Estimation of Haemoglobin on Basis of Hounsfield Unit in Computed Tomography Head Trauma Patients

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ABSTRACT

Many studies had been done indifferent anatomical areas in the body to find correlation between the Haemoglobin (Hb) and Hounsfiled (HU) values. Some investigators have done this correlation study on the thorax and brain to find values with anaemia patients.Aim of our study to find gender-related variation of Hb and HU values during brain Computed Tomography (CT) scan. Another objective to see the relation between HU with Hb values at the level of Internal Carotid Artery (ICA) & Vertebral artery after the scan.This was a prospective randomized study in which 114 Patients, who all referred to CT scan with history of trauma to the department of Radiology. Patients are randomly selected and sampled using student's t test. HU were measured with the help of region of interest (ROI) which is available in the CT monitor. By keeping ROI in the vertebral artery and ICA, HU values are obtained. 3ROI circles of varying volume, that are ranging from 2.5to 4 mm^2, were taken in each of the subjects to assess for any significant variability.There was a difference in measurements of Hb, vertebral artery and ICA according to gender($p< 0.05$).The, right vertebral artery is more significant to predict Hb based on HU in males(p-0.008*) and shows there is no any significant value for females.36 to 49 HU can be average range of blood density in male patients with normal Hb value and Females it will be 36 to 43 HU. Study shows the relationship between Hb levels and outcome measures according to gender. Here 36 HU shows low HB range which can be considered as anaemic due to traumatic blood loss.

INTRODUCTION

The Computed Tomography (CT) is very exceptional in diagnosing disease compared with diagnostic information that obtained by conventional x-ray techniques. Invention of CT was made achievable through the work of large number of researchers, most notably Godfrey Newbold Hounsfield and Allan MacLeod Cormack[1].

Cross-sectional image of the body is reconstructed by CT and it uses a computer to do the reconstruction from large measurements of x-ray transmission through thin slice of patient tissue. The x-ray photons attenuated through body section absorbed by detector system. The process absorption and scattering will occur as it passes through the patient. By using a computer algorithm, each pixel which will represent the CT image are dispensed with CT number and it measure transmitted x-rays in each pixel of the image[2-4].

The attenuation measurements are added together to produce numeric representation of the object. These numerical representations are known as CT numbers. This displayed on a checkboard style known as matrix. Then the array is converted into a picture form by assigning a grayscale or Hounsfield to the number[5].

Radiodensity of the pure water at standard pressure and temperature (STP) is considered as zero HU whereas the radio density of the air at STP is defined as −1000 HU. From CT images of all body tissues it is possible to obtain the radio density value, which are almost fixed for particular tissue. Depend up on the varying density of the different organ or fluid there will be variation in values of HU[6].

For diagnosis and management of different disease the density measurements by HU unit can play a significant part. A study was conducted in patients with β-thalassemia major and they correlated the density measurements of the liver with serum ferritin levels[7].Di Giandomenico et al[8]. have been showed a significant difference in blood attenuation values

between healthy and anaemic patients through the CT density measurements of intravascular blood.

Patients will undergo CT imaging especially in the acute situations, who are often lack an accompanying haemoglobin laboratory values at the existing time of CT imaging. Of these, investigative significant is Hb level, some considerable number of abnormalities can be a consequence of reduction in Hb value[6].

Motivated by those studies, in our study we are decided to check the attenuation value of vertebral artery and internal carotid artery of the brain after unenhanced CT scan. Our intention was to correlate those attenuation value with biochemically derived Hb value within 12 hours of patient admission. Study was conducted only on head trauma patients to estimate the Hb by the use of HU value. further, the study might help in case of any trauma cases, we will able to obtain Hb values by calculating the HU's result. Here we can find out the haemorrhagic anaemia which will occur due to blood loss, because the cases in this study included only the head trauma patient

MATERIALS AND METHODS

After obtaining institutional ethical committee clearance for this study we had taken patient's informed consent taken before the study. Patients scan was performed according to the routine protocol. A total of 114 random adult patients who had undergone CT head scan with history of trauma were enrolled sequentially after informed consent and identification details such as name, age sex, hospital registration number were recorded.

