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Diagnosing Cerebral Venous Sinus Thrombosis on Unenhanced Computed Tomography -Measuring the Hounsfield Unit. Does it Add to the Confirmation of Diagnosis?

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Background: Over past decade, epidemiology of cerebral venous sinus thrombosis (CVST) has significantly changed. CVST is being diagnosed clinically and by non- invasive imaging techniques early in its course and has better prognosis and non-fatal outcomes.
Methods: Institutional ethical review committee approval was obtained prior to start of this retrospective study. All Magnetic resonance venogram (MRV) performed between January 2007 and December, 2016 were reviewed retrospectively. Only positive cases were included which show thrombosis on MRV. We calculated sensitivity, specificity, positive predictive value and negative predictive value on the basis of CT density taking post contrast MRV as gold standard.

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Results: Total 554 positive venous sinuses in 350 patients were included. Mean age was 37.46 ± SD 15.4 years, range: 72 years, minimum 4, and maximum 76 years. Only those cases were included who had MRV and non-contrast CT (NCT) within 24 hours of each other. 554 positive venous sinuses were analyzed as well as 2246 negative sinuses were analyzed in the same cohort. The average (Hounsfield unit) HU of vessels containing a thrombus was 60 ± 1.56 which was significantly higher than that of any other normal sinus in same patient 40 ± 0.28 ($p < 0.05$).
Sensitivity, specificity, positive predictive value and negative predictive value were calculated as 99.6%, 89.05%, 69.17% and 99.9% respectively.
Conclusion: Hounsfield unit is highly sensitive and specific for CVST and can be used as a good screening tool.

Keywords: Cerebral thrombosis; neurological disorder; computed tomography; hounsfield unit.

1. INTRODUCTION

Cerebral venous sinus thrombosis (CVST) is thrombosis within the cerebral veins and dural sinuses. It hinders proper drainage of deoxygenated blood from brain resulting in drastic hemodynamic changes which can be fatal. It is more common in younger age group and women of child bearing age [1]. It is not uncommon in South Asian subcontinent; however no multi-center or multinational registry is available to define the numbers, potential risk factors and patterns of involvement and outcomes [2].

Over the past decade, epidemiology of CVST has significantly changed and is not a rare disorder anymore. CVST was first diagnosed by Ribes in 1825, who described thrombosis of dural venous sinuses on autopsy of a man who suffered from seizures and delirium [3].

In 1940s, Dr Charles Symonds and others made clinical diagnosis of CVST on the basis of lumbar puncture and specific signs and symptoms [4]. The introduction of venography in 1951, further enhanced diagnosis of CVST in living subjects. It also helped in differentiating cases of idiopathic intracranial hypertension which have similar presentation [5]. The treatment of CVST with heparin was introduced by British gynecologist Stansfield in 1942 and reinforced by clinical trials in 1990s [6].

The clinical presentation and causal factors of this disorder is highly variable. Therefore, imaging plays a prime role on its diagnosis. Magnetic resonance (MR) imaging, non contrast CT (NCT), unenhanced and enhanced MR venography (MRV), contrast enhanced CT venography (CTV) are the current techniques used to detect CVST and related brain parenchymal complications [6].

CVST, being diagnosed by non- invasive imaging techniques early in its course and has better prognosis and non-fatal outcomes. We attempted to determine in retrospectively the sensitivity, specificity, positive predictive value and negative predictive value on the basis of density Hounsfield unit (HU) of cerebral venous sinuses as confirmed on post contrast MRV. We also calculated mean HU of positive cases.

2. METHODS

Institutional ethical review committee approval was obtained prior to start of this retrospective study. All MRV performed between January 2007 and December, 2016 were retrospectively reviewed. Only positive MRV were included.MRV is considered positive when there is non- filling of the respective sinus on dynamic post contrast sequences.

The site of thrombus was identified from MRV where applicable and the (HU) of the corresponding cerebral venous sinus in NCT were measured on axial plane by drawing region of interest (ROI) at the site of maximum high density. It was compared with contralateral normal sinus in same patient or any other major normal dural sinus in the same patient. We considered value of 60 HU as reference value from the study by Roland T, Jacobs J, [3], Linn J, Pfefferkorn T, Ivanicova K, et al. [4] and Black DF, Rad AE, Gray LA, et al. [5].

