Anatomical landmarks to locate the junction between transverse and sigmoid sinuses in translabyrinthine and retrosigmoid open surgical approaches

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Abstract

Introduction

Hematoma due to dural-sinus damage is a known complication when introducing burr holes in open transcranial surgery. Our objective was to identify safe areas to avoid dural-sinus damage based on anatomical landmarks in translabyrinthine and retrosigmoid open surgical approaches where neuronavigation facilities are not available.

Methods

A descriptive anatomical study was conducted on adult skulls. Distances to transverse and sigmoid sinuses on either side were measured using fixed anatomical landmarks: asterion, inion, margins of suprameatal triangle and superior nuchal line. Measurements were standardized according to the cranial indices (cranial index=anteroposterior diameter/transverse diameter) of each skull.

Results

Thirty-two adult skulls (male:female=22:10) were studied. Mean cranial index, width of transverse and sigmoid sinuses were 0.785±0.045, 9.1±2.3mm and 9.7±1.2mm respectively. Mean vertical distances from asterion and inion to the transverse sinus were 1.1±3.4mm and 14.7±5.9mm respectively. Posterior border of the sigmoid sinus was located 14.7±5.9mm, and 59.9±7.4mm anterior to asterion and inion respectively. t-tests did not show significant differences of these distances on either sides (p>.05). Pearson's correlations were insignificant between the measurements and the cranial indices (p>.05). Measurements from the suprameatal triangle to the dural-sinuses had the minimum variance. In >95% of the times the sigmoid sinus was located ≤23 mm posterior and ≤7 mm superior to the suprameatal triangle.

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Discussion and conclusions

Suprameatal triangle was a consistent surface landmark to locate dural-sinuses. Dural-sinus damage could be avoided in 95% of the times by placing burr hole at least 7mm superior and 23 mm posterior to the suprameatal triangle.

Introduction

Cerebellopontine angle (CPA) approach during neurosurgery is challenging (1). CPA is located posterior to the petrous part of temporal bone, anterior to the frontal part of cerebellum, superior to the arachnoid tissue of lower cranial nerves (1). CPA is a frequent site of neoplasms and vascular anomalies (2). The commonest pathology that requires surgical resection in this area is the CPA tumors, which has an incidence of 4% (2, 3). Acoustic schwannomas are benign tumors accounting for approximately 80% of tumors of the CPA (4). This pathology requires surgical resection as the definitive treatment method (3-5).

The traditional method of CPA tumor removal is open surgery which involves placement of burr holes (6). The main advantage in open surgery is to have a good visualization of the surrounding structures (5). The common surgical methods in making the initial burr hole to reach the pathologies in the CPA are the subtemporal retrosigmoid (7,8) and translabyrinthine approaches(9). Retrosigmoid approach involves cranial opening posterior to the sigmoid sinus preceded by retraction of the cerebellum to reach CPA (7). Translabyrinthine approach includes opening on to the CPA angle with external burr hole made in close proximity to transverse sinus and inner opening next to the sigmoid sinus (9). This method is only done when hearing preservation is not required (8). Transverse and sigmoid sinus junction will be closely related in translabyrinthine approach (9).

During the cranial drilling process and visualization, the surrounding neurovascular structures are prone to get damaged (10). Transverse sinus and sigmoid sinus are susceptible for injury leading to morbidity and mortality in patients during retrosigmoid and translabyrinthine craniotomy (11,12). Neuronavigation is a novel neurosurgical adjunct used in operative management of brain pathologies (13). Localizing intracranial structures can be aided by preoperative image superimposition using stereotactic neuron-

avigation techniques (14). Although the localization of these dural sinuses can be done using neuronavigation equipment; these advanced techniques are not readily available in all the centers around Sri Lanka. To prevent damage to these dural-sinuses, surface landmarks can be used as a guide to recognize the transverse sigmoid sinus junction (12). Asterion, inion, superior nuchal line and suprameatal triangle were such structures believed to be helpful in locating the transverse sigmoid sinus junction (15, 16). However, during recent years cadaveric research on the location of these was found to be inconstant among individuals (15, 17).

In different populations the skull size and shape vary (18). There were a few studies done in the Western countries to locate the safe area in burr hole placement for CPA surgery (19). However, in Asia we could not find any articles addressing this issue. In this study we focused on finding a safe area of cranial entrance in initial burr hole making for CPA surgery, avoiding damage to the dural venous sinuses.

