

## Anatomical Variations of the Superior Sagittal, Transverse and Sigmoid Dural Venous Sinuses in the Cerebral MRV Images of Adult Bangladeshis

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### Abstract

### Original Research Article

**Background:** The understanding of the dural venous sinus anatomy and normal anatomical variations is fundamental for appropriate diagnosis of cerebral venous sinus pathology and also for surgical planning and treatment of neurological diseases. Cerebral MRV (Magnetic Resonance Venography) is an exclusive imaging technique for appropriate identification of the normal anatomical variations as well as pathology of the dural venous sinuses. Most of the variations have been detected in the superior sagittal, transverse and sigmoid venous sinuses. **Objectives:** To identify and determine the frequencies of some selected anatomical variations- symmetry, hypoplasia and aplasia (as applicable) of the superior sagittal, transverse and sigmoid dural venous sinuses in the cerebral MRV images of adult Bangladeshis. **Methods:** The research was observational in nature, carried out in the Department of Anatomy, Bangabandhu Sheikh Mujib Medical University (BSMMU) in collaboration with the Department of Neuroradiology & Imaging, National Institute of Neuroscience and Hospital (NINS), Dhaka, from March 2020 to June 2021. A total of 70 adults (35 males and 35 females) Bangladeshi participants were included in this research. The MRV scans were produced by using 3 Tesla magnetic field strength following the routine standard protocols of the institution. By using the Radiant DICOM Viewer software, the MRV images were evaluated by the researcher and the co-investigator independently to identify the selected anatomical variations of the dural venous sinuses. **Results:** Bilateral symmetrical transverse and sigmoid sinus was found in 38% and 47% of total participants respectively. Among the variations of the transverse sinuses, the left sided hypoplastic transverse sinus was found in 17.1% participants whereas the right sided hypoplasia was found only in 2.9% participants. Regarding sigmoid sinus, hypoplasia and aplasia were found only on the left side respectively in 7.1% and 1.14% participants. Rostral hypoplastic superior sagittal sinus was found in 4.3% of the research participants. **Conclusions:** The findings of this research may provide an idea about the frequencies of the common anatomical variations of the superior sagittal, transverse and sigmoid dural venous sinuses in a sample of adult Bangladeshi population. Awareness of these variations may be helpful to prevent misdiagnosis of the venous sinus pathologies.

**Keywords:** Magnetic Resonance Venography (MRV), superior sagittal sinus, transverse sinus, sigmoid sinus, hypoplasia, aplasia, symmetry, variations.

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## INTRODUCTION

The superior sagittal, transverse and sigmoid sinuses are the group of dural venous sinuses that drain blood and CSF from the major part of the brain [1]. These sinuses are related to some of life-threatening neurological conditions, as for example, cerebral venous sinus thrombosis (CVST) which is a potentially damaging neurological disorder. Though cerebral

venous sinus diseases are considered as a rare disease due to their low incidence rate, recently they have received an increased amount of attention by clinicians because of their non-specific clinical manifestations and diagnostic difficulty [2, 3]. The dural venous sinuses are also involved with many other neurological conditions like cerebral venous sinus stenosis, intracranial hypertension or hypotension, intracranial space occupying lesion, hydrocephalus, glaucoma etc.

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These sinuses have also gained attention in the field of anatomical research because anatomical variations of the dural venous sinuses are frequent [4]. The common anatomical variations like hypoplasia, aplasia, asymmetry between the paired venous sinuses, etc. are considered as ‘normal’ because they don’t produce any kind of disturbances in venous flow of the brain [5]. But these normal variations often mimic the clinical conditions, such as; cerebral venous hypoplasia and aplasia often resemble venous sinus thrombosis or stenosis that creates diagnostic dilemma as well as confusion in treatment planning. Among all dural venous sinuses the superior sagittal, transverse and sigmoid venous sinuses are the commonest sites for anatomical variations [5].

Cerebral MRV (Magnetic Resonance Venography) is a well-established and authentic technique for the evaluation and assessment of the dural venous system [6, 7]. It is also a convenient technique to differentiate the normal anatomical variations from dural sinus pathologies [1].

