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RESEARCH ARTICLE

VARIANT ANATOMY IN MR VENOGRAPHY OF BRAIN

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Abstract

Introduction: Identifying the variations in cerebral dural venous sinus anatomy on magnetic resonance (MR) venography is important for the adequate diagnosis of cerebral venous sinus thrombosis (CVST). There is limited documentation available on gender differences in cerebral dural venous sinus anatomical variants.

Aims and Objectives: This study aimed to investigate gender-related variations as well as the typical variance of the cerebral venous system anatomy in asymptomatic individuals as shown by MR venography (3D).

Material and Methods: This Hospital-based retrospective study was carried out over 24 months from December 2020 to November 2022 at the Department of Radiodiagnosis, Narayana medical college, Nellore. The study was done on 100 patients. All patients underwent 3D MR Venography on 3.0 Tesla (GE DISCOVERY 750W) MRI machine.

Results:

1. Headache was the most prevalent clinical symptom for an MR venography (81%).
2. The most frequent anatomical variant was hypoplastic left transverse sinus (27%).
3. Males had a greater likelihood than females to have a hypoplastic left transverse sinus (12 versus 11).
4. Hypoplastic anterior one-third SSS was the most prevalent anatomical variant of the superior sagittal sinus (SSS).

Conclusion: In the current research, the most frequent structural variant was found to be hypoplastic left transverse sinus, which was more prevalent in males than females. Other dural venous sinus structural differences did not show a significant difference between genders.

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Introduction:-

Normal Anatomy of Cerebral Venous System:

The dural venous sinuses and the cerebral veins are the two primary components of the intracranial venous system.

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Dural Venous Sinuses:

The anteroinferior group and the posterosuperior group constitute the dural venous sinuses.

The posterosuperior group is the most notable and comprises the superior sagittal sinus (SSS), the inferior sagittal sinus (ISS), the Straight sinus (SS), the Sinus confluence (torcular herophili), the Transverse sinuses (TSs), the Sigmoid sinuses, and the Jugular bulbs.

The anteroinferior group comprises the cavernous sinus (CS), the superior and inferior petrosal sinuses (SPSs and IPSs), the ciliary venous plexus (CVP), and the sphenoparietal sinus (SphPS).

Table 1:- Dural Venous Sinuses Classification.

Posterosuperior group	Anteroinferior group
Superior sagittal sinus	Cavernous sinus
Inferior sagittal sinus	Superior petrosal sinuses
Straight sinus	Inferior petrosal sinuses
Sinus confluence (torcular herophili)	Clival venous plexus
Transverse sinuses	Sphenoparietal sinus
Sigmoid sinuses	
Jugular bulbs	

Superior Sagittal Sinus(SSS):

The superior sagittal sinus is a broad, curvilinear sinus that courses parallel to the inner calvarial vault. It emerges anteriorly from the ascending frontal veins and courses along the midline at the intersection of the falx cerebri and the calvaria. The extracranial scalp veins are connected to the SSS through emissary veins and bridging veins. Several so-called "venous lakes" are located in the diploic regions of the calvaria and drain into SSS. As SSS travels posteriorly, it continues to expand in thickness, eventually draining a number of unidentified small superficial cortical veins and the prominent anastomotic vein of Trolard [2].

Normal Variants:

The atresia of the proximal one-third of the SSS was the most prevalent variation. Hypoplasia of the middle one-third of the SSS, hypoplasia of the anterior one-third of the SSS, hypoplasia of the anterior two-thirds of the SSS, and hypoplasia of the anterior half of the SSS were some of the other variations.

Inferior Sagittal Sinus (ISS):

In comparison to the SSS, the ISS is a much more compact and undulating curvilinear channel that can be found at the base of the falx cerebri.

The inferior sulcal sinus (ISS) is located above the corpus callosum and the cingulate gyrus and courses posteriorly along the inferior border of the falx, collecting minor tributaries as it travels. The ISS comes to an end at the falcotentorial junction, at which point it connects with the great cerebral vein of Galen (VofG) to create the Straight sinus (SS) [1].

Normal Variants:

ISS that is too small is not visualized consistently across imaging investigations.

Straight Sinus (SS):

The straight sinus is from the union of the ISS and the VofG. It originates at the falcotentorial apex and continues posteroinferiorly.

