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RESEARCH ARTICLE
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A COMPARATIVE STUDY OF CT VENOGRAPHY WITH MR VENOGRAPHY IN CEREBRO SINOVENOUS THROMBOSIS

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ABSTRACT

BACKGROUND:

Cerebral venous thrombosis is an uncommon condition. Its presentation is varied and often dramatic. It often affects young to middle aged patients, and more commonly women. Although recognized for more than 100 years, it has only in recent years, come of importance. This is partly due to improved non-invasive imaging techniques for diagnosing cerebral venous thrombosis.

CSVT can lead to devastating disability and even death, if not timely diagnosed and treated[1].It is associated with a wide spectrum of etiologic factors, clinical presentation is often nonspecific, and the diagnostic imaging features can be subtle.[2]

MATERIALS AND METHODS:

A prospective study of 40 patients was done in the Department of Radiology, MGM Hospital Warangal-Telangana from December 2020 to June 2022.

The plain CT with CT venography was carried out on GE lightspeed 16 slice CT machine and plain MR with MR venography was carried out on 1.5 Tesla GE MR machine in our department. 40 patients were referred to the Department of Radiodiagnosis with clinical suspicion of cerebral venous thrombosis and plain CT showing suspicious signs of CSVT.

RESULTS:

In our study 31-40 years was the common age group involved with 43% patients falling into this bracket. Sensitivity of plain CT in diagnosing CSVT-60% Specificity of plain CT in diagnosing CSVT-87%. Percentage of hemorrhagic lesion detected on T1W/T2/FLAIR- 91% Percentage of hemorrhagic lesion detected on GRE- 100%. Percentage of hemorrhagic lesion detected on T1W/T2/FLAIR- 91% Percentage of hemorrhagic lesion detected on GRE- 100%. The most common sinus involved- SSS (37.5%) Incidence of superficial venous thrombosis-81% Incidence of deep veins thrombosis- 20% Incidence of cortical venous thrombosis- 7.5%.

CONCLUSION:
CSVT was common in 31-40 years old age group and male sex in our study. Dehydration followed by alcohol abuse and post-partum status were the most common risk factors. Sensitivity and specificity of plain CT was 60% and 87% respectively with diagnosing features being hyperdense sinus/cord sign, hemorrhagic infarct and non-hemorrhagic infarct. Parenchymal changes in cerebral venous thrombosis were better evaluated on MRI. Venous abnormalities were better depicted in MRI as loss of flow voids in T1, T2 and with dark signal on GRE. Hemorrhagic bleeds were easily evaluated on MRI with 100% sensitivity with GRE sequence; few showed only hypodensity on CT probably related to chronicity of bleed. CT Venography was easier to interpret, showed better and faster depiction of sinuses, with thin section reformatted images, when imaged with a delay of 45 seconds. CT venography showed higher spatial resolution compared to MR venography. Hypoplastic sinuses were easily visualized on CT Venography with smaller ipsilateral jugular foramen on bone window. Thorough evaluation of all pulse sequences is important, to detect slow flow, arachnoid granulation and loss of flow voids in thrombus. We conclude that CT venography is superior to MR venography in identifying cerebral veins and in diagnosing dural sinus thrombosis.

INTRODUCTION
Cerebral venous thrombosis has an annual incidence of 3-5 cases per million in adults in general population. It has been thought that the incidence of CSVT may be more in India compared to the western countries. 3 out of 4 people with CSVT are women. CSVT has an acute fatality rate of less than 5% and almost 80% of the patients recover without any sequelae. Venous infarcts are an important cause of strokes. Venous infarcts account for 10-20% of strokes in young individuals. So accurate and prompt diagnosis is crucial, because timely and appropriate therapy can reverse the disease process and reduce the risk of complications. However, CSVT is a challenging diagnosis. The diagnostic difficulty results in large part from the wide variety of clinical manifestations of this uncommon disorder. The mode of onset can vary from acute to chronic. CSVT presents with a wide spectrum of symptoms and signs. Headache is the most common presenting symptom. Focal deficits such as hemiparesis, seizures, impairment of consciousness and papilledema occur in a few cases. CSVT most commonly involves superior sagittal sinus followed by transverse sinus. In 30- 40% of patients more than one sinus is involved.
The correct diagnosis of CSVT relies on neurologic imaging. Radiologists play a crucial role in patient care by providing early diagnosis through interpretation of imaging studies. Early diagnosis leads to prompt treatment that can be effective. Delayed diagnosis is associated with high morbidity and mortality[2].

Imaging modalities of choice in CSVT are CT scan, CT venography, MRI and MR venography. CT scan may be normal in 15-30% cases but MRI with MRV is almost diagnostic. MRI and MR venography are the preferred investigations done for cerebral venous thrombosis. In a developing country like India, as per 2010 census, we have about 3000 CT scanners and 500 MRI machines. There are many districts in our country without a single MRI machine facility. As CT is a more available investigation in our country, we are trying to demonstrate the efficacy of CT venogram in diagnosing cerebral venous thrombosis by taking MR venogram as a gold standard investigation.
Plain CT shows nonspecific signs like venous infarcts, diffuse brain oedema and specific signs like dense sinus sign, cord sign. CT venography is a rapid, readily available technique for detecting venous thrombosis. CT venography is defined as a fast-thin section volumetric helical CT examination performed with a time optimized bolus of contrast medium to enhance the cerebral venous system.
On conventional MRI, patent dural sinuses are seen as flow voids. This is better seen when the imaging plane is orthogonal to blood flow direction. On T1, thrombus with methemoglobin is seen as a hyperintensity. On T2, exaggerated signal loss is due to deoxyhemoglobin, methemoglobin. Diffusion weighted techniques allow sub classification of parenchymal abnormalities as vasogenic edema (increased ADC values due to venous congestion) or cytotoxic edema (decreased ADC values related to cellular energy disruption); MR venography can be performed using a TOF technique or by

using gadolinium.
Current therapy options for CSVT include anti-thrombotic therapy with unfractionated heparin, low molecular weight heparins, oral anticoagulants and rarely intravenous thrombolysis, local thrombolysis. As 80% of patients recover without any sequelae, it has been found that early diagnosis of CSVT is essential because early treatment may prevent morbidity and is lifesaving.

