Evaluation of Anatomical Variants of Dural Venous Sinuses by Magnetic Resonance Venography among Sohag Population

Marina Makram Sabah Nashed*, Mohamed Tharwat Mahmoud Solyman, Yasser Abd El-Karim Amin
Diagnostic and Interventional Radiology Department, Faculty of Medicine, Sohag University, Sohag, Egypt
***Corresponding Authors:** Marina Makram Sabah Nashed, **Mobile:** (+20) 01201796003, **Email:** marina.m.sabah@gmail.com

ABSTRACT

Background: Dural venous sinuses (DVSs) are venous channels that connect the endosteal and meningeal layers of the dura mater in the brain. They include the superior sagittal sinus (SSS), inferior sagittal sinus (ISS), straight sinus (SS), confluence of sinuses (torcular Herophili), transverse sinuses (TS), and sigmoid sinuses.

Objective: We conducted this study to use the MRV to depict the prevalence of anatomical variants of DVSs in Sohag population, which can help to avoid potential pitfalls in the diagnosis of DVS thrombosis, and venous hemorrhage.

Patients and methods: This cross-sectional study was carried out on 169 patients (80 male, 89 female) attended to Sohag University Hospitals. Routine MRI brain sequences were done with complementary maximum intensity projection (MIP) 3D TOF MRV. **Results:** This study included 169 patients with age range from 3 months to 84 years, MRI examination of studied patients showed that 35 patients (20.7%) had left attenuated/asymmetrical transverse sinus, right attenuated/asymmetrical transverse sinus prevailed in 7.1%. MRI examination of sigmoid sinus of studied patients showed that 24 patients (14.2%) had left attenuated/asymmetrical sinus, right attenuated/asymmetrical sinus prevailed in 2.4%. Concerning SSS, a larger percentage of patients (89.9%) had type I. About 10% of patients had abnormal SSS.

Conclusion: Neuroradiologists must be familiar with common dural venous anatomical variations to accurately differentiate normal variance from pathology.

Keywords: Magnetic Resonance Venography, SSS, TS, SS.

INTRODUCTION

Dura mater lined with endothelium makes up the walls of the DVSs. The sinuses are linked to several potentially fatal neurological conditions, such as cerebral venous sinus thrombosis (CVST), a potentially dangerous neurological condition [(1)]. The common anatomical variations, such as asymmetry between the paired venous sinuses, hypoplasia, and aplasia, are regarded as "normal" because they do not cause any kind of disruption in the brain's venous flow. In any case, these normal variations often mimic the clinical conditions; for instance, cerebral venous hypoplasia and aplasia often resemble VST or stenosis, which causes demonstrative problems and confusion in treatment planning. Of all the DVSs, the superior sagittal, transverse, and sigmoid venous sinuses are the most common sites for anatomical variations [(2)].

SSS is an unpaired area on the falx cerebri's linked edge. It allows blood to flow to the sinus confluence from the lateral portions of the anterior cerebral hemispheres. The corresponding transverse sinus is the next step. Typically, the SSS is divided into three sections: anterior (from the foramen cecum to the bregma), middle (from the bregma to the lambda), and posterior (from the lambda to the conjunction) [(3)]. Atresia at the rostral end of the SSS is the most prevalent variant [(2)].

San Millán Ruíz *et al.* identified four types of the rostral end of the SSS: type 1, a fully developed rostral SSS, type 2, duplication of the rostral SSS with bilateral hemi-SSS, type 3, complete hypoplasia of the rostral SSS with bilateral parasagittal superior frontal veins, and type 4, a unilateral hemi-SSS with a compensatory contralateral parasagittal superior frontal vein [(4)].

Torcular Herophili are another name for sinus confluence. Bisaria outlines a three-type categorization scheme for torcular Herophili. In type 1, there is no link between the two transverse sinuses (separate circuits); the SSS drains into one and the SS drains into the other. In type 2, the SS and SSS both split or fork too soon, and the resulting forks unite to create a transverse sinus on either side. A "confluence of sinuses" was noted in type 3 [(5)].