Hounsfield values were measured with the help of region of interest (ROI) which is available in the CT monitor. By keeping ROI in the vertebral artery and internal carotid artery HU values are obtained.3 ROI circles drowned on artery which have varying volume, that are

ranging from 2.5to 4 mm2, were taken in each of the subjects to assess for any significant variability.

Patient's laboratory report of the Haemoglobin test collected within 12 hours with the help of PACS facility for the correlation purpose with HU values.The Sample size was obtained by taking by considering statistical analysis where the level of significance was set for 5% and power of 80%. The overall average HU value has taken from three measurements of artery with two persons at different places &the measurement was finalised by averaging all these three measurements

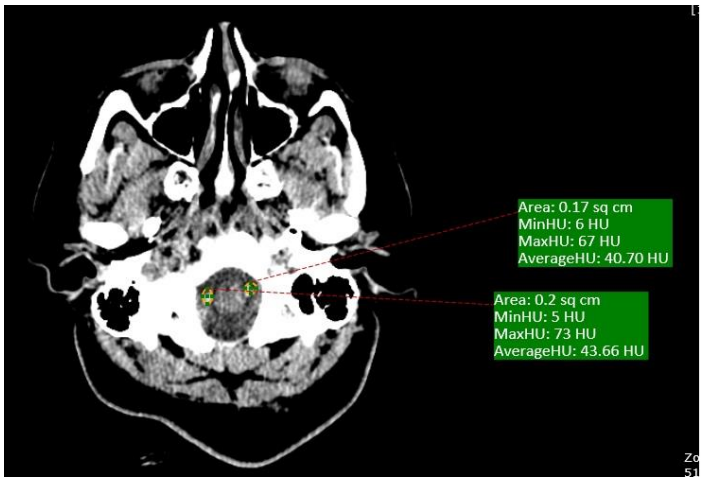

Figure 1.Measurement of HU value in right and left vertebral artery

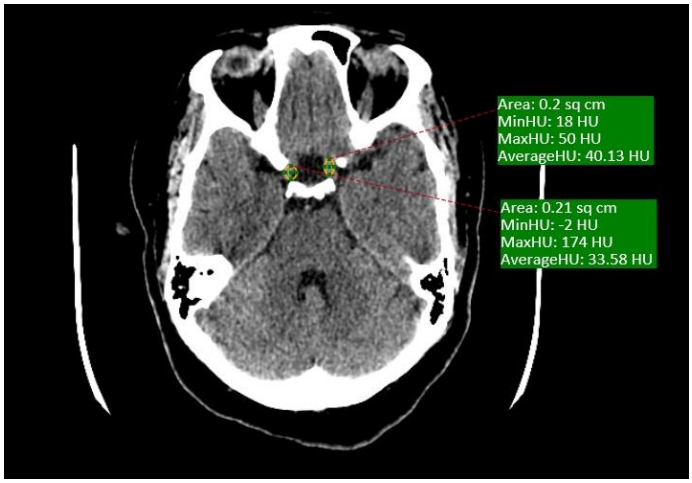

Figure 2.HU value measurement in RICA and LICA

Statistical analysis

Collected data was computed on Microsoft excel 2013.All data were subjected to Independent sample "t" test to compare the study characteristics haemoglobin the obtained p values are < 0.05.Pearson correlation coefficient was used to find the relationship between two characteristics measurements.Pearson correlation coefficient was used to find the relationship between Haemoglobin levels and other outcome measures separately for each gender.Multiple Linear regression model used to predict Haemoglobin based on HU.P value was calculated by using independent t test.P value < 0.05 considered statistically significant.

RESULT

114 patients were included in this study, in that 22 female patients and 92 male patients were included(Figure 3). here we included CT brain normal study who all came under history of trauma and the mean age group is 40.37 and the mean Hb is 13.61. Age distribution of subject ranged from 18 to 80.

