RESEARCH ARTICLE

Diagnostic accuracy of plain computed tomography in detecting acute cerebral venous sinus thrombosis keeping magnetic resonance venography as gold standard

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Abstract

Objective: To determine the diagnostic accuracy of plain computed tomography using the ratio between hounsfield unit and haematocrit of cerebral venous sinuses in cases of acute cerebral venous sinus thrombosis taking magnetic resonance venography as the gold standard.

Method: The cross-sectional validation study was conducted at the Department of Diagnostic Radiology, Combined Military Hospital, Rawalpindi, Pakistan, from March 9 to September 8, 2021, and comprised patients regardless of age and gender presenting with acute neurological and visual signs and symptoms of cerebral venous sinus thrombosis for <5 days. The patients were brain-imaged on 128-slice computed tomography scanner, and the image was assessed and the attenuation values in terms of Hounsfield unit of dural venous sinuses were calculated by taking appropriate region of interest. Haemoglobin and haematocrit values were noted from blood reports, and then the ratio between Hounsfield unit and haematocrit ratio was calculated. Magnetic resonance venography of the patients were performed and the patients were assessed for dural venous thrombosis. Data was analysed using SPSS 23.

Results: Of the 201 patients, 98(48.8%) were males and 103(51.2%) were female. The overall mean age was 35.32±19.707 years (range: 1 month-70 years). According to the Hounsfield unit-haematocrit ratio, acute cerebral venous sinus thrombosis was detected in 173(86.01%) patients, while magnetic resonance venography detected 178(88.6%). The Hounsfield unit-haematocrit ratio had sensitivity 91.01%, specificity 52.17% and diagnostic accuracy 86.57%.

Conclusion: Computed tomography attenuation value and Hounsfield unit-haematocrit ratio on unenhanced computed tomography could be used as a reliable method to detect acute cerebral venous sinus thrombosis in emergency settings.

Keywords: Computed tomography, Acute cerebral venous sinus thrombosis, Magnetic resonance venography.

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Introduction

Cerebral venous sinus thrombosis (CVST) is an unusual manifestation of thromboembolic phenomenon involving cerebral sinuses and veins.[1] Reported annual incidence is 15.7 per million in two different geographical settings.[2,3] Gradual increase in its incidence seems to have been underestimated.[3] It predominantly affects younger age group having a mean age of 35 years.[4] Prevalence reported in Pakistan is 11.055%.[5] It accounts for 0.5-3% of all types of strokes.[6] Mortality rate of severe CVST is 34.2%.[7] Annual incidence in the paediatric group is approximately 7 cases per million, and is relatively higher in neonates.[8] Gender-specific risk factors, like pregnancy, puerperium, oral contraceptive pills, certainly suggests female predilection with 3:1 female-male ratio.[9] The absence of these risk factors in paediatric and older age groups obviates any gender predominance.[9] Virchow triad (hypercoagulability, blood stasis and endothelial injury) explains the causes and risk factors of venous thrombosis, including specific risk factors like chronic inflammatory diseases (systemic lupus erythematosus, inflammatory bowel disease), malignancy, vasculitis (Wegener's granulomatosis), local infections (mastoiditis), head injury, neurosurgical procedures, direct injury to the sinuses or jugular veins (iatrogenic) and even lumbar puncture.[9]

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Variable clinical spectrum and broader age distribution makes acute CVST a diagnostic challenge for the clinicians. Patients usually present with non-specific neurological and visual signs and symptoms, mostly headache, secondary to increased intracranial pressure.[9]

Non-contrast/plain computed tomography (CT) is the first-line imaging modality for patients with neurological symptoms as it is widely available, cost-effective and also suitable for individuals having any contraindication to intravenous (IV) contrast.[9] Early diagnosis of acute CVST is crucial for its management and to avoid its complications such as venous infarction, sub-arachnoid haemorrhage, brain herniation and pulmonary embolism.[10]

Acute CVST disease manifests as hyper attenuating material in the cerebral sinuses/cortical veins referred to as dense triangle sign and cord sign, respectively, which lasts for 1-2 weeks. Normally, veins appear slightly denser than brain tissue, so it is necessary to quantify clot density by measuring its CT attenuation value in Hounsfield unit (HU), thus excluding false positive (FP) results.[11,12]

