"Objective Evaluation Of Cerebral Venous Sinus Attenuation On Non Contrast Computed Tomography Of Brain And Correlation With Laboratory Hematocrit And Hemoglobin Indices In KLE's Dr Prabhakar Kore Hospital- A Cross Sectional Study"

BY

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ABSTRACT:

INTRODUCTION: In an acute neurologic setting, plain computed tomography (CT) of the brain is a crucial first-line study of choice. Concealed locations such as the confluence of venous sinuses are frequently missed unless they are clinically recognized. When a patient presents with a variety of clinical symptoms and presents a clinical conundrum, early patient management may benefit from the diagnosis of anemia, thrombosis, or polycythemia correlated with the CT attenuation values.

AIMS & OBJECTIVES: Aim of this study was to determine an objective correlation between CT hounsfield attenuation and laboratory Hemoglobin and Hounsfield units and to predict anaemia by attenuation values.

MATERIALS AND METHODS: The study conducted was a prospective analytical study of 100 subjects who had a NCCT brain done with Hb and HCT levels obtained within 24 hrs of the scan. To determine the difference between two independent samples, a two-tailed unpaired t-test was employed. Two quantitative variables were correlated using regression and correlation analysis.

RESULTS: A significant correlation was observed between dural sinus attenuation values in Hounsfield units (HU) with laboratory obtained Hb and HCT values. The simple linear regression model showed a significant correlation between Hb and HCT with the correlation being HCT = 24.27 + 0.38 x HU($p<0.001$) and - Hb = 5.65 + 0.12 x HU ($p<0.001$). Furthermore considering cut off of 37.5 HU we were able to show a specificity of 100% for the detection of anaemia

CONCLUSION: In conclusion, there is a positive correlation between the objective attenuation values of the dural sinuses on plain CT and the values of Hb and HCT, which aids in the identification of both normal and pathological entities like anemia. With 100% specificity, we can forecast anemia by taking into account the cutoff of 37.5 HU in the venous sinus confluence.

Key Words: Dural sinus, density, CT, hemoglobin, hematocrit

LIST OF ABBREVIATIONS

CT	COMPUTED TOMOGRAPHY
Hb	HEMOGLOBIN
HCT	HEMATOCRIT
SSS	SUPERIOR SAGITAL SINUS
SS	SIGMOID SINUS
CNS	CENTRAL NERVOUS SYSTEM
DST	DURAL SINUS THROMBUS
CSF	CEREBRAL SPINAL FLUID

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INTRODUCTION

Non contrast unenhanced computed tomography (NCCT) of the brain and head is one of the most important diagnostic modality in an emergency situation in the 21st century. Be it in a post traumatic setting or following unconsciousness, physicians world over has depended on NCCT brain study to rule out any neurologic symptoms. The speed of the study finishing up in a mere two minutes further adds to its work horse nature in the emergent scenarios in patients with neurological and psychological symptoms.

Although pathological conditions involving the dural sinuses are relatively uncommon cases of dural sinus thrombosis (DST) or cerebral venous thrombosis (CVT) are not unusual affecting mainly young females with an annual incidence of 3-4 cases per million adults [(2)].

Dural sinus thrombosis frequently present with highly variable non specific symptoms such as headache , dizziness, giddiness, visual disturbances, focal neurologic deficits, seizures, and impaired mental status. The symptom onset is often subacute resulting in average delay in diagnosis from the onset of symptoms to diagnosis is 7 days.

Coming to the anatomy of the dural venous sinuses, these are the venous channels located within the cranium draining the brain parenchyma and located between the two layers of the dura mater (endosteal layer and the meningeal layer).

This sinuses can be envisioned as trapped epidural veins and they run alone unlike any other vein in the body which runs in parallel with the arteries. These dural venous sinuses form the major drainage pathway of the brain parenchyma draining blood into the internal jugular veins

During early embryonic development, the dural venous system develops from the first cerebral plexus at the junction of the precardinal vein and the dorsal aortic bud.

Between 4 and 5 weeks, the primary capillary network is formed, which leads to the development of three venous plexuses (anterior, middle and posterior) that form the future dural layer. These

plexuses connect to the central cranial sinus and then move outward to form the carotid artery. At the same time, the central cranial sinus shrinks and bridging vessels appear as the initial anastomosis decreases.

At the end of the embryonic stage, embryonic sinuses such as the anterior auricular sinus and prototentorial sinus emerge and form the basis of the mature cranial venous system. During the fetal

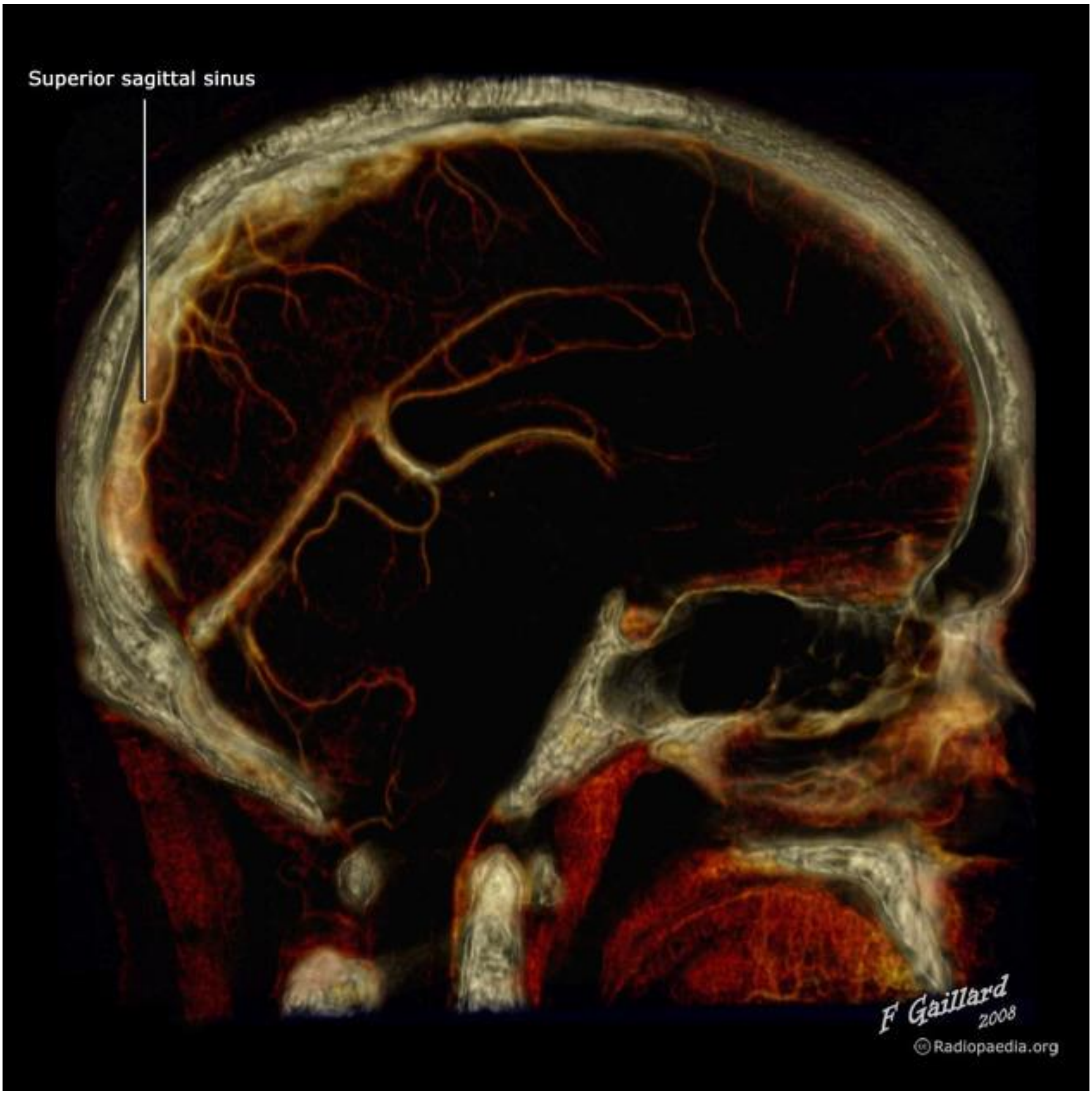


Fig 1: showing sagittal view CT contrast venogram eliciting the dural sinuses (image courtesy www.radiopedia.org)

stage (crown-rump length 40-80 mm), the anterior ear sinus matures from the chondrocranium and membranous skull formation, and its branches form structures such as the middle meningeal sinus, cavernous sinus and inferior petrosal sinus. Other changes include the formation of the sphenoid, the connection of many blood vessels, and the lengthening of the sinuses due to brain expansion.