Demographic parameters:

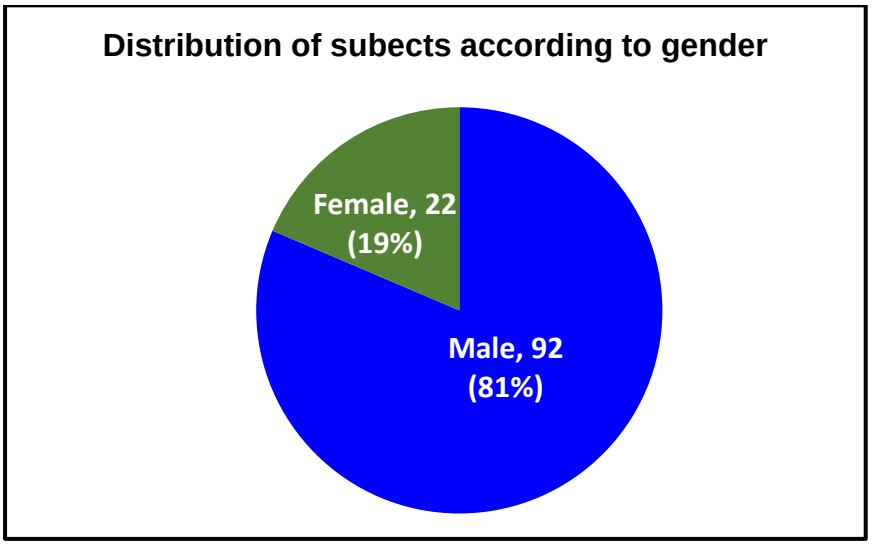

Figure 3. Bar chart showing gender distribution

(n = 113)	Minimum	Maximum	Mean	S. D	95% C.I for mean
Age	18	80	40.37	14.23	37.72 to 43.02
Haemoglobin	7.2	18.1	13.61	2.26	13.19 to 14.03
(R)vertebral Artery-HU	31.6	48.6	41.77	3.93	41.04 to 42.50
(L)vertebral Artery-HU	31.4	48.8	41.67	3.93	40.94 to 42.40
(R)internal Carotid Artery	30.2	47.5	40.58	3.92	39.85 to 41.31
(L)Internal Carotid Artery	30.5	47.3	40.50	3.90	39.77 to 41.22

Table 1. Descriptive Statistics for the study characteristics

		Mean	S.D.	"t"	p value
Age	Male	39.74	13.50	0.989	0.325
	Female	43.14	17.17		
Haemoglobin	Male	13.95	2.26	3.53	0.001*
	Female	12.11	1.61		
(R) Vertebral Artery-HU	Male	42.23	3.96	2.655	0.009*

	Female	39.77	3.13		
(L) Vertebral Artery-HU	Male	42.14	3.95	2.768	0.007*
	Female	39.59	3.15		
(R) internal Carotid Artery	Male	41.03	3.95	2.602	0.011*
	Female	38.62	3.19		
(L) Internal Carotid Artery	Male	40.95	3.91	2.653	0.009*
	Female	38.51	3.26		

Table 2. Comparison of study characteristics according to gender. (* Significant)

Mean age of male patient was 39.74 and female 43.14.There is no significant difference in male and female concerning age (p=.325).Independent sample "t" test was used to compare the study characteristics according to gender. The obtained p values are < 0.05 except for the comparison of age. Hence there was a difference in measurements of Haemoglobin, vertebral artery and internal artery according to gender.

	"r"	p value
(R)vertebral Artery-HU	0.915	< 0.001*
(L)vertebral Artery-HU	0.909	< 0.001*
(R)internal Carotid Artery	0.901	< 0.001*

(L)Internal Carotid Artery	0.898	< 0.001*

Table 3. Relationship between Haemoglobin levels and outcome measures irrespective of gender

Pearson correlation coefficient was used to find the relationship between Haemoglobin levels and other outcome measures. The obtained p values are < 0.05 and hence there exist a positive linear relationship between haemoglobin levels and other outcome measures irrespective of gender.

	Male		Female	
	"r"	p value	"r"	p value
(R)vertebral Artery-HU	0.927	< 0.001*	0.778	< 0.001*
(L)vertebral Artery-HU	0.921	< 0.001*	0.768	< 0.001*
(R)internal Carotid Artery	0.908	< 0.001*	0.807	< 0.001*
(L)Internal Carotid Artery	0.905	< 0.001*	0.799	< 0.001*

Table 4. Relationship between Haemoglobin levels and outcome measures according to gender

Pearson correlation coefficient was used to find the relationship between Haemoglobin levels and other outcome measures separately for each gender. The obtained p values are < 0.05 for both the gender and hence there exist a positive linear relationship between haemoglobin levels and other outcome measures according to gender.

