RESEARCH ARTICLE

ULTRASONOGRAPHIC MEASUREMENT OF SUBARACHNOID SPACE AND FRONTAL HORN WIDTH IN HEALTHY IRANIAN INFANTS

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Abstract

Objective

ultrasonography is among the most general evaluating methods for central nervous system (CNS) assessment, especially for detecting extra axial collection via anterior fontanel. There are few studies showing values of this technique in normal developing infants for detection of subarachnoid space width. Association between age and sex and cerebrospinal fluid (CSF) spaces are controversial. Therefore, we conducted this study to evaluate the relationship between subarachnoid space and sex and age in Iranian infants.

Material & Methods

we used ultrasonography with a 7.5MHZ linear probe to evaluate 74 healthy infants who were referred to our departments for other reasons. Sinocortical width (SCW), craniocortical width (CCW), interhemispheric width (IHW) and frontal horn width (FHW) were evaluated. Data was collected and analyzed using STAT 9.1 software.

Results

Fifty four percent of the patients were male and 45% were female. Mean age of cases was 71 days. Mean SCW was 2.8 ± 1.33 mm (5% and95% were 1.2-5.8). Mean CCW was 2.52±1.37mm (5% and 95% were 1.1 and 5.2mm, respectively) and mean IHW was 4.39±2mm (5% and 95% were 1.7 and 8mm, respectively). Mean FHW was 2.9+/-1.09mm in females and 3.52±1.34mm in males (5% and 95% were 1.4 and 5mm in females & 1.7 and 5.8mm in males, respectively). There was no significant difference in subarachnoid space width between boys and girls except for FHW which was wider in males than females. All space diameters correlated with age and were wider in older infants.

Conclusion

Although our sample size was rather small for accurate conclusion, we found a normal range which was wider than western countries but similar studies conducted in China. Delayed maturation of arachnoid villi is one of the most important reasons of subarachnoid space widening in infants younger than one year which seems occur later in Iranian infants.

Keywords: Ultrasonography;subarachnoid space; infant.

Introduction

Cerebrospinal fluid (CSF) is a vehicle to transport metabolites, neurotransmitters and nutrient substances to different parts of central nervous system (1). Most of the CSF is produced in choroid plexuses of ventricles and enters the subarachnoid space via basilar cisterns (2). Finally, CSF drains to dural venous system through arachnoid villous (3). This widening of sub arachnoid space in the fetal period is evaluated by MRI which reveals a maximum diameter of 6mm in frontal sub arachnoid space at 32 weeks gestation with a subsequent reduction to 1.2-1.7mm in term (4). A study by Mcardel (5) in 29-42 weeks postconception neonates revealed a subarachnoid space width between 0-4mm and recommended follow-up if the spaces were wider. A study by Narlia (6) on 203 cases in the first 24 days after birth showed that the width of subarachnoid space correlated with weight, height and head circumference but not with sex. Subarachnoid space widening can be seen in some diseases like brain atrophy, meningitis and hemorrhage. However, it should be kept in mind that benign conditions associated with subarachnoid space widening have been recognized; also, associations have been detected with prematurity, trauma, vitamin A deficiency and genetic syndromes (7). Available inexpensive sonography via anterior fontanel is the modality of choice for the evaluation of these spaces in infants without exposure to ionizing rays or utilization of more expensive modalities like MRI (8, 9). Many studies have revealed usefulness of sonography in brain evaluation. A study by Govaert (10) showed that evaluation by ultrasound was easy and reproducible. Anderson (9) reported that sonography could evaluate the subarachnoid space similar to MRI although 3D sonography can be used, especially for ventricle assessment (11) and ventricular evaluation (12). Studies by Grant (13) and Kossoff (143) also highlighted that ultrasonography could correctly evaluate CSF spaces. Estimation of the subarachnoid space in normal infants to find the normal range of this space, especially when confronting a case with a large cranium or increased head circumference, is important. An age-related increase and then decrease in CSF spaces are reported by Lam (15). Also, a study by Kleinman (16) on 34 cases using CT scan revealed that CSF volume of the infants under 2 years was greater than that of infants older than 2 year although this difference was not significant. Some studies have revealed no relationship or a negative relationship between this spaced and age (17, 18). We tried to evaluate the diameters of this space in our participants and find its causative relationship with age in our normal cases.