Although a number of studies are available on the anatomical variations of the superior sagittal, transverse and sigmoid sinuses using different imaging modalities [4, 8, 5, 9].

The purpose of our study is to identify and determine the frequencies of some selected anatomical variations of the superior sagittal, transverse and sigmoid sinuses in the cerebral MRV images of adult Bangladeshis.

## MATERIALS AND METHODS

The research was cross-sectional in nature with descriptive components. It was carried out in the Department of Anatomy, Bangabandhu Sheikh Mujib Medical University (BSMMU) in collaboration with the Department of Neuroradiology & Imaging, National Institute of Neuroscience and Hospital (NINS). An evaluation of the cerebral MRV images of 70 adult Bangladeshis (35 males and 35 females), who came to the Department of Neuroradiology & Imaging, NINS for cerebral MRV was done during the research period. Patients aged 18 years or above, Bangladeshi by nationality and residence, male or female by sex, having normal cerebral MRV reported by a registered Neuroradiologist and consented to participate in the research work was included in this research. Having the diagnosis of cerebral venous sinus thrombosis, congenital or acquired intracranial abnormalities, ischemic or hemorrhagic stroke, intracranial hypertension, intracranial space occupying lesion, and previous head injury or neurosurgery was the exclusion criteria of this research. During selection of the participants, each participant of this research was informed about the purpose and the ethical aspects relevant to the research and their voluntary consent was taken by signature/thumb impression. The clinical

indication for cerebral MRV was noted in each patient and institutional review board clearance from both institutes was received.

### MRV imaging study

For each participant, MRV imaging was performed with 3-T MRI machine using either ‘contrast’ or ‘non-contrast (phase contrast)’ method. The basic parameters of the contrast MRV were: TE/TR/FA: 1.14/3.09/20<sup>0</sup>, FOV: 280 mm, slice thickness: 1.40 mm, and resolution matrix: 260 x 204. For non-contrast (phase contrast) MRV technique the parameters were: TE/TR/FA: 7.39/4.56/15<sup>0</sup>, FOV: 230 mm, and resolution matrix = 230 x 229. Post processing of the source images was done using the maximum intensity projection (MIP) method. The softcopies of the participant’s cerebral MRV images were collected into compact disc (CD-R) for identifying the anatomical variations of the superior sagittal, transverse and sigmoid venous sinuses.

### Analysis of the MRV images

Obtained MRV source images were viewed in coronal and sagittal planes for the anatomical variations of the studied sinuses. The variables of this research were the hypoplasia, aplasia and symmetry between the right and left transverse/sigmoid sinuses and rostral hypoplasia of the superior sagittal sinus. These variations were identified either by measuring and comparing of the diameters of the venous sinuses or through meticulous viewing of the MRV images.

The measurements were taken through using of RadiAnt DICOM Viewer [Version no. 2020.1 4/8/2020 (64-bit)] software. Each measurement was taken two times by each of the two investigators of this research independently to identify the selected anatomical variations.

### Operational definitions

Hypoplasia of the superior sagittal sinus was defined as the rudimentary rostral segment of the superior sagittal sinus in the presence of a prominent parasagittal frontal cortical vein joining the middle third of the superior sagittal sinus (Figure 1) [4].

To identify the transverse and sigmoid sinus hypoplasia, their diameters were measured and compared with the measured diameter of the superior sagittal sinus.

When the diameter of the transverse sinus was found less than half of the diameter of the superior sagittal sinus in coronal view, then it was defined as hypoplastic transverse sinus. Both diameters of the superior sagittal and transverse sinuses were measured 1 cm distance from the confluence of sinuses (Figure 2) [10, 5, 11].

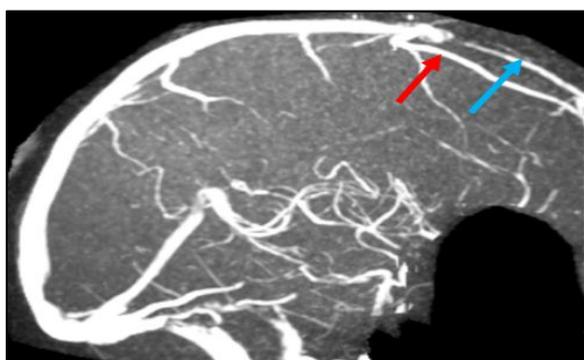
Similarly, when the diameter of the sigmoid sinus was found less than half of the superior sagittal

sinus diameter in coronal view, then it was defined as hypoplastic sigmoid sinus. Here the diameter of the sigmoid sinus was measured 1 cm below from transverse-sigmoid junction (Figure 3) [12]. The transverse-sigmoid junction was defined as the site in where transverse sinus ends by its vertical descent [13].

