Original Article

Relationship of superior sagittal sinus with sagittal midline: A surgical application

Dan Zimelewicz Oberman1, Nicollas Nunes Rabelo2, Jorge Luiz Amorim Correa1, Pablo Ajler3

1Department of Neurosurgery, Hospital Força Aérea do Galeão, Rio de Janeiro, Brazil, 2Department of Neurosurgery, Atenas Medical School, Passos, Minas Gerais, Brazil, 3Department of Neurosurgery, Hospital Italiano de Buenos Aires, Buenos Aires, Argentina.

E-mail: *Dan Zimelewicz Oberman - danzoberman@gmail.com; Nicollas Nunes Rabelo - nicollasrabelo@hotmail.com; Jorge Luiz Amorim Correa - jorgeluizacorrea@gmail.com; Pablo Ajler - pablo.ajler@hospitalitaliano.org.ar

INTRODUCTION

Interhemispheric approach is widely used for surgical management of midline tumors and vascular lesions in and around the third ventricle. Complete exposure of the superior sagittal sinus to obtain adequate working space of midline lesion is difficult, because of the risk to inadvertent injury to the sinus and bridging veins, which may cause several neurological deficits. Understanding the SSS neuroanatomy and its relationships with external surgical landmarks avoid such complications. The objective of this study is to accurately describe the position of SSS and its displacement in relation with sagittal midline by magnetic resonance imaging.

METHODS

A retrospective cross-sectional, observational study was performed. Magnetic resonance image of 76 adult patients with no pathological imaging was analyzed. The position of the halfway between nasion and bregma, bregma, halfway between bregma and lambda, and lambda was performed. The width and the displacement of the superior sagittal sinus accordingly to the sagittal midline were assessed in those landmarks.

RESULTS

The mean width of superior sagittal sinus at halfway between nasion and bregma, bregma, halfway between bregma and lambda, and lambda was 5.62 ± 2.5, 6.5 ± 2.8, 7.4 ± 3.2, and 8.5 ± 2.1 mm, respectively, without gender discrepancy. The mean displacement according to the midline at those landmarks showed a statistically significant difference to the right side among sexes.

CONCLUSION

In this study, we demonstrate that sagittal midline may approximate external location of the superior sagittal sinus. Our data showed that in the majority of the cases, the superior sagittal sinus is displaced to the right side of sagittal midline as far as 16.3 mm. The data we obtained provide useful information that suggest that neurosurgeons should use safety margin to perform burr holes and drillings at the sagittal midline.

Keywords: Anatomical study, Bregma, Coronal suture, Dural sinus, Superior sagittal sinus

ABSTRACT

Background: Interhemispheric approach is widely used to surgical management of midline tumors and vascular lesion in and around the third ventricle. Complete exposure of the superior sagittal sinus to obtain adequate working space of midline lesion is difficult, because of the risk to inadvertent injury to the sinus and bridging veins, which may cause several neurological deficits. Understanding the SSS neuroanatomy and its relationships with external surgical landmarks avoid such complications. The objective of this study is to accurately describe the position of SSS and its displacement in relation with sagittal midline by magnetic resonance imaging.

Methods: A retrospective cross-sectional, observational study was performed. Magnetic resonance image of 76 adult patients with no pathological imaging was analyzed. The position of the halfway between nasion and bregma, bregma, halfway between bregma and lambda, and lambda was performed. The width and the displacement of the superior sagittal sinus accordingly to the sagittal midline were assessed in those landmarks.

Results: The mean width of superior sagittal sinus at halfway between nasion and bregma, bregma, halfway between bregma and lambda, and lambda was 5.62 ± 2.5, 6.5 ± 2.8, 7.4 ± 3.2, and 8.5 ± 2.1 mm, respectively, without gender discrepancy. The mean displacement according to the midline at those landmarks showed a statistically significant difference to the right side among sexes.