Method

A descriptive anatomical study was conducted on adult skulls obtained by self-donated cadavers in the Departments of Anatomy and Forensic Medicine, Faculty of Medicine, University of Colombo, Sri Lanka from March to June 2018. Both male and female adult skulls of Sri Lankan nationality were selected randomly. Skulls with deformities, trauma and previous surgeries were excluded from the study.

Definitions

The anatomical landmarks used in the present study were defined as below

- Inion – the most prominent point of external occipital protuberance (6)

- Nasion – the point on cranium where frontonasal and internasal sutures unite (6)

- Asterion- the junction of lambdoid, parieto-mastoid and occipito-mastoid sutures (6)

- Suprameatal triangle – a triangle formed by the posterior border of the external auditory canal, supramastoid crest and the vertical tangent to the posterior wall of the bony external auditory canal (6). The superior margin of the suprameatal triangle was taken as the reference point for all the vertically measured distances and the anterior margin was taken as the reference point for all the horizontally measured distances.

- Cranial index was calculated by dividing the maximum anteroposterior diameter of the skull by its maximum transverse diameter (6).

Measurements

All the measurements were recorded with the skull in the anatomical position in Frankfurt plane (6). The following measurements were obtained using a Vernier caliper [Manufacturer- Mitutoyo (Kanagawa- Japan) (Model No-505-633-50)] and standard measuring tapes (Figure 1).

1. The horizontal distance from asterion to the posterior border of the sigmoid sinus

2. The vertical distance from asterion to the inferior border of the transverse sinus

3. The horizontal distance from the posterior border of suprameatal triangle to the anterior border of the sigmoid sinus

4. The vertical distance from the superior border of suprameatal triangle to the inferior border of the transverse sinus

5. The horizontal distance from the midpoint of nasion and inion to the posterior border of the sigmoid sinus

All the horizontal measurements towards the anterior aspect of the skull were considered positive and towards the posterior aspect were considered negative. All the vertical measurement towards the superior aspect of the skull was considered positive and towards the inferior aspect was considered negative. If any anatomical landmark used overlied the corresponding sinus, the distance was considered as zero.
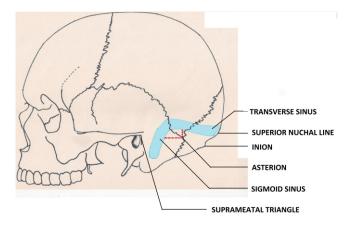

Figure 1. Diagrammatic representation of the anatomical landmarks used to locate the transverse and sigmoid sinuses. All the measurements were obtained with the skull positioned in Frankfurt plane. The horizontal and vertical distances measured from the asterion to the posterior border of the sigmoid sinus and the inferior border of the transverse sinus are marked in an interrupted line.

Statistical Analysis

Standard descriptive analyses were conducted with a priori alpha of .05. Measurements were standardized according to the cranial indices of each skull. A safe zone was described for the transcranial burr hole placement using the measurements which had the least variation.

Results

Thirty-two adult skulls were studied. Of them, majority (n=22, 68.7%) were male skulls. Mean cranial index was 0.785±0.045. Mean width of transverse and sigmoid sinuses were 9.1±2.3mm and 9.7±1.2mm respectively. Mean vertical distances from asterion and inion to the transverse sinus were 1.1±3.4mm and 14.7±5.9mm respectively. Posterior border of the sigmoid sinus was located 14.7±5.9mm, and 59.9±7.4mm anterior to asterion and inion respectively. The asterion (right side) was located on the transverse sinus in 10 (31%) skulls, inferior to the transverse sinus in 6 (19%) skulls and superior to the transverse sinus in 16 (50%) skulls. A summary of the measurements from standard anatomical landmarks to the respective sinuses are given in the Table 1. The distances were examined to determine the extent to which the assumption of normality was met. Shapiro-Wilk tests for each measurement (p>.05) suggested that normality is a reasonable assumption. Independent sample t-tests were conduct to see if there is a significant difference of the above mentioned measurements on left and right sides of the skull. The results showed no significant differences of these distances on either sides (p>.05) (Table 1). Thus, measurements of left and right sides were pooled together in subsequent analyses. Independent sample t-tests did not show significant differences of any of these measurements between males and females (p>.05). Relationship between the cranial indices and the measurements were investigated using Pearson product-moment correlation coefficient. Preliminary analyses were performed to ensure no violations of the assumptions of linearity and homoscedasticity. No significant correlations were found between the two variables (p>.05). Results of the Pearson correlations are summarized in the Table 1. Interquartile ranges of each measurement are summarized in a boxplot in Figure 2. Minimum variances were noted in the measurements from the suprameatal triangle to transverse sinus (8.6), asterion to transverse sinus (11.8) and suprameatal triangle to sigmoid sinus (13.8). In >95% of the times the sigmoid sinus was located ≤70.0mm anterior to the inion, ≤25 mm anterior to the asterion and ≤23 mm posterior to the posterior border of the suprameatal triangle. The transverse sinus was located ≤16 mm inferior to the superior nuchal line, ≤9 mm superior to the asterion and ≤7 mm superior to the superior margin of the suprameatal triangle (supramastoid crest).