Therefore, a prospective observational study has been undertaken to describe the clinical profile and diagnosis of CSVT.

ABBREVIATIONS
CSVT- Cerebral sinovenous thrombosis, MDCT- Multidetector Computed Tomography, MRI- Magnetic resonance imaging, DWI- Diffusion weighted imaging, ADC-Apparent diffusion coefficient, T1W- T1 weighted, T2W- T2 weighted, FLAIR- Fluid attenuated inversion recovery, GRE-Gradient recalled echo, DSA-Digital subtraction angiography, MP RAGE- Magnetization-prepared rapid acquisition with gradient echo, MIP- Maximum intensity projection, SSD- Surface shaded display, VR-Volume rendering, SSS- Superior sagittal sinus, TS-Transverse sinus, LS- Lateral sinus, V. of Galen- vein of Galen, TOF-Time of flight, NEX-Number of excitations, FOV-Field of volume, GCS- Glasgow coma scale.

AIM
To compare CT Venography and MR Venography in the diagnosis of cerebral venous thrombosis and to determine the reliability of CT venography in diagnosing CSVT using MR venography as the gold standard.

OBJECTIVES
- To identify the anatomic components of the cerebral venous system.
- To evaluate the imaging characteristics of cerebral venous thrombosis on CT and MR imaging.
- To appreciate the diagnostic pitfalls of MR venography and CT venography in the diagnosis of cerebral venous thrombosis.

Materials and methods
PLACE OF STUDY: Department of Radiology, MGM Hospital Warangal-Telangana
DURATION OF STUDY: December 2020 to June 2022 (2 Years 6 months)
SAMPLE SIZE: 40
STUDY DESIGN: A prospective study of 40 patients was done in our department. Institutional ethics committee clearance was obtained prior to study. Written informed consent was obtained from subjects for inclusion of their images in the study, with standard disclosures.
The plain CT with CT venography was carried out on GE lightspeed 16 slice CT machine and plain MR with MR venography was carried out on 1.5 Tesla GE MR machine in our department.

INCLUSION CRITERIA:
40 patients referred to the Department of Radiodiagnosis with clinical suspicion of cerebral venous thrombosis and plain CT showing suspicious signs of CSVT in a period of 2 years 6 months from 2020 to June 2022 were subjected for the study.

DIAGNOSTIC CRITERIA:
Patients presenting with history and examination suggestive of cerebral venous thrombosis and confirmed by CT venography and MR venography.
CT venography shows filling defect with enhancing dural sinus walls, MR venography shows loss of hyperintense signal within the thrombosed sinuses.

EXCLUSION CRITERIA:

- Patients with high renal parameters
- Patients with metallic implants
- Claustrophobic patients
- Pregnant patients
- Patients with hypersensitivity to CT contrast agents and patients in whom CT is contraindicated due to any other reason

METHOD:

PREPARATION OF PATIENTS:

Prior to performing the scan patient was explained details of procedure and advised not to move during procedure to avoid motion artefacts.

Written informed consent for participation in the study was taken prior to the scan. Sedation was given by anaesthetists or paediatricians to patients whenever required.

CT and CT VENOGRAPHY:

CT is usually the first imaging study performed on an emergency basis. CT and CT venography were performed on GE lightspeed 16 slice machine. The important patient factor influencing CT is motion. Therefore, patients were instructed to be motionless during the procedure. CT venography was acquired as fast thin section volumetric helical CT examination performed with a time-optimized bolus of contrast medium in order to enhance the cerebral venous system[3]. To visualize the intracranial veins and sinuses, the examination included the region from the calvarial vertex down to the first vertebral body. We include the atlas (C1) in the study to ensure incorporation of the origin of the jugular internal veins.

Patient position- supine with their arms by their side

Scout- C1 to the vertex

Scan extent-C1 to the vertex

Scan direction-caudocranial

Contrast injection considerations- injection ;75-90 ml of non-ionic iodinated contrast at 4.5ml/second with pressure injector with a saline chase of 35 ml at 3ml/second

Scan delay-45 seconds

Respiration phase- suspended

Data acquisition and analysis

Images are analyzed on a dedicated workstation.

Proper evaluation of dural sinuses indicates proper inspection of the axial thin-section contrast-enhanced source images of a helical CT scan.

Two-dimensional (2D) & three-dimensional (3D) multiplanar images, as well as rendering techniques such as maximum intensity projection (MIP), surface shaded displays (SSD) and volume rendering (VR) in a sagittal, coronal, and oblique planes were acquired.

An essential step in CT venography is the removal of bone from the images, by graded subtraction.

Postprocessing

Because all methods of three-dimensional (3D) imaging are subject to some loss of information, none of them can substitute for the thorough analysis of source images. Evaluation of venous structures includes multiplanar reformatting on a 3D workstation, in which the loss of information is minimized. With an isotropic volume acquisition, sagittal, coronal, and oblique planes can be reformatted with the same quality as the source image [4]. Our practical analysis of CT venography is standardized and involves the following steps:

First, two-dimensional (2D) MPR images are used to visualize dural venous sinuses and cerebral veins, with adequate window level and width. Windows settings are wider than those typically used for brain parenchyma[5]. The source images are displayed with a window higher than or equal to 260 HU and a level of approximately 130 HU to clearly visualize the cerebral veins and dural sinuses as

separate from the adjacent bone of the calvaria. Second, 2D maximum intensity projection (MIP) series are created and saved.

