Original Article

The Morphological Variants of Dural Venous Sinuses

Sercan Özkaçmaz, Yeliz Dadali[1], Muhammed Alpaslan[1], Ilyas Uçar[2]

Department of Radiology, Faculty of Medicine, Yuzuncu Yil University, Van, [1]Department of Radiology, Faculty of Medicine, Kırşehir Ahi Evran University, [2]Department of Physical Therapy and Rehabilitation, Institute of Physical Therapy and Rehabilitation, Kırşehir Ahi Evran University, Kırşehir, Turkey

Abstract

Introduction: In this study, we aimed to analyze the dural venous system variations in Turkey by magnetic resonance imaging examinations. **Material and Methods:** Images of a total of 200 patients (65 males, 135 females M/F: 0.48) who underwent a magnetic resonance venography examination were retrospectively screened. **Results:** Variation was detected in 101 patients (53.85% of males [35/65] and 48.89% of females [66/135]). In 16.5% of the patients, only one variation of dural venous system was detected, while the most common variation was left transverse hypoplasia in this group. Twenty-six percent of the patients had two variations of the dural venous system since the most common dual variations were left transverse hypoplasia + left sigmoid hypoplasia in this group. In 8% of the patients, three or more variations of the dural venous system were observed as the most common variations were right transverse hypoplasia + right sigmoid hypoplasia + presence of occipital sinus in this group. **Discussion and Conclusion:** It is essential to know the anatomical variations of the dural venous system for the discrimination between pathological processes such as thrombosis and physiologic conditions. Furthermore, the association of these variations with each other must be kept in mind for the explanation of the presence of multiple variations in the same individuals.

Keywords: *Anatomy, dural venous sinuses, magnetic resonance venography, variation*

Introduction

The dural venous system, comprised widespread venous structures including superior sagittal (unpaired), inferior sagittal (unpaired), transverse, sigmoid, straight (unpaired), superior-inferior petrosal, tentorial, occipital (unpaired), cavernous, sphenoparietal, petrosquamous, anterior-posterior intercavernous sinuses (unpaired), torcular herophili (unpaired), basilar and falcine venous plexuses. Because of this complex texture, various variations may be seen in the dural venous system.[1]

Thrombosis and septic thrombophlebitis are the main pathological conditions of the dural venous system, which leads to severe neurological consequences and even death.[2] For the differentiation of anatomic variations and pathological conditions such as dural venous thrombosis-thrombophlebitis, anatomy and the variations of the dural venous system must be well-known to prevent misdiagnosis.[1] Advances in imaging techniques provide a better examination of main dural venous structures. Especially Computed Tomography Venography and magnetic resonance venography (MRV) are very useful for the discrimination of variations and thrombosis.[3]

In this study, we examined the frequency and associations of anatomical variations of the dural venous system in our patients by MRV.

Material and Methods

Medical records of 206 patients (41 ± 19 years old [18–78]) who underwent MRV with complaints of headache, nausea, vomiting, vertigo, seizure or neurological deficits between June 2017 and June 2019 were screened in the hospital database. Six patients were excluded from the study in whom a dural venous sinus thrombosis was detected. Among these 6 ones, thrombosis was seen in only right transverse sinus in two patients, in only superior sagittal sinus (SSS) in one patient. In two patients, left transverse + left sigmoid sinus thrombosis was detected. SSS + left transverse sinus thrombosis was observed in remained one patient. Finally, 200 patients were included in this study.