Conclusion: In this study, we demonstrate that sagittal midline may approximate external location of the superior sagittal sinus. Our data showed that in the majority of the cases, the superior sagittal sinus is displaced to the right side of sagittal midline as far as 16.3 mm. The data we obtained provide useful information that suggest that neurosurgeons should use safety margin to perform burr holes and drillings at the sagittal midline.

Keywords: Anatomical study, Bregma, Coronal suture, Dural sinus, Superior sagittal sinus

Surgical Neurology International • 2020 • 11(309) | 1
In general, the superior sagittal suture has been used to approximate the location of SSS, which is considered an external landmark of SSS between the bregma and the lambda, and it is still being used in neurosurgical practices. However, this external anatomical landmark is not useful anteriorly to the bregma, and previous studies showed that it is not accurate to predict the location of the SSS.[7,20,23]

Complete exposure of the SSS to obtain adequate working space of midline lesion is difficult because of the risk of inadvertent injury to the sinus and bridging veins, which may cause several neurological deficits.[8,14] To guide our neurosurgical planning, understanding the SSS neuroanatomy and its relationships with external surgical landmarks avoid such complications.[6,16]

Although there are some reports about the anatomy of SSS and its relationship with sagittal suture, most of them were performed on cadaveric specimens with relatively low number of cases, and further studies are needed. Our aim is to accurately describe the position of SSS and its displacement in relation with sagittal midline, but unlike the previous reports, to measure them on a wide quantity of samples by magnetic resonance imaging.

MATERIALS AND METHODS

Patients

Magnetic resonance imaging (MRI) examinations were retrieved from our electronic medical records. The study included adult patients who consulted the health care of our hospital between March 2018 and February 2020 and who had no pathological imaging findings.

Anatomical definitions

The width of the superior sagittal sinus from different sagittal midline convexity craniometric points was performed: (Na-Br) halfway between the nasion and bregma, Br in the bregma, Br-Lamb halfway between the bregma and lambda, and Lamb in the lambda. Subsequently, we measure the displacement of the SSS to the right and to the left accordingly to the sagittal midline in those landmarks. We also evaluated the dominant transverse sinus that primarily drains the SSS [Figure 1].

Anatomical key points were defined as shown below:

- Nasion: Intersection point between frontal and nasal bones, located in a depressed area that connects the nasal bridge and the glabella.
- Bregma: Intersection point between frontal and sagittal sutures. It was first located in the upper axial planes of the skull, to accurately identify it in the sagittal plane. It appears as a hypointense line that interrupts the full-thickness continuity of the hyperintense bony signal.
- Lambda: Intersection point between lambdoid and sagittal sutures. It was first located in the upper axial planes of the skull, to accurately identify it in the sagittal plane. It appears as a hypointense line that interrupts the full-thickness continuity of the hyperintense bony signal.

Magnetic resonance imaging data acquisition and image processing

Coronal T2 MRI was acquired using a 1.5-T MR imaging unit (Signa®; General Electric Medical Systems) with a multislice scanning acquisition protocol. Intravenous contrast administration was not required. The images were processed and analyzed by the software OsiriX MD image program, version 11.0 in axial, coronal, and sagittal planes for the following points: Na-Br, Br, Br-Lamb, and Lamb.

Statistical analysis

An observational retrospective cross-sectional study was made. All analyses were performed using the Statistical Software Package (Stata for Macbook version 13.0). A Shapiro–Wilk test was used to test the normality assumption. For the interobserver reproducibility analysis, we used the intraclass correlation coefficient (ICC). Relative frequencies were calculated for categorical data. Continuous data were expressed as mean ± standard deviation (SD). A two-tailed independent sample t-test was performed to compare means between groups. P <0.05 was considered to be statistically significant.
RESULTS

During this period, 76 patients were included in this study. Forty (52.6%) were female and 36 (47.4%) were male [Table 1]. The mean age of the population was 58.7 years (39.6–77.8).