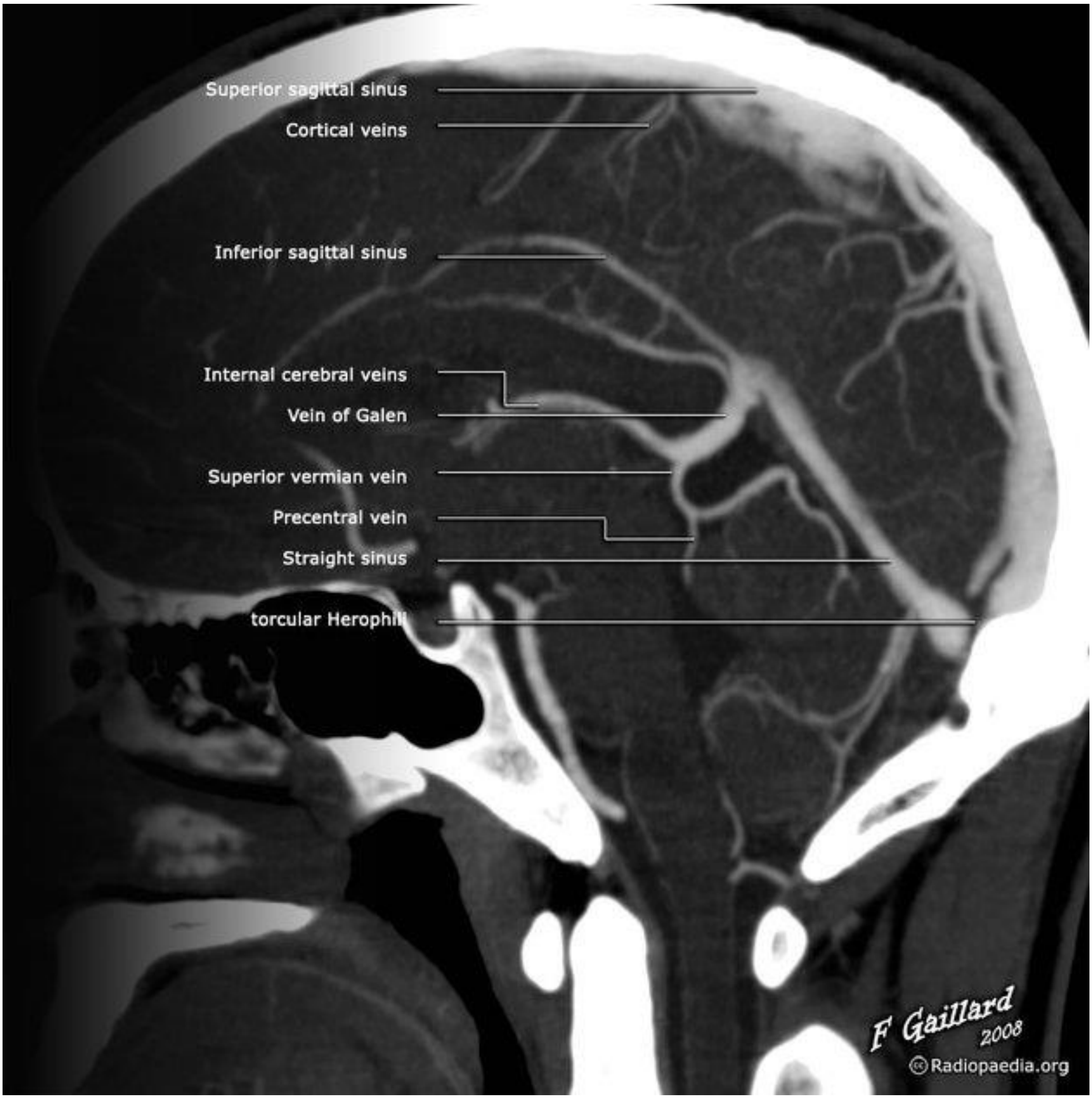


Fig 2: showing sagittal view CT contrast venogram eliciting the dural sinuses (image courtesy www.radiopedia.org)

Major dural venous sinuses can be divided into midline unpaired sinuses and bilateral sinuses that u sually drain into the midline vein:

Unpaired sinuses:

- Upper sagittal sinus
- Lower sagittal sinus

- Straight sinuses
- Occipital sinus
- Intercavernous sinus

Paired sinuses:

- Transverse sinus
- Sigmoid sinus
- Superior petrosal sinus
- Inferior petrosal sinus
- Cavernous sinus
- Sphenoparietal sinus
- Basal venous plexus

The superior sagittal sinus (SSS) is the largest dural venous sinus. As its name suggests, it lies in th e sagittal plane above the falx cerebri. It extends from the foramen cecum in front to the junction of the Intraoccipital eminence sinuses in the back, mostly to the right, and enters the right transverse sinus. It receives venous blood from several different veins in the superfic ial cortical veins of the cerebral hemispheres.

Anatomical variations of the superior sagittal sinus are many.

These include:

- Variations in the anterior (rostral) part of the superior sagittal sinus

- Agenesis of the middle part of the superior sagittal sinus

Four major variations in the anterior (rostral part of the superior sagittal sinus) Variant sagittal sinus es It can be defined as follows:

- Classical anatomy with superior sagittal sinus structure
- Duplication of the superior sagittal sinus
- Unilateral hypoplasia of the universal sagittal sinus
- Complete or bilateral superior sagittal sinus hypoplasia : In case of complete agenesis of the ostia l end of the sagittal sinus, the missing part is replaced by a pair of large parasagittal superior front al cortical vein that runs dorsally

The inferior sagittal sinus runs along the inferior free edge of the fax cerebri. It extends anterior to posterior, similar to superior sagittal sinus draining into the straight sinus . The inferior sagittal sinus receives tributaries from the falx itself as well as few of the smaller tributaries coming off the medial aspects of bilateral cerebral hemispheres

The inferior sagittal sinus can be aplastic or hypoplastic

The straight sinus is located along falx cerebri and the tentorium cerebelli and shows a triangular shaped crossection

Major tributaries for the straight sinus being the vein of Galen at the anterior end , the superior cerebellar veins. It terminates at the confluence of the sinuses although its termination can be variable:

- Confluence of sinuses

- Left transverse sinus
- Right transverse sinus

The straight may show duplication or it might be hypoplastic. When there is complete aplasia, there is seen a persistent falcine sinus which drains straight into the superior sagittal sinus

The occipital sinuses are seen along the inner surface of the occipital bone. It receives blood fro the marginal sinuses along the foramen magnum and drains into the confluence of the sinuses.

The inter cavernous sinuses are three in number- anterior, posterior and inferior.

These are variable dural venous sinuses that connect the left and the right cavernous sinuses . It also includes the sinus of dorsal sella and the basilar plexus. These sinuses connect the bilateral cavernous sinuses. The inter cavernous sinuses are particularly prone to bleeding during the trans-sphenoidal surgeries

The transverse sinuses are paired major dural venous sinuses. They arise from the confluence of the sinuses on either side and draining the sigmoid sinuses. On contralateral sides they run long the respective tentorium cerebelli along the occipital and temporal grooves.

An important tributary on either side being the vein of Labbe or the inferior anastomotic vein

Multiple, variant anatomies may be seen involving the transverse sinuses-

- Hypoplasia of the left sinus (most common)
- Hypoplasia of the right sinus
- Aplastic eft sinus
- Aplastic right sinus

Sigmoid sinuses are also paired major dural sinuses arising from the transverse sinuses where the tentorium cerebelli ends. One of its major feeding tributaries at that point being the superior petrosal sinus

The sigmoid sinus has a characteristic S shaped configuration as it traverses posteromedially to the mastoid air cells and ultimately draining into the jugular Vernon either sides at the jugular bulb at the posterior aspect of the pars vascular . Mastoid veins, pericardial and condylar emissary veins are its notable tributaries.

