Original Research Article

Study of accuracy of attenuation value in plain computed tomography in diagnosing acute cerebral venous thrombosis (CVST)

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Abstract

Background: Cerebral venous sinus thrombosis (CVST) is thrombosis of the intracranial veins and sinuses, and accounts for 0·5 % of all strokes, with mortality 5 to 15%. Non-contrast computed tomography (NCCT) is the most frequently performed imaging study for evaluation of patients with new headache, focal neurological abnormalities, seizure, or change in mental status. Early detection of CVST is important as initiation of anticoagulation therapy is thought to prevent the propagation of thrombus and subsequent venous infarcts and hemorrhage. The goal of the present study was to evaluate the diagnostic accuracy of NCCT in the diagnosis of acute CVST. **Material and Methods:** Present study was a prospective, observational study conducted in patients underwent plain computed tomography for suspicion of acute cerebral venous thrombosis. During study period, clinically suspected cases of CVST underwent plain CT scan of head, findings were later confirmed by gold standard investigation i.e. M.R. venography. Average venous sinus attenuation value of individual subject from patient and control group was used for statistical evaluation. Student's t-test was used to compare HUs. Fischer's exact test was used to compare categorical data. Comparison between the two groups was made by unpaired t-test. A p value < 0.05 was considered significant. **Results:** After inclusion and exclusion criteria, total 108 patients were studied. A significant difference was noted between age of cases and controls (p = 0.024). In present study male to female rato was 1.5:1. Most patients underwent imaging on same day of acute symptoms (cases -64% and controls-58%). Mean attenuation value (in Housefield units) was significantly more in cases. Statistical difference for attenuation value was significant between cases and controls (p = 0.001). However no statistically significant difference was noted for attenuation value among males and females, for both cases and control group. Most common locations for CVST in present study were superior sagittal sinus (68%), transverse sinus (59%), sigmoid sinus (53%) and cortical veins (32%). Others were straight sinus (21%), internal jugular veins (12%), vein of Galen (12%), internal cerebral vein (9%) and cavernous sinus (6%). On plain CT, CVST was diagnosed in 30 cases, while failed to diagnose 4 cases, which were positive on MR venography. At HU levels 62, specificity and sensitivity of plain CT for diagnosing CVST was 88 % and 95 % respectively. Accuracy of plain CT at 62 HU was 93% for diagnosing CVST. **Conclusion:** Plain CT is affordable, widely available and gives reports quickly. Prompt diagnosis and treatment of CVST has a better outcome, so early diagnosis is essential. Plain CT is imaging technique of choice for evaluation of patients with suspected acute CVST.
Key Words: plain CT, acute cerebral venous thrombosis (CVST), attenuation value, housefield units (HU).

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INTRODUCTION

Cerebral venous sinus thrombosis (CVST) is thrombosis of the intracranial veins and sinuses, and accounts for 0·5 % of all strokes, with mortality 5 to 15%.[1] CVST blocks proper drainage of deoxygenated blood from brain resulting in drastic hemodynamic changes which can be fatal. The causes of CVST are prothrombotic disorders (such as malignancies, haematological disorders and vasculitis), recent surgery, trauma to pregnancy,

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puerperium, and drugs like oral contraceptives.[2] Clinical presentation of CVST range from headache to seizures and even coma that make it as a challenge of diagnosis and often not diagnosed clinically at presentation.[3] Accurate and prompt diagnosis of CVT is crucial because timely and appropriate therapy can reverse the disease process and significantly reduce the risk of acute complications and long-term sequel. Magnetic resonance (MR) imaging, plain CT, unenhanced and enhanced MR venography (MRV), contrast enhanced CT venography (CTV) are the current techniques used to detect CVST and related brain parenchymal complications.[4] Non-contrast computed tomography (NCCT) is the most frequently performed imaging study for evaluation of patients with new headache, focal neurological abnormalities, seizure, or change in mental status.[5] Hyperattenuating signs on CT are non-specific. They are frequently seen when an acute thrombus is formed with in a blood vessel. A typical imaging finding in patients with CVST is direct visualization of a hyperattenuating thrombus in the occluded sinus (dense sinus sign). [6] 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. This mechanism can result in increased attenuation of the thrombus to 60-90HU.[7] Early detection of CVST is important as initiation of anticoagulation therapy is thought to prevent the propagation of thrombus and subsequent venous infarcts and hemorrhage. This in turn reduces the mortality and morbidity associated with long-term neurological sequelae.[8] The goal of the present study was to evaluate the diagnostic accuracy of plain CT in the diagnosis of acute CVST in the emergency setting.