	Male				Female			
	B	S. E	t	p value	B	S. E	t	p value
Regression coefficient	-8.368	0.976	-8.577	< 0.001*	-3.561	3.065	-1.162	0.262
(R) Vertebral Artery-HU	0.615	0.225	2.736	0.008*	0.181	0.940	0.192	0.850
(L) Vertebral Artery-HU	-0.033	0.223	-0.147	0.884	-0.282	0.838	-0.337	0.741
(R) Internal Carotid Artery	-0.034	0.224	-0.150	0.881	0.768	0.894	859	0.403
(L) Internal Carotid Artery	-0.021	0.209	-0.102	0.919	-0.259	0.776	-0.334	0.743

Table 5. Multiple Linear regression model to predict Haemoglobin based on HU

Here the table results, the right vertebral artery is more significant to predict Hb based on HU in males(p-0.008*) and shows there is no any significant value for females. Average range of blood density in males and females can be predicted trough HU.Unable to find accurate HU value to predict exact particular Hb value.Patients with anaemic condition can be predicted through HU.

Regression Plot:

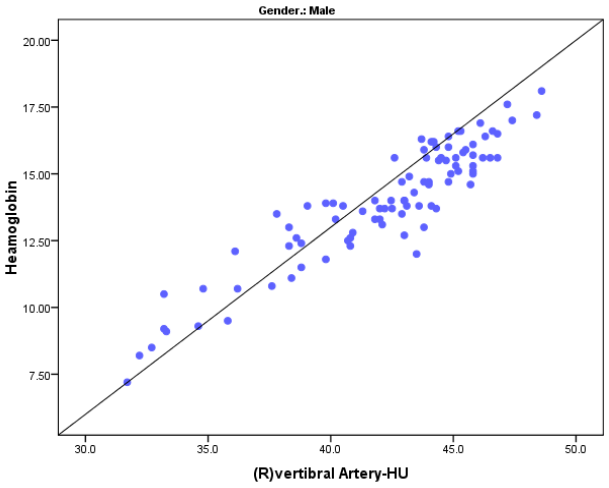

Figure 4. Relationship between haemoglobin and right vertebral artery HU value in male

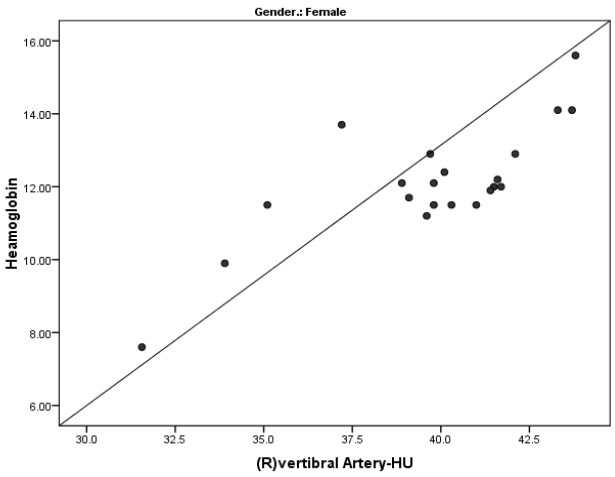

Figure 5. Relationship between haemoglobin and right vertebral artery HU value in female