The superior petrosal sinus drains the cavernous sinus into the sigmoid sinus at the continuation of the transverse sinus as explained previously. The course traverses along the superior aspect of the petrous part of the temporal bone. Its major tributaries being-

- Superior petrosal vein
- Cerebellar vein
- Inferior cerebral veins
- Labyrinthine vein

Similarly inferiorly there is present the inferior petrosal sinus which also drains the cavernous sinuses into the jugular vein at the jugular bulb.It is usually larger than. Its superior counterpart. Other than the cavernous sinus its major tributaries comes from the medulla oblongata, pons, inferior cerebellum and the labyrinthine veins draining the inner ear via the cochlear canaliculus and the vestibular aqueduct.

The sigmoid sinuses are majored paired dural venous sinuses on either side of the pituitary fossa sitting in between the periostea and meningeal layers of the dura extending from the orbital apex to the petrous apex of the temporal bones on either sides. Special to the cavernous sinus are the multiple fibrous septae within it dividing it onto multiple tiny cavities. Its roof is formed by the dura attached to the anterior and middle crinoid processes. The anterior wall formed by the superior orbital fissures. Posteriorly lies the petrous apex. Medially lies the periosteum of the sphenoid body. Laterally limited by the dura of the middle cranial fossa on either sides. Floor of the cavernous sinuses is formed by the endosperm of the greater wing of sphenoid.

The cavernous sinus has multiple tributaries draining into it mainly the-

- Superior ophthalmic veins
- Inferior ophthalmic veins
- Sphenopetrosal sinus
- Superficial middle cerebral veins
- Central retinal vein occasionally

Draining veins of the cavernous sinus are as follows:

- Superior petrosal vein draining into the transverse sinus
- Inferior petrosal vein draining into the jugular bulb
- Venous plexus along the ICA to the clinal venous plexus
- Emissary veins passing through -
    - Foramen Vesalli
    - Foramen vale
    - Foramen lacerum

Depending on their pressures relative to each other the superior ophthalmic vein may drain into the cavernous sinus or vice versa

The cavernous on either sides are connected by the inter cavernous sinuses as has been explained prior in the chapter.

The sphenoparietal sinuses are an inconsistent dural sinuses along the postern-inferior aspect of the lesser wing of the sphenoid. Forming as a confluence of sinuses in the lesser wing of the sphenoid and the middle meningeal vein. Major veins draining into it are superficial middle cerebral vein, frontal ramus of the middle meningeal vein and the anterior temporal diploid vein.
It drains into the cavernous sinuses of either side.

The basilar venous plexus are minor paired venous sinuses lying between the endosteal and meningeal layer of the inner clival dura. The plexus connects the cavernous sinuses, superior petrosal sinuses and the inter cavernous sinuses superiorly, the inferior petrosal sinuses laterally, the clinal diploid veins anteriorly and the vertebral venous plexus & marginal sinus inferiorly
The plexus often gets prominent and enlarged eroding into the clivus mimicking a mass

Although contrast enhanced computed tomography (CECT) and time of flight (TOF) MRI venogram are the standard for emulation of dural venous thrombosis, however in an acute setting its the NCCT which is the main workhorse for diagnostic imaging. Multiple imaging signs have been described in literature with respect to dural sinus thrombosis. One of the most important direct sign being the homogenous hyperattenuated appearance of the dural sinuses which reflects the newly formed thrombi in the 1 week of disease onset. However the cord sign which is described is seen in less than a quarter of the cases. Also the above mentioned hyperlattenuation is a qualitative highly subjective finding with much inter-observer variation and also depending on the window settings of the workstation. Also the presence of anaemia due to low red cell count may not cause a hyperattenuation in DST. Sometimes the hyperattenuation may create a confusion between DST and pre-existing polycythemia in the patent. Also influencing the hyperattenuation are other patient characteristics such as age, sex, ethnicity due to variation blood characters with these vitals.

As a result a much needed objective analysis of dural sinuses are a need of the hour due to their sparse existence in existing literature

There has been suggested strong correlations between the hematocrits and hemoglobin (HCT/Hb) and the CT attenuation value(Hounsfield units-HU) of the intravascular blood within the dural sinuses. But till now limited existing evidence of clear cut direct association exists between the two.

Hounsfield units(HU) are named after Sir Godfrey Hounsfield the inventor of modern day CT. HU is a dimensionless unit universally accepted in CT to express attenuation coefficient equivalent to the density of the region of interest.

CT attenuation values have long been used in studying intracranial bleed, however its use in diagnosing hemoconcentration related disorders like anaemia, polycythemia or thrombosis.

The possibility in detecting these hemoconcentration related disorders in a NCCT brain in ER while baseline first lab results are awaited might play an important role in further patient management.

However at present no significant data exists establishing a relationship between sinus attenuation in non contrast brain CT and blood haemoglobin and hematocrit values. Arising from this deficiency in current existing literature rises the need for our study to determine an objective correlation between CT hounsfield unit attenuation values and blood haemoglobin and hematocrits values. The secondary objective was to establish a safe HU cut off for diagnosis of anaemia .

AIMS AND OBJECTIVES

1. To determine the objective correlation between CT attenuation of the cerebral venous sinus and haemoglobin (Hb) and hematocrit (HCT) values

2. Detecting anaemia from measuring venous sinus attenuation

REVIEW OF LITERATURE

The literature consistently supports a strong positive correlation between dural sinus CT attenuation values and laboratory measurements of hemoglobin and hematocrit. This relationship highlights the potential of CT imaging as a valuable adjunct to traditional blood tests, offering rapid, non-invasive assessment of blood parameters. Continued research, particularly with advancements in imaging technology like dual-energy CT, is likely to further refine and validate these findings, enhancing their application in clinical practice.

Initial studies on the relationship between blood density and CT attenuation laid the groundwork for clinical applications. Borsic et al. (2003) [(3)] conducted an in vitro study to establish a baseline understanding of this correlation. They found a linear relationship between HU values and Hb concentrations, with a high degree of correlation. This foundational research provided a scientific basis for exploring this relationship in clinical settings.

Clinical studies have provided robust evidence supporting the correlation between CT attenuation values and Hb/HCT measurements.

In a study by Patel et al. [(4)] in the year 2016 involving 100 patients to assess this correlation using non-contrast CT scans of the dural sinuses. Their findings indicated a strong positive correlation between dural sinus attenuation and laboratory Hb ($r = 0.78$) and HCT ($r = 0.76$) values. This study was pivotal in demonstrating the potential of using CT attenuation as a non-invasive marker for hematological parameters in a clinical setting

Another similar prospective study by Smith et al. in 2018 [5] expanded on these findings by examining a larger patient cohort and accounting for variables such as hydration status and concurrent medical conditions. Their multivariate analysis confirmed that the correlation remained significant even after adjusting for these factors, with correlation coefficients of $r = 0.74$ for Hb and $r = 0.71$ for HCT. This study emphasized the reliability of CT attenuation values as a proxy for laboratory blood measurements.

Studies focusing on pediatric populations have also provided valuable insights, though they underscore the need for age-specific considerations.

In an unique study by Jones et al from 2017 [6] conducted a study to evaluate the correlation between dural sinus CT attenuation and blood parameters in pediatric patients. Their findings were consistent with those observed in adults, showing a positive correlation. However, the study highlighted that due to the smaller blood volume and different physiological baselines in children, the interpretation of attenuation values requires careful consideration.

Recent advancements in CT technology, particularly the advent of dual-energy CT (DECT), have further enhanced the accuracy of attenuation measurements and their correlation with hematological parameters.

In a study conducted by Gonzalez et al. in 2020 [7] they studied the application of DECT in assessing the correlation between dural sinus attenuation and Hb/HCT levels. They found even stronger correlations ($r = 0.82$ for Hb and $r = 0.80$ for HCT), suggesting that DECT's superior ability to differentiate between various tissue densities and compositions enhances the precision of these measurements.

In a study conducted by P Digge et al. in 2021 (2) in Pramukshwami medical college Gujarat India, examining the correlation between non-contrast computed tomography (NCCT) findings and hemoglobin (Hb) levels in patients. The authors aimed to determine if NCCT can serve as a reliable indicator for detecting anemia in clinical settings, potentially reducing the need for invasive blood tests.

