

Different normal anatomical variations of the transverse dural sinus in magnetic resonance venography (MRV): do age and sex matter?

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SUMMARY

The anatomical variations of the intra-cranial venous dural sinuses must be put in consideration in diagnosing magnetic resonance venography (MRV) to avoid the diagnostic pitfalls resulting from over-diagnosis of cerebral venous dural sinus occlusion or thrombosis. The available data regarding the age and sex difference of the magnetic resonance venography (MRV) anatomical variations is still limited. A retrospective study is done for 500 patients ranging from 20 to 70 years. Only 363 patients (142 males and 221 females) were included in our final analysis: all have normal MRI brain & posterior fossa. Magnetic resonance venography (MRV) is done to detect the presence or absence of the transverse venous dural sinuses and to detect any age- or sex-related differences. Also 64 dry Egyptian skulls (41 males and 23 females) were employed to detect symmetry of transverse sulcus and to determine age and sex difference. Hypoplastic left transverse sinus was by far the commonest asymmetrical transverse sinus variants representing 22.0% of total: it was noted in 38 male and 38 female. Even if the asymmetrical transverse sinus is more common in females,

there is no significant difference between both genders. In the dry skull, symmetrical transverse sulcus was observed in 67.2% of total, while asymmetrical transverse sulcus was recorded in 32.8% of total, which were more observed in female skull 17.2% of total with no significant difference.

Key Words: Magnetic resonance venography (MRV) – Transverse sinus – Aplastic – Hypoplastic – Transverse sulcus – Symmetry

INTRODUCTION

The transverse sinus (lateral sinus) is one of the bilateral dural venous sinuses, that arises from superior sagittal sinus or straight sinus or the confluence of superior sagittal sinus and straight sinus. The transverse sinus drains into the sigmoid sinus, which in turn connects to the internal jugular vein (Standing, 2016). The transverse sinus courses horizontally and passes laterally between the attached margin of the two layers of tentorium cerebelli (Kiliç and Akakin, 2008). The transverse sinuses are often unequal in size, one sinus is usually larger than the other, namely the one which drains the superior sagittal sinus (Sinnatamby, 2011). So the left is more common to be hypoplastic than the right one, and that can be anatomically explained as that the right is the direct continuation of the superior sagittal sinus, while the left is the continuation of the straight sinus, and that the superior

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sagittal sinus is larger in size (Bayaroğullari et al., 2018).

Each transverse sinus receives tributaries from cerebral and cerebellar hemispheres, in addition to the superior petrosal sinus at its termination (Snell, 2000).

The transverse groove or sulcus is a wide groove situated on the internal surface of the skull. The sagittal groove at the internal occipital protuberance turns to one side forming the transverse groove (usually the right. The other one (usually the left transverse groove) is narrower. It extends from the midline at internal occipital protuberance to sigmoid groove. The transverse sulcus lodges transverse sinus, which grooves the occipital bone beside the mastoid angle of the parietal bone (Singh et al., 2004; Standring, 2016).

Magnetic resonance venography (MRV) is an ideal, well-established and non-invasive technique that plays an important role in visualizing and evaluating the cerebral dural venous sinuses and to assess its anatomical variations (Ayanzen et al., 2000; Alper et al., 2004; Widjaja and Griffiths, 2004; Fukusumi et al., 2010; Massrey et al., 2018).

MRV is very useful in distinguishing developmental hypoplasia of examined venous sinus from acquired venous sinus occlusion or thrombosis (Gökçe et al., 2014; McCormick et al., 2016).

The main purpose of our study is to study the normal anatomical variations of the transverse dural venous sinus, depicted by 3D MRV in normal MRI patients, and to evaluate if there is any age- or sex-related differences.

MATERIALS AND METHODS

The Patients were referred from Neurology and Neurosurgery outpatient clinics in Zagazig University hospitals to do MRI brain and MRV examination in the MRI Unit of Radiology department of Zagazig University, from November 2016 to November 2018.