These first two steps require approximately 5 minutes and are sufficient in cases of superficial sinus and deep cerebral venous thrombosis. Optional reformations include 3D MIP and volume rendering display algorithms, which typically require less than 5 minutes. Again, postprocessing with a 3D integral display algorithm is performed in cases of cortical venous thrombosis and requires 10 –15 minutes.

MR and MR VENOGRAPHY:

Patient preparation

- Magnetic resonance venography (MRV) brain
- A satisfactory written consent form must be taken from the patient before entering the scanner room.
- Ask the patient to remove all metal objects including keys, coins, wallet, cards with magnetic strips, jewelry, hearing aid and hairpins.
- If possible, provide a chaperone for claustrophobic patients (e.g. relatives or staff) Offer earplugs or headphones, possibly with music for extra comfort.
- Explain the procedure to the patient. Instruct the patient to keep still.
- Note the weight of the patient.

Positioning - Magnetic resonance venography (MRV) brain

Headfirst supine

Position the head in the head coil and immobilize with cushions Give cushions under the legs for extra comfort.

Centre the laser beam localizer over the glabella.

Suggested protocols, parameters and planning

Localizer

A three-plane localizer must be taken to plan the sequences. Localizers are normally less than 25seconds, T1 weighted low resolution scans.

T2 TSE axial

Plan the axial slices on the sagittal image; angle the position block parallel to the genu and splenium of the corpus callosum. Slices must be sufficient to cover the whole brain from the vertex up to the line of the foramen magnum. Check the positioning block in the other two planes. An appropriate angle must be given in a coronal plane on a tilted head (perpendicular to the line of 3rd ventricle and brain stem).

Parameters: TR-3000-4000, TE-100-200, Slice thickness- 5mm, Flip 130-150, Phase- R>L, matrix-320X320, FOV- 210-230, gap- 10%, NEX- 2.

T2 FLAIR axial

Parameters: TR-7000-9000, TI-2500, TE-110, Slice thickness-5mm, Flip 130, Phase R>L, FOV – 210-230, matrix-320X320, gap-10%, NEX-2

T1 SE axial :

Parameters:TR-400-600, TE-15-25, Slice thickness-5mm, Flip-90, Phase-R>L, FOV-210- 230, matrix-320X320, gap- 10%, NEX-2

DWI epi3scan trace axial

Parameters: TR-7000-9000, TE-110, Flip-130, NXA -4, Slice-5mm, FOV-210-230, Phase- R>L, B value- 0,500,1000

GRE / T2* axial:

Parameters: TR-825, TE-25.9, Flip- 20, slice- 5mm, phase- R>L, matrix -320X320, NXA-2, gap-10%

2D time-of-flight (TOF)

Plan the sagittal 3D or 2D block on the axial plane; angle the position block 10° to midline of the brain. Check the positioning block in the coronal plane and angle 10° to midline of the brain. This angulation is to reduce the inplane saturation effects. Position the saturation band at the bottom of the

block in the sagittal and coronal plane to void the arterial signals.
Parameters: 2D time-of-flight (TOF):TR- 28-35, TE5-8, FLIP 60, SLICE 2MM, FOV250, PHASE A>P
Maximum intensity projection (MIP)
MIP is the most commonly used post-processing technique in MRI vascular studies. MIP reconstructs a 2D projection image from 3D data by a ray tracing algorithm, which produces an image of white pixels representing the highest intensity signal in that location within the examined volume.

Results

Table1: Showing Age distribution of CSVT

Age in years	No. of patients	Percentage
10-20	4	10
21-30	9	22
31-40	17	43
41-50	7	18
>50	3	7

In our study 31-40 years was the commonest age group involved with 43% patients falling into this bracket.

Table 2: Showing distribution of risk factors

	No. of patients	Percentage (%)
Postpartum	5	12.5
Alcoholics	6	15
Hyperhomocystinemia	1	2.5
Oral contraceptives	3	7.5
Mastoiditis	2	5
HIV	1	2.5
Malignancy	1	2.5
Dehydration	9	22.5
Anemia	2	5
AT3, protein C and protein S	2	5
Other comorbidities- CCF, nephrotic syndrome	2	5
No risk factor	6	15

Table 3: Showing distribution of symptoms at presentation

Symptoms	No. of patients	Percentage
Headache	37	91
Seizures	22	44
Vomiting	27	75
Diplopia	20	36
Fever	15	27
Aphasia	17	42
Focal deficits	24	37
Altered sensorium	21	53.5

Table 4: Showing distribution of mode of onset

Mode of onset	No. of patients	Percentage(%)
Acute(<48 hours)	14	35
Sub-acute(48-1 month)	24	60
Chronic(>1 month)	2	5
Total	40	100

Table 5: Showing clinical signs at presentation

Signs	No. of patients	Percentage (%)
Hemiparesis	15	37.5
Papilledema	15	37.5
Pallor	8	20
Cranial nerve involvement	12	30
Dysphasia	6	17.5

Table 6: Showing distribution of NCCT findings

	No. of patients	Percentage
Hyperdense sinus/cord sign	24	60
Non hemorrhagic infarct	9	22.5
Hemorrhagic infarct	23	57.5

Table 7: Lobe wise distribution of bleed on CT

	No. of patients	Sinus involved	Percentage
Frontal lobe	Right-2	SSS (9/9)	22.5
	Left-4		
	Bilateral-3		
Parieto-temporal lobe	Right-7	Transverse sinus (11/12)	27.5
	Left-5		
Thalami	Bilateral-2	Deep Veins (2/2)	5%

Sensitivity of plain CT in diagnosing CSVT-60% Specificity of plain CT in diagnosing CSVT-87%

Table 8: Showing distribution of thrombus on CT Venography

	location	No. of sinuses involved	percentage
Superior sagittal sinus		16	40
Transverse sinus	right	12	30
	left	13	32.5
	both	7	17.5
Sigmoid sinus	right	12	30
	left	9	22.5
	both	4	10
IJV	right	9	22.5
	left	10	25
	both	2	5
Vein of Galen and deep veins		9	22.5
Straight sinus		10	25
Cortical veins		4	10