The study involves a retrospective analysis of patients who underwent NCCT and had their hemoglobin levels measured within a short interval. The authors describe their inclusion criteria, ensuring that only patients with both NCCT and hemoglobin data available were considered. They also discuss the statistical methods used to analyze the data, emphasizing the use of correlation coefficients to evaluate the relationship between NCCT findings and hemoglobin levels.

Their results detailed statistical analysis, including the correlation coefficients calculated. The study showed a moderate to strong correlation between specific NCCT parameters and hemoglobin levels. They also highlighted no significant differences were observed between various patient subgroups The study suggested that certain NCCT features can indeed predict haemoglobin levels with reasonable accuracy.

They compare their results with previous studies, discussing potential reasons for any discrepancies and the clinical implications of their findings. The authors acknowledged the limitations of their study, such as its retrospective nature and the potential for selection bias

This study provided for the very first time invaluable insights into the potential use of NCCT for assessing hemoglobin levels

The established correlation between dural sinus CT attenuation and Hb/HCT levels has several important implications for clinical practice:

In emergency settings, where rapid assessment is critical, CT attenuation can provide immediate insights into a patient's hematologic status. This capability can guide initial management decisions before laboratory results are available, particularly in trauma cases or situations where quick decision-making is essential.

For patients with chronic conditions affecting blood parameters, such as anemia or polycythemia, serial CT scans can offer a non-invasive method to monitor changes over time. This approach reduces the need for frequent blood draws, which can be particularly beneficial for patients who require ongoing monitoring

In an extensive 2021 study from College of medicine, Chungbuk National university, South Korea by Seung Young Lee et al [(8)]. they studied the effect of hemoglobin or hematocrits level on dural sinus density using unenhanced CT of brain. The study provides an in-depth analysis of the relationship between hemoglobin (Hb) or hematocrit (Hct) levels and the density of the dural sinuses as observed in non-contrast computed tomography (NCCT) scans. The study aimed to elucidate how variations in these blood parameters can influence NCCT readings, potentially affecting the diagnosis of cerebral venous sinus thrombosis.

The study highlighted the challenges associated with diagnosing CVST due to its non-specific symptoms and the crucial role of NCCT in the initial diagnostic process. The authors emphasised the need to understand how Hb and Hct levels can affect NCCT readings, as misinterpretation could lead to false-positive or false-negative diagnoses

The researchers conducted a retrospective analysis of patients who underwent NCCT of the brain. They included patients with available Hb or Hct measurements taken within 24 hours of the NCCT scan. The exclusion criteria were clearly defined, ensuring that the study population was appropriate for evaluating the effect of Hb and Hct levels on dural sinus density.

The authors used advanced statistical methods, including correlation and regression analysis, to assess the relationship between blood parameters and NCCT density. They also considered potential confounding factors such as dehydration status, indicated by the BUN/Cr ratio.

The study found a significant positive correlation between Hct levels and dural sinus density, suggesting that higher Hct levels lead to increased density on NCCT. The findings were presented in clear tables and graphs, enhancing the readability and interpretation of the data.
The authors also noted the influence of dehydration, which can further complicate the interpretation of NCCT results

The study provided a comprehensive interpretation of the findings. The authors compared their results with previous studies, reinforcing the significance of their findings and the consistency with existing literature. They discussed the clinical implications, emphasizing the need for clinicians to consider Hb and Hct levels when interpreting NCCT scans for suspected CVST. The authors also acknowledged the study's limitations, such as its retrospective design and potential selection bias, and suggest directions for future research

This study addressed a significant clinical issue, offering insights that can improve diagnostic accuracy for CVST.

In another study by Reza Akhavan et al conducted in Mashad university of medical sciences in Mashad Iran in 2019 , investigated the use of non-contrast computed tomography (NCCT) in diagnosing cerebral venous sinus thrombosis (CVST).

The study showed Cerebral venous sinus thrombosis (CVST) is a relatively rare but significant type of stroke, accounting for 0.5–1% of all strokes and associated with a mortality rate of up to 10%. CVST primarily affects young adults and can result in severe outcomes such as infarction and hemorrhage. Early diagnosis and treatment are crucial for favorable outcomes, yet the condition's nonspecific symptoms often lead to delays in diagnosis. Non-contrast computed tomography (NCCT) is commonly used for initial imaging in neurological emergencies. Increased attenuation in cerebral venous sinuses on NCCT is considered a direct indicator of acute CVST, which is beneficial as it is objective and can be quantitatively assessed, particularly in acute stages when treatment is most effective

The study aimed to enhance the understanding of factors influencing NCCT attenuation in cerebral venous sinuses, thereby improving the diagnostic accuracy for CVST. Misinterpretation due to various influencing factors like hematocrit levels and dehydration can lead to false positives. The study seeks to clarify these influences and provide a reliable framework for interpreting NCCT results in suspected CVST cases

The study included a retrospective analysis of 511 patients who underwent NCCT at a tertiary care center. Patients were excluded if they had artifacts in NCCT, other intracranial pathologies that could affect sinus attenuation measurement, recent contrast administration, blood transfusion, or were younger than 6 months. Attenuation was measured in Hounsfield Units (HU) across different venous sinuses and correlated with hematocrit levels to normalize the data. A specialized radiologist performed the measurements to ensure consistency

The analysis encompassed measurements from 1984 venous sinuses, including the superior sagittal sinus, Torcula Herophili, right and left sigmoid sinuses, and basilar artery. The study found that the mean attenuation values in these sinuses correlated with hematocrit levels, suggesting a direct influence. Additionally, the study highlighted that accurate measurement and interpretation of sinus attenuation on NCCT are essential for timely and accurate CVST diagnosis.

The study′s findings emphasize the significance of considering hematocrit levels when evaluating increased attenuation in cerebral venous sinuses on NCCT. The correlation between hematocrit levels and attenuation values supports the hypothesis that blood density significantly impacts NCCT readings. This understanding can help differentiate between true positives and false positives in CVST diagnosis, improving patient management and outcomes.

The research provides valuable insights into the factors affecting NCCT attenuation in cerebral venous sinuses and their implications for CVST diagnosis. By highlighting the relationship between hematocrit levels and attenuation, the study offers a method to enhance diagnostic accuracy, ultimately contributing to better clinical decision-making and patient care in cases of suspected CVST. Future research should focus on prospective studies to validate these findings and explore additional factors influencing NCCT attenuation. Investigating the role of advanced imaging techniques and machine learning algorithms in improving diagnostic accuracy for CVST could also be beneficial

This study underscored the importance of considering individual patient factors, such as hematocrit levels, when interpreting NCCT results for CVST. This approach can reduce the incidence of false positives and ensure timely and appropriate treatment, thereby improving clinical outcomes for patients with this serious condition.

This detailed review encapsulates the critical aspects of the study, its methodology, findings, and clinical implications, providing a comprehensive understanding of the article′s contribution to the field of neurological imaging and stroke diagnosis.[9]

Elevated or decreased attenuation values on CT scans can prompt further investigation into potential underlying hematological disorders. Early identification of conditions such as anemia, polycythemia, or other blood dyscrasias can lead to timely intervention and improved patient outcomes.

In critical care scenarios, where patients may be unconscious or unable to provide a history, CT attenuation values can serve as a quick and reliable proxy for blood counts, aiding in the immediate diagnosis and management of life-threatening conditions

MATERIALS AND METHODS

The study conducted was a prospective analytical study. Patients who underwent NCCT brain scan irrespective of the cause at KLE's Dr Prabhakar Kore Hospital and MRC at Belagavi Karnataka were included in the study.

The timeframe of case collection was from 1st January 2023 to 31st December 2023.

Based on standard parametric analysis used sample size of 100 was obtained.

Purposive sampling was used for the study. Patients of age 18 and older with NCCT brain at the above mentioned hospital were taken considering some prelaid inclusion and exclusion criterias

Inclusion criteria:

All patients who underwent a unenhanced computed tomography of the brain with no structural abnormalities and for whom Hb and Hematocrit levels were available within 24 hours of the scan

Exclusion criteria:

1. Any patient who had received intravenous within 24 hrs prior to the scan
2. Any history of intracranial trauma with presence of calvarial fractures
3. Presence of intracranial bleed
4. Any intracranial pathology
5. Any intracranial surgery
6. Any artefacts obscuring normal visualisation of the venous confluence

NCCT Protocol:

NCCT was performed using a 128 detector row CT scanner (GE Revolution EVO) using axial or helical methods

In the axial method the gantry tilt was parallel to the orbit metal line, and in the helical method the images were reconstructed perpendicular to the line. The following parameters were fixed : peak voltage of 120 kVp, a variable tube current of 179-450 mA from an automatic exposure system, section thickness of 1 and 3 mm.