Fukusumi *et al.* describe four distinct SSS drainage patterns into the transverse sinuses. Type Sc is the classic anatomy, in which the SSS drains into a true confluence; type Sd is when the SSS prematurely divides into the right and left limbs and drains into the same-sided transverse sinus; type Sr is when the SSS preferentially drains into the right transverse sinus; and type SI is when the SSS preferentially drains into the left transverse sinus [(6)].

The transverse and sigmoid sinuses' diameters were measured for the study and compared to the SSS's diameter. This was done to check for hypoplasticity in the sigmoid and transverse sinuses. In the coronal view, a transverse sinus was deemed hypoplastic if its width was less than half that of the SSS. One centimeter from the sinus confluence, the diameters of the transverse and superior sagittal sinuses were measured [(7)].

Asymmetrical (unilateral dominance) transverse sinuses are a typical variation. When there is asymmetry of the transverses, the right sinus is more likely to be prominent [(8)]. A frequent variation is congenital lack of the ISS. The beginning or stopping point of this sinus might not be conventional. It may, for example, drain into the SSS rather than the SS [(9)].

We conducted this study to understand the DVS architecture and typical anatomical changes, which is critical for accurate diagnosis of cerebral venous sinus pathology as well as surgical planning and treatment of neurological illnesses. Cerebral MRV is a selective

Received: 20/02/2025
Accepted: 22/04/2025

imaging approach for fitting recognized evidence and determining the frequencies of normal anatomical changes of the superior sagittal, transverse, and sigmoid DVSs, as well as disease of the DVSs.

PATIENTS AND METHODS

This is a cross-sectional study conducted at Radiology Department, Sohag University Hospital from January 2024 to December 2024 on 169 patients.

Participants in this study were from Sohag by country and place of residence, male or female by sex, with a reported normal cerebral MRV, who gave their agreement to take part in the study. Patients having a diagnosis of CVST, a history of head trauma, or absolute or relative contraindications for imaging, such as claustrophobia, metallic implants, pacemakers, or prosthetic heart valves for MRI, were not allowed to participate in the research.

All patients were subjected to:

The examination was conducted using standard head coils with thin sections and a narrow field of view. Using complementary MIP 3D TOF MRV, routine brain MRIs were performed, including axial T1WI, T2WI, FLAIR, coronal T2WI, and sagittal T1 WI. Siemens Magnetom Altea1.5T MRI (Siemens Healthineers, Germany) or Philips Achieva1.5T MRI (Philips Achieva, Netherlands) were used to capture the imaging results of the veins and sinuses. It was noted whether there were any anatomical variations in these sinuses or their discharge.

To determine the chosen anatomical variances of the DVSs, the researcher and the co-investigators separately assessed the MRV pictures.

Ethical considerations:

The Medical Research Ethics Committee of Sohag University's Faculty of Medicine gave its approval to this study methodology. Adult patients or the caregivers of the children patients gave their informed permission; both orally and in writing, after explaining the purpose and nature of the study. Confidentiality of patient data was preserved. The study adhered to the Helsinki Declaration throughout its execution.

Statistical analysis

SPSS version 25.0 was used to do a statistical analysis on the gathered data. The qualitative data were shown as relative percentages and frequencies. Anatomical variations of the cerebral venous sinuses were examined for predominance using X^2-test or Monte Carlo test. The p-value was deemed significant if it was 0.05 or less.

RESULTS

Concerning complaints, 36.1% had disturbed conscious level/confusion and 16% of patients presented with headache. The frequency of other complaints is shown in table 1.

Table (1): Patients in the study were distributed based on their complaints.