A retrospective evaluation of the MRV data of 500 patients during the study period was done. Patients' age range from 20 to 70 years. Patients with any congenital, inflammatory, neoplastic or ischemic intracranial abnormalities, as well as patients with previous surgery, were excluded from our study. Patients with hypoplastic or aplastic any venous dural sinus other than the transverse one were also excluded from our study: thus 363 patients with normal conventional MRI exam, 142 males and 221 females, were included in our final analysis.

All patients underwent:

- Full history taking.
- Thorough clinical and neurological examination
- MRI and MRV examination were performed at (1.5 T) super conducting MR machine (Philips Achieva, class II). The examination was done using the standard head coil with small field of view

(FOV 230) and thin sections (slice thickness 1.2mm). Routine MRI brain including Axial T1WI, T2WI, FLAIR, Coronal T2WI, and Sagittal T1 WI were done with complementary Maximum intensity projection (MIP) 3D MR venography.

Image analysis

3D MRV MIP images were viewed in the sagittal, transverse and coronal planes. MRI Source images were also evaluated for any anatomical variations of the transverse sinus, and to see if there was any accessory sinus. The presence or absence of both transverse dural sinuses was noted. If it is not clearly visualized, it will be diagnosed as aplastic transverse dural sinus; and if its diameter is less than half the Superior sagittal sinus (SSS) diameter, it will be diagnosed as hypoplastic transverse dural sinus (Goyal, 2016).

Detection of symmetry of transverse skulls on dry skulls

Fifty-two adult dry skulls 41 males and 23 females of Egyptian origin were used in this study. The skulls were obtained from Department of Human Anatomy, Faculty of Medicine, Zagazig University. Any skull with malformations or damage was excluded. Determination of the ages of the skulls were performed by using closure of the cranial suture (Meindle and Lovejoy, 1985) in addition to both dental eruption and tooth wear (Vodanovic et al., 2011; D'incua et al., 2012).

The sex of dry skulls was estimated by using standard known criteria mentioned by Buikstra and Ubelaker (1994), and also by Pickering and Bachman (1997). These criteria include prominence of the occipital, mastoid and supraorbital regions. Also the sex was proved by using characteristics of the mid sagittal curve (Bigoni et al., 2012).

The symmetry of the shape of the transverse sulcus were observed and stored on computer sheet to determine age and sex difference.

Statistical analysis

Statistical analysis was performed by using SPSS version 19. Chi-square analysis was used to explore the statistically significant difference of Transverse dural sinus anatomical variations and symmetry of transverse sulcus among different examined age groups and both genders. A difference was significant if P value is < 0.05.

RESULTS

Our study included 363 patients (142 male, 221 female, and age range from 20 to 70 years old.

Indications

The most common indication for MR Venography was headache (46.8%). Other less common indications were headache & vomiting (19.6%), vertigo & dizziness (13.8%), headache & vertigo (10.7%),

Table 1. Clinical indication for MRV in both genders

Indication	Male 142	Female 221	Total 363
Headache	60(42.3%)	110 (49.8%)	170(46.8%)
Headache and vomiting	31 (21.8%)	40 (18.1%)	71 (19.6%)
Vertigo and dizziness	19 (13.3%)	31 (14%)	50 (13.8%)
Headache and vertigo	17 (12%)	22 (10%)	39 (10.7%)
Seizures	12 (8.5%)	14 (6.3%)	26 (7.2%)
Altered sensation	2 (1.4%)	2 (0.9%)	4 (1.1%)
Mood disorders	1 (0.7%)	2 (0.9%)	3 (0.8%)

Table 2. Symmetrical and asymmetrical transverse sinus with sex crosstabulation

		Male	Female	Total	P value
symmetrical	Number	90	150	240	0.221
	% within sex	63.4%	67.9%	66.1%	
	% of Total	24.8%	41.3%	66.1%	
asymmetrical	Number	52	71	123	
	% within sex	36.6%	32.1%	33.9%	
	% of Total	14.3%	19.6%	33.9%	