Normal Variants:

Straight sinus variations are not very prevalent, while a continuous falcine sinus is a rare variant that is found in only 2% of typical people. The continuous falcine sinus will create a straight connection between the SSS and either the ISS or the VofG. Patients who have a continuous falcine sinus are more likely to have missing or rudimentary SS [4].

Sinus Confluence:

The venous sinus confluence (torcular herophili) is formed when the SSS and TSs are joined together, at the end of the straight sinus. The venous sinus confluence is typically asymmetric, consisting of septations and intersinus pathways that connect the TSs. [4]

Transverse Sinuses (TS):

The transverse sinuses, which are also referred to as the lateral sinuses, are located in the space that is created between the extensions of the tentorium cerebelli towards the inner table of the skull. After curving horizontally from the torcular to posterior boundary of the petrous temporal bone, the TSs then shift inferiorly to become the sigmoid sinuses. [6]

Normal Variants:

In many cases, the bilateral TSs are asymmetric, with the right side normally being larger than that of the left. One-third of the population has hypoplastic/stenotic segments. Arachnoid filling defects are seen in some.

Sigmoid Sinuses:

The sigmoid sinuses are the posterior continuations of the bilateral TSs. They follow a gradual S-shaped slope, descending posteriorly to the petrous temporal bone, and ending up as the internal jugular veins (IJV), which run from side to side. It is common and even typical for the sigmoid sinuses to be asymmetrical.

Normal Variants:

Unilateral hypoplastic or aplastic/atretic sigmoid sinuses, and bilateral hypoplastic sigmoid sinuses are seen [5].

Jugular Bulbs:

At the base of the skull, between both the sigmoid sinuses and internal jugular veins, are venous dilatations known as the jugular bulbs. The IJVs are the primary venous vessels arising from the brain. In a healthy individual, additional non-jugular venous (NJV) channels are present, and they have the potential to develop into significant routes of collateral flow in case of sinus thrombosis /intracranial hypertension.

Both the vertebral plexus and pterygopalatine plexus are considered to be significant NJVs.

There is a correlation between the size variation of the corresponding osseous foramina and the jugular bulbs. Pseudolesions of the jugular bulb that exhibit flow imbalance are quite prevalent, but they must not be confused with actual masses (such as Schwannoma or paraganglioma) [5].

Cavernous Sinus:

The CSs are irregular in shape and are trabeculated or compartmentalized venous sinuses that course along the sides of the sella turcica and extend from the superior orbital fissure anteriorly and posteriorly up to the clivus and petrous apex.

The superior, inferior ophthalmic veins, as well as the SphPSs, drain into the CSs. Intercavernous venous plexuses form communications between the two CSs [8].

Superior and Inferior Petrosal Sinuses :

After emerging from CS, the SPS runs in a posterolateral direction along the petrous temporal bone and continues on to the sigmoid sinus. From the inferior portion of the CVP to the jugular bulb is the IPS course, located superior to the petro occipital fissure.

Clival Venous Plexus:

The CVP is a network of inter-connected venous pathways that course parallel to the clivus superiorly from the dorsum sellae up to the foramen magnum. CVP connects the CS, the petrosal sinus, and the suboccipital veins around the foramen magnum [4].

Sphenoparietal Sinus:

At the border of the middle cranial fossa, the sphenoparietal sinus circles the lesser sphenoid wing. The superficial petrosal sinus (SphPS) receives superficial branches from the anterior temporal lobe, which then drain into the cavernous sinus as well as the inferior petrosal sinus [5].

