoffman JR, Hiatt JR, et al. Is the use of pan-computed tomography for blunt trauma justified? A prospective evaluation. J Trauma. 2009;67(4):779-87. doi: 10.1097/TA.0b013e3181b5f2eb.