ORJİNAL ÇALIŞMA

ÇOK KESİTLİ BİLGİSAYARLI TOMOGRAFİ İLE AKUT RİNOSİNÜZİTİN KRONİK RİNOSİNÜZİTTEN AYIRT EDİLMESİ

Differentiation of Acute Rhinosinusitis From Chronic Rhinosinusitis Using Multidetector Computed Tomography

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ÖZET

Amaç: Akut rinosinüziti kronik rinosinüzitten klinik olarak ayırt etmek zordur ve bugüne kadar her iki durumda da benzer görünen hava-sıvı seviyesi veya opaklaşma ile radyolojik olarak değerlendirilebilirler. Amacımız, klasik radyolojik yaklaşımlarla birlikte hava dansitesinin analizinin, akut ve kronik rinosinüzit arasında ayrım yapmak için yeni bir araç olarak kullanılıp kullanılamayacağını incelemekti.
Yöntem: Bu retrospektif çalışma paranazal sinüs çok kesitli bilgisayarlı tomografi (ÇKBT) yapılan 550 hastada toplam 2419 sinüs içermekteydi. Hastalar sinüs durumlarının klinik tanısına göre üç gruba ayrıldı: grup 1 (n = 176) akut enfeksiyonlu, grup 2 (s = 191) kronik rinosinüzitli hastaların oluşturduğu ve grup 3 (s = 181) sağlıklı sinüslerin oluşturduğu gruptur. Herbir gruptaki paranazal sinüsler içerisindeki ortalama hava yoğunluğu ve standart sapma, hava ile dolu sinüsün merkezindeki 0.5 cm2 lik ilgili alan (ROI) sinüs duvarı hariç olmak üzere hesaplandı ve ölçüm takip eden 4-6 BT kesitinde tekrarlandı.
Bulgular: Ortalama hava dansitesi grup 1'de grup 2 ve 3 ile karşılaştırıldığında anlamlı olarak yüksekti (sırasıyla - 810 HU, -973 HU ve -1010 HU; p <0.05) ve SD (89.3 HU, 21.1 HU ve 20.9 HU sırasıyla; p <0.05).
Sonuç: Paranazal sinüslerde artmış hava yoğunluğu akut rinosinüzitin kronik rinosinüzitten ayrılmasında yardımcı olabilir.

Anahtar Sözcükler: *Çok kesitli bilgisayarlı tomografi; Rinosinüzit, hava yoğunluğu.*

ABSTRACT

It is difficult to differentiate acute from chronic rhinosinusitis clinically, and to date they are assessed radiologically via air-fluid level or opacification, which can appear similar in both cases. Our purpose was to examine whether air density analysis combined with classical radiological approaches can be used as a new tool to differentiate between acute and chronic sinusitis.
This retrospective study included a total of 2419 sinuses in 550 patients who underwent paranasal sinus multidetector computed tomography (MDCT). Patients were divided into three groups according to clinical diagnosis of sinus status: acutely inflamed as group 1 (n=176), the chronic sinusitis as group 2 (n=191) and healthy sinuses (n=183) as group 3, the control group. The mean air density and standard deviations (SD) within the paranasal sinuses in each group were calculated by the measurements of air density with a region of interest (ROI) of 0.5 cm2, located in the center of the air-filled sinus avoiding the sinus wall, and repeated the measurement in 4-6 consequent CT slices, where available.
The mean air density was significantly higher in group 1 compared with group 2 and 3 (- 810 HU,-973 HU and -1010 HU respectively; p < 0.05), as well as SD (89.3 HU, 21.1 HU and 20.9 HU respectively; p < 0.05).
In conclusion; increased air density in paranasal sinuses may aid in distinguishing acute from chronic rhinosinusitis.

Keywords: Multidetector computed tomography; Rhinosinusitis, air density.