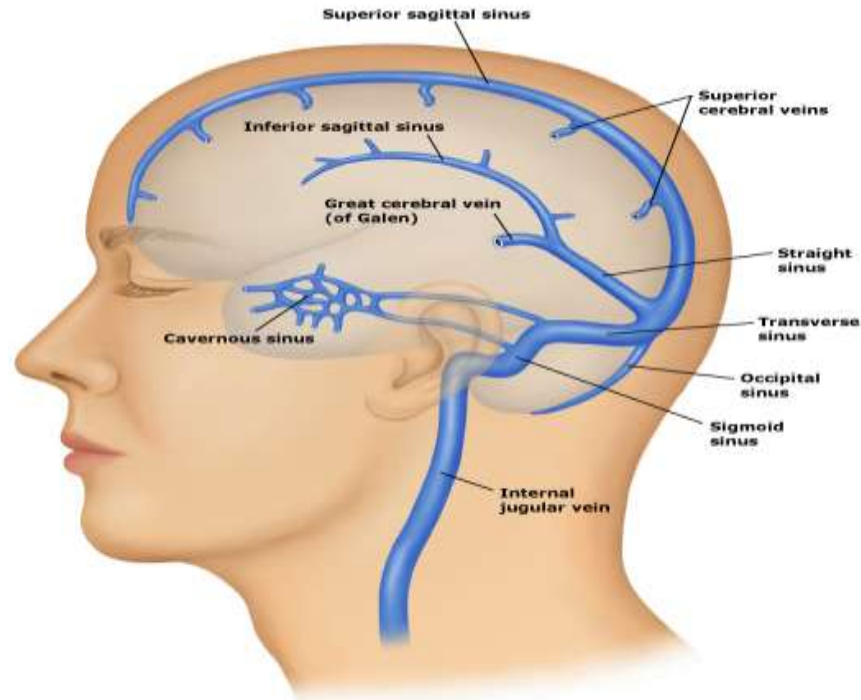


Figure 1:- Normal Cerebral Venous Anatomy.

Material And Methods:-

Patients who were sent for MRV examination in Narayana medical hospital, Department of Radio diagnosis from December 2020 to November 2022 were enrolled in this study. MRV data from 100 patients during the study period were retrospectively reviewed.

Inclusion criteria:

Patients, older than 10 years of age were included in this study.

Exclusion criteria:

Patients with any congenital or acquired intracranial abnormality, venous thrombosis, or previous surgery were excluded from the study.

In normal individuals, a retrospective study was conducted on normal cerebral venous anatomy and variations, as illustrated by 3D MR venography. A 3.0 Tesla (GE DISCOVERY 750W) MR machine with a conventional head coil was used for imaging.

In the sagittal plane, a three-dimensional MR venography was carried out with the following parameters: TE-50, TR-500, FOV-230-250, slice thickness 1mm, matrix 240x256, and ip angle 50.

In addition, routine T2WI axial /FLAIR axial sequences were also carried out.

Image analysis:

At the MR station, maximum intensity projections (MIPs) were generated for the 3D-MR venography data collection. The sagittal, horizontal, and coronal planes were utilized to examine the MIP pictures.

3D MRV and MIP images were analyzed in order to determine the structural differences that can occur in the dural venous sinuses. The superior sagittal sinus, sigmoid sinus, transverse sinus, straight sinus, and occipital sinus are all examples of the different types of dural venous sinuses that were investigated in this research. It was observed that the transverse as well as sigmoid sinuses both exhibited typical variations (symmetrical development, hypoplasia, and either aplasia or atresia)

A distance of 1 cm was used to measure the transverse sinuses from the Torcula herophili, and a distance of 1 cm was used to measure the sigmoid sinuses from the transverse sigmoid junction. These measurements were compared to the superior sagittal sinus.

It was considered hypoplastic if the measurement was lesser than half the length of the superior sagittal sinus, and was considered aplastic/atretic if the TS was not visualized. The internal jugular vessels were excluded.

Arachnoid granulations (AG) were documented. AGs are well-defined protuberances with signal intensity similar to CSF that extend into the dural sinus. They are typically associated with adjacent cortical veins.

Illustrations:

Case 1:

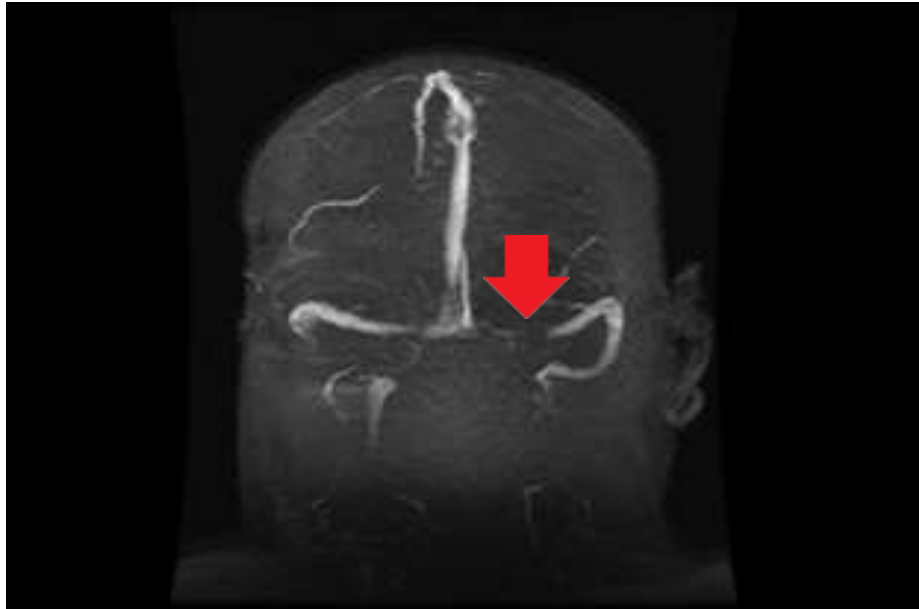


Figure 2:- MRV Brain – Aplastic Left Transverse Sinus (➡).