MRV examinations were performed by using a two-dimensional TOF MRV

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Address for correspondence:
Dr. Sercan Özkaçmaz, Department of Radiology, Faculty of Medicine, Yuzuncu Yil University, Bardakçı, Van 65100, Turkey. E-mail: sercanozkacmaz@hotmail.com

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technique on GE Signa Excite 1.5 Tesla Magnetic Resonance Imaging system (Signa Excite HD; GE Medical Systems, Milwaukee, WI, USA) with a standard head coil. Time of repetition/time of echo (TR/TE) was 28/10.8, and a Flip angle of 60° was used. The field of view was 240 mm, with a matrix size of 256 × 160. Images were acquired in coronal planes with a slice thickness of 1.5 mm. Maximum pixel intensity projection images were obtained, and the images were interpreted by two radiologists. The sinuses, except occipital and falcine sinuses, were reported as normal, hypoplastic, or agenetic. Occipital and falcine sinuses were reported as absent or present.

Patients were classified into four groups as having no dural venous variation (Group C), only one variation (Group O), two variations (Group D), and three or more variations (Group T+).

The study was approved by a local ethics committee on August 06, 2019, with a number of 2019-14/142

Results

Among these 200 patients, variation was observed in 101 ones. The overall variation rate was 50.5%. The incidence of dural venous system variation was found to be as 53.85% (35/65) in males and 48.89% (66/135) in females. The variation rate was found higher in males than in females [Table 1]. These variations are believed to be occurring as a consequence of a congenital condition with no association with aging and other pathological processes as they may be seen in childhood and do not exhibit an alteration at the subsequent imaging examinations.[4]

Groups

In 99 patients (49.5%) (control Group 1 [C]) there was no dural venous system variation. Only one variation was detected in 33 patients (16.5%) (Group 2 [O]) [Table 2]. Two variations were observed in 52 patients (26%) (Group 3 [D]) [Table 3]. Three or more variations were seen in 16 patients (8%) (Group 4 [T+]) [Table 4].

The most common single variation was left transverse hypoplasia, which was detected in 17 patients (8.5%) [Figure 1]. Left transverse hypoplasia + left sigmoid hypoplasia was the most common dual variation that was detected in 25 patients (12.5%) [Figure 2]. The most common triple or more variations was right transverse hypoplasia + right sigmoid hypoplasia + presence of occipital sinus, which was observed in 4 patients (2%) [Figure 3].

There was no significant difference for the presence of complaints between the groups as the symptoms were observed with similar rates in these four groups.

Transverse sinuses

A total of 33 variations were detected in the right transverse sinus. The frequency of variation of the right transverse sinus was found to be 16.5%. Hypoplasia was observed in 30 patients while aplasia in remained three ones.

A total of 59 variations were detected in the left transverse sinus. The frequency of variation of the left transverse sinus was found to be 29.5%. Hypoplasia was observed in 56 patients, while aplasia remained three ones [Figure 4].

Sigmoid sinuses

A total of 23 variations were detected in the right sigmoid sinus. The frequency of variation of the right sigmoid sinus was found to be 11.5%. Twenty-two of the variations of right sigmoid sinus were hypoplasia while one aplasia detected.

A total of 37 variations were detected in the left sigmoid sinus. The frequency of variation of the left sigmoid sinus was found to be 18.5%. Thirty-six of the variations of left sigmoid sinus were hypoplasia, while aplasia was detected in one patient.

Superior sagittal sinus

A total of two variations of the SSS were observed, while all of them were hypoplasia. No aplasia of SSS was detected. The frequency of variation of SSS was found to be 1%.

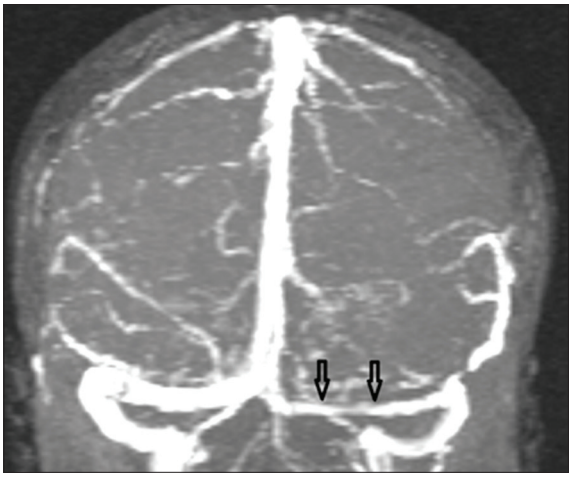

Figure 1: Left transverse sinus hypoplasia (arrows)