Table 3. Symmetrical and asymmetrical transverse sinus with age crosstabulation

		Group20-29	group30-39	group40-49	group50-59	group60-	Total	P
Symmetrical	Count	47	48	45	46	54	240	0.001
	% within group	90.4%	62.3%	70.3%	54.8%	62.8%	66.1%	
	% of Total	12.9%	13.2%	12.4%	12.7%	14.9%	66.1%	
Asymmetrical	Count	5	19	29	38	32	123	
	% within group	9.6%	36.7%	29.7%	37.2%	45.2%	33.9%	
	% of Total	1.4%	8.0%	5.2%	8.8%	10.5%	33.9%	

seizures (7.2%), altered sensation (1.1%), and mood instability (0.8%) (Table 1).

Anatomical variations of the Transverse sinus

Our study included 363 patients, 142 male and 221 female, with normal MRI brain and posterior fossa. MRVenography was done to evaluate the presence and the relative caliber of the transverse dural sinus in comparison to the superior sagittal sinus: we found that there was 240 patient (66.1%) (24.8% male and 41.3% female) had normal bilateral symmetrical transverse sinuses, and 123 patients (33.9%) including 52 male (14.3%) and 71 female (19.6%) had asymmetric transverse sinus. No statistical significant difference between males and females was found ($P > 0.05$) (Table 2).

In respect to distribution of asymmetrical sinus, highly statistical significant difference was recorded among age groups ($P < 0.05$) (Table 3).

Hypoplastic right transverse sinus (at which the caliber of the RT transverse sinus is relatively less than half the caliber of the superior sagittal sinus) was found in 29 (8%) patients (21 females and 8

males). Aplastic right transverse sinus (at which the RT transverse sinus is not visualized at all) was found in 6 (1.7 %) patients (5 females and 1 male), while hypoplastic left transverse sinus (at which the caliber of the LT transverse sinus is relatively less than half the caliber of the superior sagittal sinus) was found in 80 (22 %) patients (40 females and 40 males). Aplastic left transverse sinus (at which the LT transverse sinus is not visualized at all) was found in 13 (3.6 %) patients (8 females and 5 males) (Table 4). In comparison, there is significant difference between males and females ($p < 0.05$).

Regarding the age difference in RT transverse sinus, the highest level of RT hypoplastic sinus was in group age above 60 (2.2 %), while least level was found group age 20-29 (0.3%). However, regarding right aplastic sinus, the distribution is nearly equal among age groups (Table 5).

Regarding the age difference in LT transverse sinus, we found that 7.2% of patients with LT hypoplastic sinus were in group age above 60, comparing with the 0.6 % that were detected in age

Table 4. Anatomical variations of right and left transverse sinus (normal, hypoplastic and aplastic) with sex cross-tabulation

		right transverse sinus			left transverse sinus				
		male	female	Total			male	female	Total
normal	Count	133	195	328	Count		97	173	270
	% within sex	93.7%	88.2%	90.4%	normal	% within sex	68.3%	78.3%	74.4%
	% of Total	2.2%	5.8%	8%		% of Total	26.7%	47.7%	74.4%
hypoplastic	Count	8	21	29	Count		40	40	80
	% within sex	5.6%	9.5%	8%	hypoplastic	% within sex	28.2%	18.1%	22%
	% of Total	2.2%	5.8%	8%		% of Total	11.0%	11.0%	22%
aplastic	Count	1	5	6	Count		5	8	13
	% within sex	.7%	2.3%	1.7%	aplastic	% within sex	3.5%	3.6%	3.6%
	% of Total	.3%	1.4%	1.7%		Count	1.4%	2.2%	3.6%
P		0.025					0.037		

