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ESTIMATION OF THE EFFECT OF HEMOGLOBIN AND HEMATOCRIT ON COMPUTED TOMOGRAPHY HOUNSFIELD UNIT (HU) VALUES OF DURAL VENOUS SINUSES.

Radio-Diagnosis

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KEYWORDS

INTRODUCTION

Computed tomography (CT) was introduced in the medical imaging in the early 1970s. The newer development of faster and more potent computers, combined with tightly collimated X-ray beam and multiple arrays of detectors made CT a powerful diagnostic tool in this era of the evidence-based medicine.

The Hounsfield unit is the basic measurement of the quantitative amount of radiodensity used in the evaluation of CT images. Radiologists use the Hounsfield unit (HU), as a relative quantitative measurement of radiodensity or attenuation, to examine CT images. The capacity of radiologists to evaluate images and the use of the HU to quantify tissue density have simplified various diagnoses.

The HU value of the intraluminal blood is influenced by the subject's levels of hematocrit (HCT) and hemoglobin (Hb). Though it is generally known that hemoconcentration or high levels of Hb or hematocrit (HCT) result in increased x-ray attenuation inside the vasculature because of the Iron content.

Men and women (with distinct values for pregnancy), different age groups, different altitudes, and smokers all have different normal HB ranges. A relative anemia or relative polycythemia may be present on account of factors that alter the plasma volume without altering the total mass of the RBCs.

Although the idea that hemoconcentration or high amounts of HB or hematocrit (HCT) cause higher x-ray attenuation inside the vasculature is commonly accepted, the evidence for this association is somewhat lacking. The triage of patients with suspected thrombosis that is possibly seen in the dural venous sinuses may be improved with a better understanding of the relationship between the hemo concentration and the CT attenuation.

AIMS AND OBJECTIVES:

To estimate the effect of hemoglobin and hematocrit on Hounsfield unit (HU) values and to estimate the association of Hounsfield unit (HU) values with demographic variables in the dural venous sinus.

MATERIALS AND METHODS:

A cross-sectional study was done by including 84 subjects of both pediatric and adult age groups except for children in the first 6 months of age to eliminate the effect of fetal hemoglobin, attending our department BGS GIMS for plain CT imaging of brain and have their complete blood count results.

In dural venous sinuses, the HU value measured in the right transverse sinus and the region of interest determined with the best-fit method. If the right sinus is hypoplastic, then the left transverse sinus was interrogated.

Exclusion criteria:

- Subjects who have bleeding tendencies.
- Subjects with history of dehydration, trauma or hemorrhage.
- Subjects with intracranial vascular anomaly and congenital heart disease.
- Subjects who had blood loss or have done voluntary blood donation in the last 6 months.
- Subjects who have undergone blood transfusion within the previous 48 hrs.
- Intravenous iodinated and gadolinium contrast-based administration within the last 48 hours at the time of CT evaluation.
- Subjects whose blood analysis has not been performed or has been done after 24 hours from the time of CT imaging.

For imaging the standard Kilovoltage peak (KVp) and milliamperes-second (mAs) maintained measuring 80 and 50 respectively. Helical mode was employed for CT imaging.

CT machine used – Siemens Somatom Multi-detector row CT machine (64 slices). Data were analyzed by using the SYNGO DICOM viewing software. Masking or blinding the HB and HCT values done before the evaluation of HU values.

Blood evaluation done within 24 hours from the time of the scan. Hydration was well maintained during the study and was assessed clinically.