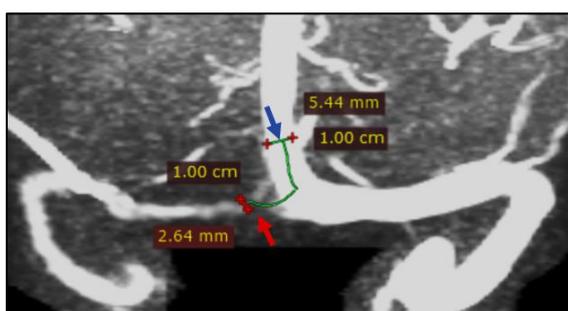
If any transverse/sigmoid venous sinus was not visualized, then it was defined as aplastic transverse/sigmoid venous sinus (Figure 4) [5].

The transverse/sigmoid venous sinuses were defined as ‘symmetrical’ when the measurement ratio of the diameters of the left and right transverse/sigmoid sinuses was equal or between 1.5 and 0.67 in coronal view [14].

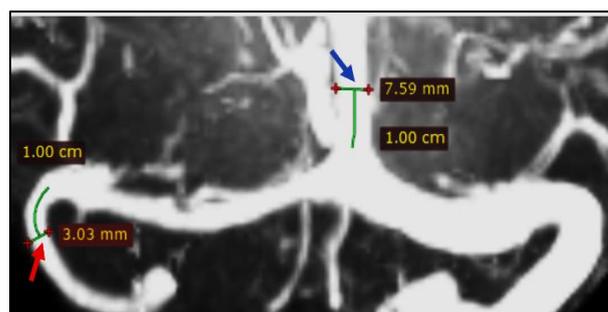
The measurement ratio was evaluated by calculating asymmetry index of the right and left transverse/sigmoid sinuses by using the measured diameters of the right and left transverse/sigmoid sinuses.



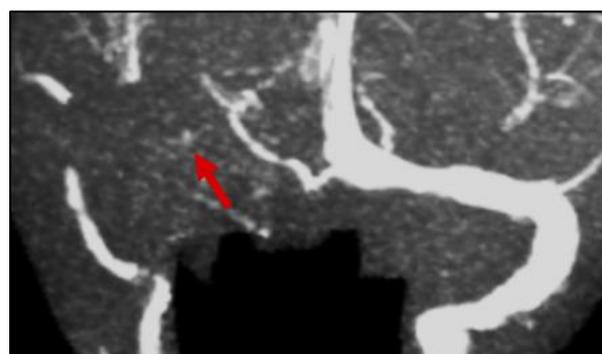
**Fig-1: Showing hypoplasia of the rostral superior sagittal sinus (blue arrow) with presence of a prominent parasagittal frontal cortical vein (red arrow)**



**Fig-2: Coronal view MRV image showing hypoplasia of the left transverse sinus (red arrow) in comparison with the diameter of the superior sagittal sinus (blue arrow). The green curved lines along the middle of the sinuses showing the distance from the confluence of sinuses**



**Fig-3: Coronal view MRV image showing hypoplasia of the left sigmoid sinus (red arrow) in comparison with the diameter of the superior sagittal sinus (blue arrow). The green curved lines along the middle of the sinuses showing the distance from the confluence of sinuses and from the transverse-sigmoid junction**



**Fig-4: Coronal view MRV image showing aplasia of the left transverse sinus (red arrow)**

**Data processing and analysis**

The observed values were analyzed by calculating the absolute and relative frequencies (percentage) in SPSS (version 26) and presented in textual description and tabulated form.

**RESULTS**

In our study according to described methods, 35 male and 35 female (total 70) participants were included and their cerebral MRV images were evaluated to identify some selected anatomical variations of the superior sagittal, transverse and sigmoid sinuses. The observed values were expressed as overall percentage of frequency and percentage of frequency in both sexes separately.