Table 5. Anatomical variations of right transverse sinus (normal, hypoplastic and aplastic) with age cross-tabulation

Groups	Group20-29	group30-39	group40-49	group50-59	group60-	p
normal	Count	50	69	57	76	76
	% within group	96.2%	89.6%	89.1%	90.5%	88.4%
	% of Total	13.8%	19.0%	15.7%	20.9%	20.9%
hypoplastic	Count	1	6	7	7	8
	% within group	1.9%	7.8%	10.9%	8.3%	9.3%
	% of Total	.3%	1.7%	1.9%	1.9%	2.2%
aplastic	Count	1	2	0	1	2
	% within group	1.9%	2.6%	.0%	1.2%	2.3%
	% of Total	.3%	.6%	.0%	.3%	.6%

Table 6. Anatomical variations of left transverse sinus (normal, hypoplastic and aplastic) with age cross-tabulation

Groups	Group20-29	group30-39	group40-49	group50-59	group60-	
normal	Count	49	56	52	54	59
	% within group	94.2%	72.7%	81.3%	64.3%	68.6%
	% of Total	13.5%	15.4%	14.3%	14.9%	16.3%
hypoplastic	Count	2	17	10	25	26
	% within group	3.8%	22.1%	15.6%	29.1%	31.0%
	% of Total	.6%	4.7%	2.8%	6.9%	7.2%
aplastic	Count	1	4	2	4	2
	% within group	1.9%	5.2%	3.1%	4.8%	2.3%
	% of Total	.3%	1.1%	.6%	1.1%	.6%

group between 20-29 years. A similar distribution left aplastic sinus among age groups was observed (Table 6).

MIP MRV anatomical variations of both transverse dural venous sinuses have been illustrated in Figs. 1-7).

The symmetry of the shape of the transverse sulcus

Sixty-four dry Egyptian skulls (41 males and 23

females) were used in this study. The age and sex of skulls were shown in (Table 7).

67.2% of dry skull showed symmetrical transverse sulcus (48.4% male skulls and 18.8% female skulls). Non symmetrical transverse sulcus were observed in 32.8% (15.6% male skulls and 17.2% female skulls) (Fig. 8) (Table 8).

Symmetrical transverse sulcus was detected in 77.8%, 62.5%, 69.6% and 62.5% in dry skulls aged from 30-39, 40-49, 50-59 and above 60, respectively. However, non-symmetrical transverse

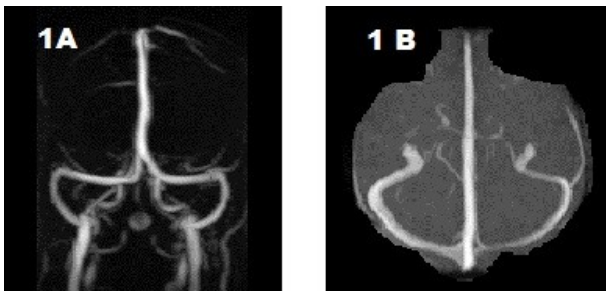


Fig 1. MIP MRV shows bilateral symmetrical transverse sinuses. (A) coronal plane, (B) transverse plane.

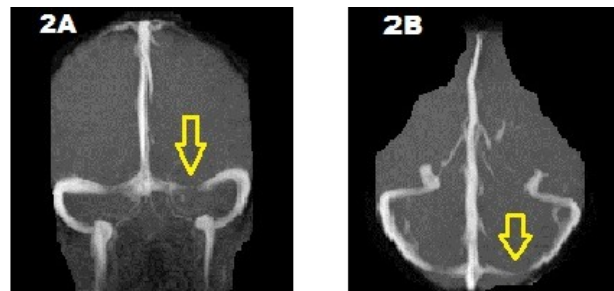


Fig 2. MIP MRV shows hypoplastic left side transverse sinus (yellow arrow). (A) coronal plane, (B) transverse plane.