Table 9: Conventional MRI findings

	Parenchymal abnormalities		Venous Thrombus
	Vasogenic edema	Hemorrhagic infarct	
T2W	20(50%)	20 (50%)	23(58%)
FLAIR	20(50%)	20 (50%)	25(63%)
T1W	15(38%)	22 (55%)	23(58%)
GRE	-	23 (55%)	25(62.5%)
DWI	-	9 (23%)	9 (23%)

Percentage of hemorrhagic lesion detected on T1W/T2/FLAIR- 91% Percentage of hemorrhagic lesion detected on GRE- 100%
Sensitivity of GRE in hemorrhagic lesions-100%
Percentage of venous thrombus detected on GRE-62.5%
Sensitivity of GRE in venous thrombus-62.5%

Table 10: Lobe wise distribution on MRI:

	No. of patients	Sinus involved in MRV	Percentage (%)
Frontal lobe	Right- 2	SSS (9/9)	5
	Left- 4		10
	Both-3		7.5
Parieto temporal lobe	Right-6	Transverse sinus (10/11)	15
	Left-5		12.5
Thalami	Unilateral-3	Deep veins (9/11)	7.5
	Bilateral-8		20

Table 11: Showing distribution of thrombus on TOF MRV

	location	No. of sinuses involved	Percentage (%)
Superior sagittal sinus		15	37.5
Transverse sinus	Right	12	30
	Left	13	32.5
	Both	7	17.5
Sigmoid sinus	Right	10	25
	Left	8	20
	Both	2	5
Vein of Galen and deep veins		8	20
Straight sinus		10	25
Cortical veins		3	7.5

MRV
The most common sinus involved- SSS (37.5%) Incidence of superficial venous thrombosis-81% Incidence of deep veins thrombosis- 20% Incidence of cortical venous thrombosis- 7.5%

Table 12: Showing frequency of visualization of sinuses on CTV and TOF MRV

Sinus or vein	Frequency of visualization on images	
	CTV	MRV
Superior sagittal sinus	40/40(100)	40/40(100)
Transverse sinus	80/80(100)	75/80(93.7)
Straight sinus	40/40(100)	40/40(100)
Galen vein	40/40(100)	40/40(100)
Internal cerebral veins	80/80(100)	80/80(100)
Basal Rosenthal veins	80/80(100)	76/80 (94.6)
Thalamostriate veins	76/80(94.6)	72/80 (90)
Inferior sagittal sinus	34/40 (85)	28/40(70)

Table 13: Common anatomical variants seen on CTV and MR venography

	CTV	MRV
Hypoplastic transverse sinus	Right- 4 , left – 15	Right- 3, left- 12
Hypoplastic sigmoid sinus	Right-3, left-10	Right- 3, left- 7
Persistent occipital sinus	2/40	2/40
Vein of Galen malformation	1/40	1/40
Arachnoid granulation	10/40	10/40

Discussion

Cerebral venous thrombosis is characterized by thrombosis of intracranial veins and sinuses which results in parenchymal damage and a rise in intracranial pressure. The radiological hallmark of this condition is thrombosis of intracranial sinuses and veins with hemorrhagic infarction and oedema with or without evidence of herniation. In this study, a total of 40 patients with clinical and radiological features of cerebral venous thrombosis were evaluated over a period of 2 years. 24 out of 40 patients were male and remaining were female. This study of 40 patients with CSVT cannot give precise information about the real incidence of the disease and hence cannot make any generalization of the results to the whole country. It has been suggested that the incidence of CSVT was higher in females and in the aged, this was not confirmed in the present series, in which male: female ratio was (1.33:1) This data is not consistent with previous Indian studies Nagaraja et al[6](1987), viz. Bansal et al (1980)[7]. High proportion of post-partum CSVT patients was also observed by Cantu et al [8](1996), from Mexico with similar socio-demographic characteristics and economic status of the patients as in India. In the present study, dehydration was the major risk factor in 22.5 % of patients. More than half of the patients of CSVT evaluated were in the second and third decade of their age (24/40). The mean age of the patients was 32.2 years (SD13.14) like earlier studies from India. Like all other series, the present one represents a selected group of patients that are not representative of the numerous causes that have been described.

However, it confirms the fact that the frequency of septic CSVT (5/40) has markedly declined with the advent of antibiotics.

In the present cohort in addition to conventional risk factors, alcohol abuse (15%), postpartum (12.5), hyperhomocystinemia (2.5%), OCP pill use (7.5%) are significant risk factors. 5% of patients had anemia. Whether this reflects high incidence of anemia in Indian population particularly in pregnant females or anemia is a real risk factor needs further evaluation. In 7/40 cases, no cause could be found, however complete etiological workup could not be completed. Headache (37/40) with or without vomiting (27/40), seizures (22/40), altered sensorium (21/40) and Focal deficits (15/40) Papilledema (15/40) were the major clinical features noted at presentation.

