Anais da Faculdade de Medicina de Olinda
Annals of Olinda Medical School

afmo.emnuvens.com.br ISSN: 2674-8487 Article Review

Anatomical variations of the transverse sinus and clinical-surgical repercussions: an integrative literature review

Variações anatômicas do seio transverso e suas repercussões clínico-cirúrgicas: uma revisão integrativa da literatura

Ismael Felipe Gonçalves Galvão[1] Marcos Antônio Barbosa da Silva[1]
Fernando Augusto Pacífico[1]

[1] Faculdade de Medicina de Olinda. Olinda, Pernambuco, Brazil.

Abstract

Introduction: The dural venous sinuses drain the blood and cerebrospinal fluid circulating through the brain toward the internal jugular veins. The transverse sinuses are bilateral structures in the posterior portion of the skull that originate at the confluence of sinuses. Such cerebral venous structures have a complex anatomy and are marked by variations. Thus, a complete understanding of the morphology and variations of these anatomical structures is essential for clinical and surgical practice. This study summarized the literature on the anatomical organization of the transverse sinuses, variations, and potential clinical-surgical repercussions. **Objective:** To review the anatomy, variations, and possible clinical-surgical implications of the transverse sinuses. **Methods:** This integrative literature review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis. Studies published in English in the last 15 years were retrieved from PubMed, Virtual Health Library, and MEDLINE databases, based on the following descriptors: transverse sinuses, anatomy, and anatomic variation. **Results:** Of the 48 studies identified after duplicate removal, 10 met the eligibility criteria and were included in the synthesis. Conclusion: Hypoplasia of the left transverse sinus is the most common anatomical variation and is more frequent in adult men over 60 years old.

Key words: Transverse sinus; Anatomy; Literature; Review.

Corresponding author:
Fernando Augusto Pacífico
E-mail: fapacifico@outlook.com
Funding: não se aplica
Ethics approval: não se aplica
Received on 20/11/2022
Accepted on 10/04/2023

How to cite: Galvão **IFG**, Silva **MAB**, Pacífico **FA**. Anatomical variations of the transverse sinus and clinical-surgical repercussions: an integrative literature review. An Fac Med Olinda 2023; 1(9):41 https://doi.org/10.56102/afmo.2023.250

Resumo

Introdução: Os seios venosos da dura-máter são canais venosos que drenam o sangue e o líquido cefalorraquidiano que circulam pelo cérebro em direção às veias jugulares internas. Os seios transversos, os quais iniciam-se na confluência dos seios estão presentes na porção posterior do crânio, sendo estruturas bilaterais. As estruturas venosas cerebrais, como o seio transverso, possuem uma complexa anatomia e são marcadas por variações. O entendimento completo acerca da morfologia e variações dessas estruturas anatômicas é essencial na prática clínica e cirúrgica. O presente estudo visa sumarizar as informações contidas na literatura sobre a organização anatômica dos seios transversos, suas variações e possíveis repercussões clínico-cirúrgicas. **Objetivo:** Revisar a anatomia, variações e possíveis repercussões clínico-cirúrgicas do seio transverso. **Métodos**: Trata-se de uma revisão integrativa da literatura redigida baseada nas recomendações do PRISMA (*Preferred Reporting Items for Systematic Reviews and Meta-Analyse*), a qual analisou estudos publicados na língua inglesa publicados nos últimos 15 anos tendo como referência as bases de dados PubMed (Public Medline or Publisher Medline), BVS (Biblioteca Virtual em Saúde) e MEDLINE empregando os seguintes descritores padronizados: Transverse Sinuses, Anatomy, Anatomic Variation. **Resultados**: Dos 48 estudos identificados após a remoção de duplicatas, 10 atingiram os critérios de elegibilidade e foram incluídos na síntese. **Conclusões:** Hipoplasia do seio transverso esquerdo é a variação anatômica mais comum dessa estrutura anatômica, geralmente mais frequente em homens e na faixa etária acima dos 60 anos.

Palavras chaves: Seios transversos; Anatomia; Literatura; Revisão.