MATERIAL AND METHODS

Present study was a prospective, observational study conducted in patients underwent plain computed tomography for suspicion of acute cerebral venous thrombosis. Study was conducted in department of radio-diagnosis, XXXX medical college and hospital, XXX. Study duration was of 1 year (July 2019 to June 2020). Institutional ethical board approval was obtained.

Inclusion criteria

- Patients referred with clinical suspicion of acute cerebral venous sinus thrombosis (CVST), referred for radiological evaluation

Exclusion criteria

- Patients who underwent a neurosurgical procedure in the preceding 10 days
- Patient known to have an old cerebral venous thrombus
- Patients with hypoplastic venous sinuses and heavily calcified ICAs

During study period, total 108 clinically suspected cases of CVST underwent plain CT scan of head, findings were later confirmed by gold standard investigation i.e. M.R. venography. 34 cases were diagnosed as CVST on M.R. venography (cases- Group A) and rest 74 cases were normal on M.R. venography (control- Group B). H.U. value of all clinically suspected case of C.V.T. was calculated on all dural sinuses and intracranial portions of the internal carotid arteries (ICAs) as they exit the carotid canal was measured. In cases with CVST, site of thrombus was identified and the Hounsfield Units (HUs) of the corresponding cerebral venous sinus in the NCT were measured. In controls, HU of the superior sagittal sinus (SSS) and both sigmoid sinuses were recorded. HUs of both intracranial portions of the internal carotid arteries (ICAs) as they exit the carotid canal were measured. Attenuation inside the thrombosed venous structures was measured. If no venous structure was classified as thrombosed, mean attenuation of up to three venous sinuses that could be reliably differentiated from surrounding brain parenchyma was documented. Presence of parenchymal hemorrhage or edema was also noted. Average venous sinus attenuation value of individual subject from patient and control group was used for statistical evaluation. Student's t-test was used to compare HUs. Fischer's exact test was used to compare categorical data. Comparison between the two groups was made by unpaired t-test. A p value < 0.05 was considered significant.

RESULTS

After inclusion and exclusion criteria, total 108 patients were studied. A significant difference was noted between age of cases and controls ($p = 0.024$). In present study male to female rato was 1.5:1. Most patients underwent imaging on same day of acute symptoms (cases -64% and controls-58%). Mean attenuation value (in Housefield units) was significantly more in cases. Statistical difference for attenuation value was significant between cases and controls ($p = 0.001$). However no statistically significant difference was noted for attenuation value among males and females, for both cases and control group.

Table 1: Comparison of baseline parameters and HU

Parameters	Group A (cases, n=34)	Group B (control, n=74)	P value
Age (mean ± SD, in years)	32.4 ± 9.8	40.4 ± 9.2	0.024
Male	31.2 ± 8.6	39.2 ± 12.1	
Female	34.1 ± 10.3	41.8 ± 10.5	
Sex (M/F) (M: F)	20/14 (1.4:1)	46/28 (1.6:1)	
Same day imaging (%)	22 (64%)	43 (58 %)	0.23
HU (mean ± SD)	74.5 ± 6.2	48.6 ± 7.7	0.001
Male	72.1 ± 5.4	51.1 ± 5.8	
Female	78.2 ± 4.7	47.9 ± 6.9	

Most common locations for CVST in present study were superior sagittal sinus (68%), transverse sinus (59%), sigmoid sinus (53%) and cortical veins (32%). Others were straight sinus (21%), internal jugular veins (12%), vein of Galen (12%), internal cerebral vein (9%) and cavernous sinus (6%)

Table 2: Distribution of CVST.

Name of the sinus	Number of cases	(Percentage)
Superior sagittal sinus	23	68%
Transverse sinus	20	59%
a. Bilateral transverse sinuses	5	15%
b. Right transverse sinus	7	21%
b. Left transverse sinus	8	24%
Sigmoid sinus	18	53%
a. Bilateral sigmoid sinuses	2	6%
b. Right sigmoid sinus	5	15%
c. Left sigmoid sinus	11	32%
4. Internal jugular veins	4	12%
a. Bilateral internal jugular veins	0	0%
b. Right internal jugular vein	3	9%
c. Left internal jugular vein	1	3%
5. Cortical veins	11	32%
6. Straight Sinus	7	21%
7. Cavernous sinus	2	6%
8. Internal Cerebral vein	3	9%
9. Vein of Galen	4	12%

All patients underwent CVST followed by MR venography. Interpreters were kept blind for other diagnosis. On plain CT, CVST was diagnosed in 30 cases, while failed to diagnose 4 cases, which were positive on MR venography.

Table 3: CVST diagnosis

MR diagnosis	PLAIN CT diagnosis		Total
	CVST	No CVST	
CVST	30	4	34
No CVST	70	4	74

t HU levels 62, specificity and sensitivity of plain CT for diagnosing CVST was 88 % and 95 % respectively. Accuracy of plain CT at 62 HU was 93% for diagnosing CVST.

