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The Relationship Between Computed Tomography Density Values and Platelet Number and Function in Acute Intracerebral Hematomas

Ebru Ünlü[1], Sena Ulu[2], Şerife Özdinç[3], Elif Dogan Baki[4], Emre Kaçar[1], Mehtap Beker Acay[1], Ergün Karavelioğlu[5], Emel Yılmaz[1], Hanife Uzel Tas[6]

[1]Afyon Kocatepe University, Faculty of Medicine, Department of Radiology, Afyonkarahisar, Turkey
[2]Afyon Kocatepe University, Faculty of Medicine, Department of Internal Medicine, Afyonkarahisar, Turkey
[3]Afyon Kocatepe University, Faculty of Medicine, Department of Emergency Medicine, Afyonkarahisar, Turkey
[4]Afyon Kocatepe University, Faculty of Medicine, Department of Anaesthesiology and Reanimation, Afyonkarahisar, Turkey
[5]Afyon Kocatepe University, Faculty of Medicine, Department of Department of Neurosurgery, Afyonkarahisar, Turkey
[6]Afyon Kocatepe University, Faculty of Medicine, Department of Public Health, Afyonkarahisar, Turkey

Abstract

Objective: The linear relationship between density of hematomas on unenhanced computed tomography and hemoglobin levels were shown before. However, there are no studies about the effects of platelet count and functions on density values of hematomas. Our aim is to investigate the relationship between the density of hematomas measured on unenhanced Computed Tomography scans and platelet count and functions.

Materials and Methods: Seventy seven patients diagnosed with intracranial hematoma by unenhanced computed tomography scans between the ages of 10 and 89, who did not have anemia or coagulopathy, were included in the study. The density values of intracranial hematomas were measured on independent computed tomography diagnostic console. Patients were divided into two groups according to their hematoma densities as higher or lower than 60 Hounsfield Units. The relationship between the densities of hematomas and platelet count, mean platelet volume, platelet distribution width, hemoglobin, hematocrit, and red cell distribution width were investigated in all the patient population among the two groups.

Results: It has been found that the hematoma densities were only significantly correlated with mean platelet volume values among the blood parameters in the study population (p=0,007). Also, a significantly statistical correlation was found between mean platelet volume values of the two groups. (p=0,003).

Conclusion: Mean platelet volume is a significant factor that affects hematoma density value on computed tomography like hemoglobin. It is considered that this finding may also be a reason that explains the differences between hematoma densities of patients without anemia and coagulopathy.

Keywords: Intracranial Hematoma; Computed Tomography; Mean Platelet Volume.

Akut İntraserebral Hematomlarda Bilgisayarlı Tomografi Dansite Değerlerinin Trombosit Sayısı ve Fonksiyonları ile İlişkisi

Özet

Amaç: İntrakranial hematomların kontrastsız bilgisayarlı tomografi dansite değerleri ile hemoglobin seviyeleri arasındaki lineer ilişki daha önceden gösterilmiştir. Ancak, trombosit sayı ve fonksiyonlarının, hematomların dansite değerlerine olan etkisi ile ilgili yapılmış bir çalışma henüz yoktur. Amacımız kontrastsız bilgisayarlı tomografi görüntülerinde ölçülen hematom dansite değerlerinin, trombosit sayı ve fonksiyonları ile ilişkisini araştırmaktır.

Gereç ve Yöntemler: Çalışmaya, ilk 12 saat içerisinde kontrastsız bilgisayarlı tomografi tetkiki ile intrakranial hematom tanısı konulan, anemisi ve koagulopatisi olmayan, 10 ile 89 yaşları arasında 77 hasta dahil edildi. Bilgisayarlı tomografi bağımsız tanı konsolunda, intrakranial hematomların dansite değerleri ölçüldü. Hastalar hematom dansite değerlerine göre, dansitesi 60 Hounsfield birimin altında olanlar ve üstünde olanlar olmak üzere iki gruba ayrıldı. İntrakranial hematomların dansite değerleri ile trombosit sayısı, ortalama trombosit hacmi, trombosit dağılım genişliği, hemoglobin, hemotokrit, eritrosit dağılım genişliği değerleri arasındaki ilişki tüm hasta populasyonunda ve iki grup arasında karşılaştırılarak değerlendirildi.