Case 2:

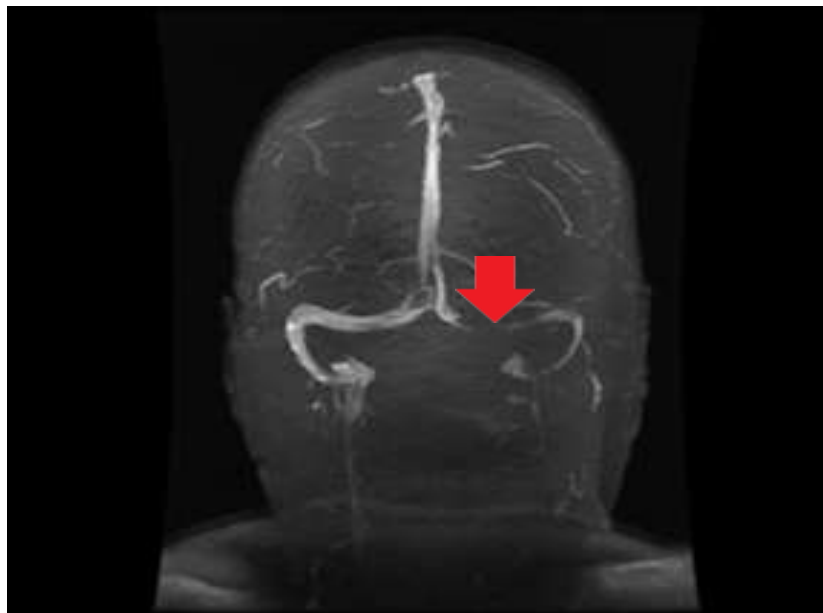


Figure 3:- MRV Brain – Hypoplastic Left Transverse Sinus (➡).

Case 3:

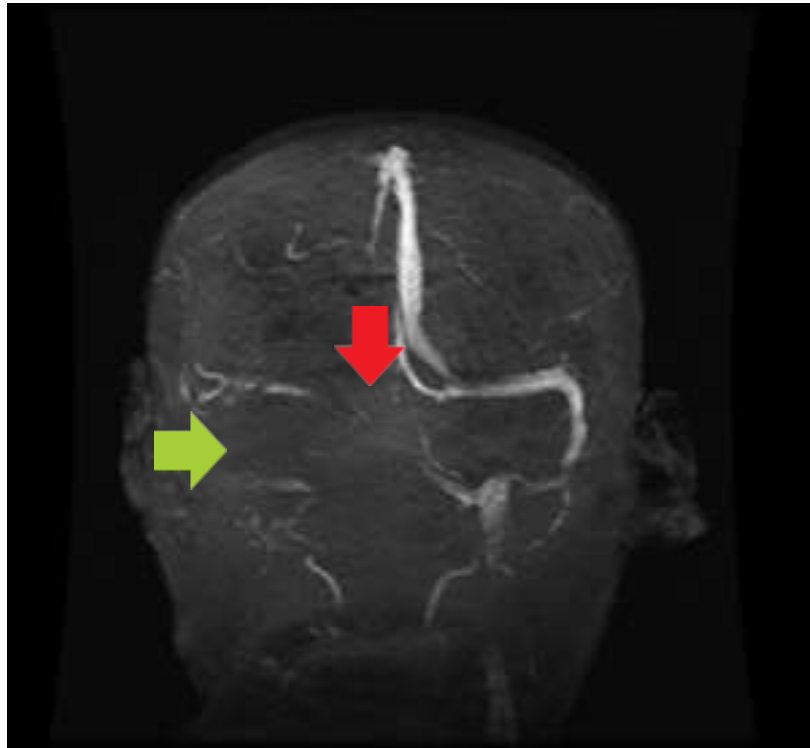


Figure 4:- MRV Brain – Aplastic Right Transverse Sinus (➡) and Hypoplastic Sigmoid Sinus (➡).