**Anatomical variations of the superior sagittal sinus**

Rostral hypoplasia of the superior sagittal sinus was found in 3 participants (1 male and 2 female). The percentage frequencies of the rostral hypoplastic superior sagittal sinus are shown in Table 1.

**Table-1: Values of percentage frequencies of the rostral hypoplastic superior sagittal sinus (SSS)**

| Variation of the SSS | Overall frequency (%) | Frequency in males (%) | Frequency in females (%) |
|----------------------|-----------------------|------------------------|--------------------------|
| Rostral hypoplastic  | 3 (4.3%)              | 1 (2.9%)               | 2 (5.9%)                 |

### Anatomical variations of the transverse sinus

Symmetrical right and left transverse sinuses were found in 38 participants (20 males and 18 females). The right sided hypoplasia was found in 2 participants (only in 2 females) and left sided hypoplasia found in 12 participants (7 males and 5

females). The left sided transverse sinus aplasia was present in 3 participants (only in 3 males). The right sided aplastic transverse sinus was not present in any participant of our research. The percentage frequencies of the anatomical variations of the transverse sinus are shown in Table 2.

**Table-2: Values of percentage frequencies of the symmetrical, hypoplastic, and aplastic transverse sinus (TS)**

| Variation of the TS     | Overall frequency (%) | Frequency in males (%) | Frequency in females (%) |
|-------------------------|-----------------------|------------------------|--------------------------|
| Symmetrical             | 38 (55.1%)            | 20 (57.1%)             | 18 (52.9%)               |
| Right sided hypoplastic | 2 (2.9%)              | (0.0%)                 | 2 (5.7%)                 |
| Left sided hypoplastic  | 12 (17.1%)            | 7 (20.0%)              | 5 (14.3%)                |
| Left sided aplastic     | 3 (4.3%)              | 3 (8.6%)               | (0.0%)                   |

### Anatomical variations of the sigmoid sinus

Symmetrical right and left sigmoid sinus were found in 47 participants (24 males and 23 females). The left sided hypoplasia was found in 5 participants (3 males and 2 females) and aplasia was present in only 1

male. The right sided hypoplastic and aplastic sigmoid sinus was not found in our research. The percentage frequencies of the anatomical variations of the sigmoid sinus are shown in Table 3.

**Table-3: Values of percentage frequencies of the symmetrical, hypoplastic, and aplastic sigmoid sinus (SS)**

| Variation of the SS    | Overall frequency (%) | Frequency in males (%) | Frequency in females (%) |
|------------------------|-----------------------|------------------------|--------------------------|
| Symmetrical            | 47 (67.1%)            | 24 (68.6%)             | 23 (65.7%)               |
| Left sided hypoplastic | 5 (7.1%)              | 3 (8.6%)               | 2 (5.7%)                 |
| Left sided aplastic    | 1 (1.4%)              | 1 (2.9%)               | (0.0%)                   |

## DISCUSSION

This research was done to identify some common anatomical variations that are considered as normal in cerebral MRV images of adult Bangladeshi population.

Though hypoplasia of the superior sagittal sinus is found in the anterior one-third, middle part, anterior two-third and anterior half of the superior sagittal sinus, the most frequently involved variation of the superior sagittal sinus is the hypoplasia of its rostral third [4, 5].

In the present research, hypoplasia of the superior sagittal sinus was found in 3 participants with the overall frequency of 4.3%. The findings of the present research are close to the findings of Pallewatte *et al.*, where rostral hypoplasia of the superior sagittal was found in 5.7% [15]. In a study on CTA (Computed Tomography Angiogram) images of 100 patient's unilateral rostral hypoplasia was found in 7% patients [4]. Though their results are slightly higher than the results of the present research, their sample size might be responsible for this difference. On the other hand, the findings of this research are markedly higher than the findings of some studies [5, 16]. Through MRV Goyal *et al.* identified hypoplasia of rostral third in 0.4% population while in anatomic specimens Kaplan and Browder found rostral hypoplasia in 1.8% of the population and both of them worked with large sample sizes [5,16]. Ozkacmaz *et al.* found frequency of 1% of the variation of the superior sagittal sinus [17]. On the basis of the percentage frequency of the reference

studies it can be said that, the rostral hypoplasia of the superior sagittal sinus is not so frequent.