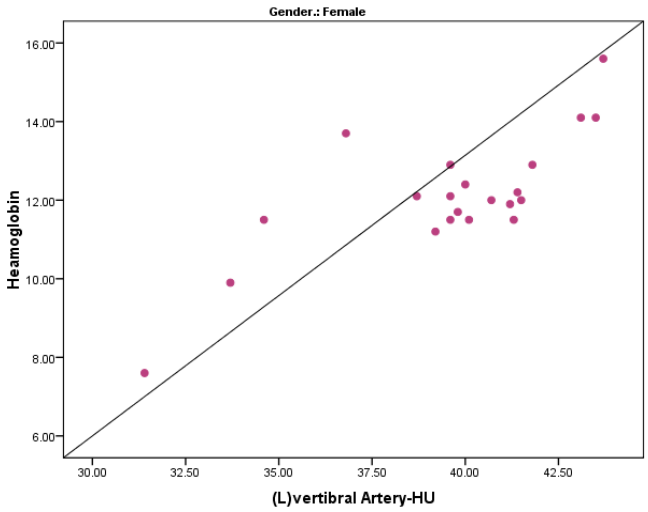

Figure 6.Relationship between haemoglobin and left vertebral artery HU value in Female

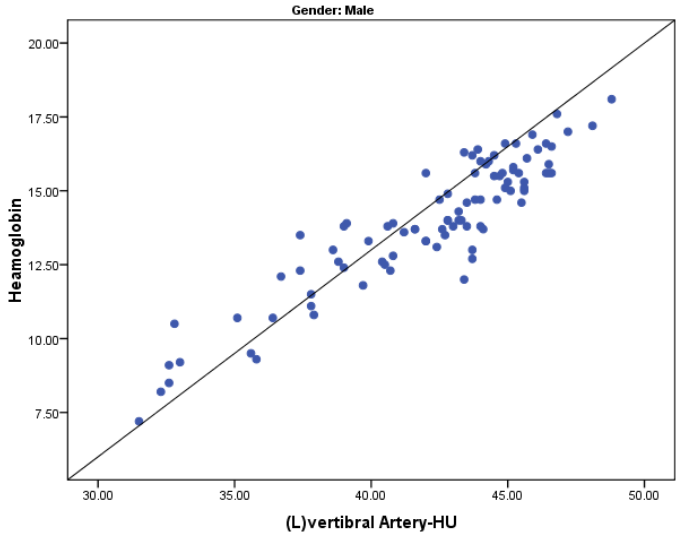

Figure 7.Relationship between haemoglobin and left vertebral artery HU value in male

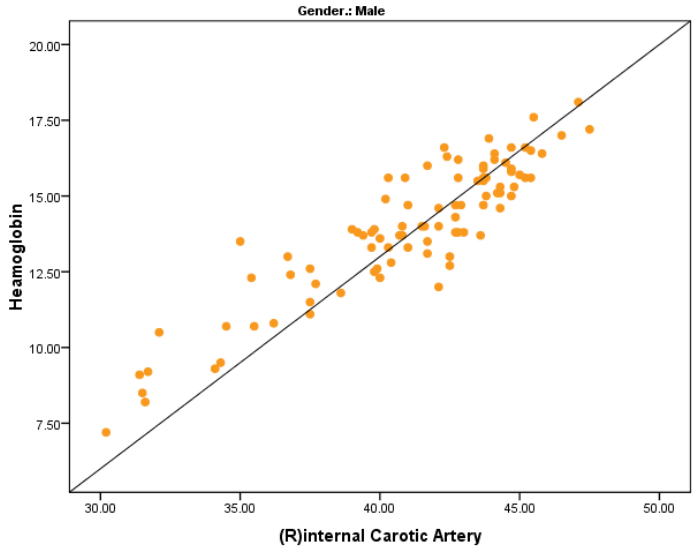

Figure 8.Relationship between haemoglobin and right ICA artery HU value in male

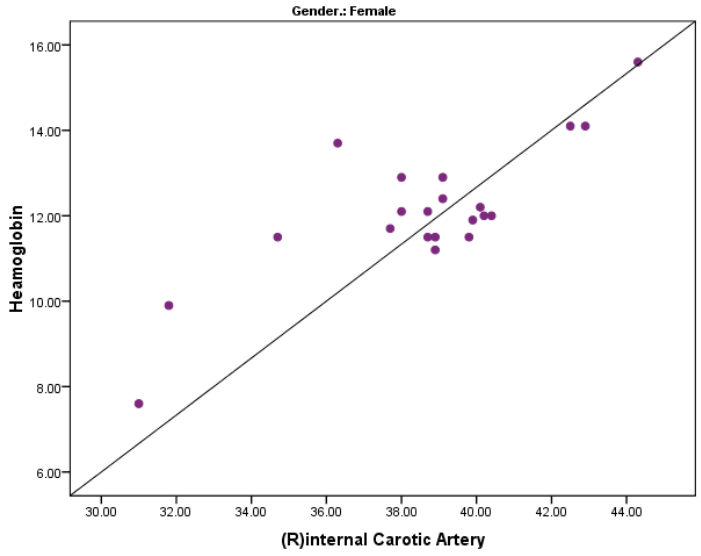

Figure 9.Relationship between haemoglobin and right ICA artery HU value in Female