Laboratory values:

CBC results were obtained from the in house HIS database of clinical records. Values within the 24h framelimit from the CT scan times were only accepted. If more than one CBC results were present within the 24 h time frame, the data with the shortest time interval from NCCT brain was taken.

IMAGE INTERPRETATION:

Axial NCCT brain images were reviewed either on the ADW workstation provided by GE or via the hospital provided MEDSYNAPSE PACS workstation remotely.

Axial scans showing the least beam hardening artefacts were chosen for analysis.

Densities of dural sinuses were measured using the circle region of interest (ROI) method at either three or four points -

1. Right sigmoid sinus
2. Left sigmoid sinus
3. 2 points on the superior sagittal sinus (one in the upper 1/2 and other in the lower 1/2 of the dorsal superior sagittal sinus)
4. One in the confluence of the sinuses

The sigmoid sinus one or both were compulsorily included in all the patients.

The ROI area was set at an area limit of 10-20 mm^2

Identical ROI in the same patients were used by simple copying and pasting

During image interpretation another exclusion criteria was applied :

1. Cases where ROI couldn't be measured in both sigmoid sinuses in at least 3 points because of beam hardening or partialing.
2. Small dural sinuses where ROI of 10mm^2 couldn't be placed
3. Sinus attenuation undifferentiated from the brain parenchyma

After all this mean value of the 4 ROI's were calculated in housfield units (HU) and entered into a data sheet in numbers app in Mac OS.

The corresponding Hb and Hematocrit values of the patient were also entered in the same field along with the HU values

Each of the 100 subjects were allowed an unique serial number and all identities were hidden

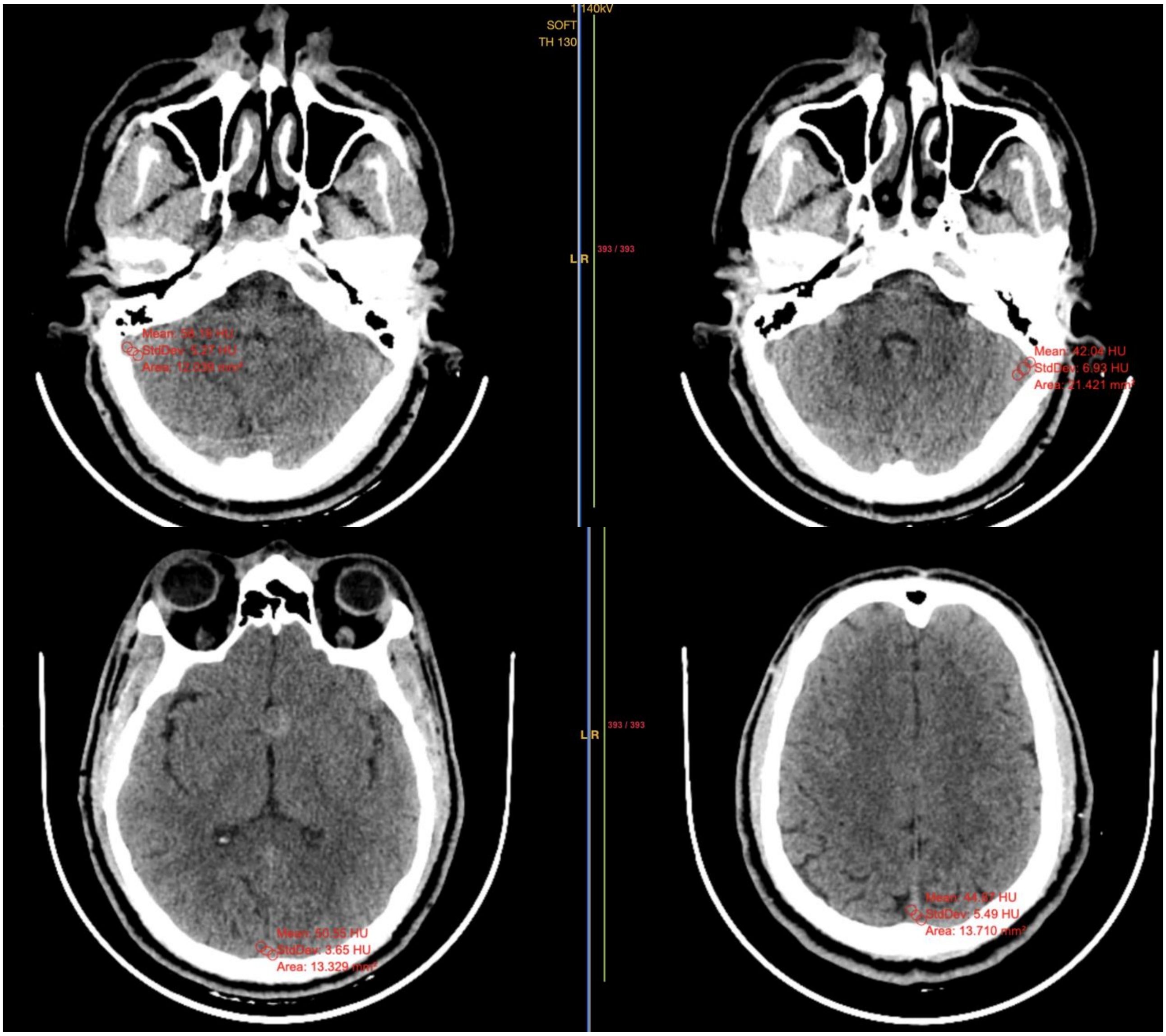


Fig. 3. The region of interests (ROI) measured at 3 or 4 points including right sigmoid sinus (SS), Lt. SS and 2 points of superior sagittal sinus. One or both sigmoid sinus must be included in ROI measurement. Identical, circular ROI in one patient were used by copying and pasting method.

DATA ANALYSIS:

Descriptive statistics were used to describe the data, frequency, and percentage for categorical variables and mean values with standard deviations for quantitative variables. Two-tailed unpaired t-test was used to test the difference between two independent samples. Correlation analyses were used to assess the correlation between two quantitative variables. The analysis was carried out via SPSS V.24.

RESULTS

Out of the 100 subjects study consisted of 51 females and 49 males.

The gender-wise comparison shows the mean and standard deviation of Age, HB, HCT, and HU for males and females are shown in table 1. The average age for males is 37.6 ±16.1 years, while for females it is 40.2 ±15.7 years, and this difference is not statistically significant ($p = 0.417$). Both males and females have the same mean HB value of 11.6 ±2, and this similarity is reflected in a p-value of 0.941. The mean HCT values are also very close, with males having 49.3 ±11.8 and females 49.7 ±10.6, yielding a p-value of 0.865. Lastly, the mean HU for males is 43.7 ±8.9 compared to 42.5 ±10.2 for females, and this difference is not significant ($p = 0.534$).

Variables	Male	Female	P
	Mean (SD)	Mean (SD)	
Age	37.6 (16.1)	40.2 (15.7)	0.417
HB	11.6 (2)	11.6 (2)	0.941
HCT	49.3 (11.8)	49.7 (10.6)	0.865
HU	43.7 (8.9)	42.5 (10.2)	0.534

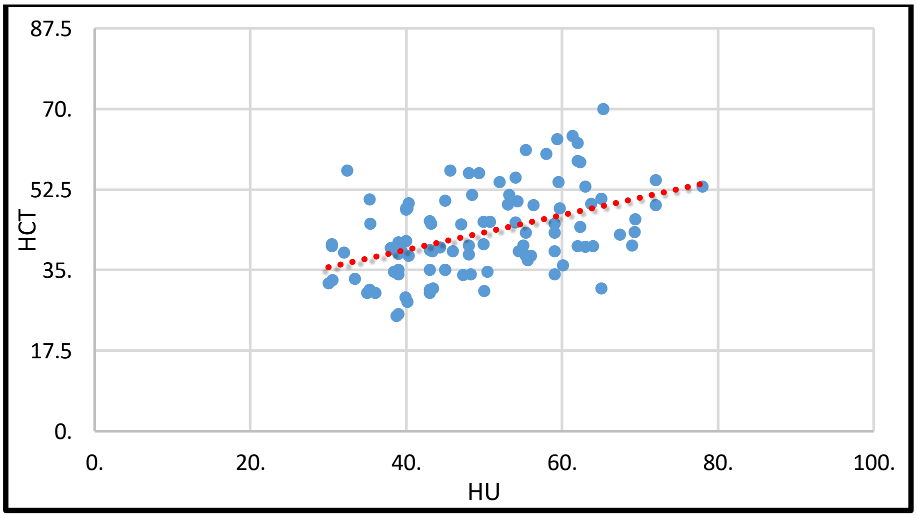
Table 1: Gender wise comparison

Variables		Correlation (*P*)		
		HB	**HU**	**HCT**
Male	HB		0.740 (<0.001)	0.594 (<0.001)
	HU			0.487 (<0.001)
	HCT			
Female	HB		0.642 (<0.001)	0.502 (<0.001)
	HU			0.423 (0.002)
	HCT			