The width of the SSS ranged from 2 to 10.9 mm in the halfway between nasion and bregma (Na-Br) (mean 5.62 ± 2.5 mm), from 1.4 to 13.4 mm in the bregma (Br) (mean 6.5 ± 2.8 mm), from 3.78 to 16.32 mm in the halfway between bregma and lambda (Br-Lamb) (7.4 ± 3.2 mm), and from 4.79 to 13 mm in lambda (Lamb) (mean 8.5 ± 2.1 mm) [Table 2].

There were no significant differences in the mean width of SSS measurements among both sexes [Figure 2]. These results are shown in [Table 3].

We also made observations and measurements concerning the alignment between midline and deviation of the SSS [Figure 3]. The mean lateral displacement was 3.16 ± 1.43, 3.7 ± 1.6, 4.7 ± 1.4, and 8.3 ± 2.1 to the right sided and 2.4 ± 1.2, 2.8 ± 1.3, 3.49 ± 1.72, and 3.7 ± 1.2 to the left sided in the following parameters Na-Br, Br, Br-Lamb, and Lamb, respectively.

A comparison between male and female showed a statistical significant difference when the measurement was related to the displacements of SSS according to the midline in the following measures (Na-Br, Br, and Lamb), but was not when related to Br-Lamb. These results are shown in [Table 4].

Finally, we determined which transverse sinus primarily drained the SSS. A dominant drain was present in 17 (22.36%) patients, of which 12 (70.5%) drained to the right sided.

There was an excellent intraclass correlation coefficient between the two observer measurements of the Na-Br, Br, Br-Lamb, and Lamb with an average k value of 0.82, 0.92, 0.97, and 0.89, respectively.

DISCUSSION

The SSS is the longest dural sinus, which courses in the midline along the superior edge of the falx cerebri, beginning just behind the frontal bone and grows larger as it continues posteriorly, as it receives blood from the frontal, parietal, and occipital superior cerebral veins and the diploic veins.[21] Intracranial venous structures have gained especial neurosurgical interest due to improvements in neuroimaging techniques and clinical applications.[3,4,18] The

Table 1: Descriptive statistics of categorical variables.

| Variable | Relative frequency (95% CI) |
|----------|-----------------------------|
| Sex (n=76) |                             |
| Female   | 40 (40–66)                  |
| Male     | 36 (33–59)                  |

CI: Confidence interval

Table 2: Descriptive statistics of continuous variables for total sample (n=76).

| Variable | Mean±SD                      |
|----------|------------------------------|
| Age      | 58.7±19.1 (years)           |
| Na-Br    | 5.62±2.5 (mm)               |
| Br       | 6.5±2.8 (mm)                |
| Br-Lamb  | 7.4±3.2 (mm)                |
| Lamb     | 8.5±2.1 (mm)                |

Na: Nasion, Br: Bregma, Lamb: Lambda, SD: Standard deviation

Figure 2: Boxplot graph shows median and interquartile range comparison of width of superior sagittal sinus between male and female group at the four landmarks points. Br: Bregma, Br-Lamb: Midpoint bregma-lambda, Lamb: Lambda, N: Nasion, Na-Br: Midpoint nasion-bregma.
distribution of cerebral bridging vein (BV) and dural venous lake through the SSS is not irregular as it was generally supposed [Figure 4]. Most of BV empty into the SSS at the level of or distal to the coronal suture. BV typically drain into dural venous lakes rather than entering directly in the dural sinus. BV and dural venous lakes may represent a significant obstacle to surgical approaches to the parasagittal region and during the opening of the dura mater adjoining to the SSS, and they may become inadvertently injured, despite extreme care to preserve it. Cerebral BV damage during neurosurgical procedures could result in various neurological complications, including postoperative brain edema and infarction, especially when it is associated with brain retraction and dural sinus occlusion, which could result in more serious venous complication. Therefore, special attention is needed to these structures.