Case 4:

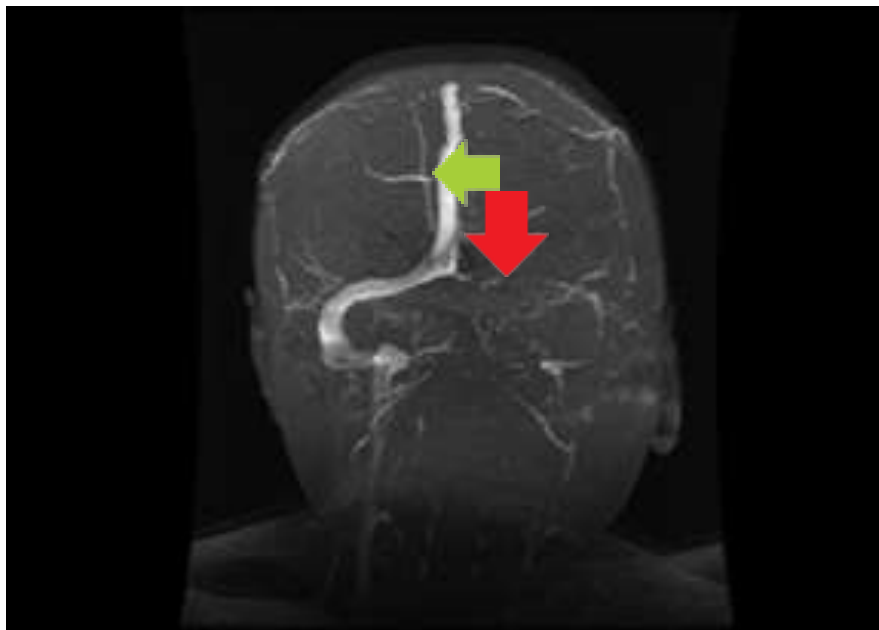


Figure 5:- MRV Brain – Aplastic Left Transverse Sinus (➡) and Aplastic Sigmoid Sinus (➡).

Case 5:

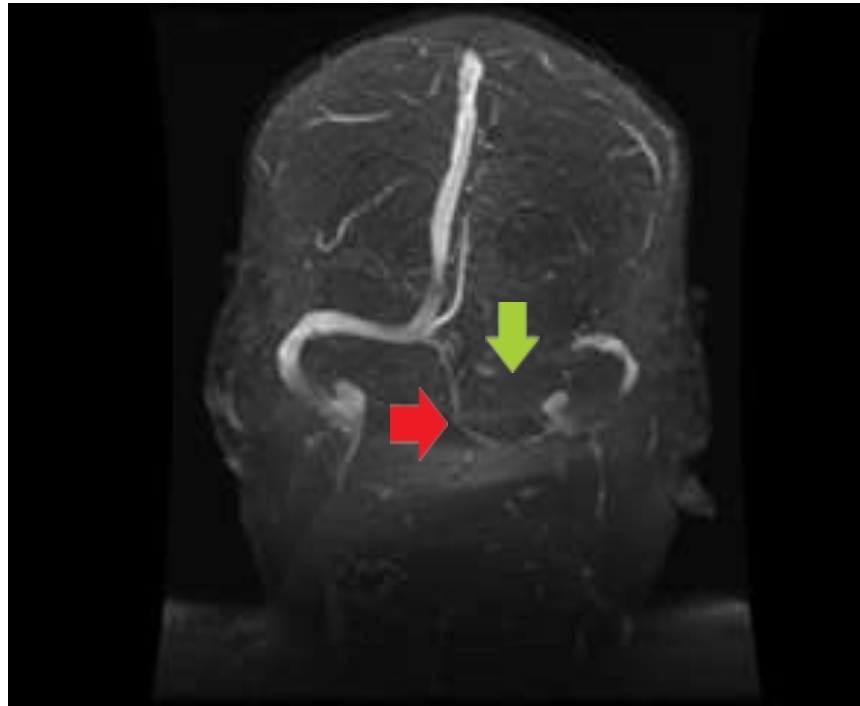


Figure 6:-MRV Brain – Persistent Left Occipital Sinus (➡) and Aplastic Left Transverse Sinus(➡).