INTRODUCTION

The dural venous sinuses are channels without muscle tissue that drain the blood and cerebrospinal fluid in the brain toward the internal jugular veins. The main venous sinuses include the superior and inferior sagittal, straight, occipital, sigmoid, and transverse[1,2].

The transverse sinuses are mostly bilateral and originate at the confluence of sinuses, which comprise the superior sagittal, straight, and occipital sinuses. These structures are present in the posterior portion of the skull adjacent to the margins of the tentorium cerebelli. The transverse sinuses receive blood from the temporal-lateral surfaces, the basal surface, and temporal and occipital lobes that reach the petrous portion of the temporal bone and flow into the sigmoid sinus. Each transverse sinus receives tributaries from the cerebral and cerebellar hemispheres[1-3].

Cerebral venous structures have complex anatomy and are marked by variations; thus, a complete understanding of the morphology and variations of these structures is essential in clinical and surgical practice (e.g., diagnosing and treating dural venous sinus diseases and neurovascular surgical interventions)[4]. Therefore, this study aims to summarize the literature on the anatomical organization of the transverse sinuses, variations, and possible clinical and surgical repercussions.

METHODS

This integrative literature review combined studies with different methodologies that critically analyzed the morphological aspects, anatomical variations, and clinical-surgical repercussions of the transverse sinuses. The guiding question of this research was, “What are the anatomical variations of the transverse sinuses and their possible clinical-surgical repercussions?”.

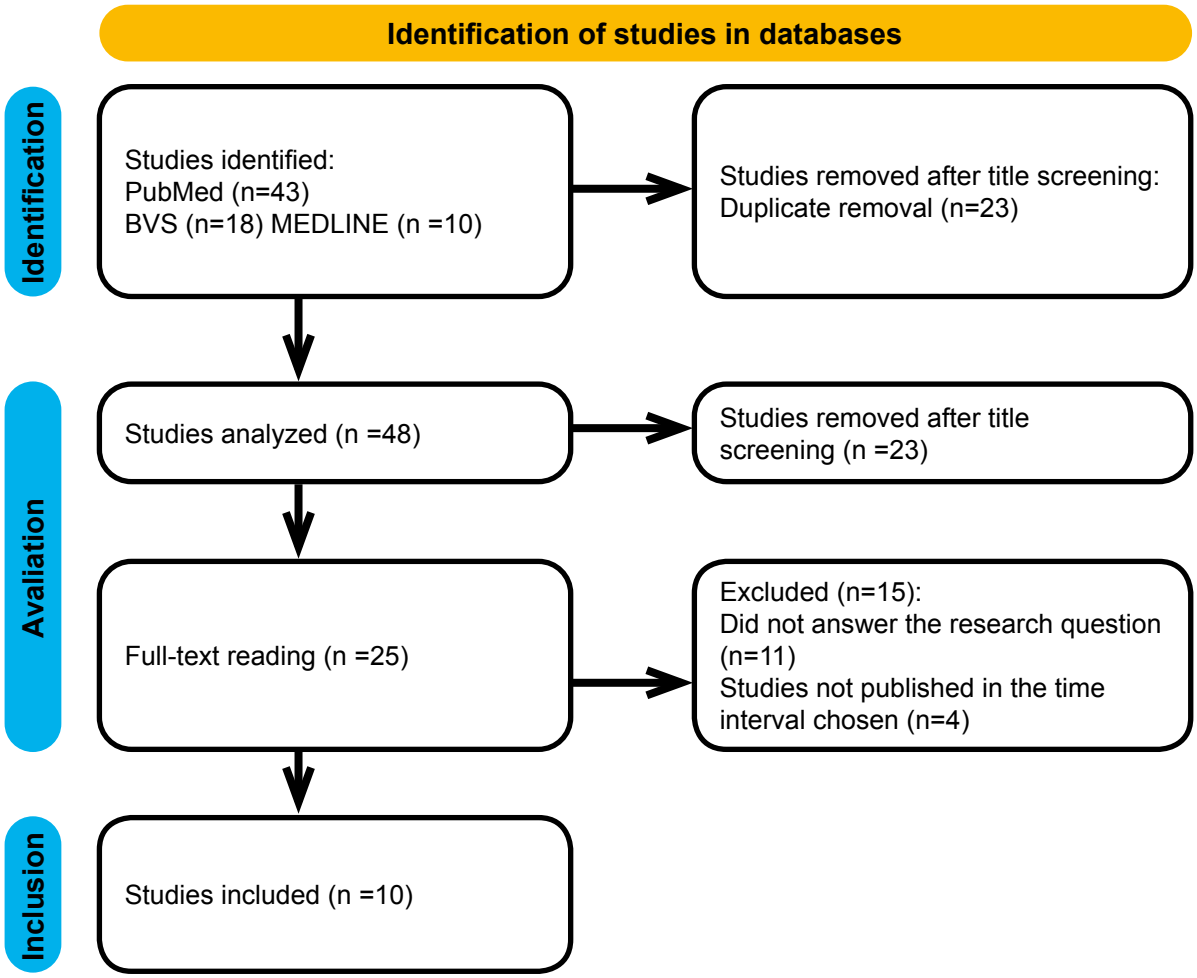
The integrative method was chosen to (1) broaden the possibilities for analyzing the literature without losing the methodological rigor of systematic reviews and (2) combine information from the theoretical literature to define concepts, identify gaps, review theories, and methodologically analyze studies. This method also allows combining and synthesizing studies into a single article, improving the accessibility of results.