Similar findings were noted in the earlier studies[1],[7]. The clinical presentation could be summarized in 3 main patterns, each of them simulating another neurological disease. The most frequent and

homogeneous one was the progressive onset of signs of intracranial hypertension (28/40). The second presentation was the sudden onset of focal deficits simulating arterial strokes but with more frequent seizures (15/40). Other less common presentations are headache of sudden onset simulating subarachnoid hemorrhage (1 patient) It is therefore clear that CSVT has no single clinical presentation, and this is why it is necessary to systematically contemplate this diagnosis in order not to overlook it. In this study of 40 cases, hyperdense sinus was seen in (24/40) cases, all of whom were presented within 3 days of onset of symptoms. According to Besachio[9], in a study done on NCCT HU value in evaluation of CSVT, applying HU threshold values of greater than 65 and veno-arterial difference values greater than 15 were considered significant for CSVT.
In the present study, HU threshold values greater than 70 and veno-arterial difference greater than 15 were considered significant for CSVT, which was confirmed on CT venography. The sensitivity of plain CT in diagnosing CSVT in our study is 60%, while specificity is 87%. Hyperdense sinus was the major presenting sign on CT in acute stage. Non hemorrhagic infarct or hypodensity was seen in (8/40) cases. In most of the 8 cases the hypodensity was bilateral and in high parasagittal location. Hemorrhagic infarct was seen in (23/40) cases. Hemorrhagic infarcts which were not seen in hypertensive locations like basal ganglia, pons, cerebellum were suspicious of venous infarcts. In patients who presented with bleed with extensive edema, right after the onset the symptoms, favored venous bleeds. In our study 11/23 cases had hemorrhagic infarcts in temporal lobes and 9/23 cases had hemorrhagic infarcts in high parasagittal sub cortical location. Four patients also presented with subarachnoid, and two patients presented with subdural hemorrhage in addition to temporoparietal bleed. In this study we saw (2/40) cases who were presented with bilateral thalamic hypodensity, which was confirmed as deep cerebral venous thrombosis. In 16 out of 40 patients, plain CT appeared normal, and further investigation was done based on clinical findings. Two patients presented with hydrocephalus and two of our patients presented with ear discharge and soft tissue density in mastoid air cells. In CT venography, a total of 107 sinuses were involved in 40 cases. SSS involvement was seen in 40% of cases, and left transverse sinus showed similar percentage. Right transverse sinus was involved in 25% of cases with involvement of bilateral transverse sinuses in 12% of the cases. The present series confirms the fact that isolated single sinus involvement was less common than multiple sinus involvement. In isolated sinus involvement most frequently involved are SSS and transverse sinus. Straight sinus was involved in 10/40 (25%) and vein of Galen was involved in 9/40 (22.5%). In our study, we did not come across any case of isolated cortical CSVT. Cortical veins were involved in 10% of patients, in which sinus involvement was also seen. Basal vein of Rosenthal was involved in (2/40) cases. In cases who presented with mastoiditis involvement of ipsilateral transverse and sigmoid sinus was noted. In two patients who presented with chronic CSVT a thin linear hypodense non enhancing, filling defect was noted in superior sagittal sinus. In one case of chronic CSVT we observed early filling of superior sagittal sinus and right transverse sinus due to formation of a dural arteriovenous fistula. In two cases who presented with signs of raised ICT and hydrocephalus, also showed basal cisternal enhancement in addition to filling defect in transverse sinuses.

We encountered 2 cases of persistent occipital sinus, and a case of congenital vein of Galen malformation with persistent falcine sinus. Anatomical asymmetry of transverse sinus was the most observed anatomical variant with involvement of 40% of cases. Left transverse sinus was hypoplastic in 81% of such cases. High splitting superior sagittal sinus was noted in 4/40 patients. Arachnoid granulations were found in 10/40 patients. These arachnoid granulations were most commonly 8/10 noted in the dominant transverse sinus , and in SSS in 2/10 patients. These are hypodense CSF attenuation non-enhancing round filling defects.

MR:
Diffusion restriction in the sinuses was seen in 9/40 cases (22.5%), diffusion restriction within the hemorrhagic infarction was also noted in 12/40 cases. The incidence of cases with cytotoxic edema in our study was 23%, whereas with vasogenic oedema was 65%. This corresponded to various stages of bleed and cytotoxic oedema within the infarction. In venous infarction, initially there is vasogenic

edema, and in later stages we have cytotoxic oedema due to congestive changes. Flow voids were better visualized on T2 images, while T1 images commonly showed peripheral hyperintense content with central flow void. Loss of flow void in T1 and T2 spin echo images was seen in 20/40 cases. The plane of imaging should be perpendicular to the sinuses to be assessed. Transverse and sigmoid sinuses were better evaluated on sagittal sections. While SSS was evaluated on coronal sections. In hemorrhagic infarct patients, all of them showed findings on GRE with marked signal loss. Dark signal was seen in the involved sinuses in 25/40 (62.5%) of patients.

In TOF MRV 98 sinuses were totally involved. Flow gaps were noted in 15 cases in the hypoplastic transverse sinuses (more commonly on the left side). This also corelated with study done by Ayanzen11.

On comparison of CT venography and 2D TOF MR venography, 107 sinuses were involved in CT venography while 98 sinuses were involved in MR venography. Transverse sinuses were better evaluated in CT venography, with the size of jugular foramen on bone window differentiating hypoplastic sinuses with ease.
Cortical veins thrombosis was visualized better in CT Venography. Basal Rosenthal veins and thalamostriate veins were better visualized on CT venography than on 2D TOF MRV. Inferior sagittal sinus was visualized in 34/40 cases in CTV and in 28/40 cases in TOF MRV. Hypoplastic transverse sinus was better evaluated in CT venography, with a confusion of flow gaps versus thrombosis on TOF MR venography. Sigmoid and IJV were better evaluated on CT venography within plane flow on TOF MRV. 80/80 transverse sinuses were visualized on CTV whereas 75/80 transverse sinuses were noted on MRV. 2/7 sinuses were thought to be thrombosed on MRV, whereas 5/7 transverse sinuses were thought to be aplastic. However, they appeared hypoplastic on CTV. Arachnoid granulation were visualized as rounded, non-enhancing, CSF attenuation filling defects noted on CT venography, whereas they showed loss of hyperintense signal on MRV, which had to be correlated with plain MR, T2/FLAIR sequences as small rounded T2 hyper/FLAIR hypointense lesions. Slow flow states, complex flow patterns present as a problem on MRV, whereas CT venograms are easier to interpret.
Comparison of the advantages and disadvantages of CT and MRI in the diagnosis of CSVT

Table 14: advantages and disadvantages of CT+CTV versus MRI+MRV

	CT+CTV	MRI+MRV
Advantages	Good visualization of superficial and deep venous sinuses Readily available Fewer motion artefacts	Good visualization of superficial and deep venous sinuses Good definition of brain parenchyma Early detection of ischemic
	Can be used in patients with pacemaker, defibrillator, or claustrophobia	changes No radiation exposure Detection of microbleeds and chronic bleeds
Disadvantages	Exposure to ionizing radiation Risk of contrast reactions Risk of iodinated contrast nephropathy Low resolution of parenchymal abnormalities	Time consuming Motion artefacts Availability Can't be used in patients with pacemakers or claustrophobia Slow flow states, complex flow patterns, and normal anatomic variations in dural sinus flow can affect the interpretation.