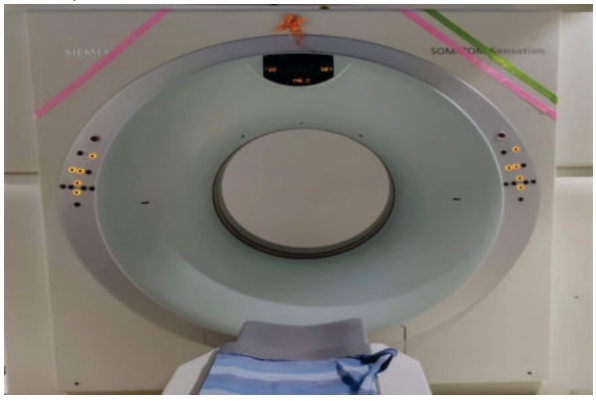


Figure 1: Image of SIEMENS SOMATOM 64 Slice CT machine used in this study.

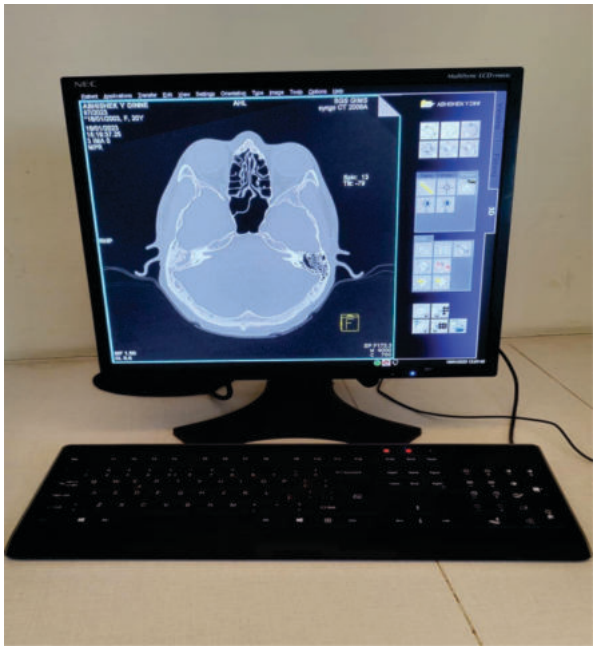


Figure 2: Image showing the workstation used for this study.

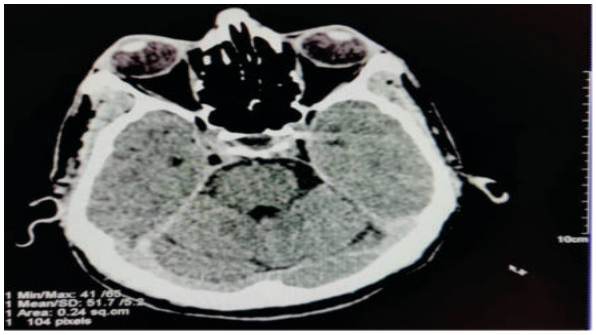


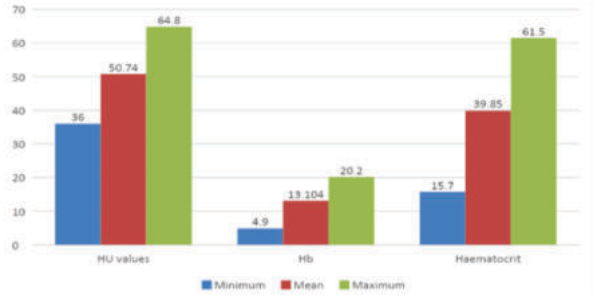
Figure 3: Selected NCCT axial image of brain in brain window showing HU values and sample volume in the right transverse sinus.

All the data were collected compiled and registered into the appropriate statistical application. Descriptive statistics calculated, and test of significance used as required. To study the correlation between variables, Pearson's correlation coefficient and Spearman's rank correlation used based on the suitability of the data. The data was analyzed using appropriate statistical software.

Table 1: Mean values of variables.

Variable	Minimum	Maximum	Mean	SD
HU values	36	64.8	50.74	6.12
Hb	4.9	20.2	13.104	2.38
HCT	15.7	61.5	39.85	6.46

In the present study, the mean HU values, Hb and HCT were found to be 50.74 ±6.12, 13.10 ±2.38 and 39.85±6.46 respectively. (Table 1).