	N=169	%
Complaint		
Acute confusion/DCL	61	36.1%
Headache	27	16%
Fits	21	12.4%
CVS	17	10.1%
Hemiparesis	16	9.5%
Hemiplegia	15	8.9%
Dysarthria/aphasia	11	6.5%
Decreased visual acuity	10	5.9%
Irritability	7	4.1%
Lower limb weakness	4	2.4%
Vertigo/unsteadiness	4	2.4%
Eclamptic fits	4	2.4%
Behavioral changes	3	1.8%
Upper limb weakness	2	1.2%
UL and LL weakness	2	1.2%
AVM	2	1.2%
Unsteady gait	2	1.2%
Facial palsy	2	1.2%
Cyanosis	1	0.6%
Tremors	1	0.6%
Hemiataxia	1	0.6%
3rd nerve palsy	1	0.6%

MRI examination of studied patients showed that 35 patients (20.7%) had left attenuated/asymmetrical transverse sinus, right attenuated/asymmetrical transverse sinus prevailed in 7.1%, while six patients had not attenuated/asymmetrical transverse sinus. Larger percentage of studied patients had not attenuated/symmetrical transverse sinus. Attenuated sinus occurred in 27.8% of patients while asymmetrical sinus occurred in 31.4%. Overall abnormalities in transverse sinus were 31.4% of patients attending our hospital.

Table (2): Incidence of transverse sinus abnormalities among the studied patients

	N=169	%
Left attenuated/asymmetrical	35	20.7%
Right attenuated/asymmetrical	12	7.1%
Not attenuated/asymmetrical	6	3.6%
Not attenuated/symmetrical	116	68.6%
Attenuation		
Not attenuated	122	72.2%
Left side attenuated	35	20.7%
Right side attenuated	12	7.1%
Symmetry		
Asymmetrical	53	31.4%
Symmetrical	116	68.6%

MRI examination of sigmoid sinus of studied patients showed that 24 patients (14.2%) had left attenuated/asymmetrical sinus, right attenuated/asymmetrical sinus prevailed in 2.4%, while 21 patients had not attenuated/asymmetrical sinus. Larger percentage of studied patients (71%) had not attenuated/symmetrical sinus. Attenuated sinus occurred in 16.6% of patients while asymmetrical sinus occurred in 29%. Overall abnormalities in transverse sinus were 29% of patients attending our hospital.

Table (3): Incidence of sigmoid sinus abnormalities among the studied patients

	N=169	%
Left attenuated/asymmetrical	24	14.2%
Right attenuated/asymmetrical	4	2.4%
Not attenuated/asymmetrical	21	12.4%
Not attenuated/symmetrical	120	71%
Attenuation		
Not attenuated	132	83.4%
Left side attenuated	24	14.2%
Right side attenuated	4	2.4%
Symmetry		
Asymmetrical	49	29%
Symmetrical	120	71%

Concerning SSS, a larger percentage of patients (89.9%) had type I. About 10% of patients had abnormal SSS.

Table (4): Incidence of SSS abnormalities

	N=169	%
Type I	152	89.9%
Type II	2	1.2%
Type III	8	4.7%
Type IV	7	4.1%

About 27%, 33% and 20% had confluence type II Sd, III Sc and III Sr respectively.

Table (5): Incidence of confluence of sinuses among the studied patients

	N=169	%
Type		
Type I SI	3	1.8%
Type I Sr	7	4.1%
Type II Sd	45	26.6%
Type II SI	1	0.6%
Type II Sr	6	3.6%
Type III Sc	55	32.5%
Type III Sd	9	5.3%
Type III SI	10	5.9%
Type III Sr	33	19.5%

Thirty patients (17.8%) had inferior sagittal sinus abnormalities.

Table (6): Incidence of ISS abnormalities among the studied patients

	N=169	%
Inferior sagittal sinus abnormalities		
Absent	139	82.2%
Present	30	17.8%

There was a statistically significant relation between age group and MRI abnormalities in sigmoid sinus. Not attenuated/symmetrical sinus was found in 80% versus 64.6% of those aged≤40 and >40 years old respectively. There was statistically non-significant relation between age group and MRI abnormalities in transverse, superior sagittal, inferior sagittal or confluence of sinus.