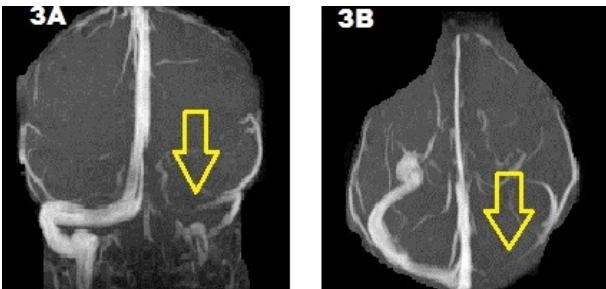


Fig 3. MIP MRV shows aplastic left transverse sinus (yellow arrow). (A) coronal plane, (B) transverse plane.

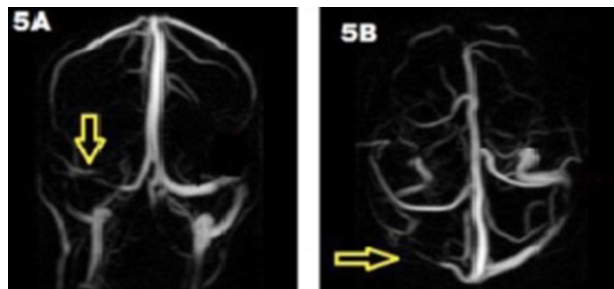


Fig 5. MIP MRV shows aplastic right transverse sinus (yellow arrow). (A) coronal plane, (B) transverse plane.

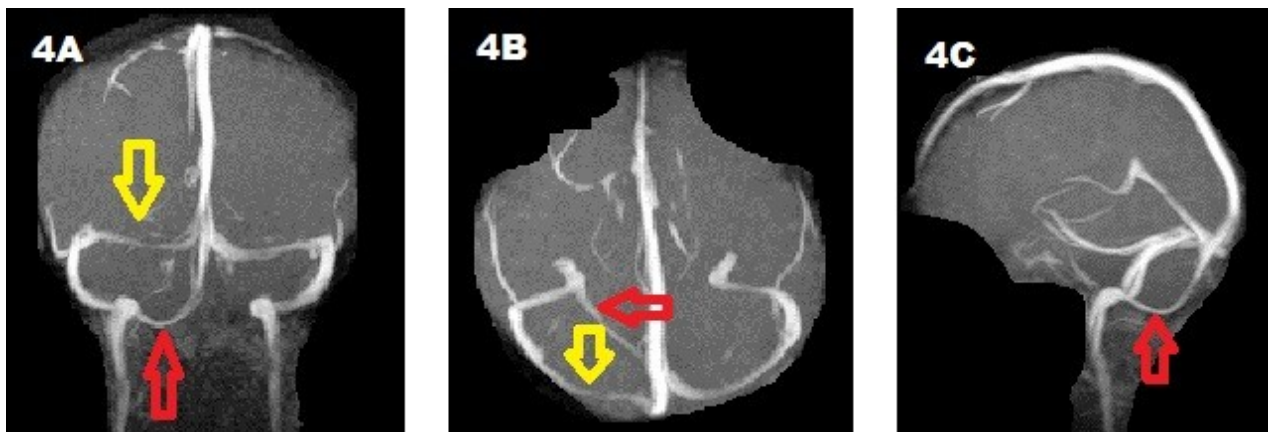


Fig 4. MIP MRV shows hypoplastic right transverse sinus (yellow arrow) and an accessory occipital dural venous sinus (red arrow). (A) coronal plane, (B) transverse plane, (C) sagittal plane.



Fig 6. MIP MRV shows bilateral hypoplastic sinuses, RT (yellow arrow) and LT (red arrow). (A) coronal plane, (B) transverse plane, (C) sagittal plane.

sulcus was observed in 22.2%, 37.5%, 30.4% and 37.5% in dry skulls aged from 30-39, 40-49, 50-59 and above 60, respectively (Table 9).