Table 4: Statistical analysis

Sensitivity	TP/(TP/FN)	88.23 %
Specificity	TN/(TN/FP)	94.59 %
Positive Predictive Value	TP/(TP+FP)	88.23 %
Negative Predictive Value	TN/(TN+FN)	94.59 %
Accuracy	(TP+TN)/(TP+TN+FP+FN)	92.59 %

CASE 1-

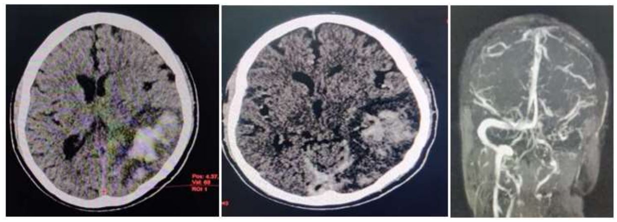

Figure 1: 50Years old male patient presented with headache, loss of memory and irrelevant speech since 2days
A: Axial plain CT shows hyperdense superior sagittal sinus with left temporo-parietal hemorrhagic infarct; **B:** Axial contrast enhanced CT shows empty delta sign with non opacification of left transverse sinus; **C:** MR Venography confirms thrombosis of distal segment of superior sagittal sinus and left transverse sinus. Hounsfield unit (HU)-68 ; Haematocrit (HCT)-42.2% ; HU: HCT=1.61

CASE 2-

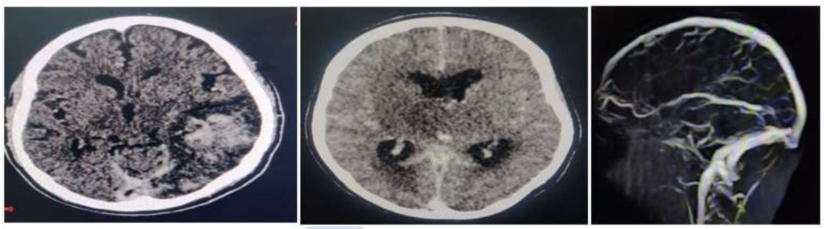

Figure 2: 26years old female patient presented with altered sensorium and 1 episode of seizure
A: Axial plain CT shows bilateral thalami infarct with hyperdense straight sinus; **B:** Axial contrast CT image shows non opacification of straight sinus confirming thrombosis, **C:** MR Venography shows occlusion of straight sinus
Hounsfield unit (HU)-63 ; Haematocrit (HCT)-42% ; HU: HCT=1.5 HU: HCT=1.61

CASE 3-

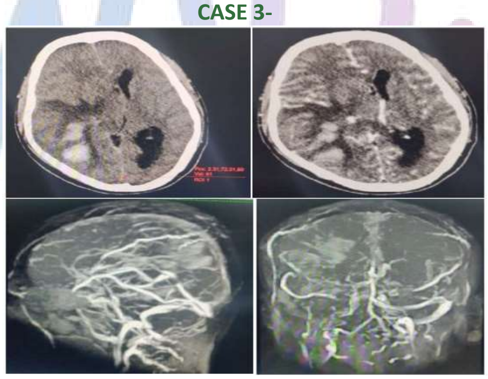

Figure 3: 40years male patient presented with altered sensorium and left hemiparesis **A:** Axial plain CT shows hemorrhagic infarct in right temporo-parietal region with midline shift to left; **B:** Axial contrast CT shows non opacification of right cortical veins and empty delta sign of superior sagittal sinus; **C and D:** MR Venography shows occlusion of superior sagittal sinus, right transverse and sigmoid sinus and right superficial cerebral veins
Hounsfield unit (HU)-61 ; Haematocrit (HCT)-41% ; HU: HCT=1.5

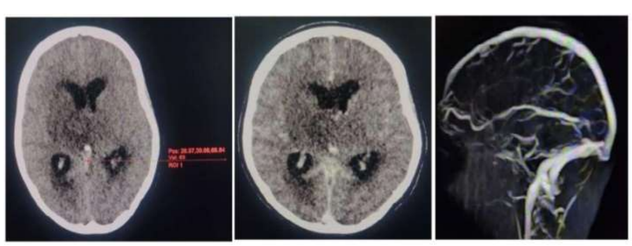

Figure 4: 26 year old patient presented with altered sensorium and 1 episode of seizure and 1 episode of seizure
A: Axial plain CT shows bilateral thalami infarct with hyperdense straight sinus; **B:** Axia contrast CT image shows non opacification of straight sinus confirming thrombosis **C:** MR venography shows occlusion of straight sinus
Hounsfield unit(HU)-63; Haematocrit(HCT)-42%; HU;HCT=1.5

