

TRANSVERSE SINUS DRAINAGE DOMINANCE PATTERNS: MORPHOLOGICAL STUDY IN CEREBRAL ANGIOGRAPHY EXAMS

Padrões de dominância de drenagem do seio transverso: estudo morfológico em exames de angiografia cerebral

Fernando Augusto Pacífico¹, Ismael Felipe Gonçalves Galvão²,
Paula Monique Barbosa Lima², Clarissa Alvim Passos²,
Hanna Ravigna Duarte Sena e Silva², Marcos Antônio Barbosa da Silva¹

¹Professor at the Faculdade de Medicina de Olinda; ²Student at the Faculdade de Medicina de Olinda

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ABSTRACT

Objective: To investigate the pattern of dural sinus drainage dominance based on the anatomical variations of the transverse sinus (TS) observed in digital cerebral angiography exams. **Methods:** This cross-sectional retrospective study with non-probabilistic convenience sampling analyzed 83 exams of 2D digital brain angiography. **Results:** The percentages of dominance patterns of TS in males were 32.43% (n = 15), 8.11% (n = 3), and 59.46% (n = 22) for the right, left, and symmetric, respectively. In females, the percentages of dominance patterns were 32.61% (n = 15), 6.52% (n = 3), and 60.87% (n = 28) for right, left, and symmetric, respectively. Considering all individuals, the symmetrical dominance presented the highest percentage (about 60.24%). **Conclusion:** The most prevalent TS drainage pattern identified was symmetrical, regardless of gender. When dominance was identified, the right pattern was the most prevalent. The most prevalent variation was left transverse sinus hypoplasia. Rare variations (e.g., TS agenesis) were also found. No differences were identified between genders.

Keywords: Anatomic variation, cerebral angiography, surgery, transverse sinuses

RESUMO

Objetivo: Investigar o padrão de dominância de drenagem sinusal dural por meio da ocorrência de variações anatômicas do seio transverso (ST) em exames de angiografias digitais cerebrais. **Métodos:** Trata-se de um estudo do tipo transversal, observacional e retrospectivo, com amostragem do tipo não probabilístico por conveniência, realizado por meio da análise de 83 exames de angiografia digitais cerebrais em 2D. **Resultados:** No sexo masculino, o padrão de dominância do ST direito foi encontrado em 32,43% dos casos; já do ST esquerdo, em 8,11%; e o padrão simétrico, em 59,46%. No sexo feminino, os percentuais foram de 32,61%, 6,52 e 60,87 para os padrões de dominância direito, esquerdo e simétrico do ST, respectivamente. Para todos os indivíduos, o maior percentual foi o de padrão simétrico do ST: cerca de 60,24%. **Conclusões:** O padrão simétrico de drenagem do ST foi o de maior ocorrência, independentemente do sexo do indivíduo. Quando uma dominância foi identificada, o padrão direito foi o mais prevalente. A hipoplasia do ST esquerdo foi a variação mais recorrente. Foram encontradas variações raras, como a agenesia do ST. Não foram identificadas diferenças entre os sexos.

Palavras-chave: Angiografia cerebral, Cirurgia, Seios transversos, Variação anatômica.

INTRODUCTION

The dural sinuses are venous channels covered by endothelium located between the inner and outer layers that compose the dura mater; the former continues with the spinal dura mater, and the latter adheres closely to the skull bones, behaving as a periosteum¹.

The blood from the superficial and deep cerebral veins, meninges, and calvarium is drained into the dural sinuses and conducted to the internal jugular veins, forming the main drainage route of the cranial cavity².

Understanding the anatomy of the cranial venous sinuses is crucial in the field of neurosurgery and radiology, especially in surgical planning and treatment of neurological diseases to prevent complications^{3,4,5,6,7,8,9}.

The dominance of cerebral venous drainage needs to be analyzed before surgeries for several neurosurgical diseases, as well as for cervical surgeries⁵. Therefore, the analysis of venous sinuses by angiography is generally indicated as the best preoperative assessment for diseases involving the major sinuses¹⁰.

In this perspective, the present study aimed to investigate the pattern of cerebral drainage dominance based on anatomical variations of the transverse sinus (TS) observed in digital cerebral angiography exams.

METHOD

This cross-sectional retrospective study was conducted between June and August 2022 using non-probabilistic convenience sampling.