We calculated Sensitivity, specificity, positive predictive value and negative predictive value by measuring intracranial sinus density on NCT images taking post contrast MRV as gold standard. NCTs were performed on a Somatom Definiation AS CT Scanners (Siemens Medical Solutions) and on a Toshiba 640 SLICER CT.

The following parameters were used: 320-360 MAs, 120 Kv, and slice collimation of 12x0.75

mm for the posterior fossa and 12x1.5 mm for the rest of the brain. We measured HU by drawing ROI in the center of sinus on Picture archiving and communication system PACS system on the axial sections.

MRI was performed on 1.5 Tesla Siemens Avanto with 6 channel head coil scanner. The data was collected in all patients using a 3 Dimensional (3D) contrast enhanced MRV with 64 locs/slab,1 mm thick, a 512 x 192 matrix, FOV = 25.6 cm x 19.2 cm (512 x 256 matrix with in-plane phase FOV = 0.75), for an in-plane resolution of 0.5 mm x 1 mm. Other parameters were: flip angle FA=30, TE/TR =12.2/34 ms for an acquisition time AT = 5 min: sec. k-space data was saved and transferred for post processing. Additional MRI sequences acquired included T2-weighted image (WI), Fluid-Attenuated Inversion-Recovery (FLAIR) and T1W. TWI both with and without a single dose intravenous bolus of0.1 mMol/Kg Gd-DTPA 5 min after injection. First dynamic source images were acquired and then maximum intensity projection images were reformatted from source data.

2.1 Population Demographics and Clinical Features

Four hundred and twenty patients who had five hundred ninety eight thrombosed sinuses on MRV were included. Two thousand and seven hundred sixty two sinuses were also studied in the same patients which were not thrombosed on MRV. Fourty four patients were excluded since there were no prior NCT. Ten hypo plastic venous sinuses were also excluded from analysis on basis of Magnetic resonance venogram. Twenty were excluded because of history of trauma and adjacent subdural hematomas.

So, in total three hundred fifty patients with five hundred fifty four thrombosed sinuses on MRV were included. Mean age was 37.46 ± SD 15.4 years, range: 72 years, minimum 4, and maximum 76 years. No patients were included who underwent an NCT more than 24 hours following their MRV. Sinuses studied were superior sagittal sinus, inferior sagittal sinus, transverse sinus, sigmoid sinus and Internal jugular vein.

Out of the total sample of 350, 189(54%) were females. Nearly half of the patients, 182(52%) were admitted in the ward, 126 (36%) presented in the Emergency and the rest were out-patient clinics 70(20%) with Neurology as the main referral. Out of the total, 168(48%) presented with an infarct and 18(15.5%) with sub-arachnoid hemorrhage (SAH). Infarcts were more pronounced in females. Regarding clinical features, most commonly presented symptoms were headache and weakness, 91 (26%) and 81 (23%) respectively. Seizures 34(9.72%) and fever 11(3%) were the least presented symptoms followed by vertigo 3(1%). There was no history available for 5 patients. Majority of the patients did not present with any co-morbid state.

3. RESULTS

Vessel HU Analysis: Three hundred and fifty positive venous sinuses were analyzed as well as 2246 negative sinuses were analyzed. The average HU of vessels containing a thrombus was 60 ± 1.56 (Fig. 1) which was significantly higher than that of any other normal sinus in same patient 40 ± 0.28.

The distribution of positive thrombosed and non thrombosed sinuses is shown in Graphic form 1, which shows thrombosed sinuses were 24.6% of the total sinuses studied.

Two by two table were drawn comparing MRV and CT. Sensitivity, specificity, positive predictive value, negative predictive value and accuracy were calculated (Table 1). HU > 60 was found to be 99.64 % sensitive and 89.05% specific for CVST.

P value <0.05 was considered as significant.

It has positive predictive value of 69.17% with negative predictive value of 99.09% respectively (Table 2).