DISCUSSION

This study was done to evaluate the normal anatomical variations of the transverse dural venous

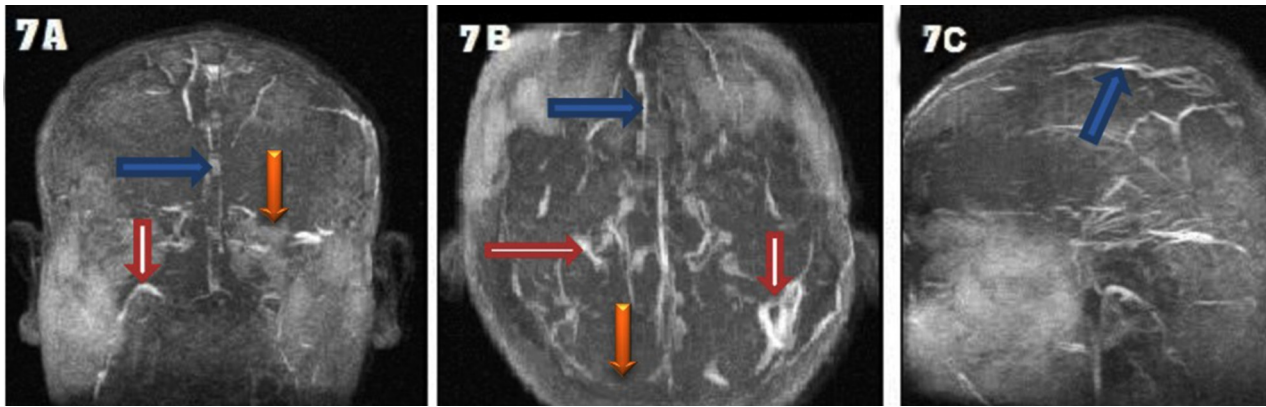


Fig 7. MIP MRV shows bilateral aplastic transverse sinuses in a 69 y male patient (orange arrow) for the anatomical site of transverse sinus, (blue arrow) for superior sagittal sinus and (red arrows) for multiple variable sized collateral. (A) coronal plane, (B) transverse plane, (C) sagittal plane.

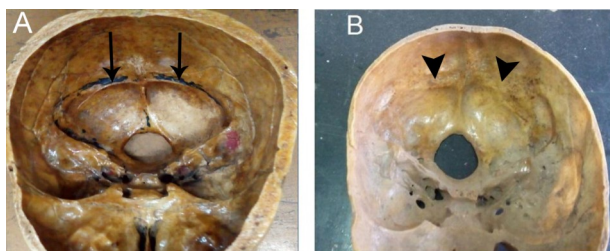


Fig 8. Samples of dry skull quoted from the museum of anatomy and embryology at Zagazig Univeristy show (A) bilateral symmetrical transverse sulcus and (B) bilateral asymmetrical transverse sulcus.

sinus, as well as the sex differences in Egyptian population. The most common clinical presentation was headache. Hypoplastic left transverse sinus was considered by far the most common normal anatomical variation representing 22%. The second common normal anatomical variation was hypoplastic right transverse sinus representing 8%; and then aplastic left transverse sinus, representing 3.6%. Aplastic right transverse sinus and hypoplastic both transverse sinuses are rare entities, as they did not exceed 2%. In our study, we found that the prevalence of hypoplastic sinuses increased with age. These results are in agreement of Goyal et al. (2016), who described the transverse sinus anatomical variations as follows; 66.9% bilateral symmetrical transverse sinus, 21.3% hypoplastic left transverse sinus, 4.1% aplastic left sinus, 5.5% hypoplastic right transverse sinus and 0.7%. Aplastic right sinus. Also Jakhar et al. (2019) reported similar results as they found symmetrical Transverse sinus in 57%, hypoplastic left TS in 32% and hypoplastic right TS in 6%.