Table 1: Distribution of the patients to the groups according to the number of variations

	n (rate%)			
	Group 1 (C) No variation	**Group 2 (O) One variation**	**Group 3 (D) Two variations**	**Group 4 (T+) ≥3 variations**
Female	69 (51.1)	22 (16.3)	34 (25.2)	10 (7.4)
Male	30 (46.2)	11 (16.9)	18 (27.7)	6 (9.2)
Total	99 (49.5)	33 (16.5)	52 (26)	16 (8)

Straight sinus

A total of four variations were detected in the straight sinus. The frequency of variation of the straight sinus was found to be 2%. Three hypoplasia and one aplasia of straight sinus were observed.

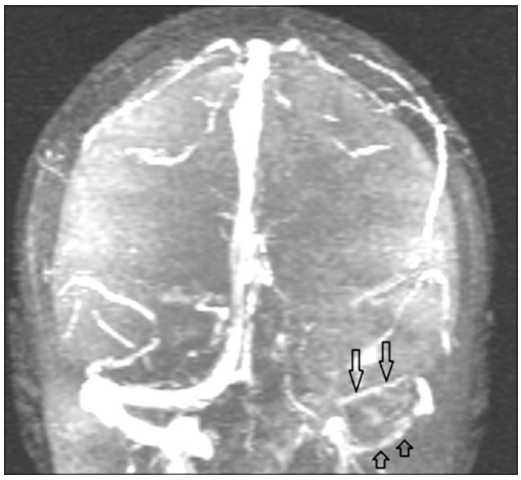

Figure 2: Left transverse sinus hypoplasia (long arrows) +left sigmoid sinus hypoplasia (short arrows)

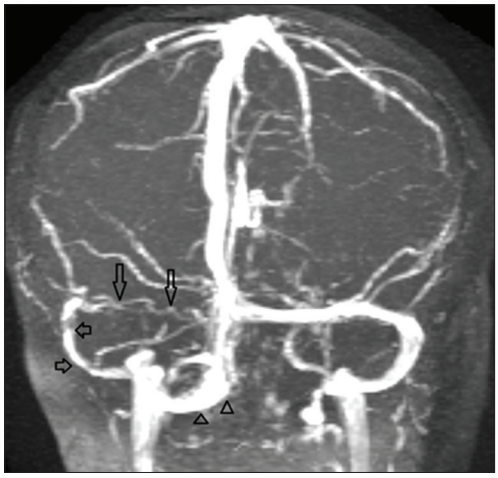

Figure 3: Right transverse sinus hypoplasia (long arrows) + right sigmoid sinus hypoplasia (short arrows) + occipital sinus (arrowheads)

Figure 4: Left transverse sinus aplasia

Inferior sagittal sinus

A total of 11 variations were detected in the inferior sagittal sinus. The frequency of variation of the inferior sagittal sinus was found to be 5.5%. Six of the variations of inferior sagittal sinus were hypoplasia, while 5 ones were aplasia.

Occipital and falcine sinus

In 19 patients (9.5%), occipital sinus was detected. The most common variations which accompanied the presence of occipital sinus were right transverse hypoplasia + right sigmoid hypoplasia [Table 5].

We did not observe falcine sinus in this study.

Discussion

As the dural venous system includes various superficial and deep structures, various pathological conditions and anatomical variations can affect this system. For accurate differentiation of these physiological and pathological conditions, the variations and their association must be well known.[5] In this study, we examined the frequency and types of variations. Furthermore, we investigated the associations of these variations with each other.