Table (7): Relation between age of patients and incidence of sinus abnormalities

		≤40 years N=70 (%)	>40 years N=99 (%)	χ^2	P
Transverse sinus	Left attenuated/asymmetrical	8 (11.4%)	27 (27.3%)	MC	0.041*
	Right attenuated/asymmetrical	4 (5.7%)	8 (8.1%)		
	Not attenuated/asymmetrical	2 (2.9%)	4 (4%)		
	Not attenuated/symmetrical	56 (80%)	60 (60.6%)		
Superior sagittal sinus	Type I	64 (91.4%)	88 (88.9%)	1.50	0.682
	Type II	0 (0%)	2 (2%)		
	Type III	3 (4.3%)	5 (5.4%)		
	Type IV	3 (4.3%)	4 (4%)		
Sigmoid sinus	Left attenuated/asymmetrical	4 (5.7%)	14 (17.5%)	MC	0.018*
	Right attenuated/asymmetrical	0 (0%)	4 (4%)		
	Not attenuated/asymmetrical	10 (14.3%)	11 (11.1%)		
	Not attenuated/symmetrical	56 (80%)	64 (64.6%)		
Confluence of sinus	Type I SI	1 (1.4%)	2 (2%)	6.60	0.580
	Type I Sr	2 (2.9%)	5 (5.4%)		
	Type II Sd	23 (32.9%)	22 (22.2%)		
	Type II SI	1 (1.4%)	0 (0%)		
	Type II Sr	1 (1.4%)	5 (5.4%)		
	Type III Sc	20 (28.6%)	35 (35.4%)		
	Type III Sd	4 (5.7%)	5 (5.1%)		
	Type III SI	3 (4.3%)	7 (7.1%)		
	Type III Sr	15 (21.4%)	18 (18.2%)		
Inferior sagittal sinus abnormalities	Absent	57 (81.4%)	82 (82.8%)	0.055	0.815
	Present	13 (18.6%)	17 (17.2%)		

χ^2: Chi square-test, MC Monte Carlo test, *: Significant

Illustrative cases:

Case 1: 58 years old male patient, known hypertensive, presented by right sided hemiparesis, hemiplegia, bilateral painless ophthalmoplegia except adduction, and nystagmus.