The study was conducted at the Faculdade de Medicina de Olinda by analyzing 83 digital 2D cerebral angiography exams of individuals of both genders, aged between 11 and 90 years, hospitalized in a private hospital in Recife. All exams were performed with a similar standard by the same radiology team and analyzed by the chief radiologist of the team.

As inclusion criteria, the examinations should have incidences in profile, oblique, and posteroanterior and present a clear visualization of cerebral venous anatomy. Those that did not have the three incidences analyzed, or procedures that avoided the visualization of vascular

venous anatomy were excluded. Initially, cerebral digital angiographies were selected.

Then, the RadiAnt DICOM Viewer (Medixant, Poznan, Poland) was used to analyze the angioarchitecture of the deep cerebral venous system in a paired manner by the researchers. The study variables were (1) sinus diameter; (2) presence of hypoplasia; (3) laterality; (4) age; (5) gender; (6) presence of anatomical variation; and (7) presence of associated diseases.

The measurement of the TS was acquired in pixels and converted to millimeters and was obtained by averaging the distance between the edges on both sides.

The sinus could be classified as dominant (i.e., when its measurement was > 50% compared with its contralateral side), symmetrical (i.e., when the difference in measurement was < 50% compared with the contralateral side), or absent (i.e., when no drainage or increase compared with the contralateral was observed).

Data were organized into spreadsheets, tabulated, and processed by the PASW STATISTICS (IBM Corp, NY, USA) 17.0 software. Data analysis was conducted descriptively; qualitative variables were described in absolute and relative values, and their association was verified using contingency tables and Fisher's exact test. The established confidence interval was 95%.

This study was approved by the research ethics committee of the Faculdade de Medicina de Olinda (no. 43998421.0.0000.8033).

RESULTS

The mean age of the individuals was 55.28 years (range: 11 to 90 years and standard deviation [SD] = 17.36). The mean age was 54.11 years for males (range: 11 to 89 years and SD = 20.16) and 56.22 years for females (range: 19 to 90 years and SD = 14.89). The distribution by gender was 55.42% female (n = 46) and 44.58% male (n = 37). Findings regarding the dominance of TS considering gender are shown in Table 1.

A prevalence of right TS dominance was evidenced in both genders compared with the left side. The percentages of dominance patterns of TS in males were 32.43% (n = 15), 8.11% (n = 3), and 59.46% (n = 22) for the right, left, and

symmetric, respectively. In females, the percentages of dominance patterns were 32.61% (n = 15), 6.52% (n = 3), and 60.87% (n = 28) for right, left, and symmetric, respectively.

Considering all individuals, the percentages of TS were 32.53% (n = 27), 7.20% (n = 6), and 60.24% (n = 50) for the right, left, and symmetrical dominance patterns, respectively (Table 2).

This data pattern suggests three interesting aspects: (1) considering all individuals, the symmetrical drainage pattern of the TS is more prevalent than the right and left drainage patterns; (2) the right drainage pattern of the TS is more prevalent than the left drainage pattern; and (3) the symmetrical, right and left drainage patterns of the TS are similar between genders. Thus, Fisher's exact test was used to verify these aspects, which revealed that the prevalence of the symmetrical pattern was higher than in the right and left patterns in all individuals ($p = 0.003$). The right pattern was not more prevalent than the left dominance patterns ($p = 0.086$), and the drainage patterns (left and right) were not similar between genders ($p = 0.830$) (Tables 1 and 2).

Additional findings

Left TS hypoplasia appeared in 24.32% (n = 9) of males and 26.09% (n = 12) of females. Left TS agenesis was observed in 8.11% (n = 3) of males and 6.52% (n = 3) of females. On the other hand, right TS hypoplasia was perceived in 5.41% (n = 2) of males and 6.52% (n = 3) of females. Right TS agenesis was found in 2.7% (n = 1) of cases but only in males.

Individuals with morphological changes in the left TS had a mean age of 57.92 years (median = 58.00) in males and 56.87 years (median = 55.00) in females. The mean age of individuals with morphological changes in the right TS was 73.67 years (median = 81.00) for males and 48.33 years (median = 54.00) for females. Last, the mean age of individuals who presented a pattern of symmetric sinus dominance was 49.36 years (median = 48.50) for males and 56.71 years (median = 56.00) for females.