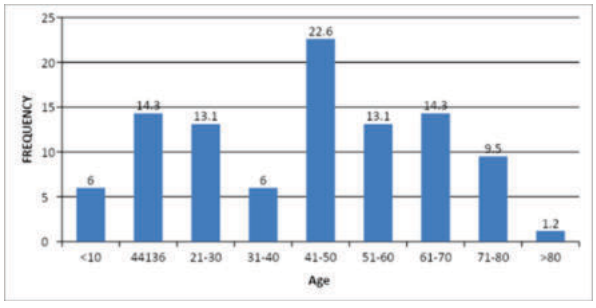


Graph 1: Mean values of variables.

Table 2 : Age distribution of study participants.

Age	Frequency	Percentage
<10	5	6
11-20	12	14.3
21-30	11	13.1
31-40	5	6.0
41-50	19	22.6
51-60	11	13.1
61-70	12	14.3
71-80	8	9.5
>80	1	1.2
MEAN+SD	43.75+21.8	

In the study, majority of the patients 22.9% (n=19) were in the age group of 41 to 50 years followed by 14.3% (n=12) in the age group of 11-20 & 61-70-years age group. The age of the patients varied from 2 years to 82 years with a mean age of 43.75. (Table 2)

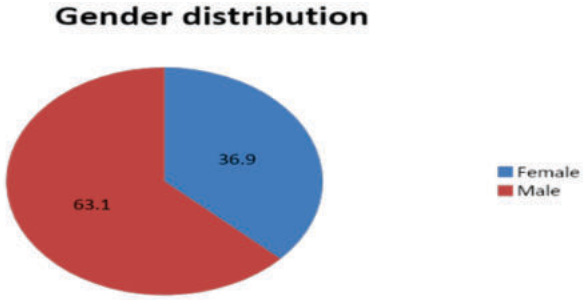


Graph 2: Age distribution of study participants.

Table 3: Gender distribution of study participants.

Gender	Frequency	Percentage
Female	31	36.9
Male	53	63.1
Total	84	100

In the present study out of 84 subjects, 53 (63.1%) were male and 31(36.9%) were female. (Table 3).

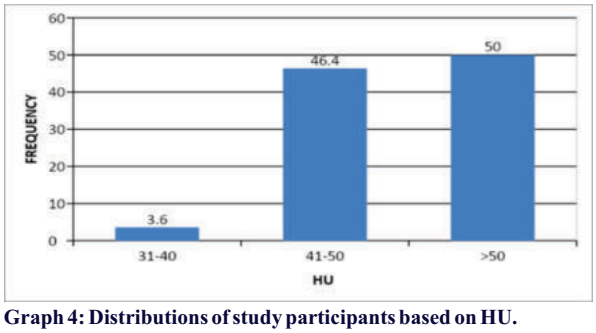


Graph 3: Gender distribution of study participants.

Table 4: Distributions of study participants based on HU.

HU	Frequency	Percentage
31-40	3	3.6
41-50	39	46.4
>50	42	50
Total	84	100

In the present study the HU values of the subjects varied from 36 to 64.8 with a mean value of 50.74. Half of the subjects had an HU value of more than >50 and 46.4% (n=39) had an HU value of 41-50. (Table 4).

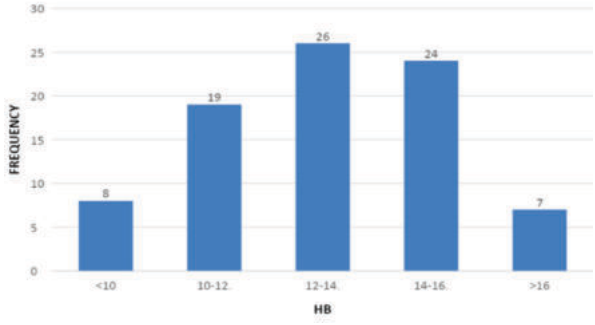


Graph 4: Distributions of study participants based on HU.