4. DISCUSSION

Previously, CVST was assumed to be a rare disease based on earlier evidences on its incidence and prevalence [7]. It was mostly reported on autopsy studies but at present it is now established that it is no more a rare disease. This may be because of better and widespread use of Neuroimaging and enhanced clinical attentiveness that has helped in early diagnosis and management [8]. Nearly half a decade before, it was reported to be 1 per 2 million persons per year in England and Wales. Bousser et al. reported in 2007, that CVST affects about 5 people per million in the English population [9].

With the advent and common use of Neuroimaging, there is better diagnosis and prognosis of CVST in this era. CVST has a broad range of symptomatology and mimics many other neurological conditions such as stroke, meningitis, encephalopathy and benign intracranial hypertension. Imaging supports early diagnosis and intervention as clinical presentation in seclusion can be misleading [10]. Avsenik, J conducted study in India have recruited large number of cases and further reported that 10-20% of young strokes are attributable to CVST [11].

Hyperattenuating signs on CT are non-specific. They are frequently seen when an acute thrombus is formed with in a blood vessel [12]. Some other conditions which increase hematocrit or sluggish flow can also give increase attenuation. The increase in attenuation is measured by increase in Hounsfield unit (HU) on CT. The increase in attenuation is caused by clot retraction reducing water and increasing the concentration of RBCs and haemoglobin [13]. This mechanism can result in increased attenuation of the thrombus to 60-90HU.

