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Differentiation of High-Attenuation Renal Cyst and RCC with CT Texture Analysis on Unenhanced CT

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Abstract

Objective: The goal of this research is to evaluate the efficiency of computed tomography texture analysis in differentiating renal cell carcinoma from a high-attenuation renal cyst on non-contrast computed tomography.

Methods: Forty-nine non-contrast abdominal computed tomography examinations, 27 patients with high-attenuation renal cyst and 22 patients with renal cell carcinoma were evaluated retrospectively. Region of interest was drawn to cover the entire lesion in the sections. Gray-level intensity (Hounsfield Unit value), entropy, standard deviation, uniformity, kurtosis, skewness, size% lower, size % mean, size% upper, values were obtained by texture analysis. The findings of both groups were compared statistically.

Results: Mean and median gray-level intensity values and entropy values were significantly higher in renal cell carcinoma than in high-attenuation renal cyst ($p<0.001$). There was no significant difference in other parameters. When receiver operator characteristics analysis was performed for the mean value, the area under the curve value was found to be 0,754. When the threshold value was selected as 34.5708, 72.7% sensitivity and 66.7% specificity was found.

Conclusion: Texture analysis may be useful in differentiating renal cell carcinoma from high-attenuation renal cysts on non-contrast computed tomography.

Key words: Texture analysis, High-attenuation renal cyst, Renal cell carcinoma

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Kontrastsız BT'de BT tekstur analizi ile Yüksek atenuasyonlu Renal Kist ve RCC'nin ayrımı

Öz

Amaç: Bu çalışmanın amacı kontrastsız bilgisayarlı tomografide, yüksek atenuasyonlu renal kist ve renal hücreli karsinom ayrımında, bilgisayarlı tomografi tekstür analizinin etkinliğini değerlendirmektir.

Yöntemler: Kırk dokuz kontrastsız abdomen bilgisayarlı tomografi incelemesi, yüksek atenuasyonlu 27 renal kistli hasta ve renal hücre karsinomlu 22 hasta retrospektif olarak değerlendirildi. İlgi alanı, kesitlerde tüm lezyonu kapsayacak şekilde çizildi. Gri seviye intensitesi (Hounsfield birim değeri), entropi, standart deviasyon, uniformite (uniformity), basıklık (kurtosis), çarpıklık (skewness), size % lower, size % mean, size % upper, değerleri tekstur analizi ile elde edildi. Her iki grubun bulguları istatistiksel olarak karşılaştırıldı

Bulgular: Ortalama ve medyan gri seviye intensitesi değerleri ile entropi değerleri renal hücreli karsinomda anlamlı olarak yüksek-atenuasyonlu kistten daha yüksekti ($p<0.001$). Diğer parametrelerde anlamlı bir farklılık yoktu. Ortalama değer için alıcı işlem karakteristikleri analizi yapıldığında, eğri altındaki alan 0,754 olarak bulundu. Kesim değeri 34.5708 seçildiğinde, %72,7 sensitivite ve %66,7 spesifite bulundu.

Sonuç: Kontrastsız bilgisayarlı tomografide, renal hücreli karsinomu yüksek atenüasyonlu renal kistlerden ayırt etmede tekstur analizi faydalı olabilir.

Anahtar kelimeler: Tekstur analizi, Yüksek atenuasyonlu renal kist, Renal hücreli karsinom

INTRODUCTION

Renal cell carcinoma (RCC) is the eighth most prevalent cancer in humans, arising from the renal tubular epithelium[1]. RCC constitutes 2% of all malignant tumors seen in adults and 80% of all kidney tumors[2]. It has clinical outcomes with wide variation[3]. Major clinical features are macroscopic hematuria (60 %), flank pain (40 %), palpable flank mass (30-40%). This triad is only seen in 10-15% of patients[4] Therefore, RCC is most commonly diagnosed incidentally with ultrasound, computed tomography (CT), or Magnetic Resonance Imaging MRI[5].