DISCUSSION

The imaging modality of choice for CVST is magnetic resonance venography as it allows direct visualisation of the dural venous sinuses and the large cerebral veins.[6] It is an invasive procedure with catheterisation of the jugular vein and therefore has associated risks. Acute thrombosis within the vessel lumen is usually seen as hyperattenuating material in NCCT performed in the acute phase of the disease. The increased attenuation, usually attributed to the decreased amount of water in the retracted clot and increased concentration of red blood cells and hemoglobin.[9] In the study by Narayan *et al.*.,[10] they noted that mean age of the patients in this study being 31.3 years and had a larger proportion of males than females. Another study which recruited 612 consecutive patients of CVT from various hospitals of Mumbai had a male to female ratio of 3:2. Narayan *et al*.. and Pai *et al*..[11], have reported only 9.8% and 8% patients in the postpartum or pregnant state, respectively. Thrombus is visible on nonenhanced CT as a high-attenuation lesion in the venous channel, producing dense triangle or cord sign represents an intravascular acute blood clot.[12] With passage of time, the thrombus gets rechannelled 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.[13,14] In literature this sign has been referred to as the hyperattenuated dural sinus CVST. In a recent study by Ali Alsafi *et al*.., 768 venous sinuses were analyzed; 46 with CVST and 720 without. The average HU of vessels containing a thrombus was 68 ± 1.56, which was significantly higher than that of normal vessels 52 ± 0.28.[15] Similar findings were noted in present study. Appreciating moderate increases in attenuation by the attenuation measurement with in the dural sinus can be helpful in the detection of acute CVST.[16] Goldstein *et al*.. found a mean attenuation of 73.9 HU in thrombosed venous sinus.[17] At HU levels 62, specificity and sensitivity of plain CT for diagnosing CVST was 88 % and 95 % respectively. Accuracy of plain CT at 62 HU was 93% for diagnosing CVST. Tayyebi S *et al*..,[18] at cutoff value of 61 HU noted a sensitivity of 82% and specificity of 100%. Avsenik J *et al*..,[19] noted sensitivity and specificity of NCCT for overall presence of CVST were 100% and 83%, respectively. The ROC analysis noted a sensitivity of 85% and specificity of 87%. Quantitative measurement of attenuation is believed to be more accurate than subjective evaluation, as it can appreciate moderate increases in mean sinus density.[20] With new advancement and with thinner CT sections, this sign is detected much more frequently. Hyperdense sign of venous sinuses on NCT scan has a sensitivity of 84% and 95% and specificity of 96% and 95% with a HU (Hounsfield unit) cut-off value of 65 and 62, respectively, as shown by some recent studies.[21,22] Shayganfar *et al*..[23] noted that the attenuation value of > 60.4 Hounsfield unit (HU) with 71.4% sensitivity and Hounsfield-hematocrit (H: H) ratio of > 1.42 with 94.3% sensitivity calculated based on unenhanced CT could strongly detect CVT in the emergency setting. Diagnosis of cerebral sinus thrombosis on plain CT has a sensitivity of 50–100% and a specificity of 83–100%.[24] A meta-analysis summarizing the diagnostic accuracy of CT (non-contrast- and contrast-enhanced) for CVT noted that, the pooled sensitivity and specificity of CT were 81% (95%CI 78–84%) and 89% (95%CI 88–91%), respectively.[25] An explanation for these wide ranges may be the different scan technologies and acquisition measures used, with a generally lower sensitivity in older studies.[26] The indirect signs for CVST diagnosis on plain CT includes differential appearance of the involved cerebral parenchyma, loss of gray-white matter differentiation, focal hemorrhaging areas, white matter edema, sulcal effacement, etc.[27] Increase in parenchymal volume without attenuation or signal intensity alterations can be found, possibly as a reflection of the capillary venous congestion, with effacement of sulci, decrease in the width of the cisterns as well as in the size of the ventricular system.[27] Plain CT is imaging technique of choice for evaluation of patients with suspected CVST. Present study was a small sample size, institution based study. Large sample, multicentric studies are much needed to confirm our findings. Digge *et al*..[9] proposed that plain CT is specific enough for the diagnosis of acute CVT, and no confirmatory imaging, such as venography, is needed. However, they concluded that parallel to age clot progression, the sensitivity of CT attenuation would decrease. According to the Indian guidelines for stroke management, patients suspected to be having a stroke due to CVT should be investigated by MRI/MRV/CTV only if the CVT is not diagnosed by a CT scan.[28]

CONCLUSION

Plain CT is affordable, widely available and gives reports quickly. Prompt diagnosis and treatment of CVST has a better outcome, so early diagnosis is essential. Plain CT is imaging technique of choice for evaluation of patients with suspected acute CVST.

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