DISCUSSION

Devoid of muscle tissue, the venous sinuses of the dura mater drain the blood and cerebrospinal

fluid circulating through the brain toward the internal jugular veins. The TS originates at the confluence of the sinuses and is located in the posterior portion of the skull, typically as bilateral structures. They curve anteriorly and laterally from the internal occipital protuberance, running along the edges of the tentorium cerebelli to the petrous part of the temporal bone, where they receive blood from several areas of the brain, such as the temporolateral surface, basal surface, and temporal and occipital lobes to be drained into the sigmoid sinus^{2,11-14}. The TS also receives blood from the anastomotic vein of Labbé, when present, and communicates with extracranial veins via mastoid emissary veins^{2,15}. Some TS parts (or a complete side) may be absent or present isolated hypoplasia, and this sinus can also be distinguished from sinus occlusion by the absence of collateral vein dilation and associated parenchymal hemorrhage².

The present alterations of the TS were considered anatomical variations to avoid confusion with pathological changes and to highlight the relevance of the analytical, evaluative, and observational nature of this study¹¹.

The cerebral venous system has a complex anatomy that may present several anatomical variations, and the TS may be subjected to some of them. Therefore, understanding these variations is important during surgeries¹⁶. During the embryological period, many procedures can occur due to this structure being predisposed to developing variations¹⁷.

As the telencephalon grows, the confluence of sinuses shifts to a more inferior craniocaudal position. This process seems to be related to a tilt of the lateral portions of the TS, which become less prominent. During embryological development, the region of the confluence of sinuses increases and reduces the caliber of its structures, which may result in hypoplasias, irregularities, absences, and asymmetries of structures in this region, especially the TS¹⁷.

The age group seems to influence some TS variations. Studies indicated a higher prevalence of TS hypoplasia in the age group above 60 years and a lower prevalence around the third decade of life¹³.

Some studies demonstrate a higher prevalence of hypoplasia of the TS in males than females. Literature also suggests that females may present a higher prevalence of symmetry of these vessels¹⁸. Conversely, the present study did not identify a significant relationship between gender and the prevalence of TS hypoplasia. The TS symmetry was the most prevalent finding in both genders. Therefore, most individuals did not present significant morphological alterations. This finding may derive from morphological characteristics of the studied population or the sample size, which may have induced statistical tendencies, justifying the need for further observational studies.

CONCLUSION

The understanding of the morphofunctional findings, including the pattern of dominance of dural drainage and the anatomical variations found in this study, is important for clinical and surgical practice, such as in the diagnosis and treatment of pathologies of the cerebral venous sinuses and neurovascular surgeries.

Although variations in the normality of the dural sinuses are common, anomalies of these structures are rare, which raises a warning since most are associated with complex vascular malformations or congenital brain malformations.

The most common drainage pattern of the TS in the studied population was symmetric, regardless of gender. When dominance was identified, the right pattern was the most prevalent. Left TS hypoplasia was the most recurrent variation, and rare variations (e.g., agenesis) were found. No differences between genders were identified.

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Table 1. Dominance of the transverse sinus according to gender.

| Gender x TS Dominance | Right | | Left | | Symmetrical or without dominance | | Total | |
|-----------------------|-------|-------|------|------|----------------------------------|-------|-------|-----|
| | N | % | N | % | N | % | N | % |
| Male | 12** | 32.43 | 3** | 8.11 | 22** | 59.46 | 37 | 100 |
| Female | 15** | 32.61 | 3** | 6.52 | 28** | 60.87 | 46 | 100 |
| Total | 27 | 32.53 | 6 | 7.23 | 50 | 60.24 | 83 | 100 |

N: number of individuals. TS: transverse sinus. %: percentage. Significant values ($p < 0.05$) – Fisher’s exact test.

**No statistical significance was observed in the relationship between sex and TS dominance ($p = 0.830$).

Table 2. TS Dominance.

| TS Dominance | Right | | Left | | Symmetrical or without dominance | | Total | |
|--------------|-------|-------|------|------|----------------------------------|-------|-------|-----|
| | N | % | N | % | N | % | N | % |
| Total | 27** | 32.53 | 6** | 7.23 | 50* | 60.24 | 83 | 100 |

N: number of individuals. TS: transverse sinus. %: percentage. Significant values ($p < 0.05$) – Fisher’s exact test

*No statistical significance was observed between the symmetrical drainage pattern when compared with the right and left patterns ($p = 0.003$).

** No statistical significance was observed between right and left dominance drainage patterns of the TS ($p = 0.086$).