Very limited data is available regarding the accuracy and cut-off values of these parameters. Literature showed the cut-off value of 70 HU with sensitivity and specificity of 92% and 100%, respectively, and HU:HCT cut-off as 1.64.[13] Elevated haematocrit (HCT) level can also contribute to hyper-density in the cerebral sinuses and veins for which HU:HCT ratio was used in acute CVST diagnosis in some studies.[13-15] A recent study documented the cut-off value of >60.4 HU with sensitivity 71.4% and specificity 100%, and HU:HCT ratio >1.42 having 94.3% sensitivity and 54.2% specificity.[15]

Magnetic resonance venography (MRV) is the gold standard imaging modality for acute CVST which demonstrates thrombus as a filling defect in the cerebral sinuses/veins. However, MRV is not universally available in emergency settings and often limited by the artefacts and flow-related voids.[15] Non contrast CT is still the imaging technique of choice in most emergency departments.[16]

The current study was planned to determine the diagnostic accuracy of plain CT using HU:HCT ratio of cerebral venous sinuses in acute CVST cases while taking MRV as the gold standard.

Patients and Methods

The cross-sectional validation study was conducted at the Department of Diagnostic Radiology, Combined Military Hospital (CMH), Rawalpindi, Pakistan, from March 9 to September 8, 2021. After taking approval from the institutional ethics review committee, the sample size was calculated using an online calculator by keeping acute CVST prevalence in Pakistan 11.055%, confidence interval (CI) 95%, precision 10%, sensitivity 94.3% and specificity 54.3%.[5,15,17] The sample was raised using non-probability, consecutive sampling technique. Those included were patients regardless of age and gender presenting with acute neurological and visual signs and symptoms of CVST, like headache, loss of consciousness, seizures or blurring of vision, for <5 days with whole blood complete picture (CP) test done within 24 hours of plain CT scan.[18] Patients with a history of trauma or intracranial surgery, and those who had received contrast 24 hours prior to the scan were excluded, and so were those not willing to take part in the study.

After written informed consent from patients, or, in case of minors, from parents, the subjects were imaged on 128-slice CT scanner, taking 3mm sections with brain window (width 80; length 40), bone window (width 2000; length 500), subdural window (width 130-300; length 50-100) and stroke window (width 8; length 32). Furthermore, coronal, sagittal reconstruction images with 1mm slice thickness were acquired along with maximum intensity projections (MIP) images.

The scans were assessed and CT attenuation values in HU terms of dural venous sinuses were calculated by taking appropriate region of interest (ROI). Haemoglobin (HGB) and HCT values were noted from the blood CP report, and then HU:HCT ratio was calculated. Contrast MRV examination of the same set of patients were performed on 1.5T machine (Siemens), which was also assessed for dural venous thrombosis.

Data was analysed using SPSS 23. Frequencies and percentages were computed for qualitative variables, while mean and standard deviation were computed for quantitative variables. P≤0.05 was considered statistically significant. Effect modifiers, like age and gender, were controlled by stratification, and then sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and diagnostic accuracy (DA) of HU:HCT ratio compared to MRV were calculated using the 2x2 model.

Results

Of the 201 patients, 98(48.8%) were males and 103(51.2%) were females. The overall mean age was 35.32±19.707 years (range: 1 month-70 years). The venous sinuses affected in paediatric and adult age groups were noted separately (Table 1).

The HU-HCT ratio detected acute CVST in 173(86.01%)

Table-1: Venous sinuses affected in paediatric and adult age groups.