In the present research, symmetry, hypoplasia and aplasia of the right and left transverse sinuses have been evaluated. Here, in 55.1% participant's symmetry between the right and left transverse sinus was observed. Tantawy *et al.* and Goyal *et al.* found symmetrical transverse sinuses in 66.1% and 66.9% from 363 and 1616 participants respectively [5, 11]. Though the finding of the present research has been found lower than their findings but in comparison with their sample size, this finding might be comparable. The results of the present research were markedly higher than a MRV image-based study of 105 participants where symmetrical transverse sinuses were identified in 31% participants [7].

Left sided hypoplasia is the commonest anatomical variations of the transverse sinus [11, 3]. In the present research, the left sided hypoplasia was found in 17.1% participants whereas Tantawy *et al.* and Goyal *et al.* (2016) found in 22% and 21.3% participants respectively [5,11]. But Alper *et al.* marked left sided hypoplasia in 39% participants and Ahmed *et al.* found left sided hypoplasia in 39.2% participants [12, 7].

In the present research, frequency of the right sided hypoplastic transverse sinus was 2.9%. This result had been found to be less than the results of Tantawy *et al.* and Goyal *et al.* who found hypoplastic right transverse sinus in 8% and 5.5% participants of their study population [11, 5]. Surendrababu and Livingstone

found right sided hypoplasia in 13 patients among 100 patients [18].

The frequency of the left sided aplastic transverse sinus in the present research was similar to the findings of Goyal *et al.* who found the left aplastic transverse sinus in 4.1% participants but noticeably less than the findings of Alper *et al.* in where left sided aplastic transverse sinus was found in 20% of their research participants [7, 5]. The right sided aplasia was not found in the present research but other authors have found it in their research in very less frequency rate [11, 5, 18].

In our research, symmetry of the right and left sigmoid sinus, hypoplasia and aplasia of the left sigmoid sinus have been identified. Here, bilateral symmetrical sigmoid sinuses were found in 47% participants that are noticeably different from the findings of Goyal *et al.* who found symmetrical sigmoid sinuses in 85.7% participants [5].

Variations in the left sided sigmoid sinus were more common in the present study which was identical to the results of others [17, 5, 18]. In the present study, the left sided hypoplasia was found in 7.1% participants which was noticeably less than Ahmed *et al.* who found hypoplastic left sigmoid sinus in 22.05% patients [12]. In the study of Ozkacmaz *et al.* the left sided hypoplasia was found in 36 patients (n = 200) while Surendrababu and Livingstone (2006) found in 19 patients (n = 100) [17, 18].

No right sided hypoplasia of sigmoid sinus was found in the present research but in the reviewed literature right sided hypoplasia have been detected in but the frequency was low [5, 18, 17].

The frequency of the left sided aplasia in the present research was equal to the frequency detected by Ozkacmaz *et al.* who found aplastic left sigmoid sinus in one participant but more than the findings of Ahmed *et al.* who found the left sided aplastic sigmoid sinus in 0.98% participants [12, 17]. Aplasia of the right sigmoid sinus was absent in the present research.

The strength of this research is that all MRV images are obtained through 3 Tesla magnetic field strength to clearly identify the continuity and sharpness of the dural venous sinuses which is essential for absolute identification of the variations of the dural venous sinuses. But, the total number of participants enrolled in the present research is insufficient to reach in a definite conclusion. Collection of samples from a single center is also an important limitation of the present research because single center study may cause selection bias and may miss more variations. Due to time limitation both contrast and non-contrast (phase-contrast) MRV images were used to assess the

variations but these two techniques are not equivalent in assessing the dural venous system.

## CONCLUSIONS

The dural venous system is a complex widespread venous structure comprised of several paired and unpaired dural venous sinuses. A number of variations are present in the venous sinus anatomy and they are prone to different pathologies also. For accurate diagnosis and differentiation of the pathologies from the anatomical variations, knowledge about the normal anatomical variations is compulsory.

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