With radiological imaging is used more often in daily practice incidental kidney lesions are determined commonly, especially among the elderly. Many of these are detected on non-contrast abdominal CT[6,7]. A non-contrast abdomen CT is used to assess flank pain, renal stone, and screening colon cancer. The most common renal lesions are cysts and renal cysts are present in ~40% of all CT scans[8]. Benign renal cysts with water attenuation, homogeneous, and well-defined are easily characterized at CT. But, some benign renal cysts have high attenuation (>20 HU) due to proteinaceous or hemorrhagic contents. Ari et al showed that a homogeneous renal lesion with an attenuation of 70 HU or higher at unenhanced CT is more than 99.9% likely high-attenuation renal cyst[9]. But hyperattenuating renal cysts with values below 70 HU may not be differentiated from RCC at non-contrast CT because both have similar densities[10]. Density measurement alone may cause errors in diagnosis[11]. Therefore, ultrasound, contrast-enhanced CT or MR imaging (especially T1 sequence) may be required. But non-contrast imaging should be done in patients with chronic kidney disease or IV contrast media allergy[12]. In addition, new imaging increases the radiation dose, cost, and workload. Therefore, it is important to differentiate RCC from high-attenuation cysts with values below 70 HU on unenhanced CT.

Tissue heterogeneity is associated with microscopic biological changes. The radiological images used for diagnosis are digital. Texture analysis is a technique for evaluating signal properties in digital images, such as gray-level intensity and pixel location. Entropy, gray-level intensity, uniformity,

skewness, and kurtosis are all measured using this post-processing technique[13].

The majority of RCCs are heterogeneous, especially when measured in the small region of interests (ROI)[14]. Texture analysis can provide information regarding intralesional heterogeneity. Therefore, texture analysis may be useful in distinguishing between cysts and RCC. In the literature, we could not find any data related to texture analysis in the differentiation of high-attenuation cyst and RCC. The aim of this study is to evaluate the efficiency of CTTA in differentiating high-attenuation renal cysts from RCC on non-contrast CT.

METHODS

Study Design and Participants

Firat University local ethics committee approved this retrospective study on 16 December 2021 (Protocol No: 2021/13-48). The research was carried out at Firat University Hospital. Images of patients who underwent non-contrast abdominal CT between 2017-2020 were examined retrospectively. Imaging indications were flank pain, renal stone, hematuria, and patients with chronic kidney disease or IV contrast media allergy. 140 renal lesions with a density higher than 20 HU were detected. Renal lesion with an attenuation of 70 HU or higher at unenhanced CT is high-attenuation renal cyst[9]. Therefore, 80 renal lesions with a density greater than 70 HU were excluded from the study. 60 renal lesions with a density higher than 20 HU were included in the study. Contrast-enhanced MRI had been performed in 49 of 60 patients. MRI findings of 27 patients were compatible with Bosniak type 2 cyst, and MRI findings of 22 patients were compatible with RCC. RCC diagnosis of 22 patients had been pathologically confirmed. Thus, forty-nine non-contrast abdominal CT examinations, 27 patients with high-attenuation renal cysts, and 22 patients with RCC were included in the study.

CT protocol and Texture analysis

CT examinations were made by a GE Optima (General Electric Medical Systems, Milwaukee, WI) with 128 detectors. The axial abdomen images were loaded into a 27-inch iMac computer. Texture analysis was measured using OsiriX V.4.9 imaging software. An ROI was drawn in the sections to cover the whole lesion. (Figure 1, Figure 2). The mean, standard deviation, median, minimum, maximum, variance, entropy, uniformity, skewness, kurtosis, size %L, size %M and size %U values were obtained from the gray level intensities of the pixels in the ROIs[13]. Measurement was made at a single slice of the lesion. An in-house MATLAB software was used to give the whole image analysis algorithm. (version R2009b; MathWorks, Natick, MA, USA). The results of both groups were compared statistically.

Figure 1: High-attenuation renal Cyst and CT texture analysis

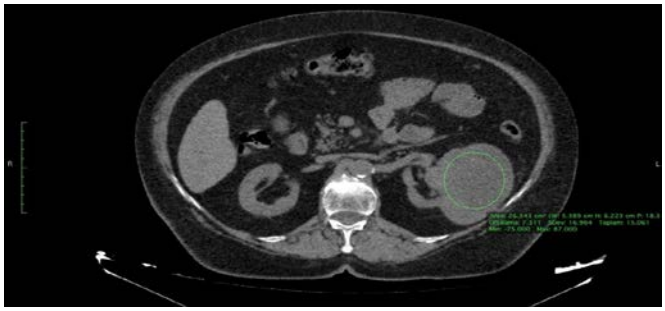

Figure 2: RCC and CT texture analysis

Statistical Analysis

IBM SPSS for Windows, version 25.0, was used to conduct statistical analyses (IBM statistics for Windows version 25, IBM Corporation, Armonk,

New York, USA). The mean ± standard deviation are used to present the data. The Kolmogorov-Smirnov test was used to determine the normality of the distribution and the Student t-test was used to compare the groups. Statistical significance was defined as a p-value of less than 0.05. The Area Under the Curve (AUC) was used to determine the predicted validity of parameters.