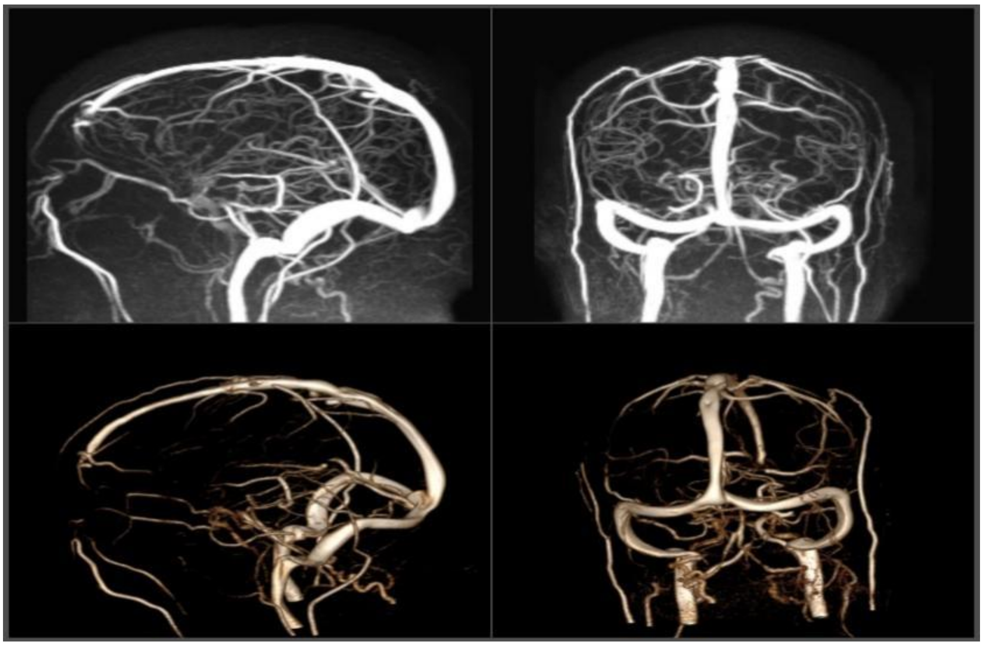

Figure 1: MIP images from MRV head examinations in the posterior projection. True torcular Herophili, with a "common pool", with fully developed SSS, and symmetrical, not attenuated both transverse and sigmoid sinuses.

Case 2: 5 years old female patient, presented with generalized fits.

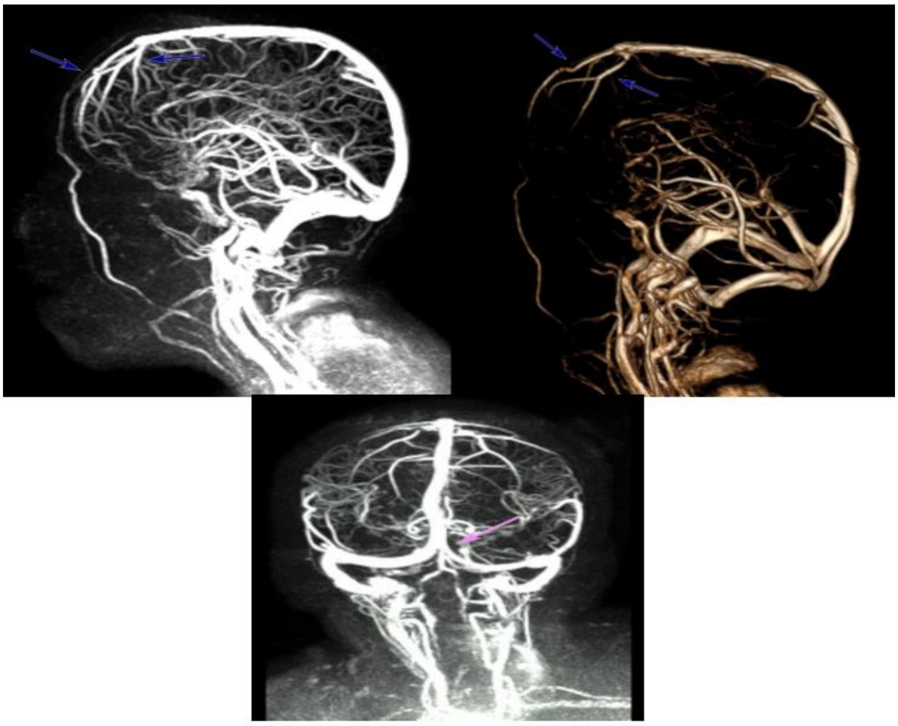

Figure 1: MIP images from MRV head examinations in the sagittal, coronal planes, with 3D reconstructed images, showing a unilateral hemi-SSS, with a compensatory contralateral parasagittal superior frontal vein (type IV) "blue arrow". Early bifurcation of the superior sagittal and straight sinuses (type II), with the SSS prematurely divides into the right and left limbs and drains into the same-sided transverse sinus "pink arrow".

Case 3: 70 years old female patient, presented with confusion, left sided hemiplegia.