Table 1. A summary of measurements to the transverse and sigmoid sinuses from fixed anatomical landmarks and the results of an independent sample t-test comparing the distances on left and right sides of the skulls (For a detailed description of measurements, please refer to the relevant section in methods). SD – Standard Deviation; Sig – Significance level; SS – Sigmoid Sinus; t- result (t-value) of the independent sample t-test; TS – Transverse Sinus.

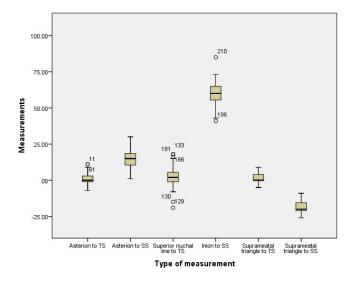| Measurement	Mean (mm)			SD (mm)			Range (mm)		No. of measurements superimposed on a sinus		Results of t-test		Results of Pearson Bivariate Pearson's correlations	
	R	L	B/L	R	L	B/L	R	L	R	L	t Value	Significance	Pearson correlation coefficient (r)	Significance
Asterion to TS	1.3	0.8	1.1	2.8	4.0	3.4	-4.0 to +11.0	-7.0 to +11.0	10	10	0.543	0.589	-0.129	0.309
Asterion to SS	14.9	14.5	14.7	6.5	5.5	6.0	+1.0 to +30.0	+3.0 to +25.0	0	0	0.251	0.803	0.075	0.555
Superior nuchal line to TS	2.4	2.2	2.3	6.4	7.0	6.6	-15.0 to +18.0	-19.0 to +18.0	6	7	0.131	0.896	0.005	0.971
Inion to SS	59.7	60.0	60.0	7.9	7.0	7.4	+45.0 to +85.0	+41.0 to +73.0	0	0	-0.168	0.867	0.080	0.530
Suprameatal triangle to TS	1.9	1.0	1.5	2.9	3.0	2.9	-3.0 to +9.0	-5.0 to +7.0	17	9	1.195	0.237	0.004	0.975
Suprameatal triangle to SS	-18.0	-18.3	-18.2	3.7	3.8	3.7	-10.0 to -261.0	-9.0 to -23.0	0	0	-0.334	0.739	0.064	0.615
Width of TS	9.2	9.0	9.1	2.2	2.5	2.3	+4.0 to +15.0	+5.0 to +15.0	0	0	0.265	0.792	0.101	0.429
Width of SS	9.9	9.6	9.7	1.3	1.1	1.2	+7.0 to +12.0	+7.0 to +12.0	0	0	0.908	0.368	-0.080	0.529

Figure 2. A boxplot of corresponding vertical and horizontal distances from the anatomical landmarks to the transverse and sigmoid sinuses. All the horizontal measurements towards the anterior aspect of the skull were considered positive and towards the posterior aspect were considered negative. All the vertical measurement towards the superior aspect of the skull was considered positive and towards the inferior aspect was considered negative. If any anatomical landmark used overlies the corresponding sinus, the distance was considered as zero. Measurements are given in millimeters.