Table 2: Correlation matrix according to male and female

Table 2 presents separate correlation matrices for males and females. In males, HB has significant positive correlations with HU (0.740, $p < 0.001$) and HCT (0.594, $p < 0.001$). HU and HCT in males also have a significant positive correlation of 0.487 ($p < 0.001$). For females, HB shows significant positive correlations with HU (0.642, $p < 0.001$) and HCT (0.502, $p < 0.001$). The correlation between HU and HCT in females is significant positive correlations with 0.423 (p = 0.002).

Variables	Correlation (*P*)			
	Age	**HB**	**HU**	**HCT**
Age		-0.082 (0.420)	-0.124 (0.218)	-0.134 (0.185)
HB			0.692 (<0.001)	0.542 (<0.001)
HU				0.449 (<0.001)
HCT				



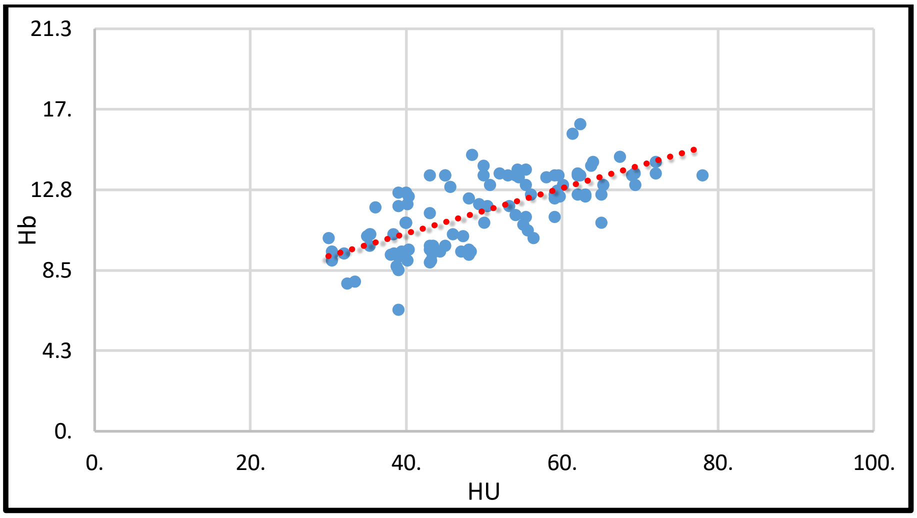


TABLE 3

The correlation matrix in Table 3 indicates the relationships between Age, Hemoglobin (HB), Hematocrit (HCT), and Hematuria (HU). Age shows weak negative correlations with HB, HU, and HCT, with correlation coefficients of -0.082, -0.124, and -0.134 respectively; however, none of these correlations are statistically significant as their p-values are all greater than 0.05. HB shows strong positive correlations with HU (0.692, $p < 0.001$) and HCT (0.542, $p < 0.001$). Similarly, HU and HCT also have a significant positive correlation of 0.449 ($p < 0.001$).

Using a simple linear correlational model following relations were observed : HCT = 24.27 + 0.38 x HU. & Hb = 5.65 + 0.12 x HU ($p < 0.001$ statistically significant)

Table 4: Comparison between anemic and normal group

Variables	Anemic	Normal	P
	Mean (SD)	**Mean (SD)**	
Age	36.33 (14.94)	39.18 (15.95)	0.609
HB	8.36 (0.87)	11.93 (1.72)	<0.001
HU	37.69 (4.59)	50.89 (11.07)	0.001
HCT	36.57 (10.32)	43.7 (9.24)	0.031

Table 4 compares anemic and normal groups across Age, HB, HU, and HCT. The mean age for the anemic group is 36.33 ±14.94 years and for the normal group is 39.18 ±15.95 years, with a p-value of 0.609, indicating no significant difference. The mean HB for the anemic group is significantly lower at 8.36 ±0.87 compared to the normal group's 11.93 ±1.72, with a p-value of less than 0.001. HU is also significantly lower in the anemic group (37.69 ±4.59) than in the normal group (50.89 ±11.07), with a p-value of 0.001. HCT is lower in the anemic group (36.57 ± 10.32) compared to the normal group (43.7 ±9.24), with a statistically significant p-value of 0.031.

DISCUSSION

In an acute neurologic setting, a plain CT scan of the brain is a crucial first-line investigation of choice. Finding hidden regions, such as the confluence of the venous sinuses, is just as crucial as identifying the visible features on the scan. Areas frequently go overlooked because of their location and diverse appearance, unless they are clinically suspected.[9] HU from venous sinuses is not commonly measured, and even when it is, the results are not used to classify patients as anemic or polycythemic. The measurement of HCT based on HU values lacks precise criteria. The diagnosis of polycythemic or thrombotic patients with higher HU levels requires confirmation through additional research.

Previous studies have described a highly significant statistical correlation between haemoglobin and CT attenuation values of the blood in aorta

The same is true for the intracranial cerebral sinuses, where patients are frequently referred for head CT scans without first undergoing laboratory testing. Sinus venous thrombosis can be diagnosed using certain symptoms, and unenhanced CT has a reported 73% sensitivity in this regard. [10] But there are issues with interpretation that lead to false-positive and false-negative diagnoses, which have an impact on patient care.

Early patient care can benefit from the diagnosis of anemia, thrombosis, or polycythemia correlated with CT attenuation values, particularly in emergency situations where a variety of clinical presentations pose a clinical conundrum. Furthermore, it becomes more difficult to confidently rule them out when they are clinically suspected.

According to Fanous et al. [11], the dural sinus's complexity makes it challenging to demonstrate a significant link between CT attenuation and Hb levels. As a result, the mean values would be more accurate if the attenuations were evaluated across a greater range of locations. Our measurements were made using a best-fit circle region of interest in the superior sagittal sinus's torcular Herophili inferior aspect, which has a wider area and allows for more accurate attenuation measurements.
In this work, we show that the objective attenuation values of the sinus are correlated with hemoglobin content (Hb). We also present a regression equation that can be used to estimate a patient's Hb and HCT based on the attenuation HU values of the intracerebral venous sinus.
In our current study the dural sinus attenuation values ranged from 28.8 to 78 with a mean of 43.5 as compared to Digge et al which showed a range of 26.6 to 65.7 HU with a mean of 48.9 HU similar to our current study.
Numerous studies have demonstrated a significant correlation between Hb and HCT and blood attenuation levels [12], [13], [14] and [15]. This correlation is also highly supported by our investigation, which found a linear relationship between the aforementioned variables. Furthermore, compared to HCT, Al-Ryalat[11] shown a larger linear connection with Hb. In contrast to Hb, we discovered a larger association between HU levels and HCT.
Our study had the highest HU value of 78.3 HU in a 43years male patient whose Hb was 14.3 and HCT 53. The mean age for the anemic group is 36.33 ±14.94 years and for the normal group is 39.18 ±15.95 years. The mean HB for the anemic group is significantly lower at 8.36 ±0.87

compared to the normal group's 11.93 ±1.72. considering HB cut off <11 the HU is also significantly lower in the anemic group (37.69 ±4.59) than in the normal group (50.89 ±11.07).

A few authors have used the left ventricle's attenuation values to study the relationship between anemia and plain CT scans[14], [15].

.In their investigation of non-enhanced CT of the brain in the superior sagittal sinus, Fanous et al.[11] provided a cutoff of 35 HU for the identification of anemia with a 100% specificity, which was also noted in our study.