This review was developed and written based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyzes5. Two independent and blinded researchers conducted the search from June 1, 2022 to September 4, 2022 in PubMed, BVS, and MEDLINE databases. The following MeSH terms were combined using the Boolean operator “AND”: transverse sinuses, anatomy, and anatomic variation.

First, titles and abstracts were screened. Studies not meeting the topics regarding anatomy, anatomical variations, and clinical-surgical repercussions of transverse sinuses in humans were not included. Second, two independent reviewers conducted a preliminary full-text reading to select articles for qualitative synthesis according to the eligibility criteria. Last, articles were explored, the relevant content was coded, and results were presented based on categories identified in the material.

Inclusion criteria were original studies using different designs; studies on anatomical aspects, variations of the transverse sinuses, and clinical-surgical repercussions of this venous sinus; studies available in English; and studies published in the last 15 years. Studies not addressing the research question, duplicates, letters to the editor, editorial or opinion articles, preprints, incomplete articles, and those unavailable for access were excluded. Figure 1 shows the flowchart of study selection.

Figure 1. Flowchart of study selection



Source: Authors

RESULTS

After duplicate removal, 43 studies were identified in PubMed. Of these, 23 were removed after title and abstract screening, 20 were analyzed in full, and 8 met the eligibility criteria. Of the 18 studies identified in the BVS, 14 duplicates were removed, none were removed after title and abstract screening, 4 were analyzed in full, and 1 met the eligibility criteria. Regarding MEDLINE, 10 studies were identified: 9 were duplicates and 1 met the eligibility criteria.

Many studies highlighted the clinical and surgical importance of understanding the anatomy and anatomical variations of the dural venous sinuses. The studies shown in Table 1 provided various perspectives for discussing the anatomical aspects, variations, and possible clinical repercussions of the transverse sinus.