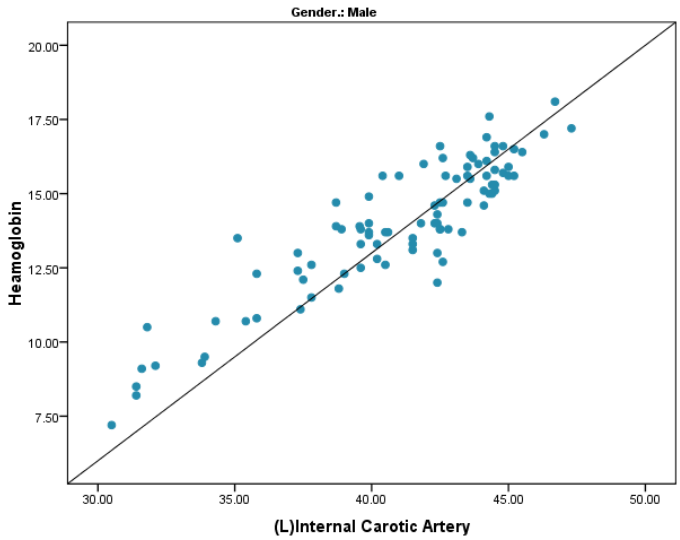

Figure 10. Relationship between haemoglobin and left ICA artery HU value in male

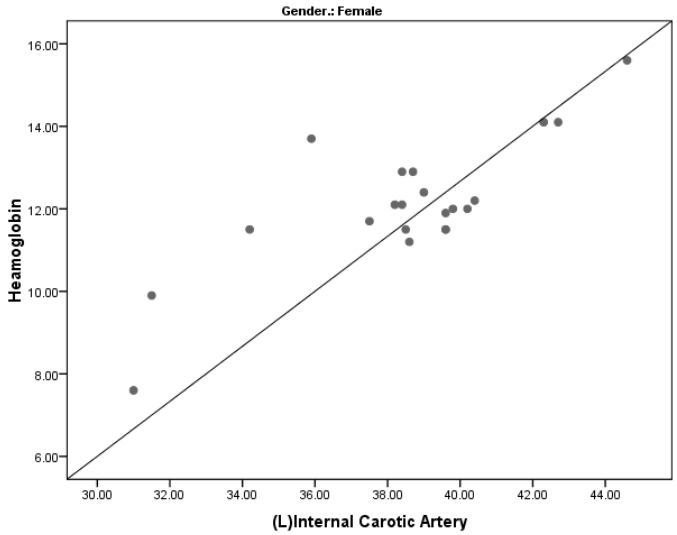

Figure 11. Relationship between haemoglobin and left ICA artery HU value in Female

DISCUSSION

Many other related studies had been done in different anatomical area in the brain and they check for correlation between the Hb and HU in all studies. Some investigators done these correlation study on thorax and all of these brain and thoracic studies done to find out the anaemia[9-16]

Our study included 114 patients in whom CT scan of brain was done in history of trauma. Gender distribution was 92 males and 22 females using statistical analysis, correlation of Hb with HU values of right and left vertebral artery, right and left internal carotid artery was determined separately and correlation coefficient rvalue and p value for Significance.

In our study we aimed to prove that through the ICA & Vertebral artery density measurements we can find out the gender related variation with Hb and HU and also here we compared the Hounsfield values with Haemoglobin values.

We confirmed through our study that there is positive linear relationship between haemoglobin levels and other outcome measures irrespective of gender and for both of the gender. also, there exist a confident linear association between haemoglobin levels and other outcome measures according to gender.so through this study when we compared arteries measurement, we understood that there was a difference in measurements of Haemoglobin, vertebral artery and internal artery according to gender.