Table 5: Distributions of study participants based on Hb.

Hb	Frequency	Percentage
<10	8	9.5
10-12.	19	22.6
12-14.	26	31.0
14-16.	24	28.6
>16	7	8.3

In the present study the Hb values of the subjects varied from 4.9 to 20.2g% with a mean value of 13.1. Hb value of 10 to 16g% was found among 82.2% (n=69) of subjects and 9.5%(n=8) had less the 10g% and 8.3%(n=7) had more than 16g%. (Table 5).

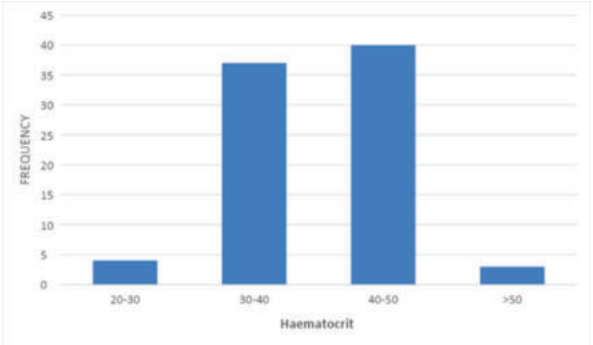


Graph 5: Distributions of study participants based on Hb category.

Table 6: Distributions of study participants based on HCT.

HCT	Frequency	Percentage
20-30	4	4.8
30-40	37	44.0
40-50	40	47.6
>50	3	3.6

In the present study the HCT value of the subjects varied from 15.7 to 61.5 with a mean value of 39.85. HCT value of 30 to 50 was found among 91.6% (n=77) of subjects and 3.6%(3) had more than 50. (Table 6).

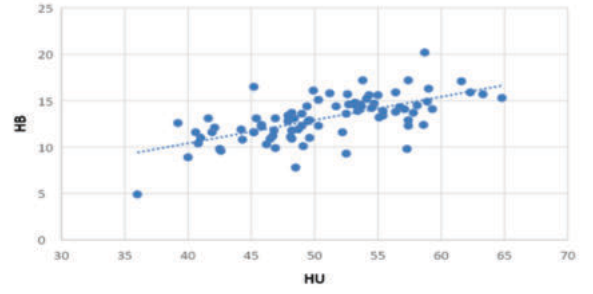


Graph 6: Distributions of study participants based on HCT.

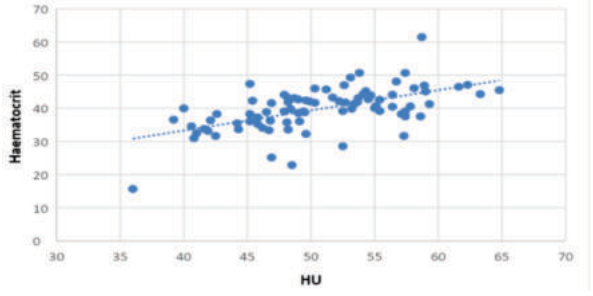
Table 7: Correlation between HU and Hb, HCT AND AGE.

HU IN DVS	Hb	HCT	AGE
Pearson Correlation	0.643	0.578	0.036
Sig. (2-tailed)	0.000	0.000	0.747

In the present study, HU values were found to show a positive correlation with Hb, HCT, and age. The correlation between HU values and Hb, and HCT was found to be statistically significant.



Graph 7a: Scatter plot between Hb and HU.