Material & Methods

we evaluated 74 infants younger than 1 year who were referred to our departments for routine health care, growth control or vaccination .We informed their parents on the purpose of the study. Upon verbal agreement, sonography of the brain using a 7.5 MHZ linear probe via anterior fontanel in coronal plane was done. No sedation or other medications were used. SCF spaces around the brain were measured in this study. We measured these spaces in the following positions:

1-Sinocortical width (SCW), which is the shortest distance between brain cortex and superior sagittal sinus in the plane of foramen monro.

2- Craniocortical width (CCW), which refers to the shortest distance between frontal cortex and calvarium.

3-Inter hemispheric width (IHW), which is the widest distance between two brain hemispheres in anterior inter hemispheric fissure.

4-Frontal horn width (FHW), which is the widest part of lateral ventricle vertical to frontal horn axis.

These spaces and planes of measurement are depicted in figures 1& 2. All of the mentioned distances were recorded as millimeters in figures 4-6. Also, age and sex were documented and any correlation between these parameters was analyzed with STATA 9.1 software. Spearman test was used for variables without a normal distribution curve and Mann-Whitney-Two sample Rank Sum was used for the evaluation of age and measured distances.

Results

Seventy four participants, 40 (54.05%) males and 34(45.95%) females, were evaluated. The age of the participants was between 4-310 days with a mean age of 51 days. We noted an increase in the diameter of CSF spaces during the first year of life, as depicted in Table 1. There was no normal distribution curve according to Spirow-wilk normality so we used non-parametric tests for analysis. At the time of measurement, mean age was 65 days for females and 77 days for males. However, no significant difference was noted. Mean SCW was 2.8± 1.3 mm and the 95th percentile was 5.8mm. There was no significant difference between males and females. On the other hand, mean CCW was 2.52±1.37mm and the 95th percentile was 5.2mm. The mean diameter of

IHW was 4.39 ±2mm and the 95th percentile was 8mm. FHW was different between males and females. It was 3.52±1.34mm in males (the 95th percentile was 5mm) and 2.9±1.09 mm in females (the 95th percentile was 5.8mm) (Tables 2-4). According to spearman test, SCW, CCW, IHW and FHW were correlated with age; this finding was also confirmed by lowess regression test (Table 5 and figure 4-6). The correlations between SCW and CCW, SCW and IHW, and SCW and FHW had P=0. 001, P=0.001 and P=0.0001, respectively. There were also correlations between CCW with FHW and IHW with P values of 0.001 and 0.003, respectively. IHW and FHW were correlated (P=0.001) (Table 6).

Discussion

Libicher (17) evaluated 89 infants without finding a correlation between age and the subarachnoid space width. Libicher reported that mean values for SCW, CCW and IHW were 1, 1, and 2.8 mm with the 95th percentiles of 3, 4, and 6mm, respectively. These diameters are considered as upper limit of the normal range for these spaces. Armstrong and his colleagues (19) considered SCW above 3.5mm for probable pathology; however, in our study, SCW, CCW, and IHW were 2.5, 2.2and 4.5mm with the 95th percentiles of 5.8, 5.2 and 8 mm, respectively. Also, Lam (15) in Hong Kong reported such deviations from Libicher. Comparison of our data with Lam's showed that our means were in the normal range of Lam. It seems that race and socioeconomic conditions or the dietary regime may affect subarachnoid space widths. We could say that our normal range (SCW=1.2-5.8mm, CCW=1.1-5.2 mm and IHW=1.7-8mm) was wider than that seen in western countries. However, more accurate evaluation through a larger sample size may yield more accurate results. Comparison of subarachnoid spaces between male and female participants revealed no significant difference; however, FHW was slightly wider (0.5mm) in boys than girls which was significant (P=0.037). The normal range for boys and girls were 1.7-5.8mm and 3.3-5mm, respectively. Frankel (18) in a study on 155 cases found a negative correlation between age and space width. Lam (15) and his colleagues found that subarachnoid space increased from birth to 28 weeks of age but decreased thereafter. We found a positive and significant (P<0. 001) relationship between age and subarachnoid space width which may be due to race; however, like Lam (15), we reached no definite document. Libicher (17) found some differences between SCW and CCW by IHW which were not significant. So, our study revealed complementary results. Our work on the correlation between FHW and subarachnoid spaces was unique and we could not find a similar article. Granulations in Pacchioni vili have a significant role in CSF drainage which develops 6-18 months after birth (20). Therefore, a spectrum of functional villous development causes uneven production and absorption of CSF in infancy. This is the cause of the accumulation of CSF and increased CSF spaces. The time of functional maturity of vili is probably affected by race, diet or socioeconomic conditions. However, we did not find any articles to support this hypothesis.