Bulgular: Tüm çalışma populasyonunda hematom dansiteleri ile tam kan parametreleri arasında sadece ortalama trombosit hacmi değerleri ile anlamlı korelasyon bulundu (p=0,007). Ayrıca iki grupta ortalama trombosit hacimleri arasında istatistiksel olarak anlamlı farklılık saptandı (p=0,003).

Sonuç: Ortalama trombosit hacmi, hematomların bilgisayarlı tomografi dansite değerlerini hemoglobin değerleri gibi etkileyen önemli bir faktördür. Bu bulgunun anemisi ve koagulopatisi olmayan hastalarda izlenen hematom dansite farklılıklarını da açıklayan bir neden olabileceği düşünülmüştür.

Anahtar Kelimeler: İntrakranial Hematom; Bilgisayarlı Tomografi; Ortalama Trombosit Hacmi.

INTRODUCTION

Acute intracranial hemorrhages (ICH), are generally of increased density relative to the surrounding brain in Computed Tomography scans. Due to high attenuation values of blood, CT is extremely sensitive in detecting AIH (1-3). Hematoma density is directly related to hemoglobin (Hb) values and clot retraction and Hb values are among the main factors affecting density. Because hematoma density is low in anemic patients, it becomes more difficult to detect hematoma and this is probably why the linear relationship between hematoma density and Hb levels have been subject to many studies (4-6). However, the case of patients with similar Hb values in routine evaluations and the presence of notable differences in hematoma densities visible in CT scans applied during the same period suggested us to consider other factors that affect the density.

Although it is taken for granted that clot retraction is one of the factors effecting density, the influence of platelet count and function on hematoma density has not been studied in detail yet. Mean platelet volume (MPV) and platelet distribution width (PDW), both of which are regarded as platelet volume indexes, are as effective as the number of platelets during clot retraction. MPV and PDW are among the routinely measured parameters in the complete blood count; especially MPV has already been accepted as an indicator of platelet function and activation (7-9).

This study has been initiated as a result of identifying hematoma in MRI examination in patients who did not have anaemia or coagulopathies or show any sign of intracerebral hematoma in CT (10-12). The aim of this study is to investigate the relationship between MPV, PDW, platelet count and the density of haematoma which has not been studied before. In addition, our study will also investigate the effects of hemoglobin and hematocrit values and erythrocyte distribution volume (RDW) on hematoma density.

MATERIALS and METHODS

In this retrospective study, we have evaluated the clinical data, CT results, and hemograms of a total of 489 patients who were admitted to the Emergency Service and diagnosed with AIH. The data obtained from the hospital database covered the period between January 2012 and November 2012. Patients with anemia, polycythemia, thrombocytopenia, and coagulation disorders were excluded from the study. In addition, we also excluded cases with bleeding associated with anticoagulant therapy, arteriovenous malformation, and brain tumors. Of the remaining patients, we conducted our research among a total of 77 individuals who received AIH diagnosis with confirmed non-contrast CT examinations conducted within the first 12 hours of the onset of symptoms and who had blood count test results of venous blood samples in ethylenediamine tetra-acetic acid tubes with completely normal complete blood counts. The following Hb values were considered normal: 14,0-17,0 g/dL for males and 12-14,5 g/dL for females. The other key parameters and their reference ranges adapted in the study were as follows: hematocrit (Hct): 33-50%; platelet: 160000-450000/ml; MPV: 6,8-10,8 fL; and PDW 11-15 fL.

All examinations were administered by using a spiral CT scanner (Brilliance 6; Philips Medical Systems, Amsterdam, the Netherlands). Cranial CT scans were performed with a slice thickness of 5mm in infratentorially planes and of 10mm in supratentorial planes with 120 kV and 175 mAs parameters without contrast material. On the independent diagnostic console, in parenchyma window, ROI (region of interest) was placed to cover intracranial hematoma and densities were measured.

Because hematoma density would quickly rise up to 60-80 HU (Hounsfield units) due to clot formation and retraction, the expected minimum hematoma density level of 60 HU in this process was regarded as the reference range and patients were divided into two groups accordingly: those with a hematoma density level below 60 HU and those above 60 HU.