In a study done by N.Khandelwal[12], in 2006, 30 of 50 patients were found to have cerebral venous thrombosis on both CT venography and MR venography with MR venography as gold standard, CT venography was found to have a specificity, sensitivity value of 75-100% depending on the sinus

involved.

In a study by Ozsvath et al[13], 24 patients underwent both CT venography and MR venography of the intracranial venous circulation. Dural sinus thrombosis was diagnosed in eight of the 17 patients with suspected CVT using MR venography. In these eight patients, the diagnosis was also made with CT venography. CT venograms revealed greater small-vessel conspicuity. The superior sagittal sinus, straight sinus, Galen's vein, and internal cerebral veins were visualized in all CT and MR venograms. Both the right and left transverse sinuses were present in all CT venograms. However, MR venography failed to show one transverse sinus in each of the four patients. CT venography was also more reliable in revealing the basal Rosenthal's veins, the thalamostriate veins, and the inferior sagittal sinus. Those authors concluded that CT venography is superior to MR venography in identifying cerebral veins and dural sinuses and is at least equivalent in diagnosing dural sinus thrombosis.

In a study by Wetzel et al.[14], 25 patients underwent both intraarterial digital subtraction angiography and CT venography to compare the reliability of the two techniques in imaging cerebral vein anatomy and pathology. When digital subtraction angiography was used as the standard of reference, MPR images had an overall sensitivity of 95% (specificity, 19%) and MIP images, a sensitivity of 80% (specificity, 44%), in depicting the cerebral venous anatomy. On the basis of an interobserver consensus including digital subtraction angiography, MPR images, and MIP images, the sensitivity and specificity were 95% and 91% for MPR, 90% and 100% for digital subtraction angiography, and 79% and 92% for MIP images. MPR images were superior to those of digital subtraction angiography in showing the cavernous sinus, the inferior sagittal sinus, and the basal Rosenthal's vein. Venous occlusive diseases were correctly recognized on both MPR and MIP images. Those authors concluded that CT venography is a reliable method for depicting cerebral venous structures.

In our study, in cases of superficial venous system thrombosis, plain CT showed normal scans in 16 cases, while MRI was normal in 12 cases. This discrepancy was probably due to late presentation of cases with resolved bleed on CT but persistent blooming foci on GRE. In patients who presented with isolated deep venous thrombosis, 2 cases showed non hemorrhagic infarcts on plain CT, which had blooming on GRE with a conclusion of hemorrhagic infarcts in bilateral thalami. In cases presenting with thrombosis of both superficial and deep venous system, 11 cases on MR showed hemorrhagic infarcts while it was diagnosed as non-hemorrhagic infarcts in 4 of these cases on CT. Our observation is that parenchymal changes were better evaluated on MRI especially those who presented with hemorrhagic infarcts as it was better and easily visualized on GRE.

Loss of flow void on MR sequences was seen in 25/40 patients. Loss of flow void was better seen on T2 images than T1. GRE showed dark signal void in the thrombosed sinuses.
Hyperdense sinus (Cord sign or delta sign) on CT was visualized in 24/40 cases of CSVT. This is probably due to density changes in bleed/ thrombus as days pass by. Venous and parenchymal abnormalities were better visualized on MRI in comparison to CT.
In CT venography 107 sinuses were involved, while on 2D TOF MRV 98 sinuses were involved.

This disparity in 9 patients was due to anatomical variant of hypoplastic transverse sinus which presented as loss of hyperintense signal in proximal 1/3rd of transverse sinus, this was better evaluated on CT venography with small hypoplastic transverse sinus and ipsilateral small jugular foramen. Arachnoid granulations were equally detected on CT Venography and using FLAIR/T2 spin echo MR sequences. Our findings also correlate with study done by Oszavath[8] which concluded that CT venography is superior to MR venography in identifying cerebral veins and dural sinuses and is at least equivalent in diagnosing dural sinus thrombosis. However, in evaluating parenchymal/venous abnormalities in CT/MR, MR showed better correlation in detecting parenchymal/venous changes.

Table 15: Unenhanced CT and MRI findings in CSVT patients

Group	no. of patients	CT/MRI findings of parenchymal abnormalities			CT/MRI findings of venous abnormalities		
		normal	Non h'gh Infarct	H'gh infarct	normal	Cord sign	Loss of flow void (MR)
Superficial venous system thrombosis	25	13/9	4/4	15/18	13/9	11	15
Isolated deep venous thrombosis	2	-	2/1	0/2	0/0	3	2
Thrombosis of both superficial and deep venous system	13	3/3	4/3	3/11	3/3	10	8
Total	40	16/12	10/8	23/31	16/12	24	25

Table 16: Frequency of thrombosis of major sinuses on CT venography and 2D TOF MR venography

Sinus or vein	location	CT venography	MR venography
Superior sagittal sinus		16	15
Transverse sinus	right	12	12
	Left	13	13
	Both	7	7
Sigmoid sinus	right	12	10
	Left	9	8
	both	4	2
Straight sinus		10	10
Vein of Galen		9	8
Cortical veins		4	3
Total sinuses		107	98