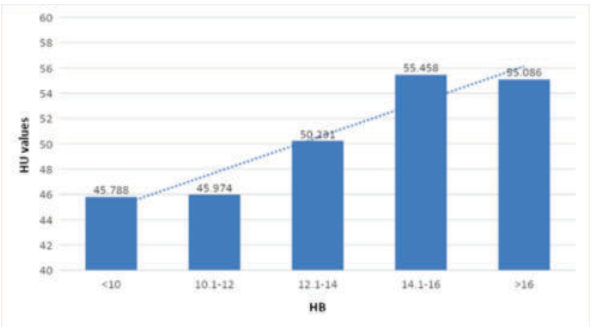


Graph 7b: Scatter plot between HCT and HU.

Table 8: Correlation between HU values in DVS & Hb.

Hb	Mean	Std. Deviation	P VALUE
<10	45.788	6.9328	0.0001
10.1-12	45.974	3.2422	
12.1-14	50.231	5.3621	
14.1-16	55.458	3.9985	
>16	55.086	5.8087	
Total	50.743	6.1269	

In the present study, the mean HU values in the DVS were found to be increasing with increasing Hb values. There was a significant statistical association between HU values in the DVS & Hb category with a p-value of 0.0001. (Table 8).

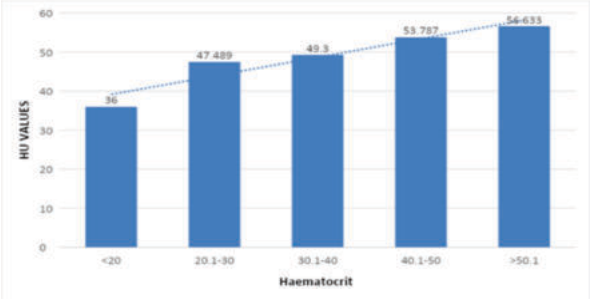


Graph 8: Correlation between HU values in DVS & Hb.

Table 9: Correlation between HU VALUES IN DVS & HCT

Hematocrit	Mean	Std. Deviation	P VALUE
<20	36.000	2.3425	0.0001
20.1-30	47.489	5.5063	
30.1-40	49.300	2.8844	
40.1-50	53.787	4.8159	
>50.1	56.633	2.5384	
Total	50.743	6.1269	

In the present study, the mean HU values in DVS were found to be increasing with increasing Hematocrit. Similarly, there was a significant correlation between HU values in the DVS & HCT category with a p-value of 0.0001. (Table 9)



Graph 9: Correlation between HU VALUES IN DVS & HCT

Table 10: Correlation between HU values in DVS & AGE

AGE	Mean	Std. Deviation	P VALUE
<10 YEARS	45.560	7.7190	0.367
11-20 YEARS	51.542	5.3822	
21-30 YEARS	50.655	6.7930	
31-40 YEARS	53.520	8.4928	
41-50 YEARS	51.768	5.5167	
51-60 YEARS	50.864	7.5995	
61-70 YEARS	51.567	4.6662	
71-80 YEARS	48.438	4.0415	
>80 YEARS	41.900	6.953	
Total	50.743	6.1269	

Table 11: Correlation between HU VALUES IN DVS & SEX

SEX	Mean	Std. Deviation	P VALUE
Female	50.558	6.1454	0.83
Male	50.851	6.1724	
Total	50.743	6.1269	

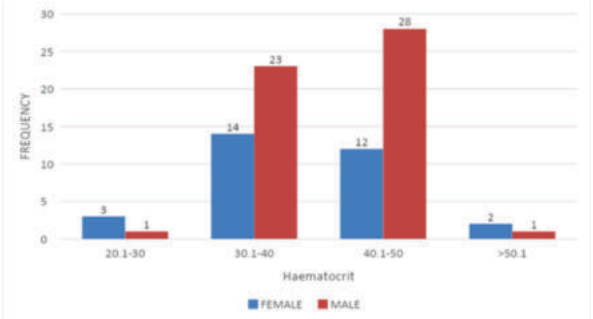
In the present study there was no significant correlation between HU values in DVS & age, sex with a p-value of 0.367 and 0.83 respectively. (Tables 10 & 11).