For statistical analysis, we made use of SPSS 17.0 (SPSS Inc., Chicago, IL, the USA) database. We determined the mean, standard deviation, minimum, and maximum values of the data. The suitability of the quantitative data to normal distribution was analyzed with the Kolmogorov-Smirnov test. For the comparison of the independent quantitative data with normal distribution between the two groups, we applied the Student's t-test; the quantitative data without normal distribution were compared using the Mann-Whitney U-test. The assessment of relations between each of the individual parameters was made with Pearson correlation analysis. Data are shown as mean values ± standard deviation. The p value of <0.05 was considered to be statistically significant throughout the comparison of the groups.

RESULTS

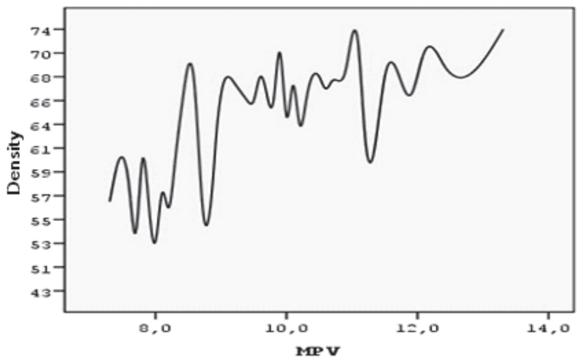
The study population was made up of 49 males and 28 females between the ages of 10 and 89 with a mean age of 47. The hematoma density of the patients ranged from 43 to 71 HU. Comparing the complete blood parameters of the two groups divided by a hematoma density value of 60 HU, There was found statistically significant differences among their MPV values (p=0,003).(Table 1). Average MPV values were 8,4+0,90 for the group with a hematoma density below 60 HU and 10,4+1,07 for the group with a hematoma density higher 60 HU. There was only a significant positive correlation of MPV values (R=0,793; P=0,007) between complete blood count parameters and hematoma density in the entire study population (Figure 1). In contrast, there was no notable relationship between hematoma density and, platelet count and PDW values (p>0,05). Mean Hb values were 13,6±1,1 and mean hematocrit values were 41,31±4,40. Mean Hb density value for patients below 60 HU was 13,8±1,0 while this value was 13,5±1,1 for patients above 60 HU and there was no statistically significant difference between the groups (p=0,3). Also, there were no significant differences between the groups in terms of hematocrit and RDW values as there was also no significant relationship between these parameters and density (p>0,05).

Table 1. Comparison of the complete blood parameters of the groups (as higher or lower than 60 HU).

HEMATOMA DENSITY	<60HU	>60HU	p
Mean platelet volume (fL)	8,4±0,9	10,45±1,0	**0.003***
Platelet count (1000/ml)	262±82	242±82	0.2
Platelet distribution width (fL)	12.7±1.8	13.3±2.4	0.2
Hemoglobin (g/dL)	13.5±1.1	13.8±1.0	0.2
Hematocrit (%)	40.7±4.4	42±4.3	0.1
Erythrocyte distribution width	4.8±6.8	5.8±6.9	0.5

Statistical analysis is based on the Student's t-test; all data provided are in mean ±SD; p<0,05 value has been considered significant in comparing the data obtained from the groups; HU: Hounsfield unit.

Figure 1. The relationship between platelet volume and hematoma density among the individuals.



DISCUSSIONS

The most important finding of our study is the significant correlation between hematoma density and MPV values in patients with acute intracerebral hemorrhage. This finding supports our initial hypothesis and shows that the sole factor that determines density is not only Hb; rather, there are other factors contributing to density.

In CT imaging, blood density value is directly associated with its protein content, In CT imaging, blood density value is directly associated with its protein content (mainly hemoglobin) (4). (4). Similarly, the relationship between CT density values and clot retraction has been reported in several studies (6). However, little is known about the effects of platelet functions on attenuation values of haematomas..