INTRODUCTION

Since rhinitis and sinusitis usually coexist and are concurrent in most individuals, the correct terminology is rhinosinusitis (RS) and defines symptomatic inflammation of the paranasal sinuses and nasal cavity (1). RS affects approximately 20% of the population worldwide (2), and is classified on the basis of duration of symptoms as acute, subacute or chronic. RS is called acute when lasting less than four weeks, subacute when lasting for four to eight weeks, and chronic when lasting longer than eight weeks (3). The most common symptoms in acute RS are nasal blockage, congestion or nasal discharge with/without facial pain or cough (4), similar to chronic RS. Although the clinical outcomes are sufficient for diagnosing acute RS most of the time (5), in complicated cases it is difficult to distinguish acute from chronic RS, and radiological support is needed. MDCT has been accepted as a gold standard for detecting sinus pathologies and the most common findings in acute RS are air-fluid level, complete loss of aeration, mucosal edema and air bubbles within the sinuses. Because these findings have low specificity, clinical and endoscopic assistance may be needed for correct diagnosis.

Given the example of the maxillary sinus, as sinus cavity becomes a closed space in acute RS, by obliteration of semilunar hiatus secondary to edema, our hypothesis originates on air density changes related to acute infection which may cause different Hounsfield unit (HU) numbers, and our purpose was to examine whether air density analysis combined with classical radiological approaches can be used as a new method to differentiate acute from chronic sinusitis. There is a recent study in the literature on this issue with limited number of cases and some technical differences (6).

MATERIALS AND METHODS

Subjects: The ethical approval was obtained from local ethics committee for this retrospective study which included a total of 550 patients in three groups who underwent paranasal sinus MDCT in one year period (January–December 2013). Patients who were admitted to otolaryngology, head and neck surgery and diagnosed as acute RS were assessed in group 1 (n=176), and patients with known chronic RS without acute exacerbation were selected as group 2 (n=191) as study groups. Patients who underwent a physical examination by the senior of otolaryngology, head and neck surgery and who were classified as acute or chronic sinusitis according to the criteria of ERS/EAACI (4) were included in this study. Patients who were referred to our department to obtain cranial or facial MDCT for various reasons such as trauma, orbital, neurological or otorhinolaryngological preliminary diagnoses and who had normal paranasal sinus findings constituted group 3 (n=183) as the control group. Exclusion criteria for group 1 and group 2 were; history of paranasal surgery or trauma, congenitally undeveloped sinuses, age less than 16 years and complete opacification in sinuses. In group 3, patients with evidence of any abnormal MDCT findings of RS were excluded. In addition, patients with any dental or facial prosthesis were excluded due to artifacts which may have a potential to change CT numbers.

Image Acquisition: The MDCT images were obtained on a 16 MDCT scanner (Toshiba 16, Alexion). The scan settings were 150 mAs, 120 kV, 2 mm slice thickness and 0.5 s/rotation. The DFOV was 25x25. All images were collected from ones that were obtained without intravenous contrast administration. A radiologist, who was blinded to clinical status of the patient, manually placed a 0.5 cm2 ROI as much in center of the air in the sinus as possible avoiding the edges of the air cavity, which is at least 0.3 cm away from the edges (Figure 1).

The measurement was repeated on 3-6 consequent MDCT slices in all sinuses involved. The densitometric measurements were applied on bilateral maxillary, frontal and sphenoid sinuses where available. Ethmoidal air cells were not enrolled for measurement in this study in order to prevent influence of volume averaging artifact, which might be inevitable since they contain closely located bony elements, and because of the difficulty of measurement technically in related fields. The mean MDCT air density and SDs were calculated for all sinuses in each group. To rule out the potential errors in air density analysis within the maxillary sinuses, MDCT density of room air with a 0.5 cm^2 ROI located outside the image was obtained, as well.

Figure 1: Coronal MDCT images of different patients with diagnosis of clinically acute RS on frontal (A), maxillary (B) and sphenoid (C) sinuses. Air densitiesare shown on both acutely inflamed sinus (red circle) and contralateral healthy aerated sinus (white circle).