Table 12: HCT between genders of the study:

HCT		GENDER		P VALUE
		F	M	
20.1-30	Count	3	1	0.215
	%	9.7%	1.9%	
30.1-40	Count	14	23	
	%	45.2%	43.4%	
40.1-50	Count	12	28	
	%	38.7%	52.8%	

>50.1	Count	2	1	
	%	6.5%	1.9%	

45.2% and 43.4% of females and males had HCT in the range of 30.1-40. The association was not found to be statistically significant between HCT and the gender of the study participants.

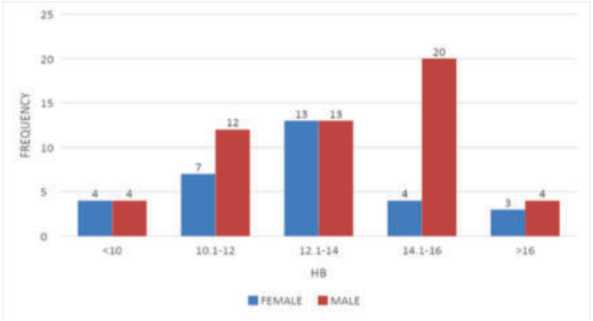


Graph 10: Distribution of frequency of hematocrit in male and female patients

Table 13: Hb between genders of the study:

HB		GENDER		P VALUE
		F	M	
<10	Count	4	4	0.121
	%	12.9%	7.5%	
10.1-12	Count	7	12	
	%	22.6%	22.6%	
12.1-14	Count	13	13	
	%	41.9%	24.5%	
14.1-16	Count	4	20	
	%	12.9%	37.7%	
>16	Count	3	4	
	%	9.7%	7.5%	

41.9% and 24.5 % of females and males had Hb in the range of 12.1-14. The association was not found to be statistically significant between Hb and the gender of the study participants.



Graph 11: Distribution of frequency of Hemoglobin in male and female patients

DISCUSSION:

The first and foremost imaging technique used to assess patients who report to the emergency room with sudden onset neurological symptoms is the non-contrast CT of the head. At the time of imaging, the patient typically does not have access to the hematological reports. On a non-contrast CT of the skull, the cerebral DVS is one of the well-known structures. It is thought that levels of Hb and hematocrit affect how much the cerebral DVS attenuates.

Our study sought to determine the degree to which patient HB/HCT levels and attenuation of the cerebral DVS on non-contrast CT were correlated.

This report confirms the long-held belief that intravascular radiodensity correlates with the degree of hemoconcentration. We demonstrated that x-ray attenuation is highly correlated with both Hb values and HCT levels. This is important because the hemo concentration may cause CT attenuation to appear as if patients have thrombosis when they in fact do not have.

We have not encountered any significant anomalies during the study.

Demographic characters of study participants:

In a present study Out of 84 subjects, 53 (63.1%) were male and 31(36.9%) were female. The age of the patients varied from 2 years to 82 years with a mean age of 43.75. The majority of the patients 22.9% (n=19) were in the age group of 41 to 50 years followed by 14.3% (n=12) in the age group of 11-20 & 61-70 years age group. Similar findings are seen in a study done by D F black et al.

HU values:

In a present study the HU values of the subjects varied from 36 to 64.8 with a mean value of 50.74. Half of the subjects had an HU value of more than >50 and 46.4% had an HU value of 41-50. Similar findings are seen in a study done by D F black et al.

In a study done by Seung Young Lee et al [6] the mean density of dural sinuses ranged from 24.67 to 53.67 HU with a mean of 43.28 and with a standard deviation (SD) of 5.82.

Hemoglobin values:

In a present study the HB values of the subjects varied from 4.9 to 20.2g% with a mean value of 13.1. HB value of 10 to 16g% was found among 82.2% (n=69) of subjects and 9.5% (n=8) had less the 10g% and 8.3% (n=7) had more than 16g%. In a study done by Seung Young Lee et al [6], HB levels ranged from 6.6 g/ dL to 16.5 g/dL with a mean of 13.17±2.18. Similar findings are seen in a study done by D F black et al [5], HB values ranged from 8.1 to 15.9 (5.9) in women and from 8.1 to 18.4 (6.9) in men.