Case 6:

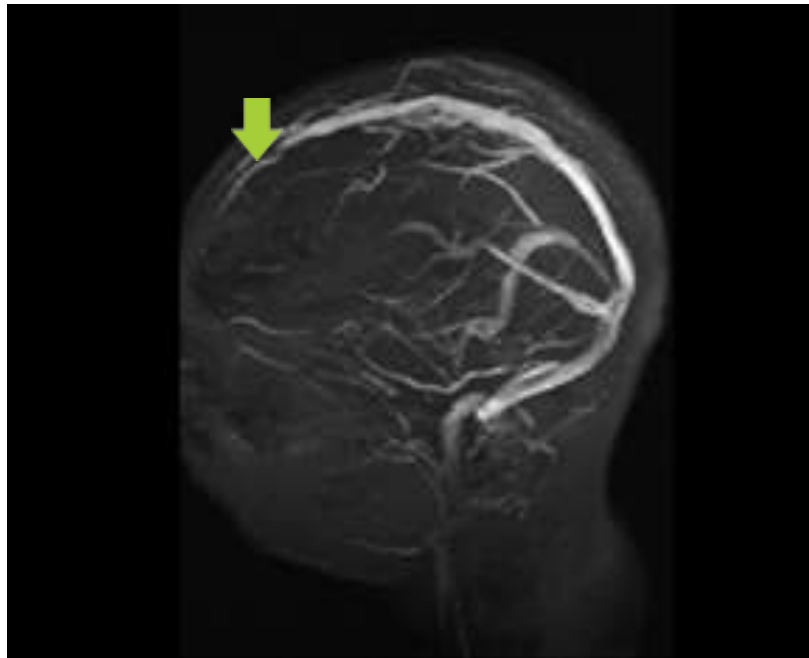


Figure 7:- MRV Brain – Aplastic Anterior 1/3rd of Superior Sagittal Sinus(➡).

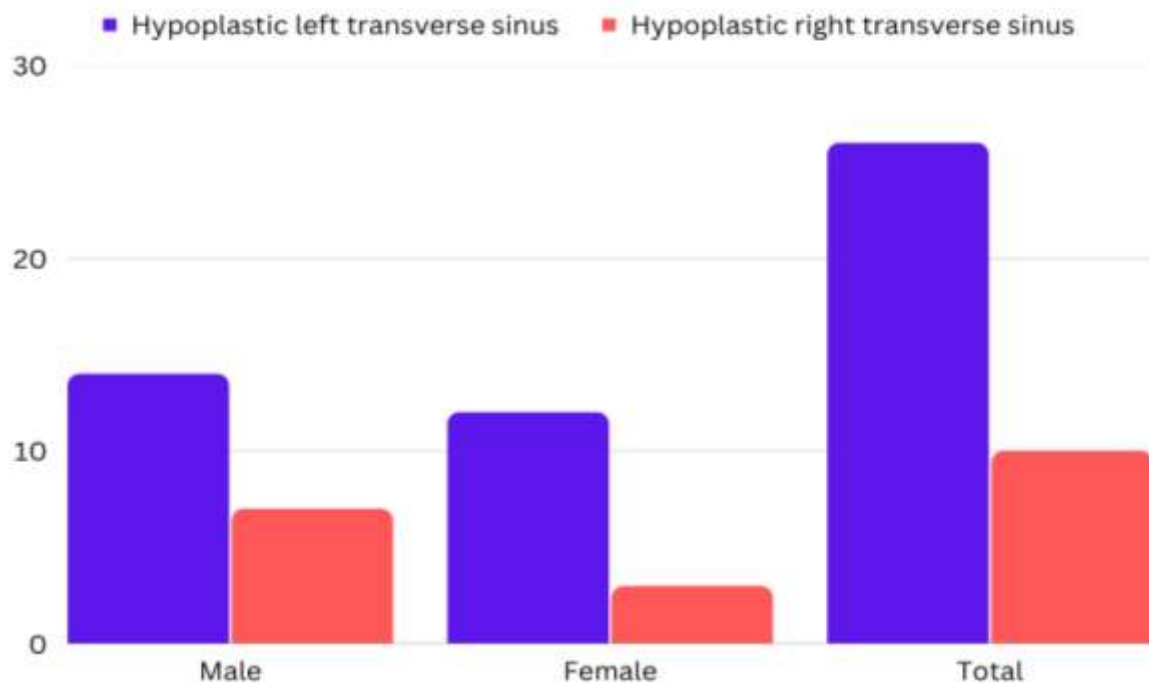
Results:-

Our research included 100 patients (45 males and 55 females). The age group was 10 to 80 years. The most common presenting symptom referred for MRV was headache (81%). Other symptoms were headache and vomiting (9%), seizures (3%), headache and vertigo (3%), vertigo (3%), and altered sensorium (1%).