Data Analysis: To compare the average air density of group 1 and group 2 patients with group 3, the paired Student t test and the one-way analysis of multivariance was applied, respectively. We also compared healthy and acutely inflamed sinuses in the same patient in group 1, in whom one or more sinuses are spared, using the paired Student t test in order to detect if there is any influence on the normal-appearing sinus in acute RS. The SD of the air density was tested as an independent variable in all analyses. All tests were two-tailed and statistically significant with a value of p <0.05. For the correlation between room air and sinus air densities, the Pearson correlation test was applied.

RESULTS

There were 176 patients (91 men and 85 women) in group 1, 191 patients (93 men and 98 women) in group 2 and 183 patients (102 men and 81 women) in group 3, and their average age was 43.3 (range 18-65) years, 47.2 years (range 21-62) and 41.3 (range 24-68), respectively. No significant differences in the age and gender between three groups were found (p > 0.05).

The mean air density value of 683 acutely inflamed sinuses in group 1 was significantly greater than those 635 sinuses in group 2 and 728 sinuses in group 3 (-810 HU,-973 HU and -1010 HU respectively; p < 0.05). The SD of sinuses air density was also higher in group 1 compared with group 2 and group 3 (89.3 HU, 21.1 HU and 20.9 HU respectively; p < 0.05). (Figure 2, 3).

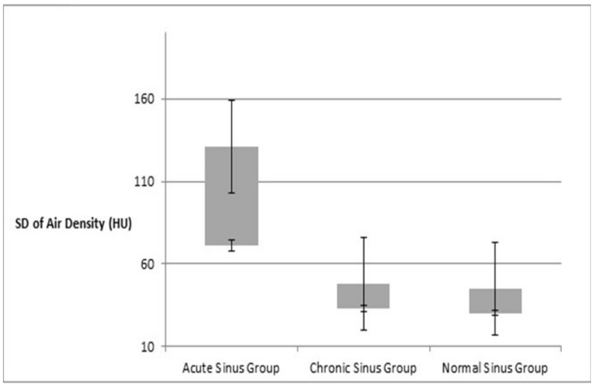

Figure 2: Boxplot of mean air density in all groups: Mean air density of acutely inflamed sinuses is significantly higher than other groups.

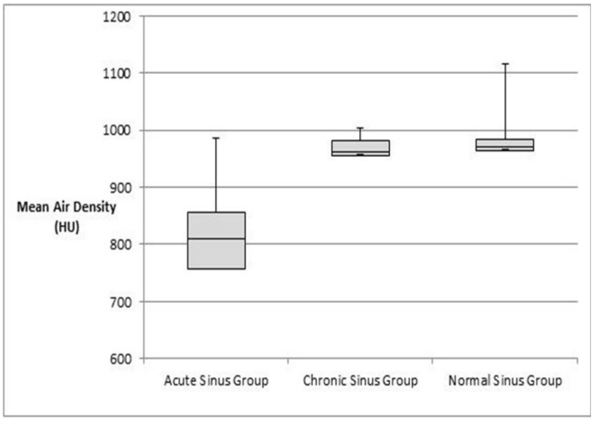

Figure 3: Boxplot of SD of air densities in all groups: SD of acutely inflamed sinuses is higher than other groups showing the significant heterogenecity.

Mean air density values and SD of sinus air densities for all groups are summarized in Table 1 and 2.

Table 1: Mean air density values and SD of sinus air densities.

	number of patiens	number of sinues	Avarge Air density (HU)	SD (HU)
group 1	176	689	-810.9±105.2	89.3±62.8
group 2	191	635	-973.7±31.3	21.1±24.9
group 3	183	728	-1010.1±87.9	20.9±15.1

Table 2: Mean air density values and SD of sinus densities in the acutely inflamed sinuses and healthy sinuses in group 1.

	number of sinues	Avarge Air density (HU)	SD (HU)
acutely inflamed sinus	683	-841.3±120.1	76.8±74.3
healthysinus	373	-987.6±17.3	26.2±16.6

On the basis of air density analysis in group 1; mean air density in the acutely inflamed sinuses was significantly greater than healthy sinuses in the same patient. (-841.3±120.1 HU, -987.6±17.3 HU respectively, $p<0.001$). The SD of sinuses air density was also higher in the acutely inflamed sinuses compared with healthy sinuses (76.8±74.3 vs 26.2±16.6 respectively, $p<0.001$). These results were shown in table 2 and were in concordance with results of the comparison of group 1, 2 and 3 patients.