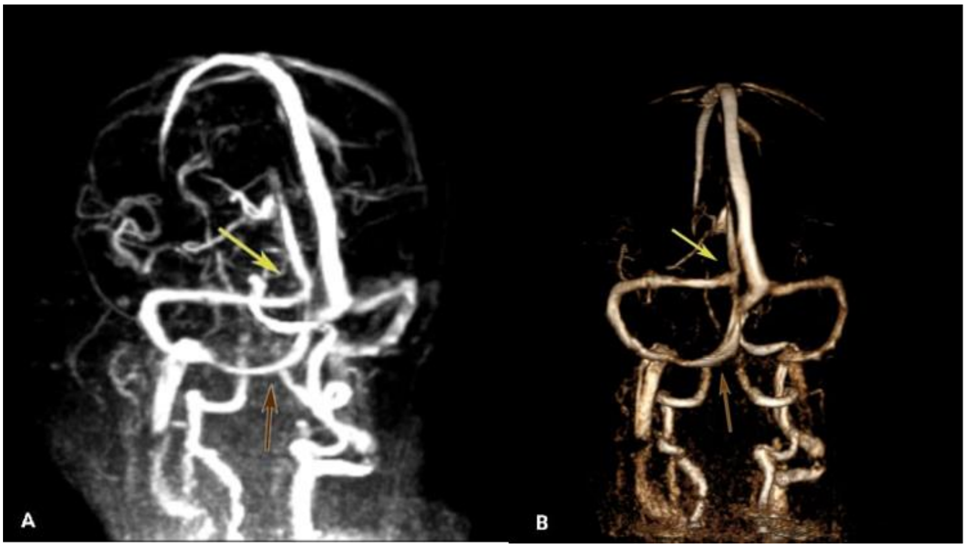

Figure 3: MIP images from MRV head examinations in the sagittal plane, with 3D reconstructed images, showing right occipital sinus (brown arrow), with independent circuits of the confluence of sinuses (yellow arrow).

Case 4: 41 years old female patient, pregnant, known epilepsy, presented by fits.

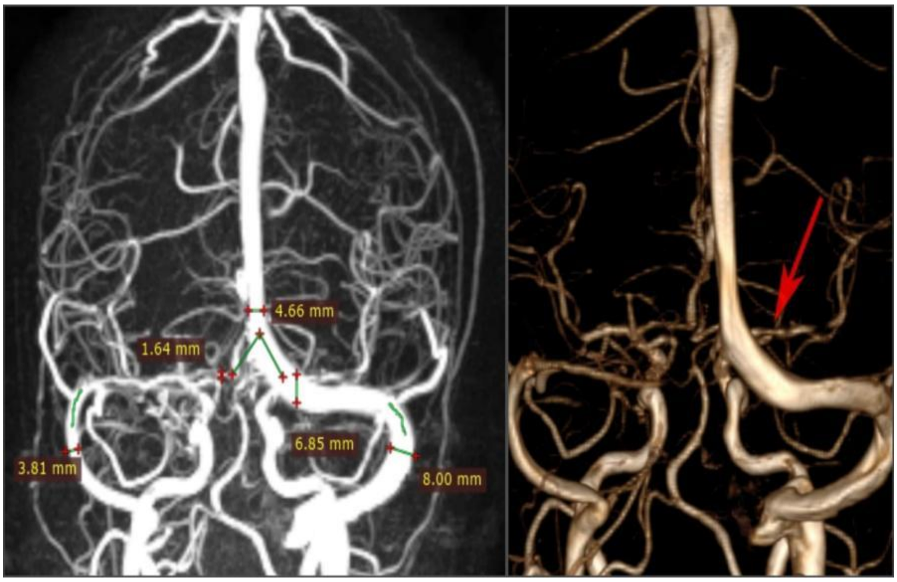

Figure 4: The coronal view MRV image demonstrating right transverse sinus hypoplasia relative to SSS diameter. The distance between the transverse-sigmoid junction and the sinus confluence is shown by the green curved lines that go through the center of the sinuses. Noted ture confluence of sinuses with the SSS drain into left (dominant) transverse sinus "SI" (red arrow).