Table 1. Characteristics of included studies

Nº	Short title	Objectives	Conclusion
1º	Variations of the transverse sinus	Report an unusual abnormality of the transverse sinus and review and discuss its anatomical variation and clinical repercussions[1]	Understanding the anatomy and variations of the transverse sinus in diseases, such as venous sinus thrombosis, is important[1]
2º	Association between transverse sinus hypoplasia and cerebral venous thrombosis	Perform a case-control study to identify relationships between transverse sinus hypoplasia and cerebral venous thrombosis[6]	Hypoplasia of the transverse sinus may predispose ipsilateral cerebral venous thrombosis, although possibly without functional impact[6]
3º	Different normal anatomical variations of the transverse dural sinus in magnetic resonance venography (MRV)	Conduct a retrospective study on the normal anatomy and variations of the transverse sinus in venograms and assess the relationships between these variations, age, and gender[3]	Hypoplasia of the left transverse sinus is the most common variation and is more frequent in men. Knowledge regarding the anatomy of the dural venous sinuses is important to avoid over-diagnosing[3]
4º	Anatomical variations of the transverse-sigmoid sinus junction intracranial hypertension	Conduct a cadaveric study to analyze variations in the transverse-sigmoid sinus junction and their implications in the endovascular treatment of idiopathic intracranial hypertension[4]	The importance of knowing these structures for surgical procedures was highlighted, with a good understanding of pathological processes in the venous sinuses, which may be related to the structures studied[4]
5º	Anatomical variations of cerebral MR venography	Identify anatomical variations in magnetic resonance venography and analyze gender-related alterations[7]	Hypoplasia of the transverse sinus was the most common anatomical variation identified and is more prevalent in men. Other anatomical variations of the dural venous sinuses did not vary significantly according to gender[7]
6º	Intracranial MR venography using low-field magnet	Analyze the normal venous anatomy and variations in intracranial magnetic resonance venography in a Nepalese population[8]	Flow gaps were an important anatomical variation observed. The visualization of veins with reduced dimensions (e.g., the vein of Labbe) was lower than in other studies[8]
7º	Cranial venous sinusdominance	Analyze the circulation in cerebral venous sinuses, emphasizing morphological and angiographic aspects[9]	A dominance pattern of the cerebral venous sinus was observed, which was not influenced by age and gender[9]

8º	The evaluation of cerebral venous normalanatomy and variations	Evaluate the anatomical variations and normal anatomy of the cerebral venous system using magnetic resonance venography with contrast[10]	The right vessel chain (transverse sinus, sigmoid sinus, and internal jugular veins) prevailed over the left side[10]
9º	Evaluation of dural venous sinuses and confluence of sinusesvia MRI venography	Determine anatomical variations in the superior sagittal sinus, confluence of sinuses, transverse, straight, and occipital sinus[11]	The prevalence of hypoplasia and agenesis of the transverse sinus was higher than in other studies. A total of 49% and 17.53% of the left and right sinuses, respectively, were hypoplastic[11]
10º	Normal variations in cerebral venous anatomy and their potential pitfalls on 2D TOF MRV examination	Assess normal cranial venous anatomy and possible anatomical variations[12]	Knowledge of the physiological anatomy of venous drainage is imperative in surgical practice and when interpreting magnetic resonance venography[12]

Regarding the design of the ten included studies, six were retrospective studies based on data derived from cerebral magnetic resonance venograms, one retrospective study analyzed cerebral angiographies, one was a cadaveric study that conducted statistical analyses, one was a case report with literature review, and one was a case-control study.

Massrey et al.[1] conducted a case report and literature review of a rare variation of the transverse sinus in a male human skull. The authors provided and discussed some of the best-documented variations in literature. Aplasia and hypoplasia of the transverse sinus were two of the most frequent variations, while agenesis of the transverse sinus was one of the most significant. The transverse sinus can sometimes originate from a bifurcation of the distal segments of the superior sagittal sinus and assume small dimensions. The study also highlighted the importance of understanding the anatomy and variations of the transverse sinus in diseases, such as venous sinus thrombosis.

The retrospective case-control study of Arauz et al6. analyzed records of patients with cerebral venous thrombosis to identify relationships between hypoplasia of the transverse sinus and cerebral venous thrombosis. One of the main sites of cerebral venous thrombosis is the transverse sinus, with a prevalence between 38% and 86% of cases. The results suggested that hypoplasia of the transverse sinus was associated with ipsilateral thrombosis, although thrombosis with these characteristics has no functional impact.

Tantawy et al.[3] retrospectively analyzed the transverse sinus of 363 patients who performed magnetic resonance venography. The right and left transverse sinuses differed greatly in size (asymmetry), and hypoplasia of the left transverse sinus was the most frequent variation. A total

of 123 patients (33.9%) presented asymmetry, but no statistically significant differences were observed between gender. Hypoplasia of the right transverse sinus (i.e., caliber lower than half the caliber of the superior sagittal sinus) was observed in 29 patients (8%), whereas 80 patients (22%) presented this variation in the left transverse sinus. Aplasia of the right and left transverse sinus (i.e., structures not identified on venogram) was found in 6 (1.7%) and 13 patients (3.6%), respectively.