Mean room air densities among all three groups were -1082.7 HU, -1010.2 HU and -987.9 HU, respectively and there was no significant correlation between room air density and sinus air densities statistically (Pearson correlation coefficient, r =0).

DISCUSSION

MDCT has an important role in the diagnosis and management of acute and chronic RS (7), and indicates the extent of the disease as well. However complicating the interpretation of sinus disease, MDCT imaging reveals a relatively high rate of abnormalities incidentally found during upper respiratory illness (8). The most symptoms in acute and chronic RS are common, such as nasal blockage, obstruction, congestion or nasal discharge with/without facial pain or cough, and it is difficult to distinguish between these two entities clinically. Therewithal, radiological findings are similar each other on the basis of mucosal edema, air-fluid level and partial sinus opacification. The results of our study supported our hypothesis on whether measuring air density may facilitate proper diagnosis to differentiate acute from chronic sinusitis.

It is known that reduction in air flow through the nasal passages contributes to the development of RS (9). Experimental studies show that presence of functional ostium with a least 5 mm2 size allows gas exchange within the sinus. In acute RS by the mechanical obstruction of the ostium secondary to edema sinus becomes a closed space; sinus cavity loses its normal sterility and becomes colonized with nasal flora. When obstruction of the sinus ostium occurs, there is a transient increase in pressure within the sinus cavity. As oxygen is depleted in this closed space, the pressure in the sinus becomes negative relative to atmospheric pressure, which, in turn, may allow the introduction of nasal bacteria into the sinuses during nose blowing or sniffing (10). After the obstruction of the sinus ostium, secretion of mucus by the mucosal cells continues, resulting in accumulation of fluid in the sinus and this provides a fertile environment for bacterial overgrowth.

Mucosal blood flow in the sinus is sufficient to bind and transport only half of the absorbed oxygen, the rest is consumed, and in sinusitis anaerobic mucosal metabolism with shortage of energy supply due to inadequate oxygen supply is observed in experimental studies. As a result of leukocyte glycolysis with local lactic acidosis a high lactate and CO2 concentration develops in purulent secretion in sinusitis. Both ostial occlusion and bacterial growth create appropriate redox potential for further bacterial growth in the affected sinus (11). Metabolic products due to bacterial overgrowth and initial inflammatory response of the mucosal epithelium lead to dissimilar gas content in maxillary sinus cavity compared with healthy sinuses, which, we suggest, can be displayed by densitometric measurement, as shown by our study.

In our study, there was no significant densitometric change in chronic RS compared with healthy group. To explain this discrepancy we suggest that the inflammation and metabolism decreases secondary to insufficient energy supply by time and some adaptations may occur in chronic RS, and as a result, densitometric values show similarity with healthy group. However this assumption must be verified in oncoming studies based on chronic RS with or without acute exacerbation versus healthy sinuses.

To avoid incorrect measurements, all densitometric values calculated by the average of consequent slices and images performed with low dose MDCT at a value of 150 mAs. Hirshoren et al. (6) studied with high dose (240 mAs) parameters and our results with 150 mAs were similar to what they have found, supporting the fact that average air density is not influenced by dose reduction, which is preferable.

CONCLUSION

Since it is difficult to distinguish acute from chronic RS clinically, radiological support is sometimes needed, and MDCT has been accepted as a gold standard for detecting sinus pathologies. In this study we discussed whether air density analysis combined with classical radiological approaches can be used as a new method to differentiate between acute and chronic sinusitis, and in conclusion, the air density of acutely inflamated RS is found to be significantly greater than chronic and healthy sinuses and can be used as a new approach for differential diagnosis.

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