DISCUSSION

Common anatomical anomalies such as asymmetry between paired venous sinuses, hypoplasia, aplasia, and so on are regarded as "normal" since they do not cause any disruptions to the brain's venous flow. However, these typical differences frequently imitate the clinical problems. The DVSs most commonly undergo morphological changes in the sigmoid, transverse, and superior sagittal sinuses [10-12].

Concerning complaints, 36.1% had disturbed conscious level/confusion, 16% of patients presented with headache, 12.4%, 10.1%, 9.5%, 8.9%, 6.5% and 5.9% of patients had fits, CVS, hemiparesis, hemiplegia, dysarthria/aphasia, and decreased visual acuity respectively. These findings are in conglomerate with **Goyal *et al.*** [(2)] who found that the most frequent reason for MRV was headache (75.4%). Seizures (5.3%), headache and vertigo (13.1%), headache and vomiting (3.2%), vertigo (2%), abnormal sensorium (0.5%), amnesia (0.3%), and others (0.2%) were further reported.

Also, **Tantawy *et al.*** [(7)] found the same as they stated that the most prevalent reason for MR venography was headache (46.8%).

Regarding MRI examination of studied patients, 35 patients (20.7%) had left attenuated/asymmetrical transverse sinus, right attenuated/asymmetrical transverse sinus prevailed in 7.1%, while six patients had not attenuated/asymmetrical transverse sinus. Larger percentage of studied patients had not attenuated/symmetrical transverse sinus. Attenuated sinus occurred in 27.8% of patients while asymmetrical sinus occurred in 31.4%. Overall abnormalities in transverse sinus was 31.4% of patients attending our hospital. These results are comparable to those of **Goyal *et al.*** [(2)] who reported that 1106 (66.9%) of the 1654 MR venograms collected showed symmetrical transverse sinuses. The left transverse sinus was aplastic/atrectic in 67(4.1%) and hypoplastic in 352 (21.3%) of the patients. Twelve patients (0.7%) had an aplastic/atrectic right transverse sinus, whereas 91 patients (5.5%) had a hypoplastic one. Bilateral hypoplastic transverse sinuses were seen in 1.6% of patients.

Concerning MRI examination of sigmoid sinus of studied patients, 24 patients (14.2%) had left attenuated/asymmetrical sinus, right attenuated/asymmetrical sinus prevailed in 2.4%, while 21 patients had not attenuated/asymmetrical sinus. Larger percentage of studied patients (71%) had not attenuated/symmetrical sinus. 16.6% of individuals had attenuated sinuses, whereas 29% had asymmetrical sinuses. In our institution, 29% of patients had transverse sinus anomalies overall. In 14.2% (24) of patients, the left sigmoid sinus was either hypoplastic or aplastic/atrectic. In four cases, the right sigmoid sinus was hypoplastic (2.4%). Like the transverse sinus, the sigmoid sinus was more frequently symmetrical in women than in men (87.2% versus 83%, $p = 0.02$). Furthermore, **Yasmin *et al.*** [(10)] confirmed our findings by observing that 47 subjects (24 men and 23 women) had symmetrical right and left sigmoid sinuses. Five subjects (3 men and 2 women) had left-sided hypoplasia.

Concerning SSS, a larger percentage of patients (89.9%) had type I. **San Millán Ruíz *et al.*** [(4)] supported our findings as they showed that the most common variation of the SSS is atresia of its rostral end.

Concerning confluence of sinuses about 26.6%, 32.5% and 19.5% had confluence type II Sd, III Sc and III Sr respectively. **San Millán Ruíz *et al.*** [(4)], had similar results as they stated that in 211 patients type I constitutes a 26.06% of whole cases, type II 59.71%, and type III 14.21% [(4)].

Concerning our results, there was statistically non-significant relation between age group and MRI abnormalities in transverse, superior sagittal, inferior sagittal or occipital sinus or confluence of sinus. **Tantawy *et al.*** [(7)] concluded the same results as they found that the significance of age differences of the anatomical variations of cerebral venous sinus wasn't present.