We identified thirty hypoplasia and three aplasias in the right transverse sinus while the overall variation frequency of right transverse sinus was 16.5%. In 56 patients, hypoplasia and in 3 ones aplasia of the left transverse sinus was detected with a total variation frequency of 29.5%. In a study by Surendrababu *et al*.[6] they detected right transverse sinus hypoplasia in 13%, left transverse sinus hypoplasia in 35%, and left transverse sinus aplasia in 1% of their patients. Our results were compatible with this study regarding variation rates of right and left transverse sinuses. Goyal *et al*.[7] observed variation of the right transverse sinus in 6.2% of their patients (hypoplasia in 5.5% and aplasia in 0.7%). They detected hypoplasia of the left transverse sinus in 21.3% and aplasia of

Table 2: Distribution of the patients with one variation (Group 2) according to their variation types

	n (rate%)		
	Female	Male	Total
Left transverse hypoplasia	11 (8.1)	6 (9.2)	17 (8.5)
Inferior sagittal hypoplasia	1 (0.7)	2 (3.1)	3 (1.5)
Right transverse hypoplasia	2 (1.5)	-	2 (1.0)
Straight sinus hypoplasia	2 (1.5)	-	2 (1.0)
Inferior sagittal aplasia	1 (0.7)	2 (3.1)	3 (1.5)
Occipital sinus	2 (1.5)	1 (1.5)	3 (1.5)
Left sigmoid hypoplasia	2 (1.5)	-	2 (1.0)
Straight sinus aplasia	1 (0.7)	-	1 (0.5)
Total	22 (16.3)	11 (16.9)	33 (16.5)

Table 3: Distribution of the patients with two variations (Group 3) according to their variation types

Double variations	*n* (rate%)		
	Female	Male	Total
Left transverse hypoplasia + left sigmoid hypoplasia	18 (13.3)	7 (10.8)	25 (12.5)
Right transverse hypoplasia + right sigmoid hypoplasia	5 (3.7)	8 (12.3)	13 (6.5)
Left sigmoid hypoplasia + left transverse aplasia	1 (0.7)	1 (1.5)	2 (1.0)
Right transverse hypoplasia + left transverse hypoplasia	2 (1.5)	-	2 (1.0)
Right transverse hypoplasia + inferior sagittal aplasia	-	1 (1.5)	1 (0.5)
Left transverse hypoplasia + occipital sinus	1 (0.7)	-	1 (0.5)
Right transverse hypoplasia + occipital sinus	1 (0.7)	-	1 (0.5)
Left sigmoid hypoplasia + inferior sagittal aplasia	1 (0.7)	-	1 (0.5)
Right sigmoid hypoplasia+ occipital sinus	1 (0.7)	-	1 (0.5)
Right transverse hypoplasia + superior sagittal hypoplasia	-	1 (1.5)	1 (0.5)
Left transverse hypoplasia + inferior sagittal hypoplasia	1 (0.7)	-	1 (0.5)
Left transverse hypoplasia + left sigmoid aplasia	1 (0.7)	-	1 (0.5)
Right transverse aplasia + occipital sinus	1 (0.7)	-	1 (0.5)
Right tranverse aplasia + right sigmoid hypoplasia	1 (0.7)	-	1 (0.5)
Total	34 (25.2)	18 (27.7)	52 (26.0)

Table 4: Distribution of the patients with three or more variations (Group 4) according to their variation types