Discussion

Anatomical structures asterion, inion, superior nuchal line and suprameatal triangle were used as landmarks to locate the junction between transverse and sigmoid sinuses (15, 16). However, further studies revealed that there were inconsistencies with the transverse and sigmoid junction and the location of these anatomical structures (15, 17). Also, asterion was difficult to locate intra-operatively (19). Retrosigmoid and translabyrinthine approaches are main methods used to gain access in the CPA tumor resection (7, 8). They were first described by Cushing, followed by further adjustments and alterations by Seiffert and Dandy among others, in order to gain entrance to the CPA (20). During this procedure with no advanced neuronavigation techniques available, the transverse and sigmoid sinus damage can cause minor injuries to major life threatening ones (11). Thus, when gaining entrance to the cranial cavity it is mandatory to have an idea of the location of tranverse and sigmoid dural venous sinuses.

A study done on 100 patients undergoing computed tomography angiography showed that the asterion was directly above the transverse and sigmoid sinus junction in 81%, superior to it in 4% and inferior to the junction in 15% (20). Another cadaveric study on 24 specimens indicated the asterion to be located over the transverse sinus in all the specimens (21). But in the same study, the asterion could not

be identified clearly in 14 sides (21). The mean vertical distance from asterion to the transverse sinus was 1.1±3.4mm in our study. Asterion was located on the right transverse sinus in 31%, inferior to the transverse sinus in 26% and superior to the transverse sinus in 42%. Distance from inion to the dural-sinuses was not described in any of the former studies. However, length from an arbitrary midline structure was used in one study to measure the length to asterion (21). Ucerler and Govsa reported; asterion to the root of zygoma was 54.1± 5.42mm on the right side and 55±5.4mm on the left side (22). Avci, et al. stated the distance from the asterion to the zygomatic root in the cadavers ranged between 45.9 mm to 69 mm (21). In our study the sigmoid sinus was located 14.7±5.9 mm and 59.9±7.4 mm anterior to asterion and inion respectively. Sheng, et al. concluded that superior nuchal line failed to make a striking impression in locating the transverse sinus (23). The findings of our study are comparable with this.

The suprameatal triangle was used as a landmark to locate the junction between transverse and sigmoid sinuses (24). Nevertheless, there were no anatomical studies indicating any distance from suprameatal triangle to the transverse or sigmoid sinus. In our study, the transverse sinus was situated superiorly at a mean vertical distance of 1.5±2.9mm and the sigmoid sinus was located posteriorly at a mean horizontal distance of 18.2±3.7mm with reference to the corresponding margins of the suprameatal triangle. The location of the dural venous sinuses with reference to the suprameatal triangle had the minimum variance. Thus, it is a promising anatomical landmark which can be used in the retrosigmoid approach to the CPA.

Only a few studies were conducted in localizing the safe area for surgical access. Tubbs et al. established that the cranial entrance should be in made 9.1mm and 9.8mm from the mastoid line (19). Right side burr hole to be made inferior to the left, because of the width and dominance of right transverse sinus (19). Bozbuga, et al. after doing a study on 84 adult skulls said the ideal burr hole placement is below the superior nuchal line and posterior to the mastoid tip and squamo-parietal suture junction (7). Nevertheless, the distances to the safe cranial entrance was not defined in both of these studies. Avci, et al. mentioned that the superior burr hole to be placed 1cm below the superior nuchal line 1cm medial to the mastoid groove (21). However, the conclusion was based after studying only 10 skulls.

Anatomical land marks to transverse and sigmoid sinuses were not measured in an Asian population before. Large scale studies are necessary for the accurate population inferences. The differences of the measurements in our study could be due to morphological variations of the skulls in sample populations. Thus, it is necessary to conduct similar anatomical studies in different ethnicities and populations.

Conclusion

We observed discrepancies of the described anatomical landmarks related to the burr hole placement in CPA tumor resection that avoids damage to the transverse and sigmoid sinuses. Since the advanced neuronavigation equipments are not readily available throughout the country, it is beneficial to have an idea of such landmarks in dural sinus location. Suprameatal triangle was a consistent surface landmark with a minimum variance. Dural sinus damage could be avoided in 95% of the times by making the initial burr hole at least 7mm superior to the superior margin of the suprameatal triangle (supramastoid crest) and 23 mm posterior to the posterior margin of the suprameatal triangle. However, large scale studies in different ethnicities with clinical and imaging correlations are necessary to confirm these anatomical landmarks.

All authors disclose no conflict of interest. The study was conducted in accordance with the ethical standards of the relevant institutional or national ethics committee and the Helsinki Declaration of 1975, as revised in 2000.

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