Our work concludes that there is statistically significant relation between age group and MRI abnormalities in sigmoid sinus. Not attenuated/symmetrical sinus was found in 80% versus 64.6% of those aged≤40 and >40 years old respectively. On the other hand, **Goyal *et al.*** [(2)] disagreed to what we found as they figured out that symmetrical sigmoid sinuses were seen in 1418 (85.7%) instances. In 11.4% (189) of instances, the left sigmoid sinus was either hypoplastic or aplastic/atrectic. Forty (2.4%) had hypoplastic right sigmoid sinuses, whereas four (0.2%) had aplastic/atrectic ones.

CONCLUSION

Multiple DVS variations can be mistaken as thrombosis, particularly in individuals with neurological symptoms, because dural venous thrombosis typically includes two or more separate dural sinuses. The incidence and relationship of numerous variants must be thoroughly understood since precise differentiation between these variations and pathological diseases like thrombosis is critical to avoiding misdiagnosis.

No funding.
No conflict of interest.

REFERENCES

1. **Gul B, Samanci C, Uluduz D *et al.* (2021):** Does measurement of the jugular foramen diameter on MRI help to differentiate transverse sinus thrombosis from unilateral transverse sinus hypoplasia? La Radiologia Medica, 126: 430-6.
2. **Goyal G, Singh R, Bansal N *et al.* (2016):** Anatomical variations of cerebral MR venography: Is gender matter? Neurointervention, 11: 92-98.
3. **Salunke P, Sodhi H, Aggarwal A *et al.* (2013):** Is ligation and division of anterior third of superior sagittal

sinus really safe? Clin Neurol Neurosurg., 115: 1998-2002.

4. **San Millán Ruíz D, Fasel J, Gailloud P (2012):** Unilateral hypoplasia of the rostral end of the superior sagittal sinus. AJNR Am J Neuroradiol., 33: 286-91.
5. **Bisaria K (1985):** Anatomic variations of venous sinuses in the region of the torcular Herophili. J Neurosurg., 62:90–95.
6. **Fukusumi A, Okudera T, Takahashi S *et al.* (2010):** Anatomical evaluation of the dural sinuses in the region of the torcular herophili using three dimensional CT venography. Academic Radiology, 17: 1103-11.
7. **Tantawy H, Morsy M, Basha M *et al.* (2020):** Different normal anatomical variations of the transverse dural sinus in magnetic resonance venography (MRV): Do age and sex matter. Eur J Anat., 24: 49-56.
8. **Ahmed M, Imtiaz S, Shazlee M *et al.* (2018):** Normal variations in cerebral venous anatomy and their potential pitfalls on 2D TOF MRV examination: Results from a private tertiary care hospital in Karachi. J Pak Med Assoc., 68(7): 1009-1013.
9. **Tubbs R, Shoja M, Loukas M (2016):** Bergman's comprehensive encyclopedia of human anatomic variation. John Wiley & Sons. Pp. 181-203. https://doi.org/10.1002/9781118430309
10. **Yasmin K, Al-Qureshi F, Islam M *et al.* (2022):** Anatomical variations of the superior sagittal, transverse and sigmoid dural venous sinuses in the cerebral MRV images of adult Bangladeshis. Scholars Journal of Applied Medical Sciences, 10(4): 485–490.
11. **Barboza M, Chiquete E, Arauz A *et al.* (2021):** A practical score for prediction of outcome after cerebral venous thrombosis. Frontiers in Neurology, 9: 882. https://doi.org/10.3389/fneur.2018.00882
12. **Deniz C, Gokce E, Berat A *et al.* (2019):** Comparative evaluation of dural venous sinuses and cerebral veins using contrast enhanced spoiled gradient recalled echo and time of-flight magnetic resonance venography. Journal of Contemporary Medicine, 9(3): 214-221.