Conversely, another study was done by Alper et al. (2004) described the transverse sinus anatomical variations as follows; 39% hypoplastic left transverse sinus, 31% bilateral symmetrical transverse sinus, 20% aplastic left transverse sinus, 6% hypoplastic right transverse sinus, and 4% aplastic

Table 7. Number of male and female skulls among age group

	Male	Female
Age group 30-39	5	4
Age group 40-49	5	3
Age group 50-59	16	7
Age group 60-	15	9
Total	41	23

Table 8. Symmetrical and asymmetrical of the transverse sulcus with sex crosstabulation

		Male	Female	Total
symmetrical	Count	31	12	43
	% within sex	75.6%	52.2%	67.2%
	% of Total	48.4%	18.8%	67.2%
asymmetrical	Count	10	11	21
	% within sex	24.4%	47.8%	32.8%
	% of Total	15.6%	17.2%	32.8%

right transverse sinus.

Another study was done by Surendrababu et al. (2006), which described the transverse sinus anatomical variations as follows: 35% had hypoplastic left transverse sinus, 13% had hypoplastic right transverse sinus, 10% had bilateral symmetrical transverse sinuses, and 1% had aplastic left transverse sinus.

Massrey et al. (2018) mentioned that, due to the fact that hypoplasia or aplasia is more common on the left side, the right jugular system seems to have an increased capacity.

In the current study, we found that females were more likely to have symmetrical transverse sinuses, as well as most of the detected anatomical variations including hypoplastic right transverse sinus, Aplastic Right and Left sinuses, and hypoplastic left transverse sinus is more common in males

Table 9. Symmetrical and asymmetrical transverse sulcus with age crosstabulation

		Group30-39	Group40-49	Group50-59	Group60-	Total
symmetrical	Count	7	5	16	15	43
	% within group	77.8%	62.5%	69.6%	62.5%	67.2%
	% of Total	10.9%	7.8%	25.0%	23.4%	67.2%
asymmetrical	Count	2	3	7	9	21
	% within group	22.2%	37.5%	30.4%	37.5%	32.8%
	% of Total	3.1%	4.7%	10.9%	14.1%	32.8%

than in females. The preceding results were in consistence with those of Goyal et al. (2016), who performed a MRV study on 1465 cases varying in ages from 19 to 86 years, including 582 males and 1072 females. They revealed that the presence of bilateral symmetrical transverse and sigmoid sinuses were more common in females than males, unlike the hypoplastic left transverse sinus, which was more common in males compared to females.

There is a gender difference reported not only in the incidence of many neurological conditions, but also in human brain morphology and overall brain volumes (Ruigrok et al., 2014).

The reported difference in brain structures between males and females can explain the relative predisposition of some neuropsychiatric disorders, but the available data regarding the gender difference of intracranial vasculature are still limited (Stefani et al., 2013).

A phase contrast MRA and MRV study done on 257 cases, varying in age from 5 to 82 years, including 91 males and 166 females, revealed that the females were more likely to have reduced right sigmoid sinus flow than males, and that there was a direct relationship between the age and the velocity of flow within the left and right sigmoid sinuses in males and females respectively (Savelyeva et al., 2012).

The strength of this study is the large sample size, and that the MRV reporting was done by many radiologists. The limitations in our study are the absence of contrast enhanced MRV and lack of long term follow up.

CONCLUSION

Knowledge of anatomical variations of cerebral dural venous sinuses is important to avoid over-diagnosis of sinus thrombosis. Hypoplastic left transverse sinus is by far the most common anatomical variation detected in our current study. The prevalence of Hypoplastic left transverse sinus is more common in males than in females, unlike the other anatomical variations that are more commonly seen in females. The significance of age and gender differences of the anatomical variations of cerebral venous sinus has not been reported yet; therefore, further studies with long term

follow up is still needed.

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