Typically an intracerebral haematoma containing fresh blood appears hyperdense on CT due to increased attenuation value. In the acute stage, unclotted freshly extravasated blood on CT usually has a measured attenuation in the range of 40-60 HU due to the formation of inhomogeneous mass which contains red blood cells, white blood cells and small clumps of platelets. Over the first 4-6 hours, the body attempts hemostasis by forming a blood clot at the site of injury. Subsequently, the density evolves because of clot formation and retraction and rapidly increases to 60-80 HU or even more, relative to normal brain, which measures 20 to 30 HU (6). During the next 48 hours, attenuation values begin to decrease due to clot lysis (6,7).

The linear relationship between CT density of blood and Hb levels is well-known for a long time and has been the subject of many studies. As a result of this relationship, in extreme anemia, acute intracranial hemorrhages whether in the brain parenchyma or within epidural, subdural, or subarachnoid spaces may be isodense with the surrounding brain and make detection very difficult on CT.In patients with severe anemia, intracranial hematomas may even occur in lower densities compared to the brain parenchyma. This occurs when the Hb levels are less than 10gm/dL (4,13). (4,13). Conversely, there is increase in the CT blood density values in with polycythemia (4, 14). The other reason of acute isodense haematoma on CT are coagulation disorders.. Hematomas observed in patients with clot retraction defects are monitored in relatively lower densities compared to those of patients without retraction; such patients may not even show hematomas in CT scanning (6). However, there are reports in the literature of patients who did not show intracerebral hemorrhage areas in CT images though they did not have severe anaemia or coagulopathy (10-12). In these cases, hemorrhage, that had remained unmonitored in CT scans, was detected in the Magnetic Resonance images.. In the light of all of this information and, though infrequently, as seen in our routine CT examinations and the case reports mentioned above, anaemia and clot retraction have so far been regarded as the reasons behind the decline in hematoma density leading to misinterpretations in diagnosis though the presence of patients with normal blood parameters and, yet, with low hematoma densities who do not show hematomas suggests that there might be other mechanisms operating behind the scenes for low hematoma density.

By involving patients with normal Hb levels in a similar range in our study, we aimed to keep the effect of Hb on density to a minimum. Because we needed to keep the impact of Hb as constant as possible to be able to see the effect of other potential parameters on hematoma density. We evaluated the CT scans obtained in the acute phase of patients with normal hemograms who did not have any coagulation disorders or history of anticoagulant/antiplatelet use. In this way, we eliminated the possible factors that would create hematoma density differences among patients. As it is known, hematoma density reaches 60-80 HU or even more with clot retraction in acute phase in healthy individuals. However, in our study, some of the patients who had normal Hb levels without any coagulation disorders showed hematoma density levels below 60 HU and, even in patients with similar Hb levels, there were notable differences in concurrently taken CT images. That was the reason why we divided the patients into two groups according to the hematoma density levels as below 60 HU and above 60 HU. As a result of statistical analysis comparing blood parameters between the two groups, the only statistically significant difference was that of the MPV values. In addition, there was a significant positive correlation between MPV values and densities for all the patients in the study group. However, we did not observe any correlation between platelet counts, PDW values, and hematoma densities.

MPV and PDW are platelet volume indexes that are routinely measured in complete blood measurements. Especially MPV, one of the platelet volume indexes, is an indicator of platelet function and activation (8, 9, 15, 16). Young platelets are larger and have denser granules; they are also hemostatically more active than those with smaller volume (8, 15, 16). The high number of young platelets manifests itself with high MPV values. According to the results of our study, in patients with low hematoma density, MPV values were also significantly lower. Therefore, although patients have normal blood parameters, the differences observed between hematoma densities suggests clues concerning patients's platelet volumes, in other words, their ability to produce younger platelets.

In conclusion, this study shows that MPV, like hemoglobin, is an effective parameter affecting hematoma density. In addition, the differences observed between hematoma densities in patients with normal blood parameters can be explained by the differences in patients platelets activities. We hope that this study will shed light on the pathophysiology of CT negative ICH patients with lack of anaemia or coagulopathy.

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Correspondence/İletişim

Ebru ÜNLÜ
Afyon Kocatepe Üniversitesi Tıp Fakültesi, Radyoloji Anabilim Dalı, AFYONKARAHİSAR, TÜRKİYE
E-mail: edunlu@yahoo.com

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