The SSS is often encountered during neurosurgical procedures for interhemispheric transcallosal approaches, among many other access points into the skull. Exposure of this dural venous sinus is often required in the management of lesions situated in proximity to the falx and tentorium. Although extremely useful, the navigation systems are not available in many countries around the world. Current location of the SSS on the external cranial surface for proper positioning of supratentorial craniotomy and for transoperative orientation is still mostly based in cranial topographic anatomy studies, performed especially in cadaveric specimens. Although the sagittal suture can be used as a rough external landmark to estimate placement of the underlying SSS, it is not an accurate landmark and disruption of the SSS can lead to serious complications. Due to this surgical challenge, it is essential that the neurosurgeon estimates the correct location of the SSS.

We found that SSS width in these different landmarks (Na-Br, Br, Br-Lamb, and Lamb) was 5.62 ± 2.5, 6.5 ± 2.8, 7.4 ± 3.2, and 8.5 ± 2.1 mm, respectively. Tubbs et al and Samadian found similar results, and their studies were performed in cadaveric specimens. Observation reinforces that MRI is a reliable source of data. We found that the majority of our measures revealed that SSS tends to deviate to the right side of the midline, which is in accordance with the previous studies. In addition, the SSS has a tendency to a dominant drainage to the right transverse sinus. In accordance with our findings, we recommend that burr holes...
placement and drillings should be at least, 1.7 cm away from sagittal midline because of the potential risk for disrupting SSS and other bridging veins.

Reis et al. measured the width of the SSS in cadaveric specimens and on in vivo patients through MRIs using the midline as a landmark. Although we found similar results with the anatomical specimens, their radiological group found higher results. It may be due to the MRI sequence they used for SSS measure, since T1 is not the best for venous sinus evaluation and measurement, and could overestimate the SSS size and displacement.

CONCLUSION

For neurosurgical approaches to the midline, neurosurgeons should be aware that sagittal midline and sagittal suture are not reliable landmarks for the SSS course. However, it can approximate the external location of the SSS. Our data, in accordance with the previous published study, confirm that SSS is in the majority of the cases displaced to the right side of the sagittal midline, as far as 16.3 mm. We suggest that neurosurgeons should use 1.7 cm as a safety margin to perform burr holes and drillings. Always when possible, neurosurgeons should carefully analyze preoperative imaging and consider SSS location and relationship with external landmarks.

Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

Financial support and sponsorship

Publication of this article was made possible by the James I. and Carolyn R. Ausman Educational Foundation.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Alvernia JE, Lanzino G, Melgar M, Sindou MP, Mertens P. Is exposure of the superior sagittal sinus necessary in the interhemispheric approach? Neurosurgery 2009;65:962-4; discussion 964-5.
2. Aryan HE, Ozgur BM, Jandial R, Levy ML. Complications of interhemispheric transcallosal approach in children: Review of 15 years experience. Clin Neurol Neurosurg 2006;108:790-3.
3. Brockmann C, Kunze S, Scharf J. Computed tomographic angiography of the superior sagittal sinus and bridging veins. Surg Radiol Anat 2011;33:129-34.
4. Brockmann C, Kunze SC, Schmiedek P, Groden C, Scharf J. Variations of the superior sagittal sinus and bridging veins in human dissections and computed tomography venography. Clin Imaging 2012;36:85-9.
5. Bruno-Mascarenhas MA, Ramesh VG, Venkatraman S, Mahendran JV, Sundaram S. Microsurgical anatomy of the superior sagittal sinus and draining veins. Neurol India 2017;65:794-800.
6. Campero A, Ajler P, Emmerich J, Goldschmidt E, Martins C, Rhoton A. Brain sulci and gyri: A practical anatomical review. J Clin Neurosci 2014;21:2219-25.
7. Cervante TP, Arnaud E, Brunelle F, di Rocco F. Unilateral coronal synostosis: Can we trust the sagittal suture as a landmark for the underlying superior sagittal sinus? J Neurosurg Pediatr 2016;17:589-94.
8. Chi JH, Lawton MT. Posterior interhemispheric approach: Surgical technique, application to vascular lesions, and benefits of gravity retraction. Neurosurgery 2006;59:ONS S41-9; discussion ONS S41-9.
9. Cho YH, Yang IC, Kim YS, Kim TS, Joo SP. Bifrontal interhemispheric approach involving cutting the superior sagittal sinus for distal anterior cerebral artery aneurysms. World Neurosurg 2019;127:e1057-63.
10. DiMeco F, Li KW, Casali C, Ciceri E, Giombini S, Filippini G, et al. Meningiomas invading the superior sagittal sinus: Surgical experience in 108 cases. Neurosurgery 2008;62:1124-35.
11. Gordon WE, Michael LM, van Landingham MA. Exposure of dural venous sinuses: A review of techniques and description of a single-piece troughed craniotomy. Cureus 2018;10:e2184.
12. Han H, Tao W, Zhang M. e dural entrance of cerebral bridging veins into the superior sagittal sinus: An anatomical comparison between cadavers and digital subtraction angiography. Neuroradiology 2007;49:169-75.
13. Kubota M, Saeki N, Yamaura A, Ono J, Ozawa Y. Influence of venous involvement on postoperative brain damage following the anterior interhemispheric approach. Acta Neurochir 2001;143:321-6.
14. Lawton MT, Gofin JS, Spetzler RF. e contralateral transcallosal approach: Experience with 32 patients. Neurosurgery 1996;39:729-34; discussion 734-5.
15. Mortazavi MM, Denning M, Yalcin B, Shoja MM, Loukas M, Tubbs RS. e intracranial bridging veins: A comprehensive review of their history, anatomy, histology, pathology, and neurosurgical implications. Childs Nerv Syst 2010;26:97-109.
16. Oberman DZ, Rasmussen J, Toscano M, Goldschmidt E, Ajler P. Computed tomographic localization of the central sulcus: A morphometric study in adult patients. Turk Neurosurg 2017;28:877-88.
17. Ohara K, Inoue T, Ono H, Kiyofuji S, Tamura A, Saito I. Technique for rerouting a bridging vein that hinders the anterior interhemispheric approach: A technical note. Acta Neurochir (Wien) 2017;159:1913-8.
18. Oliveira MF, Teixeira MJ, Norremose KA, Matushita H, Oliveira ML, Shu EB, et al. Surgical technique of retrograde venous sinus shunt is an option for the treatment of hydrocephalus in infants after surgical repair of myelomeningocele. Arq Neuropsiquiatr 2015;73:1019-25.
19. Reis CV, Gusmão SN, Elhadi AM, Dru A, Tazinao U, Zabranski JM, et al. Midline as a landmark for the position of the superior sagittal sinus on the cranial vault: An anatomical
and imaging study. Surg Neurol Int 2015;6:121.
20. Samadian M, Nazparvar B, Haddadian K, Rezaei O, Khormae F. Anatomical relation between the superior sagittal sinus and the sagittal suture with surgical considerations. Clin Neurol Neurosurg 2011;113:89-91.
21. Seker A, Martins C, Rhoton AL. Meningeal Anatomy. Meningiomas. Amsterdam: Elsevier; 2010. p. 11-51.
22. Shapiro M, Srivatanakul K, Raz E, Litao M, Nossek E, Nelson PK. Dural venous channels: Hidden in plain sight. Reassessment of an under-recognized entity. AJNR Am J Neuroradiol 2020;41:1434-40.
23. Tubbs RS, Salter G, Elton S, Grabb PA, Oakes WJ. Sagittal suture as an external landmark for the superior sagittal sinus. J Neurosurg 2001;94:985-7.

How to cite this article: Oberman DZ, Rabelo NN, Correa JL, Ajler P. Relationship of superior sagittal sinus with sagittal midline: A surgical application. Surg Neurol Int 2020;11:309.