RESULTS

The age range of patients with cysts was between 40 and 77 years. The age range of patients with RCC was between 44 and 73. Of the patients with hyperattenuating cysts, 15 were male and 12 were female. Of the patients with RCC, 14 were male and 8 were female. No significant difference was observed between the two groups in terms of gender and age. Density values of the hyperattenuating cysts were between 20 and 39 HU. Density values of the RCCs were between 34 and 64 HU. Mean gray-level intensity, median value, and entropy values were significantly higher in RCC than in high-attenuation renal cysts (p<0.001) (Figure 3, Figure 4). Other parameters did not show a significant difference (Table 1). When receiver operator characteristics (ROC) analysis was performed for the mean value, the AUC value was found to be 0,754. When the threshold value was selected as 34.5708, 72.7% sensitivity and 66.7% specificity was found (Figure 5).

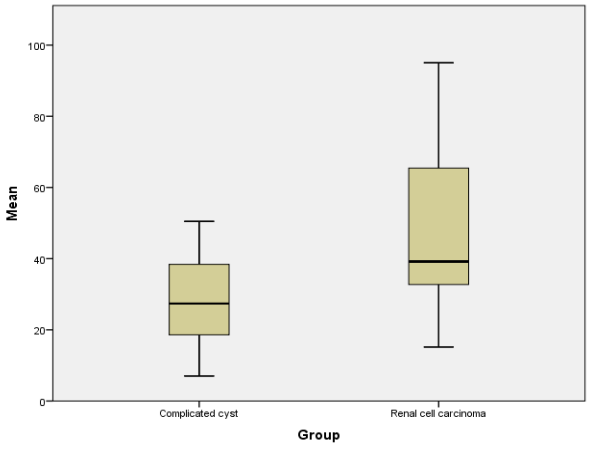

Figure 3. Mean values of RCC and high-attenuation renal cyst

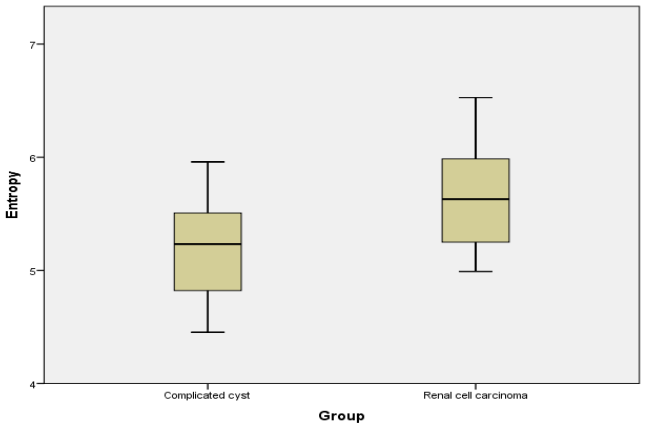

Figure 4. Entropy values of RCC and high-attenuation renal cyst

Table I: Texture analysis parameters for renal cyst and RCC

	High-attenuation renal cyst (n=27)		Renal cell carcinoma (n=22)		p
	Mean	Standard Deviation	Mean	Standard Deviation	
Mean	**28.44**	**12.57**	**47.78**	**22.79**	**<0.001**
Standard Deviation	21.50	18.25	26.23	38.91	0.577
Minimum	-18.70	29.40	-9.23	47.34	0.395
Maximum	181.04	303.56	190.45	324.17	0.917
Median	**26.98**	**13.67**	**43.27**	**18.21**	**<0.001**
Variance	782.96	1532.05	2133.36	6360.87	0.291
Entropy	**5.15**	**0.52**	**5.64**	**0.41**	**<0.001**
Size%L	12.94	6.08	13.57	4.91	0.697
Size%U	13.26	4.85	14.83	1.87	0.159
Size%M	73.79	10.39	71.60	6.60	0.394
Kurtosis	15.68	32.87	4.91	4.91	0.135
Skewness	1.24	2.79	0.43	1.11	0.205
Uniformity	0.25	0.15	0.23	0.09	0.592

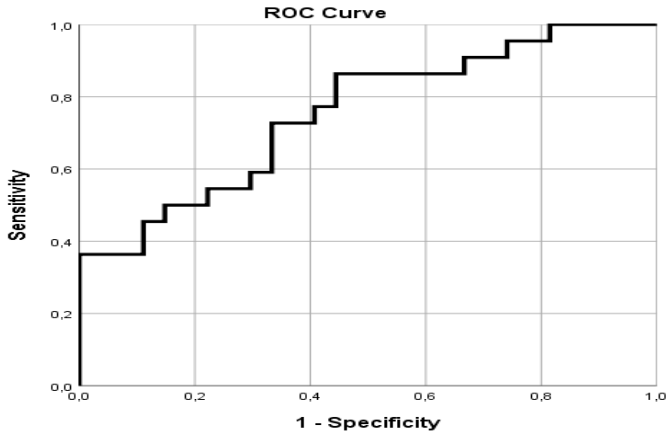

Figure 5. ROC curve for the mean value (AUC=0.754).