Three or more variations	*n* (rate%)		
	Female	Male	Total
Right transverse hypoplasia + right sigmoid hypoplasia + occipital sinus	3 (2.2)	1 (1.5)	4 (2)
Left transverse hypoplasia + left sigmoid hypoplasia + occipital sinus	-	2 (3.1)	2 (1)
Right transverse hypoplasia + Left transverse hypoplasia + occipital sinus	2 (1.5)	-	2 (1)
Right transverse aplasia + Left transverse hypoplasia + right sigmoid hypoplasia	-	1 (1.5)	1 (0.5)
Right transverse hypoplasia + left transverse hypoplasia + inferior sagittal hypoplasia	1 (0.7)	-	1 (0.5)
Right transverse hypoplasia + right sigmoid hypoplasia + straight hypoplasia	-	1 (1.5)	1 (0.5)
Left transverse aplasia + left sigmoid hypoplasia + occipital sinus	1 (0.7)	-	1 (0.5)
Left transverse hypoplasia + Left sigmoid hypoplasia + superior sagittal hypoplasia	1 (0.7)	-	1 (0.5)
Left transverse hypoplasia + left sigmoid hypoplasia + occipital sinus + inferior sagittal hypoplasia	-	1 (1.5)	1 (0.5)
Right transverse hypoplasia + left transverse hypoplasia + right sigmoid hypoplasia + right sigmoid hypoplasia + occipital sinus	1 (0.7)	-	1 (0.5)
Right transverse hypoplasia + right sigmoid aplasia + occipital sinus	1 (0.7)	-	1 (0.5)
Total	10 (7.4)	6 (9.2)	16 (8)

Table 5: The association of presence of occipital sinus with other variations

Variations	*n* (rate%)		
	Female	Male	Total
Occipital sinus (one variation)	2 (1.5)	1 (1.5)	3 (1.5)
Left transverse hypoplasia + occipital sinus	1 (0.7)	-	1 (0.5)
Right transverse hypoplasia + occipital sinus	1 (0.7)	-	1 (0.5)
Right sigmoid hypoplasia + occipital sinus	1 (0.7)	-	1 (0.5)
Right transverse aplasia + occipital sinus	1 (0.7)	-	1 (0.5)
Right transverse hypoplasia + right sigmoid hypoplasia + occipital sinus	3 (2.2)	1 (1.5)	4 (2.0)
Left transverse hypoplasia + left sigmoid hypoplasia + occipital sinus	-	2 (3.1)	2 (1.0)
Right transverse hypoplasia + left transverse hypoplasia + occipital sinus	2 (1.5)	-	2 (1.0)
Left transverse aplasia + left sigmoid hypoplasia + occipital sinus	1 (0.7)	-	1 (0.5)
Left transverse hypoplasia + left sigmoid hypoplasia + occipital sinus + inferior sagittal hypoplasia	-	1 (1.5)	1 (0.5)
Right transverse hypoplasia + left transverse hypoplasia + right sigmoid hypoplasia + right sigmoid hypoplasia + occipital sinus	1 (0.7)	-	1 (0.5)
Right transverse hypoplasia + right sigmoid aplasia + occipital sinus	1 (0.7)	-	1 (0.5)
Total	14 (10.4)	5 (7.7)	19 (9.5)

the left transverse sinus in 4.1% of their patients (total variation rate was 25.4%). While our left transverse sinus variation rate was similar to their results, but our right transverse sinus variation rate was markedly higher. Their bilateral transverse sinus hypoplasia rate was 1.5%. We found bilateral transverse sinus hypoplasia in our 6 patients (3%). Our bilateral transverse sinus hypoplasia rate was compatible with their study. Alper *et al*.[8] detected left transverse sinus hypoplasia in 39%, aplasia in 20%, right transverse sinus hypoplasia in 6%, and aplasia in 4% of their patients. When compared with their study, our left transverse sinus variation rate was lower and right transverse sinus variation rate was higher. Tantawy *et al*.[9] reported left transverse sinus hypoplasia in 22%, aplasia in 3.6%, right transverse sinus hypoplasia in 8%, and aplasia in 1.7% of their 363 patients. When compared with their results, our transverse sinus variation rate was higher on both sides (right and left).