Table 2:- MR Venography Indications.

Indications	Male	Female
Headache	40	41
Headache and vomiting	4	5
Seizures	2	1
Headache and vertigo	2	1
Vertigo		3
Altered sensorium		1

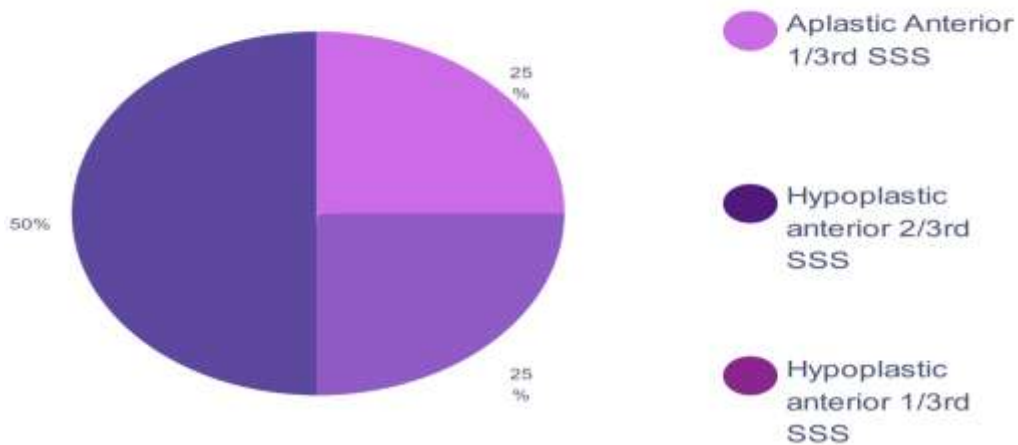
The transverse sinus was reported to be symmetrical in 52 patients out of a total of 100 individuals whose MR venograms were acquired. In 26 cases, the left transverse sinus is hypoplastic, while in 11 cases, it is aplastic or atretic. Ten patients showed hypoplastic right transverse sinus, while aplastic or atretic in none. One patient presented with hypoplastic bilateral transverse sinuses.

**Graph 1:-** Incidence of Hypoplastic Left and Right Transverse Sinuses.

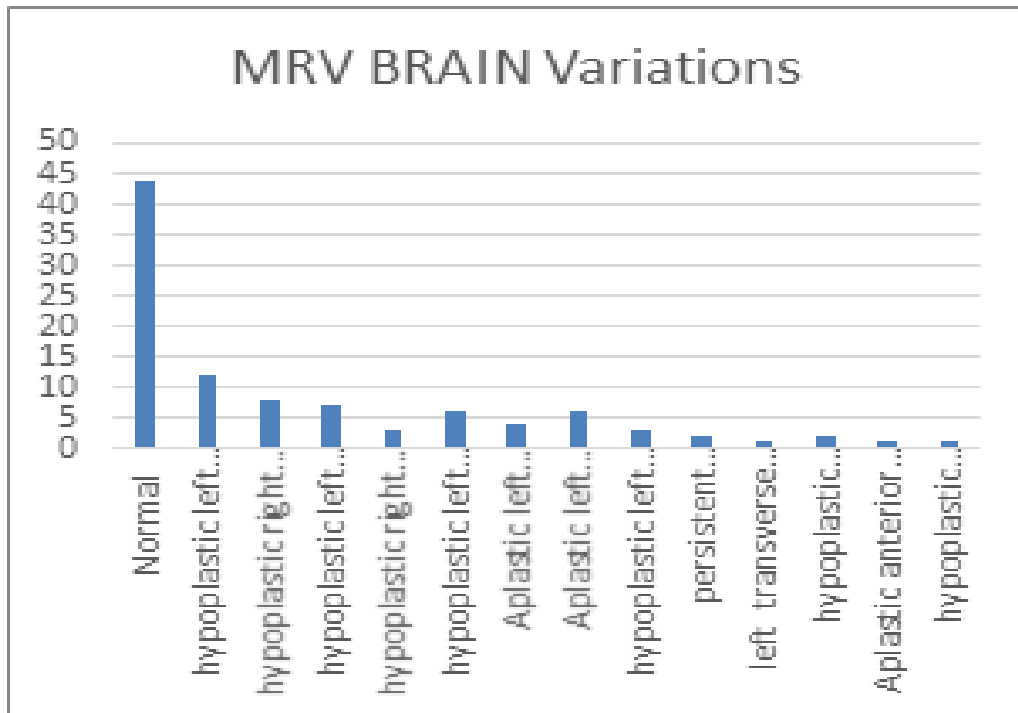
When compared with males, females demonstrated a significantly higher degree of the bilaterally symmetrical transverse sinus. It was discovered that a higher percentage of males than females had hypoplastic left transverse sinuses (14 versus 12).