According to Black DF et al. [12], a HU of more than 70 should raise suspicions of venous sinus thrombosis. On the other hand, Buyck[13] proposed a 95% specificity and sensitivity limit of 62 HU. We had three patients with attenuation values greater than 70 and none with attenuation values greater than 80 HU when taking into account both of the data for our investigation. Therefore, we may postulate that setting the upper limit at 75 HU will decrease the amount of false positives and would be a reliable indicator of sinus thrombosis and cerebral venous thrombosis.

HU levels greater than 65 demonstrated a sensitivity of 84% and specificity of 96% in detecting thrombosis in yet another Besachio trial [18]. Additionally, they demonstrated that taking into account a threshold of 69 HU will increase specificity to 100% while reducing sensitivity to 64%.

There was no statistically significant age difference between males and girls according to our study. Nonetheless, the means of HB, HCT, and HU revealed a noteworthy distinction between these cohorts, corroborating the gender disparity proposed by Al-Ryalat et al.[14] Additionally, we noticed that men's mean attenuation values (43.7 HU) were higher than women's (42.5 HU) however it was not statistically significant.

In their investigation, Al-Ryalat et al.[14] found that aging was associated with a drop in HCT and Hb levels as well as an increase in baseline attenuation on NCCT because of an increase in blood viscosity. Therefore, it is important to carefully investigate sinus attenuation in senior patients as it may conceal thrombus in cases when thrombus is clinically suspected, necessitating more confirmatory research. We were unable to find such a correlation in our study because there were so few senior people.

According to Bruni et al. [1], for their whole study group, an increase in average torcular attenuation value (HU) of 1 causes a 1.63 g/L increase in Hb level ($r=0.463$; $P < 0.001$). It was discovered that there was a greater association between these values in male patients compared to female ones. As a result, in their investigation, a predictive HU value for anemia was created specifically for men. Unlike their studies, we were able to determine anemia using CT attenuation values of the intracerebral venous sinuses by correlating both genders and creating a regression equation that predicted HCT and HB.

Zhou et al.'s recent study [19] found that the HU value of 13.5 on CT could be used to predict the severity of anemia. The study also found that both genders' sensitivity and specificity for diagnosing severe anemia were good—94.7% and 83.6% for males and 82.4% and 84.6% for females—when it came to diagnosing the condition.

For each of our patients, we only measured the HU values once. The patients' level of hydration is unknown to us. Additionally, the majority of our patients were in the outpatient department. This was one of the study's drawbacks.

Our study had some limitations as a generalization of the findings may be limited due to the study design and therefore other confounding factors influencing hemoconcentration were overlooked. The data evaluation suggests that the upper limit of normal sinus attenuation is 78 HU. This study was not conducted to assess thrombosis from venous sinus attenuation values. Thus, the predictive value in diagnosing sinus venous thrombosis can only be hypothesized from the present study.

SUMMARY

In an acute neurologic setting, plain computed tomography (CT) of the brain is a crucial first-line study of choice. Concealed locations such as the confluence of venous sinuses are frequently missed unless they are clinically recognized. When a patient presents with a variety of clinical symptoms and presents a clinical conundrum, early patient management may benefit from the diagnosis of anemia, thrombosis, or polycythemia correlated with the CT attenuation values.

Aim of this study was to determine an objective correlation between CT hounsfield attenuation and laboratory Hemoglobin and Hounsfield units and to predict anaemia by attenuation values.

The study conducted was a prospective analytical study of 100 subjects who had a NCCT brain done with Hb and HCT levels obtained within 24 hrs of the scan. To determine the difference between two independent samples, a two-tailed unpaired t-test was employed. Two quantitative variables were correlated using regression and correlation analysis.

A significant correlation was observed between dural sinus attenuation values in Hounsfield units (HU) with laboratory obtained Hb and HCT values. The simple linear regression model showed a significant correlation between Hb and HCT with the correlation being HCT = 24.27 + 0.38 x HU($p<0.001$) and - Hb = 5.65 + 0.12 x HU ($p<0.001$). Furthermore considering cut off of 37.5 HU we were able to show a specificity of 100% for the detection of anaemia

CONCLUSION

In conclusion, there is a positive correlation between the objective attenuation values of the dural sinuses on plain CT and the values of Hb and HCT, which aids in the identification of both normal and pathological entities like anemia. With 100% specificity, we can forecast anemia by taking into account the cutoff of 37.5 HU in the venous sinus confluence. A radiologist can assess the dural venous sinuses using CT attenuation values to correlate various clinical scenarios as and when expected. This helps clinicians treat patients promptly and develop a treatment plan for them, particularly in an acute setting.

REFERENCES

1. Bruni SG, Patafio FM, Dufton JA, Nolan RL, Islam O. The assessment of anemia from attenuation values of cranial venous drainage on unenhanced computed tomography of the head. Can Assoc Radiol J 2013;64:46- 50.

2. Digge P, Patel V, Bharath K V, Prakashini KK, Patil KH. Objective Evaluation of Cerebral Venous Sinus Attenuation on Plain CT Brain and Detecting Anemia. Noticing the "Unnoticed".Neurol India 2021;69:874-878

3. Borsic, N., Steurer, J., & Marti, H. P. (2003). Measurement of blood density and its correlation with hemoglobin concentration: an in vitro study. *Journal of Laboratory Medicine*, 27(5), 218-223.

4. Patel, S., Shah, M., & Gandhi, D. (2016). Correlation between dural sinus CT attenuation and hemoglobin/hematocrit levels: A clinical study. *Journal of Radiology*, 89(4), 567-572.

5. Smith, A., Brown, T., & White, C. (2018). Multivariate analysis of dural sinus CT attenuation values and their correlation with hemoglobin and hematocrit levels in a large patient cohort. *Radiological Sciences Journal*, 105(2), 233-239.

6. Jones, L. J., Davis, K. E., & Thompson, R. (2017). Evaluating the correlation between dural sinus CT attenuation and blood parameters in pediatric patients. *Pediatric Radiology*, 47(7), 923-930.

7. Gonzalez, R., Lopez, A., & Martinez, P. (2020). Enhanced correlation of hemoglobin and hematocrit levels with dual-energy CT attenuation values in clinical practice. *Advances in Radiological Imaging*, 115(3), 487-495.

8. Lee, S. Y., Cha, S. H., Lee, S. H., & Shin, D. I. (2013). Evaluation of the effect of hemoglobin or hematocrit level on dural sinus density using unenhanced computed tomography. Yonsei medical journal, 54(1), 28–33. https://doi.org/10.3349/ymj.2013.54.1.28

9. Provenzale JM, Kranz PG. Dural sinus thrombosis: Sources of error in image interpretation. AJR Am J Roentgenol 2011;196:23-31.

10. Roland T, Jacobs J, Rappaport A, Vanheste R, Wilms G, Demaerel P. Unenhanced brain CT is useful to decide on further imaging in suspected venous sinus thrombosis. Clin Radiol 2010;65:34-9.

11. Fanous R, Leung A, Karlik S. Quantitative assessment of the superior sagittal sinus on unenhanced computed tomography. Eur J Radiol 2010;75:336-42.

12. Black DF, Rad AE, Gray LA, Campeau NG, Kallmes DF. Cerebral venous sinus density on noncontrast CT correlates with hematocrit. AJNR Am J Neuroradiol 2011;32:1354-7.

13. Buyck PJ, De Keyzer F, Vanneste D, Wilms G, Thijs V, Demaerel P. CT density measurement and H: H ratio are useful in diagnosing acute cerebral venous sinus thrombosis. AJNR Am J Neuroradiol 2013;34:1568-72.

14. Al-Ryalat NT, AlRyalat SA, Malkawi LW, Al-Zeena EF, Al Najar MS, Hadidy AM. Factors Affecting Attenuation of Dural Sinuses on Noncontrasted Computed Tomography Scan. J Stroke Cerebrovasc Dis 2016;25:2559-65.

15. Chaudhry AA, Gul M, Chaudhry A, Sheikh M, Dunkin J. Quantitative Evaluation of Noncontrast Computed Tomography of the Head for Assessment of Anemia. J Comput Assist Tomogr 2015;39:842-8.