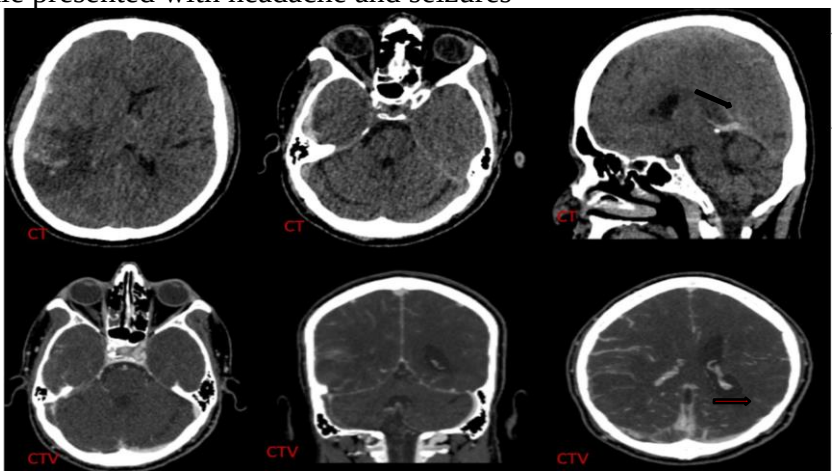
Table 17: Sensitivity, specificity, positive predictive value(PPV), negative predictive value(NPV), and accuracy of CT venography when using MR venography as gold standar

	sensitivity	specificity	PPV	NPV	Accuracy
SSS	100	88.24	77.78	100	91.67
Right transverse sinus	90	100	100	92.31	95.45
Left transverse sinus	100	83.33	84.62	100	91.3
Right sigmoid sinus	100	89.47	85.71	100	93.55
Left sigmoid sinus	100	94.74	92.86	100	96.86
Straight sinus	100	100	100	100	100
Vein of Galen	100	100	100	100	100

Table 18: Comparison of sensitivity and specificity values of CTV in comparison with 2D TOF MRV between our study and N.Khandelwal study[15]

Sinus or vein	Our study		N.Khandelwal study[15]	
	sensitivity	specificity	sensitivity	specificity
SSS	100	88.24	94.7	81.8
Right transverse sinus	90	100	83.3	94.4
Left transverse Sinus	100	83.33	100	100
Right sigmoid sinus	100	89.47	100	85.7
Left sigmoid sinus	100	94.74	90	90
Straight sinus	100	100	80	96
Vein of Galen	100	100	75	96

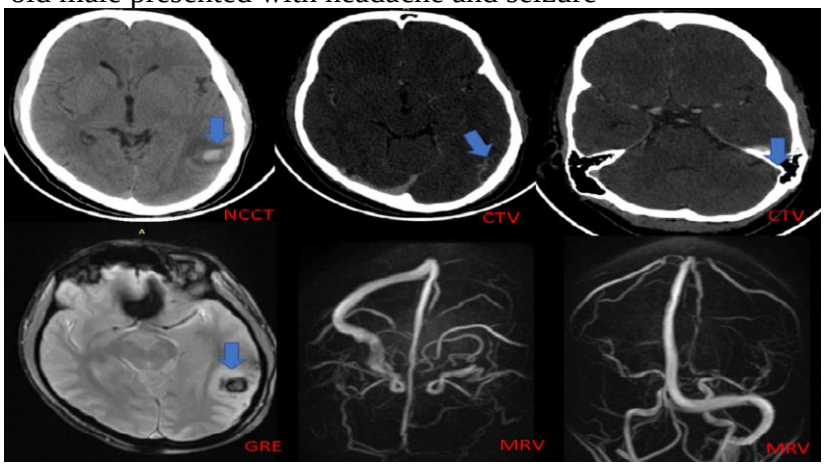
Case 1:
A 36-year-old male presented with headache and seizures



CT-hemorrhagic infarct in right temporal lobe, SDH along right temporal convexity, hyperdense vein of galen, straight sinus; CTV- right transverse, right sigmoid, straight sinus thrombosis.

Diagnosis- CSVT involving right transverse, sigmoid and straight sinus with right temporal lobe hemorrhagic infarction and SDH along right temporal convexity.