We observed 23 variations in the right sigmoid sinus, while 22 of them were hypoplasia and one was aplasia. The variation rate of the right sigmoid sinus was 11.5%. There were 36 hypoplasia and one aplasia in the left sigmoid sinus with a variation rate of 18.5%. The variation rate of the left sigmoid sinus was higher than the right sigmoid sinus variation rate. In a study by Ahmed *et al*.[5] they detected right sigmoid sinus hypoplasia in 2.9% (n = 6) of their patients, but they did not observe right sigmoid sinus aplasia. The variation rate of left sigmoid sinus was 23.3% while they found left transverse sinus hypoplasia in 22.05% (n = 45) and aplasia in 0.98% (n = 2) of their patients. Our variation rate of the left transverse sinus was mildly lower than their results (18.5% vs. 23.3%), but we observed higher variation rates of the right sigmoid sinus (11.5% vs. 2.9%). Shirodkar *et al*.[10] reported right transverse sinus variations in 6% (hypoplasia in 5% and aplasia in 1%) and left transverse sinus variations in 13% (hypoplasia in 7% and aplasia in 6%) of their patients. Our results were similar to their results, but the rate of aplasia of the left transverse sinus was lower in our patients (1.5% vs. 6%).

A total of 2 variations of the SSS were observed in our study, while all of them were hypoplasia of 1/3rd of the SSS. No aplasia of SSS was detected. The rate of variation of SSS was found to be 1%. Goyal *et al*.[7] reported a 2.3% variation rate (0.4% (n = 6) was hypoplasia of anterior 1/3rd part) of SSS. Ahmed *et al*.[5] did not observe any SSS variations in their 204 patients. Our variation rate results of SSS was compatible with previous studies.

Three hypoplasia and one aplasia (2% n = 4) of straight sinus were detected in our study. Ahmed *et al*.[5] reported no variation of the straight sinus in their patients. Goyal *et al*.[7] identified 4 hypoplasia (0.2%) in their patients. We found higher variation rates of straight sinus when compared with previous studies.

Among 11 variations (5.5%) of inferior sagittal sinus variations, 6 ones were hypoplasia, and 5 ones were aplasia in our study. Ahmed *et al*.[5] reported a 13.95% variation rate of the inferior sigmoid sinus. Ayanzen *et al*.[11] detected inferior sagittal sinus in only 52% of their patients. The variation rate of the inferior sagittal sinus in our study was lower than the results of previous studies.

We detected occipital sinus in 19 patients (9.5%). Goyal *et al*.[7] reported occipital sinus in 1.4% of their patients. However, in literature, some studies suggested that occipital sinus was found in 4%–10%[11,12] of individuals. Our occipital sinus results were similar to previous studies.

Falcine sinus is a dural venous sinus variation with an incidence of 5.3%, which may be associated with straight sinus variations.[13] We did not observe any falcine sinus in especially our patients with hypoplastic/agenetic straight sinus.

We detected dual venous sinus variations in 51 patients (25.5%). The most common dual variations were left transverse hypoplasia + left sigmoid hypoplasia (n = 25, 12.5%), right transverse hypoplasia + right sigmoid hypoplasia (n = 13, 6.5%), left transverse aplasia + left sigmoid hypoplasia (n = 2, 1%), and right transverse hypoplasia + left transverse hypoplasia (n = 2, 1%).

We observed three or more variations in 16 patients (8%). The most common three or more variations were right transverse hypoplasia + right sigmoid hypoplasia + occipital sinus (n = 4 2%), left transverse hypoplasia + left sigmoid hypoplasia + occipital sinus (n = 2 1%) and right transverse hypoplasia + left transverse hypoplasia + occipital sinus (n = 2 1%).

We observed that in the patients with multiple dural venous variations, ipsilateral transverse and sigmoid variations usually accompany each other, and also frequently an occipital sinus presents with such conditions. This is probably due to provide the drainage via the occipital sinus.

Conclusion

Multiple dural venous sinus variations may be misdiagnosed as thrombosis especially in the patients with neurological complaints as dural venous thrombosis usually involves two or more different dural sinuses. The frequency and the association of multiple variations must be well known because accurate discrimination between these variations and pathological conditions such as thrombosis is essential to prevent misdiagnosis.

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Conflicts of interest

There are no conflicts of interest.

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