McCormick et al.[4] conducted a study in which 36 sigmoid and transverse sinuses of cadaveric heads from the Applied Learning Center of the Wake Forest University were dissected to identify anatomical variations of the transverse-sigmoid sinus junction. Approximately 72.2% of the sinuses contained a variation in the lumen, such as septations or blind pouch. The difference between these luminal variations was based on blood flow, in which the blind pouch was characterized by blood flow blockage.

Goyal et al.[7] conducted a retrospective study that analyzed data from magnetic resonance venography and noted the importance of knowledge about the morphological aspects and anatomical variations of the transverse sinus. Lack of this knowledge may lead to false positive diagnoses of thrombosis in the transverse venous sinus. Regarding the influence of gender, women presented a higher prevalence of symmetry of the transverse sinuses (69.2% of cases compared with 62% in men), whereas men had a higher prevalence of hypoplasia of the left transverse sinus (24.9% of cases compared with 19.4% in women).

Sharma et al.[8] also conducted a retrospective study analyzing 100 Nepalese patients using brain magnetic resonance venography. Dominance of the right transverse sinus and flow gaps were found in 73% and 47% of the population studied, respectively; 91% of flow gaps occurred on the non-dominant side. Also, hypoplasia and aplasia were mostly identified in the left transverse sinuses.

Kitamura et al.[9] retrospectively analyzed 100 cerebral angiographies to analyze circulation in the cerebral venous sinuses. The authors highlighted the importance of neurosurgeons and radiologists understanding these structures, especially for planning and treating of neurological diseases. In the population studied, no significant differences associated with age, gender, or dominance of the circulation were reported. Sinuses appeared to be larger in men and were significantly larger on the right than the left side (6.5 ± 1.84 to 5.1 ± 1.72 mm). Right-sided dominance was observed.

Doğan et al.[10] developed a retrospective study to analyze the anatomy and variations of 136 cerebral magnetic resonance venograms. Right transverse sinus dominance was found in 38.23% of cases, left transverse sinus dominance was identified in 27.95% of cases, and co-dominance accounted for 32.35%. In women, transverse sinus co-dominance rates (36.04%) were higher than in men (32%). Understanding the dominance of the cerebral venous systems is crucial for surgical

procedures, such as radical neck dissections and excisions of invasive tumors in the dural venous sinuses and jugular veins.

Bayaroğulları et al.[11] highlighted the importance of knowledge about cerebral venous anatomy in a retrospective analysis of 211 patients using cerebral resonance venography. Due to the high incidence of anatomical variations in the dural venous sinuses, knowledge of these structures is crucial for neurosurgeons, neurologists, and radiologists, who may avoid several complications and iatrogenesis. The study also showed high rates of hypoplasia of the transverse sinus compared to data obtained in the literature.

Ahmed et al.[12] conducted a retrospective study assessing magnetic resonance venograms of patients between 2 and 75 years to determine the normal anatomy and variations in the cerebral venous system. The study divided venous drainage anomalies into intra- and extracranial, which can also be characterized as intra- and extraluminal. Abnormal valves, septal flaps, and vessel plexuses were considered intraluminal diseases, whereas extraluminal pathologies included reduced vessel caliber. The study also highlighted that arachnoid granulations may appear isolated in the transverse sinus and cause venous obstruction and hypertension.

DISCUSSION

The dural venous sinuses are positioned between the inner lamina and the outer layer of the dura mater, which are considered margins and microanatomical points in neurosurgery. These sinuses are references for accessing lesions located in the parenchyma of the region and lesions located in the cerebral ventricles[13].

Variations in the venous vessels of the brain are important when planning a surgery, especially when dissecting the cerebral planes, because these structures present many variations that may complicate surgical procedures. For example, venous vessels may vary between the hemispheres of the same individual; thus, they are relevant structures in neurosurgery. Adequate knowledge regarding the morphofunctional anatomy of these structures is needed to reduce post-operative neurological deficits[13].