Case 2:
A drowsy 28-year-old male presented with headache and seizure

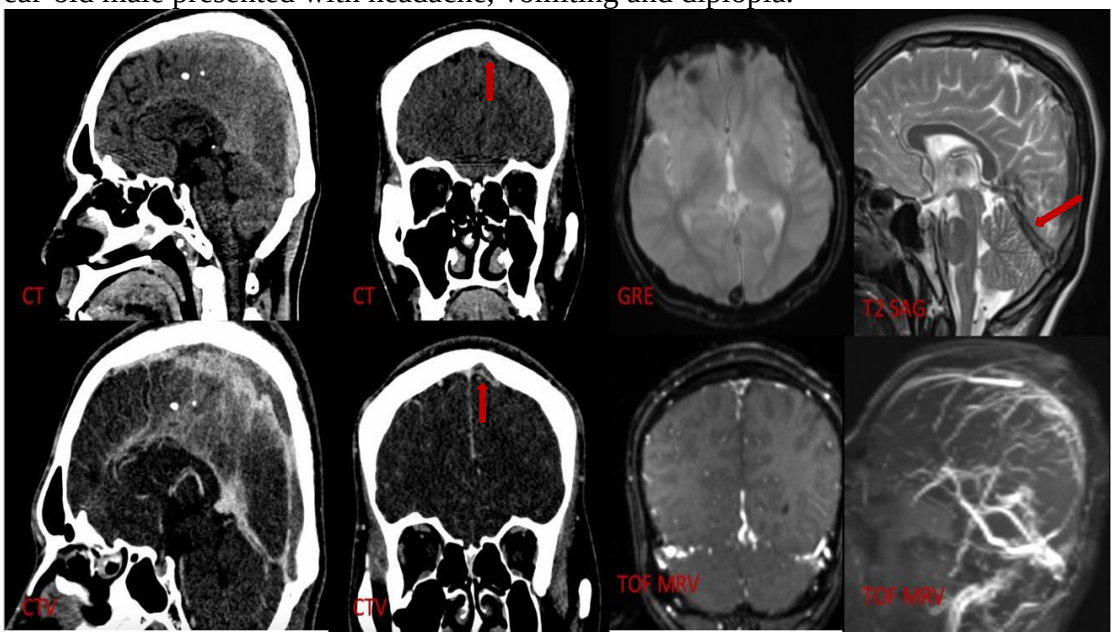


NCCT – hemorrhagic infarct in left temporal lobe CTV – Filling defect noted in left transverse and sigmoid sinus MRI (GRE) – Blooming in left temporal lobe. MRV – loss of normal signal intensity of left transverse and sigmoid sinus.

Diagnosis- CSVT involving left transverse and sigmoid sinus with left temporal lobe hemorrhagic infarct.

Case 3:

A 25-year-old male presented with headache, vomiting and diplopia.

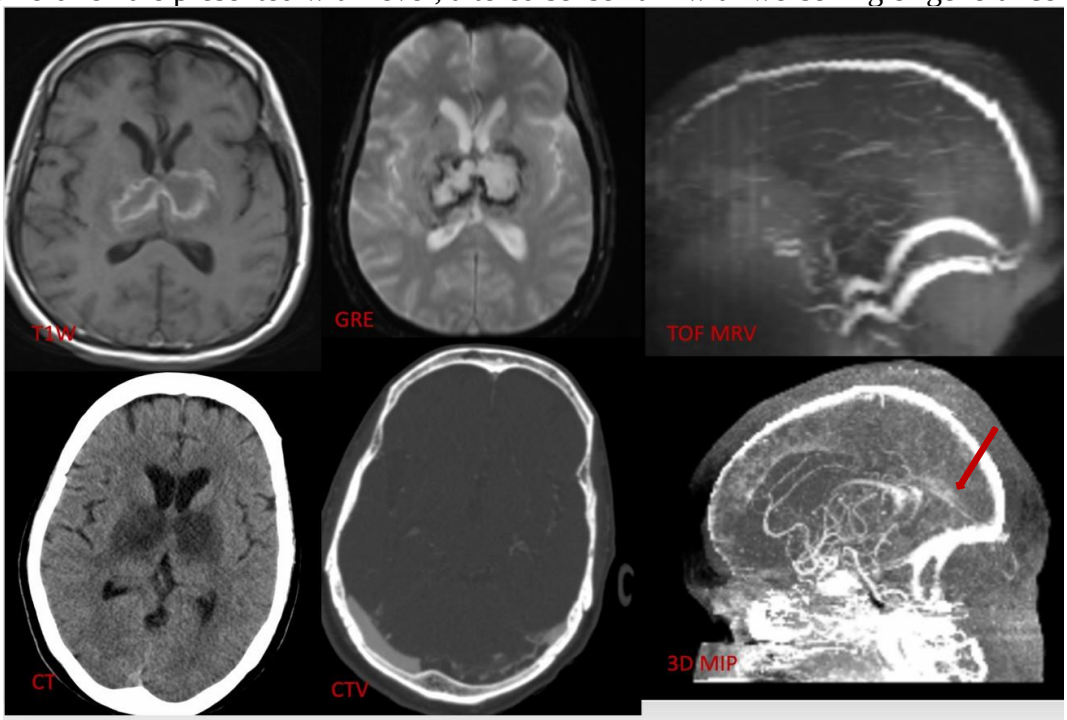


CT-hyperdense SSS, straight sinus, left frontal cortical vein; CTV- SSS, straight, left frontal cortical vein thrombosis; GRE- blooming in SSS, T2 sag - loss of flow void in straight sinus, TOF MRV-non visualization of posterior part of SSS

Diagnosis- CSVT involving SSS, straight sinus, left frontal cortical vein.

Case 4:

A 47-year-old female presented with fever, altered sensorium with worsening of general condition.



MRI- T1W, GRE - hyperintensity/blooming in both thalami; TOF MRV- non-visualization of straight sinus; CT- bilateral thalamic hypoattenuation; CTV- left transverse sinus, straight sinus thrombosis.
Diagnosis- Deep CSVT with hemorrhagic infarcts in bilateral thalami.

Conclusion

CSVT was common in 31-40 years old and male sex in our study Dehydration followed by alcohol abuse and post-partum status were the most common risk factors in our study Headache was the most common presenting symptom in our study Sensitivity and specificity of plain CT was 60% and 87% respectively with diagnosing features being hyperdense sinus/cord sign, hemorrhagic infract and non-hemorrhagic infract. Parenchymal changes in cerebral venous thrombosis were better evaluated on MRI Venous abnormalities were better depicted in MRI as loss of flow voids in T1, T2 and with dark signal on GRE. Hemorrhagic bleeds were easily evaluated on MRI with 100% sensitivity of GRE sequence; few showed only hypodensity on CT probably related to chronicity of bleed. CT Venography was easier to interpret, showed better and faster depiction of sinuses, with thin section reformatted images, when imaged with a delay of 45 seconds. CT venography showed higher spatial resolution compared to MR venography. Hypoplastic sinuses were easily visualized on CT Venography with smaller ipsilateral jugular foramen on bone window. Imaging plane parallel to sinuses, loss of hyperintense signal in proximal transverse sinuses, entry slice phenomenon were some artefacts to be kept in mind during MR Venography. Thorough evaluation of all pulse sequences is important, to better evaluate slow flow, arachnoid granulation and loss of flow voids in thrombus. We conclude that CT venography is superior to MR venography in identifying cerebral veins and in diagnosing dural sinus thrombosis.

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