Thrombosed cerebral venous sinuses	n (%)
Adult age group	
Superior saggital sinus	93 (69)
Right transverse sinus	88 (62)
Left transverse sinus	71 (53)
Left sigmoid sinus	63 (47)
Right sigmoid sinus	49 (36)
Straight sinus	47 (35)
Inferior saggital sinus	8 (6)
Cavernous sinus	1 (1)
Paediatric age group	
Right transverse sinus	27 (72)
Superior saggital sinus	24 (64)
Left transverse sinus	24 (64)
Right sigmoid sinus	17 (44)
Left sigmoid sinus	16 (41)
Straight sinus	9 (23)
Inferior saggital sinus	4 (10)
Cavernous sinus	1 (3)

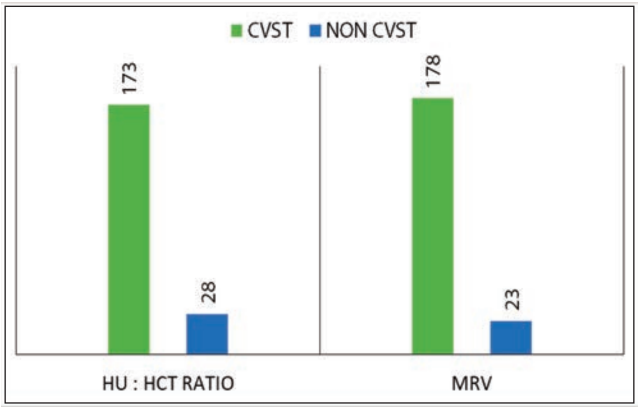

Figure: Results on plain computed tomography (CT) of suspected acute cerebral venous sinus thrombosis patients using Hounsfield unit:hematocrit (HU:HCT) ratio and taking magnetic resonance venography (MRV) as the gold standard.

Table-2: Stratification of HU:HCT ratio for the detection of acute CVST in comparison with MRV with respect to age (n = 201).

HU:HCT	MRV		Total
	Positive	Negative	
< 35 years			
Positive ratio	TP= 77	FP= 9	86
Negative ratio	FN= 7	TN= 8	15
≥ 35 years			
Positive ratio	TP= 85	FP= 2	87
Negative ratio	FN= 9	TN= 4	13
Total	178	23	201

HU: Hounsfield unit, HCT: Hematocrit, CVST: Cerebral venous sinus thrombosis, MRV: Magnetic resonance venography. TP: True positive, TNL: True negative, FP: False positive, FN: False negative.

patients, while MRV detected it in 178(88.6%) (Figure). The HU-HCT ratio was found to have sensitivity 91.01%, specificity 52.17%, PPV 93.64%, NPV 42.86% and DA 86.57%. HU:HCT and MRV findings were stratified with respect to <35 years and >35 years age groups (Table 2).

Discussion

The current study included patients presenting within 48 hours of the onset of symptoms. CT attenuation values also depend upon blood HCT values as it decreases in anaemic patients and this possibility was eliminated in current study using the HU:HCT ratio. The study found HU-HCT ratio to have sensitivity 91.01%, specificity 52.17%, PPV 93.64%, NPV 42.86% and DA 86.57%. To the best of our knowledge, no local study has been conducted at the national level in Pakistan with which the current finding could be compared.

Digge et al. reported >70HU as the recommended density to diagnose acute CVST on plain CT scans with sensitivity 92% and specificity 100%, and the suggested HU;HCT cut-off value was >1.6413. Studies carried out in the paediatric age group have suggested optimal cut-off CT attenuation value of >58HU, and HU:HCT ration >1.4 with 100% sensitivity to diagnose CVST.[14] Black et al. showed that in 7 of 8 cases with sinus thrombosis, the attenuation was >70HU.[19] Internationally, Buyck et al. measured the attenuation of the venous sinus in 20 patients with CVST compared to 20 controls, and reported that the mean of attenuation in thrombosed venous sinuses was 73.9 HU. The study reported optimal threshold of >62HU with 95% sensitivity and specificity which can be used to diagnose the patients with acute CVST.[20] In one study, the mean of attenuation in patients with CVST was 68HU, and it reported that the attenuation of the venous sinus ≥67HU was associated with a high probability of diagnosing CVST.[21] Another study reported >61 HU and HU:HCT ratio of >1.4 as cut-off diagnostic values.[22] Matteo Bonatti et al. reported >63HU as the cut-off value.[23]

Conclusion

Study showed that HU:HCT ratio cut-off of 1.4 detected acute CVST in most of patients. So CT attenuation value (>65 HU) and HU:HCT ratio (>1.4) on unenhanced CT could be used as a reliable method to detect acute CVST in emergency settings without access to contrast-dependent modalities.

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