96 of the 100 cases showed normal superior sagittal sinuses. The hypoplastic anterior 1/3rd SSS was the commonest variation that occurred in 3% of cases. Other variations such as hypoplasia of the middle part of the SSS, hypoplasia of the anterior 2/3rd of the SSS, and hypoplasia of the anterior half of the SSS, which was not observed in the present study.

Superior Sagittal Sinus Variation



Graph 2:- Variations of Superior Sagittal Sinus.



Graph 3:- MRV Brain variations.

Discussion:-

Headache was the most prevalent symptom reported by patients who underwent MRV brain during this research. The most prevalent anatomical variant was hypoplastic left transverse sinus, and it was significantly more common in males than in females. Other anatomical variants of transverse or sigmoid sinuses that were examined did not reveal any significant difference between the genders. Even though there was no significant gender difference, the most prevalent variation of SSS was hypoplasia of the proximal one-third of SSS.

Gouravgoyal et al. [6] outlined the characteristics of transverse sinus irregularities. The transverse sinus has been reported to be symmetrical among 1106 patients (66.9%) out of a total of 1654 individuals whose MR venograms

were collected. In 352 individuals or 21.3%, the left transverse sinus has been hypoplastic, while 67 cases, or 4.1%, were aplastic or atretic. In 91 (5.5%) of the patients, the right transverse sinus has been hypoplastic, while in 12 (0.7%), it was aplastic or atretic. 1.6% of patients were found to have hypoplastic transverse airways on both sides.

Alper et al. [11] outlined the characteristics of transverse sinus irregularities. 31% of patients were found to have symmetrical transverse sinuses. In 39% of individuals, the left transverse sinus has been hypoplastic, while in 20% of cases, it was aplastic. 6% of patients had hypoplastic right transverse sinuses, while 4% had aplastic ones. In another investigation of 100 patients, 10% of those patients showed symmetrical transverse sinuses, 35% of those patients had hypoplastic left transverse sinuses, 13% of those patients had hypoplastic right transverse sinuses, and 1% of those patients had aplastic left transverse sinuses. In comparison, the results of our research revealed that 52% of participants had symmetrical transverse sinuses, 26% had hypoplastic left transverse sinuses, and 10% had hypoplastic right transverse sinuses. When there is complete hypoplasia of the anterior SSS, a pair of significant parasagittal superior frontal cortical veins will take the place of the missing anterior portion of the SSS. These veins will travel dorsally to join the origin of the SSS in a location that is relatively close to the coronal suture.

The occipital sinus is the smallest among dural venous sinuses. It may be isolated, replicated, or comprised of a network of venous collaterals. The occipital sinus is contained within the fixed border of the falx cerebelli, and it connects the torcula with the IJV [12].

13% of patients younger than 25 months of age were found to have persistent occipital sinuses in a survey of 100 children [21], whereas only 2% of children over the age of 5 years were found to have these sinuses.

Among the individuals who participated in our research, the occipital sinus was detected in 3% of the cases. The incorrect interpretation of other vascular structures as occipital sinuses or ethnic disparities between examined communities can attribute to the over-reporting of the frequency of occipital sinus in literature. Through the use of subsequent postmortem sequences, accurate data regarding the prevalence of occipital sinuses may be gathered.

Conclusion:-

It is essential to know the various anatomical variants of the cerebral dural venous sinuses. Without this, conditions like flow gaps in the venous sinuses and hypoplasia or aplasia of the transverse sinus may be misinterpreted as venous sinus thrombosis. In this particular research, the hypoplastic left transverse sinus is the most common anatomical variant and is more common among males when compared to females. The reason for this predominance is not clearly understood. There is no substantial difference between males and females in other anatomical variants of the cerebral venous sinuses.

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