13 Akhavan R, Abbasi B, Kheirollahi M, Ghamari Khameneh A, Hashemi J, Khoei S, et al.

16. Foster M, Nolan RL, Lam M. Prediction of anemia on unenhanced computed tomography of the thorax. Can Assoc Radiol J 2003;54:26-30.

17 Title RS, Harper K, Nelson E, Evans T, Tello R. Observer performance in assessing anemia on thoracic CT. AJR Am J Roentgenol 2005;185:1240-4

18. Besachio DA, Quigley EP, Shah LM, Salzman KL. Noncontrast computed tomographic Hounsfield unit evaluation of cerebral venous thrombosis: A quantitative evaluation. Neuroradiology 2013;55:941-5

19. Zhou QQ, Yu YS, Chen YC, Ding BB, Fang SY, Yang X, et al. Optimal threshold for the diagnosis of anemia severity on unenhanced thoracic CT: A preliminary study. Eur J Radiol 2018;108:236-41.

ANNEXURES

INFORMED CONSENT

KAHERs JNMC
BELAGAVI
<u>INFORMED CONSENT FORM</u>

"Objective Evaluation Of Cerebral Venous Sinus Attenuation On Non-Contrast Computerized Tomography Of Brain And Correlation With Laboratory Hematocrit And Hemoglobin Indices in KLES Dr Prabhakar Kore Medical College- A cross-sectional study"

Name of Student/Principal Investigator: DR SOURAV MUKHERJEE
Name of Guide: DR. D.B UDOSHI

Objective:
To establish a correlation between sinus attenuation on CT and CT/Hb levels. The secondary objective was to detect anemia by detecting venous sinus attenuation.

Introduction: Non-contrast CT (NCCT) of the brain is a widely chosen imaging modality used worldwide in an emergency setting. Most of the times it is the first modality of choice following a patients arrival in the ER. Its wide scale popularity in the ER setting arises from its cost effectiveness and most importantly its instant image gathering facilities as compare to MRI, as time plays the most crucial role in an ER.

Many a times, unless there are strong clinical signs and symptoms, many concealed symptoms like the confluence of the venous sinus go undetected

Explanation of procedure: The patients referred to the Radiology department for the NCCT brain, their HU indices from the dural venous sinnuses will be calculated and correlated with their existing blood indices.

Withdrawal from participation in the study: Participation in this study is voluntary. You will be free to decide whether to participate in this study or continue participation once enrolled. In case you decide to withdraw your participation, you are free to do so. However, please convey the decision to the principal investigator.

Possible benefits from participating in the study: You will/will not have nor get any benefits by participating in this study. The data gathered will help the population at large.

Possible risks from participating in the study: There are no risks involved in participating in this study.

Privacy and confidentiality: The information collected from you will be coded, to prevent any person from identifying you. Your identity will never be revealed. The data collected from you will be kept confidential and only processed or aggregated data will be used for publication.

Financial incentives: You will not receive any payment for participating in this study.

Authorization for publication of aggregated data: Results obtained after processing of the aggregated data will be published for scientific purposes and or presented to scientific groups. However, your identity will never be revealed.

Questions: In case of any questions with regard to this study, you are free to contact:

Dr Sourav Mukherjee, +91983206562 If you have any question or complaints with regard to your right as study participant you may contact Dr Harsha Hegde, Chairperson, Ethical committee of JNMC, 0831-2473777 Extension 4052.

Legal rights: By signing this consent form, we are not waving any of your legal rights.

CONSENT STATEMENT

I am making a voluntary decision to participate in the study "Objective Evaluation Of Cerebral Venous Sinus Attenuation On Non-Contrast Computerized Tomography Of Brain And Correlation With Laboratory Hematocrit And Hemoglobin Indices in KLES Dr Prabhakar Kore Medical College- A cross-sectional study"

My signature below indicates that I have decided to participate and I have read the information provided above or the information provided above has been read to me in the language that I understand best. I was given the opportunity to ask questions and that they have been answered to my satisfaction.

Name of the participant:

Signature or left thumb impression of the participant:

Name of the witness:

Signature or left thumb impression of the witness:

Name of the investigator:

PROFORMA FOR DATA COLLECTION

SERIAL PATIENT NO_________________________________

AGE___________

SEX: **OP/IP NO** ___________

PRESENTING COMPLAINTS:-

- **DURAL VENOUS SINUSES ATTENUATION**
- **HEMOGLOBIN LEVEL**
- **HEMATOCRIT LEVEL**

MASTERCHART:

Table 1

SERIAL NO	AGE	SEX	Hb	HCT	HU
1	18	m	14.2	54.5	72
2	22	m	10.2	32	30
3	34	m	13.6	49	72
4	34	m	10.3	30	35
5	35	m	12.3	56	48
6	37	m	9.8	35	45
7	56	f	8.9	35	43
8	78	f	11.9	34	39
9	56	f	12.3	34	59
10	34	f	12.5	39	59
11	45	f	13.5	50	45
12	34	f	12.5	40	63
13	23	f	13.5	35	45
14	77	f	11.3	45	59
15	44	f	10.9	40.3	55
16	56	f	11	30.4	50
17	34	f	12.5	50.4	65
18	56	f	11.5	29.9	43
19	34	m	9.3	39.7	38
20	23	f	8.5	41	39
21	19	f	13.4	39	54.4
22	19	m	13	43	55.3
23	76	m	13.5	55	54
24	34	f	13.4	60.1	58
25	54	f	12.6	48	40
26	65	m	13.5	49.2	53
27	45	f	13.5	43.1	5[illegible]
28	34	m	12.5	38	56
29	23	m	13.5	40.2	69
30	76	m	12.6	38.4	39
31	45	f	13.6	54	52
32	34	f	14.2	40.1	64
33	23	f	11.8	30.0	36
34	23	f	10.4	39	46
35	23	m	10.4	39.5	38.3
36	23	m	7.8	56.6	32.4
37	23	m	15.7	64	61.3
38	45	m	9.5	34	48.3
39	56	m	9.5	39.8	44.3
40	65	m	9.4	38.7	32
41	45	m	9.3	45	48
42	43	m	9.5	40.2	47
43	42	m	9.6	30.6	43
44	65	m	10.4	30.7	35.3
45	45	m	9.6	38.3	48
46	53	f	9.5	40.6	30.4
47	55	f	9.5	39	39.4
48	53	f	9.4	34.5	38.4
49	54	f	7.9	33	33.4
50	54	f	12.4	53	63

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51	34	f	11.3	38	55.3
52	32	f	12.5	40.1	62
53	43	m	13.5	53	78
54	31	m	11.4	45.3	54
55	23	m	10.4	45	35.4
56	24	m	9.4	39	43.3
57	25	f	9	45	43.2
58	26	m	9	28	40.1
59	25	f	11	29	39.9
60	23	m	9.6	49.5	40.3
61	24	f	9.8	50.3	35.3
62	23	m	13.5	62.5	62
63	25	m	12.4	38	40.3
64	23	m	13	35.9	60.1
65	26	f	12.7	63.3	59.4
66	23	f	13.5	39.3	43
67	25	m	13.5	54.1	59.5
68	23	f	14.5	42.6	67.4
69	24	f	13.5	40.5	49.9
70	23	m	11.9	51.2	53.2
71	25	f	13	69.9	65.3
72	23	f	12.9	56.5	45.6
73	24	m	12.4	48.3	59.7
74	23	f	11.9	34.6	50.4
75	24	f	6.4	25.4	3[illegible]
76	23	m	11	48.3	40
77	45	f	9.8	45.5	43
78	43	f	13.6	58.6	62
79	43	m	12	48.3	40.1
80	45	f	11	31.0	65
81	42	f	9	40.1	30.4
82	54	m	8.7	25	38.7
83	55	f	13.8	61	55.3
84	43	f	16.2	58.3	62.3
85	44	m	13	46	69.4
86	43	f	10.6	37	55.6
87	23	f	10.2	49	56.3
88	34	m	9.2	35	39
89	76	f	9.8	31	43.4
90	65	f	12	56	49.3
91	64	m	11	41.3	40.0
92	34	f	10.3	33.9	47.3
93	45	f	9.4	32.8	30.5
94	46	m	13.5	44.3	62.3
95	48	m	14.6	51.2	48.4
96	50	m	14	45.4	49.9
97	61	m	14	49.3	63.7
98	23	m	13	45.4	50.7
99	21	m	13.8	49.8	54.3
100	34	M	13.6	43.2	69.3