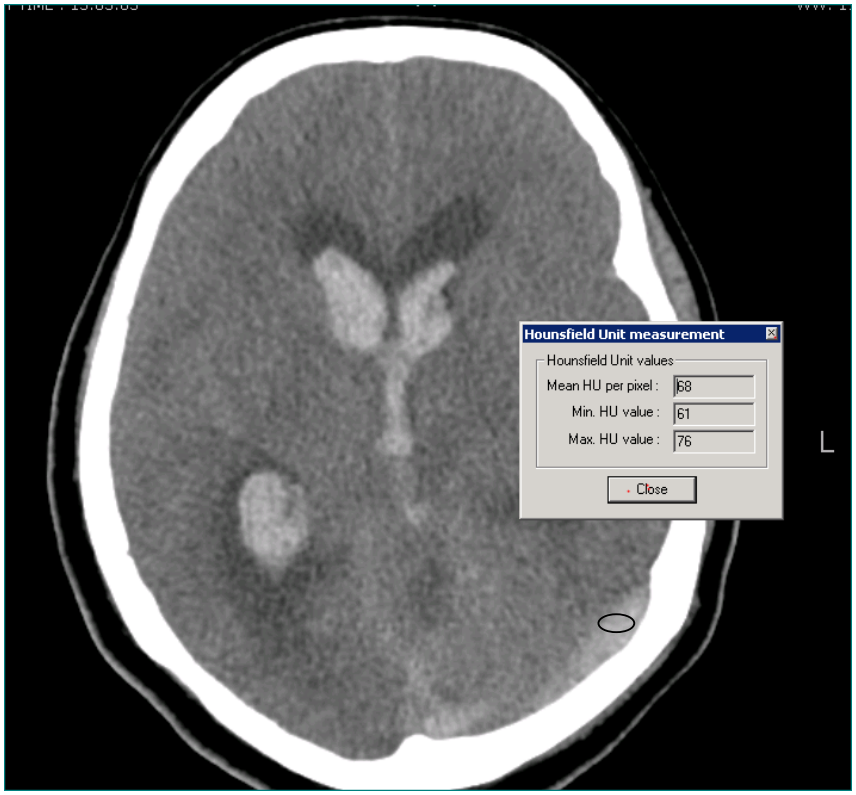


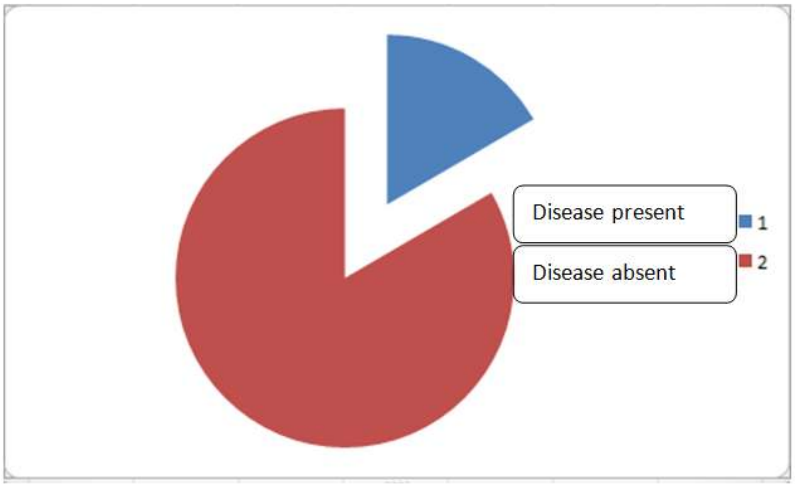
Fig. 1. Method of drawing ROI on the venous sinus

Table 1. Sensitivity, specificity, positive predictive value, negative predictive value and accuracy were calculated

	Disease				
Test	**Present**	**n**	**Absent**	**n**	**Total**
Positive	True Positive	a= 552	False Positive	c= 246	a + c = **798**
Negative	False Negative	b= 2	True Negative	d= 2000	b + d = **2002**
Total		a + b = **554**		c + d = **2246**	

Table 2. Depicts positive and negative predictive values

Statistic	Formula	Value	95% CI
Sensitivity	$\frac{a}{a+b}$	99.64%	98.70% to 99.96%
Specificity	$\frac{d}{c+d}$	89.05 %	87.68% to 90.31%
Positive Likelihood Ratio	$\frac{Sensitivity}{100-Specificity}$	9.10	8.08 to 10.24
Negative Likelihood Ratio	$\frac{100-Sensitivity}{Specificity}$	0.00	0.00 to 0.02
Disease prevalence	$\frac{a+b}{a+b+c+d}$	19.79% (*)	18.32% to 21.31%
Positive Predictive Value	$\frac{a}{a+c}$	69.17% (*)	66.60% to 71.63%
Negative Predictive Value	$\frac{d}{b+d}$	99.90 % (*)	99.60% to 99.97%



Graphic 1. Pie chart showing distribution of thrombosed sinuses out of total sinuses

With passage of time, the thrombus gets rechanneled as well as RBC and haemoglobin are degraded. The hyper attenuating signs can serve as unique findings indicating an acute stage, this is the stage when treatment is most effective and if identified early can have a great outcome on patient management [14].

In literature this sign has been referred to as the hyperattenuated dural sinus CVST. It was originally found in only a few of patients with CVST and this was regarded as a non specific sign. An early study reported sensitivity of approximately 25% [15].

With new advancement and with thinner CT sections, however, this sign was detected much more frequently. Another study reported sensitivity of 64% of the dural sinus for CVST [16].

Appreciating moderate increases in attenuation by the attenuation measurement with in the dural sinus can be helpful in the detection of acute

CVS T. Cobelli et al. [16,17] and Goldstein et al. found a mean attenuation of 73.9 HU in thrombosed venous sinus. In this article, they gave references of HU of clots else where in the body by other studies else where with in the body and in pulmonary emboli and abdomen venous thrombi respectively. Their study suggested a threshold of 62 HU can be used to discriminate patients with acute CVST from those with out. Positive correlation and significant association has been established with both haemoglobin and hematocrit and attenuation of blood on unenhanced CT [17]. Patients with anemia have low haemoglobin levels and therefore low attenuation of blood. In a same way, in patients with Polycythemia Vera or in young children blood may appear hyperattenuating. These findings have been reported to be the most common cause of false positive readings in CVST. As in an article by Sasidharan et al. [18], Radiology is essential for diagnosis however, relying on it alone can lead wrong diagnosis clinical picture should always be in mind [19].

5. LIMITATIONS OF THE STUDY

We did not eliminate HU fluctuations caused by low haemoglobin, haemo-dilution, dehydration, and so forth. For future reference, we should standardize the venous sinus HUs to the average HU of the corresponding internal carotid arteries.

6. CONCLUSION

Hounsfield unit is highly sensitive and specific for cerebral venous sinus thrombosis and can be used a good screening tool in patient suspected of CVST.

CONSENT

It is not applicable.

ETHICAL APPROVAL

As per international standard or university standard, written approval of Ethics committee has been collected and preserved by the author.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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