The cerebral venous system is divided into superficial and deep. The superficial system comprises the sagittal sinuses and the superior superficial cerebral veins, which drain the medial surface and the upper half of the superolateral surface of each hemisphere. This system also comprises the basal and transverse sinuses and the inferior superficial cerebral veins, which drain the inferior surface and the lower half of the dorsolateral surface of each hemisphere. The deep system includes the straight sinus and great cerebral vein (formed by the confluence of the internal cerebral and basal veins), which are responsible for the venous drainage of the corpus striatum, internal capsule, diencephalon, and part of the medullary white center. Both systems drain into the internal jugular veins[2].

The confluence of sinuses, also reported as torcular Herophili, is the main drainage site for venous blood from the brain, meninges, and calvaria. This structure is defined as the union of the superior sagittal sinus, transverse sinuses, and straight sinus. In 60% of cases, the superior sagittal sinus originates in the right transverse sinus, justifying some drainage patterns[2,14].

The right transverse sinus is generally larger and receives most blood drained from the superior sagittal sinus. Therefore, the right transverse sinus, sigmoid sinus, and internal jugular vein contain more blood from the superficial parts of the brain. On the other hand, the left vessels contain blood mainly from the deeper parts, drained from the internal cerebral basal and great cerebral veins[2].

A vascular mesh in the transverse sinus was one of the variations identified in the literature. In almost all variations, the transverse sinus was smaller on the side of the anatomical variation. When hypoplasia or aplasia of the transverse sinus occurs, the internal jugular system increases its capacity. The superior sagittal and straight sinuses drain more blood into the right and left transverse sinuses, respectively. Fenestrations of the transverse sinus, a rare anatomical variation of this structure, are not well documented in the literature[1].

Age may influence the prevalence of some variations in the transverse sinus. The highest prevalence of transverse sinus hypoplasia was found in patients over 60 years old, while the lowest prevalence was identified in individuals aged 20 to 29 years. The prevalence of transverse sinus aplasia was similar in both age groups[3].

During embryological development, as the telencephalon enlarges, the confluence of sinuses is positioned inferiorly in the craniocaudal direction. This process is probably associated with an inclination of the lateral portions of the transverse sinuses, which become less prominent. The region of the confluence of sinuses undergoes an increase and subsequent decrease in the caliber of the venous structures. This characteristic may predispose to hypoplasia, irregularities, or even the absence of structures in this region, mostly in the lateral portion of the transverse or sigmoid sinus[8].

A venous sinus is dominant when its measurement is greater than 50% of the contralateral side, and the ratio between the measure of the right and left sides is greater than 1.5 (right dominant) or less than 0.67 (left dominant). Sinuses are classified as symmetrical when the ratios are equal or between 1.5 and 0.67 for the right and left sinus (i.e., between the limit of 50%), respectively. An important repercussion of variations in the transverse sinus is the absence or isolated hypoplasia of part or all this structure, which can be distinguished from sinus occlusion due to lack of dilation of collateral veins and absence of associated parenchymal hemorrhage[9].

One of the clinical and surgical repercussions of the transverse sinus is the possible relationship with idiopathic intracranial hypertension. Stenosis of the junction between the

transverse and sigmoid sinuses generates a change in venous flow, favoring the development of idiopathic intracranial hypertension. Thrombosis, stenosis, and occlusion of the venous sinuses are also relevant to these anatomical structures. Anatomical changes interfering with the flow of the venous system (e.g., septum and spaces in the sinus walls) may be associated with the etiology of venous sinus diseases. Understanding these variations is essential to diagnose and treat neurosurgical diseases[4].

In this review, evidence on the topic was scarce, especially for the Brazilian population. Therefore, some of the included studies may present outdated information.

CONCLUSION

Knowledge about the morphological aspects of the transverse sinus is relevant to clinical and surgical practice. Most studies discussed the morphological aspects and anatomical variations of the transverse sinus using cadaveric studies and brain magnetic resonance venography. Hypoplasia of the left transverse sinus is the most common anatomical variation of this structure and is more frequent in men over 60 years old. Although these variations are important to be considered in surgical procedures, few studies were conducted in Brazil to identify the incidence and factors (e.g., age and gender) interfering with their prevalence.

CONFLICTS OF INTEREST

None.