DISCUSSION

The aim of this research was to evaluate the efficiency of CTTA in differentiating renal cell carcinoma from a high-attenuation renal cyst on non-contrast CT. In our study, mean and median gray-level intensity values and entropy values were significantly higher in renal cell carcinoma than in high-attenuation renal cyst ($p<0.001$).

Most incidental renal lesions are benign cysts. Some of the benign cysts are complex cysts. A hemorrhagic cyst with an attenuation of >70 HU is also a complex cyst and the diagnosis is already straightforward on CT. But differentiation of other high-attenuation renal cysts from RCC can be difficult on unenhanced CT. Contrast-enhanced imaging should be performed in differentiating high-attenuation renal cyst from RCC. The aim of this study was to demonstrate the efficacy of CTTA in differentiating complicated cysts and RCC without the need for contrast-enhanced imaging. According to the findings of our study, texture analysis may be useful in differentiating hyperattenuating renal cysts and RCC on unenhanced CT images.

Hyperattenuating renal cysts do not even need follow-up. But contrast-enhanced imaging should be performed in patients with RCC to make the subtype differentiation, staging, and evaluate the relationship with adjacent structures (collecting system, vascular structures). CTTA can provide an effective triage for additional imaging. CTTA may identify hyperattenuating cysts and this eliminates the need for contrast imaging.

RCCs are generally heterogeneous[14]. Texture analysis can reveal details about heterogeneity. The degree of lesion heterogeneity is important in evaluating renal masses. In our study, lesion heterogeneity was evaluated by texture analysis. Texture analysis not only evaluates gray-level attenuation, but also kurtosis, uniformity, skewness, and entropy. Entropy assesses the irregularity of the pixel histogram. Our study showed entropy values were significantly higher in RCC than in high-attenuation renal cysts ($p<0.001$)

Schieda et al showed that sarcomatoid RCC is more heterogeneous than clear cell RCC[15]. Yu et al.[16] showed that texture analysis is a tool for distinguishing RCC and oncocytomas. Raman et al.[17] showed that texture features including standard deviation, entropy, and mean gray-level intensity may be useful in differentiating malignant and benign renal masses on contrast-enhanced CT. Our study was performed on non-contrast CT. Nathan et al. reported that high entropy may be useful to differentiate cysts from low-attenuation RCC at non-contrast CT and sensitivity and specificity of entropy were better than the other analysis parameters[18]. Other studies showed that entropy can be used to differentiate RCC from fat-poor renal angiomyolipoma[19-21]. Texture parameters, especially mean gray-level intensity and entropy are useful in characterizing renal lesions. In our study, entropy and mean gray-level intensity values were significantly higher in RCC than in high-attenuation renal cyst. When a high-attenuation renal lesion is incidentally detected on non-contrast CT, texture analysis can be used for lesion characterization.

Takahashi et al.[22] showed that skewness is useful in differentiating RCC from angiomyolipoma on unenhanced CT. Skewness value was not significant in our study. Besides all these, CT texture features, especially entropy, are associated with tumor histopathologic results[23].

There were a few limitations to our study. This study was conducted retrospectively and with a small number of cases. Texture analysis measurement was made at a single slice of the mass. There was no pathologic proof of a high-attenuation renal cyst.

In conclusion, hyperattenuating renal cyst and RCC may have a similar appearance on non-contrast CT. Our study purposed to demonstrate the effectiveness of CT texture analysis in differentiating hyperattenuating cysts and RCC on unenhanced CT. According to the findings of our study, texture analysis can be useful in differentiating hyperattenuating renal cyst from RCC on non-contrast CT. According to texture analysis, it can be decided whether to perform contrast-enhanced imaging or not.

Ethics Committee Approval: Firat University local ethics committee approved this retrospective study on 16 December 2021 (Protocol No: 2021/13-48).

Conflict of Interest: The authors declared no conflicts of interest.

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