Padma v Badhe et al[6], gone through similar study on unenhanced CT of abdomen and measured the attenuation value of aorta, inferior vena cava, left ventricle. They found that the relationship between HU and Hb concentration was seen *in vivo* ($r = 0.73$, $p < 0.001$). When they measured the 42 HU in sample, the expected Hb value was 12.6 gm/ dL (± 1.5 SD).

They also proven that normal subjects and anaemic patients had shown significant difference of blood attenuation value between each group. So, this difference in their study is showed

different cut-off density value for males and females, which the patient is sure to be anaemic with base result of 33 HU for females and 36 HU for males[6].Through that study they couldn't give accurate Hb value as their degree of correlation was not strong, but the study showed possible value and to greater extent so the presence or absence of anaemia identified through their study.

In our study agreeing the result of Padma V Badhe et al[6] that we cannot find accurate HU value to predict exact particular Hb value. We understood that the patients Hb level below 10g/dl, HU value of vertebral artery and ICA reduces under 35 HU in patients who all are between age of 30 to 40 years. We observed and confirmed that HU value between 36 to 49 can be average range of blood density in male patients with normal haemoglobin value. Whereas Female population shows between 36 to 43 HU values.

There is a study with noncontract CT scan of thorax or abdomen done by Collins et al[17], they have shown in their study, correlation coefficient for the analysis of aortic, IVC attenuation value, and Hb was stronger with "r" value of 0.64 and 0.58, respectively. They concluded that patients who all have aortic attenuation value greater than 50 HU in male and above 45 HU in female considered as non-anaemic.

In our study we got an average range of blood density in male between 36 to 49 HU and in female patients 36 to 43 HU with normal haemoglobin value which will be useful to conform no haemorrhagic anaemia occurred due to trauma.

In a study by Black et al[18]. found a direct correlation between the cerebral venous sinus density on plain CT of head and haematocrit study proved statistically significant correlation between HGB and HCT values with HUs was found in both men and women.

In our study the relationship between Haemoglobin levels and other outcome measures separately for each gender shows positive linear relationship (p values are < 0.05 for both gender).

A study done by Seung Young Lee et al[19]. shows strong correlation between mean HU density and Hgb level (r=0.832). In our study shown positive linear relationship between Hb and HU within each ICA and Vertebral Artery (r=.898-.915). Its shows the strong correlation of Hb and HU in each ICA & vertebral artery in comparing with their study, highest mean density 53.67 HU shown in 47-year-old male with an Hgb of 15.9 g/dL and 28-year-old female represents lowest mean density was 24.67 HU with an Hgb of 8.4 g/Dl Through our study we are measuring four artery blood density attenuation value and comparing with Hb level. A male person who have Hb 18.1g/dl 32 years old shows mean value of HU 47.8 (average of four artery HU values) and a female patient 35 years old represented mean HU value 44.1 with Hb value 15.6 g/dl.

However, our study proved that the gender related variation is present with the Hb and HU. Finally, through table 5 which is linear regression model to predict Hb value based on HU the right vertebral artery in male group showed significance (p-0.008*) value and the correlation coefficient shows (p=< 0.001*) significant. The study shows low HU values reveals with low Hb & higher HU value with normal range of Hb in trauma patients. The findings were interesting because the study opened a possibility towards assessing Hb values of patients after history of trauma based on HU values.Patients history of blood pressure, physiological variation, which can reduce the Hb level in blood are not mentioned in our study.

CONCLUSION

The results demonstrate a significant difference in measurements of Haemoglobin, vertebral artery and internal artery according to gender because the obtained p values are < 0.05. Further,the relationship between Haemoglobin levels and other outcome measures shows a positive linear relationship between haemoglobin levels and other outcome measures irrespective of gender (p values are < 0.05).Study confirmed that, there is positive linear relationship between haemoglobin levels and other outcome measures according to gender.Besides, finally study shows right vertebral artery is more significant to predict Hb based on HU in males(p-0.008*) and shows there is no any significant value for females

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