ACKNOWLEDGMENTS

IFGG main investigator, preparation of the proposal, preparation of the timetable, literature searches, data collection and analysis, drafting of the article, proofreading the article, and submission of the article; **MABS** co-supervision, manuscript revision, and final approval; and **FAP** supervision, preparation of the proposal, preparation of the timetable, manuscript revision, and final approval.

REFERENCES

1. Massrey C, Altafulla JJ, Iwanaga J, Litvack Z, Ishak B, Oskouian RJ, Loukas M, Tubbs RS. Variations of the Transverse Sinus: Review with an Unusual Case Report. Cureus 2018 Set; 10(9):e3248.
2. Kiliç T, Akakin A. Anatomy of cerebral veins and sinuses. Front Neurol Neurosci. 2008; 23: 4-15.
3. Tantawy, Heba F; Morsy, Manal M; Basha, Mohammad A; Nageeb, Rania S. Different normal anatomical variations of the transverse dural sinus in magnetic resonance venography (MRV): do age and sex matter? Eur. j. anat. 2020; 24(1): 49-56.
4. McCormick MW, Bartels HG, Rodriguez A, Johnson JE, Janjua RM. Anatomical Variations of the

Transverse-Sigmoid Sinus Junction: Implications for Endovascular Treatment of Idiopathic Intracranial Hypertension. Anat Rec (Hoboken) 2016 Ago; 299(8):1037-42.

5. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tet- zlaff JM, Akl EA, Brennan SE, Chou R, Glanville J, Grimshaw JM, Hróbjartsson A, Lalu MM, Li T, Loder EW, Mayo-Wilson E, McDonald S, McGuinness LA, Stewart LA, Thomas J, Tricco AC, Welch VA, Whiting P, Moher D. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021 Mar 29;372:n71.
6. Arauz, A., Chavarria-Medina, M., Patiño-Rodriguez, H. M., Varela, E., Serrano, F., Becerril, M., & Barboza, M. A. Association between Transverse Sinus Hypoplasia and Cerebral Venous Thrombosis: A Case-Control Study. J Stroke Cerebrovasc Dis. 2018 Out; 27(2): 432-437.
7. Goyal G, Singh R, Bansal N, Paliwal VK. Anatomical Variations of Cerebral MR Venography: Is Gender Matter? Neuroint. 2016 Set; 11(2):92-8.
8. Sharma UK, Sharma K. Intracranial MR venography using low-field magnet: normal anatomy and variations in Nepalese population. JNMA J Nepal Med Assoc. 2012 Abr-jun; 52(186):61-5.
9. Kitamura MAP, Costa LF, Silva DOA, Batista LL, Holanda MMA, Valença MM. Cranial venous sinus dominance: what to expect? Analysis of 100 cerebral angiographies. Arq Neuropsiquiatr. 2017 Maio;75(5):295-300.
10. Doğan E, Apaydın M. The evaluation of cerebral venous normal anatomy and variations by phase-contrast cranial magnetic resonance venography. Folia Morphol (Warsz). 2022; 81(2):314-323.
11. Bayaroğulları H, Burakgazi G, Duman T. Evaluation of dural venous sinuses and confluence of sinuses via MRI venography: anatomy, anatomic variations, and the classification of variations. Childs Nerv Syst. 2018 Jun;34(6):1183-1188.
12. Ahmed MS, Imtiaz S, Shazlee MK, Ali M, Iqbal J, Usman R. Normal variations in cerebral ve- nous anatomy and their potential pitfalls on 2D TOF MRV examination: Results from a private tertiary care hospital in Karachi. J Pak Med Assoc. 2018 Jul; 68(7):1009-1013.
13. Cosar M, Seker A, Ceylan D, Tatarli N, Sahin F, Tokmak M, Songur A, Kilic T, Ozen OA. De- termining the morphometry and variations of the confluens sinuum and related structures via a silicone painting technique on autopsy patients. J Craniofac Surg. 2014 Nov; 25(6):2199-204.
14. Cheng Y, Li WA, Fan X, Li X, Chen J, Wu Y, Meng R, Ji X. Normal anatomy and variations in the confluence of sinuses using digital subtraction angiography. Neurol Res. 2017 Jun;39(6):509- 515.