HCT value:

In a present study, the HCT value of the subjects varied from 15.7 to 61.5 with a mean value of 39.85. HCT value of 30 to 50 was found among 91.6% of subjects. Similar findings are seen in a study done by D F black et al. In a study done by Seung Young Lee et al [6], HCT levels ranged from 20.3% to 48.2% with a mean of 38.89±6.22.

Correlation between hemoglobin, HCT value, and HU values in DVS

In the present study, HU values were found to show a positive correlation with HB, HCT, and age. The correlation between HU values and HB, and HCT was found to be statistically significant. In a study done by Seung Young Lee et al [6], there was a strong correlation between mean HU and HCT level (r=0.840).

Correlation between HB category and HU values in DVS

In a present study the HB category of <10, 10.1 to 12, 12.1 to 14, 14.1 to 16, and >16 and the HU category of 31-40, 41-50 & >50 had shown a significant association with a P value of <0.00001. In a study done by Seung Young Lee et al, there was a strong correlation between mean HU and HB level (r=0.832), so it may be possible to use regression equation such as mean HU=13.966+2.226 HB (p< 0.001). This study showed the importance of quantitative assessment. In an earlier report, Fanous et al, suggested that the lack of a strong correlation between attenuation values and HB levels may be due to the dural sinus complexity. The lateral venous lacunae and cavernous spaces contribute to structural heterogeneity. Therefore, if the dural sinus attenuations are measured at larger and more numerous points, then the mean values will be more precise.

In a present study, The HCT category of <20, 20.1 to 30, 30.1 to 40, 40.1 to 50, and >50.1, and the HU category of 31-40,41-50 & >50 had shown a significant association with a p-value of <0.00001. But the age category of <10, 11 to 20, 21 to 30, 31 to 40, 41-50, and >80 and the HU category of 31-40,41-50 & >50 had shown no significant association with a p-value of <0.138 and also sex of male & female had shown no association with HU category of 31-40,41-50 and >50 with a p-value of 0.96.

A study done by New and Aronow, used blood product preparations to demonstrate an in vitro correlation between HU and HCT, whereas Ben Salem et al, retrospective analysis of 10 non-contrast head CTs found that an HCT 60% generated attenuated-appearing vasculature. Nelson et al., reported 15 patients with attenuated appearing dural sinuses on CT without thrombosis, and many of these had elevated Hbs or HCTs. Other case reports indicate that patients with high HCTs may have very high attenuation within the dural sinuses on unenhanced CT, mimicking the appearance of sinus thrombosis. Still, other case reports demonstrate that patients with low Hb or HCT values may exhibit unexpectedly low HUs within areas of intracranial hemorrhage.

Summary

Following points can be drawn from my study-

- Dural venous sinus attenuation on non-contrast CT of the head, significantly depends on hemoglobin/ hematocrit values. A high degree of positive correlation was observed between hemoglobin/ hematocrit levels and dural venous sinus attenuation.
- My study correlates well with the study done by Black DF et al. Cerebral venous sinus density on non-contrast CT correlates with hematocrit.
- The mean HU values of hemoglobin and hematocrit in females were found to be less as compared with the male subjects, eventually influencing HU values being slightly less in females in comparison with male subjects.

CONCLUSION:

My study concludes that we can rely on the HU values for relative anemia/ polycythemia in emergency cases where a complete blood count was not available at the time of the scan and to exclude dural venous sinus thrombosis. The mean HU values of hemoglobin and hematocrit were found to be less in female subjects as compared with the male subjects in concurrence with the gender differences.

Limitations:

- Proximity of the transverse sinuses to the occipital bone.
- Relatively small sample size.

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