In conclusion, we found that the normal range of SCW, CCW, IHW and FHW was wider than western countries, but close to what is seen in Eastern Asia. There were significant relationships between subarachnoid space and age in our cases. Maturity of arachnoid villi is one of the most important reasons of CSF widening in infants younger than one year which seems to occur with more delay in our race. Limitation and solution: for more correct evaluation of CSF spaces for our country, studies with a larger sample size from different parts of the country are required. The difference between two hemispheres is not supported by other studies; however, there are studies revealing differences between ventricle width in two hemispheres which may influence our results regarding the diameter of FHW and the differences between boys and girls.

Fig 1. A 24-day-old boy; coronal sonography with a 7.5MHZ linear probe via anterior fontanel revealed subarachnoid effusion. Distance between lateral wall of superior sagittal sinus and frontal lobe cortex (SCW) is marked A. Distance between frontal cortex and cranium (CCW) is marked B and lateral ventricular width (FHW) vertical to ventricular axis is marked C.

Fig 2. A 24-day-old boy; coronal sonography with a 7.5MHZ linear probe via anterior fontanel revealed subarachnoid effusion. Inter hemispheric width (IHW) is shown. The deepest part of the inter hemispheric fissure is measured.

Table 1: Normal range of CSF spaces in first and second 3 months and second 6 months of life

Spaces	First 90 days	Second 90 days	Last six months
SCW	1.1-3.4 mm	2.1-7.3 mm	3.2-5.4 mm
CCW	1.1-3.2 mm	1.2-6 mm	2.6-6.8 mm
IHW	1.7-6.2 mm	3.1-8.5 mm	6.3-9 mm
FHW	1.4-4.9 mm	2-6.8 mm	3.6-7 mm

Table 2: Statistical analysis of CCW,SCW& IHW.

Statistic	Age	SCW	IHW	CCW
Mean	70.97297 days	2.809589 mm	4.390541 mm	2.524324 mm
SD	58.67 days	1.33 mm	2.00 mm	1.37 mm
P50	51 days	2.5 mm	4.55 mm	2.2 mm
P5	8 days	1.2 mm	1.7 mm	1.1 mm
P75	105 days	3.3 mm	5.9 mm	3.2 mm
P95	180 days	5.8 mm	8 mm	5.2 mm
Min	4 days	1 mm	1.4 mm	0.7 mm
Max	310 days	7.3 mm	9 mm	6.8 mm
Total	74	74	74	74

Table 3: Statistical analysis of FHW in boys and girls.

Statics	FHW in girls	FHW in boys
Mean	2.90 mm	3.52 mm
SD	1.09 mm	1.34 mm
P50	2.8 mm	3.3 mm
P5	1.7 mm	1.4 mm
P75	4.5 mm	3 mm
P95	5.8 mm	5 mm
Min	1.3 mm	1.2 mm
Max	7 mm	6.8 mm
Total	34	40

Table 4: Spirow-Wilk test of age, CCW, SCW, IHW & FHW.

Spirow-Wilk test	P value
Age	0.000001
SCW	0.00002
CCW	0.000001
IHW	0.007
FHW	0.00017

(P value >0.05 reveal normal distribution curve).

Table 5: Correlation of age by CCW, SCW &IHW with Spearman test.

	rs	Pvalue
SCW vs age	0.61	0.00001*
CCW vs age	0.69	0.00001*
IHW vs age	0.65	0.00001*
FHW vs age	0.45	0.00001*

*= significant

Table 6: Correlation of SCW, CCW, IHW & FHW

	rs	Pvalue
SCW vs CCW	0.83	0.00001
SCW vs IHW	0.73	0.00001
FHW vs SCW	0.46	0.0001

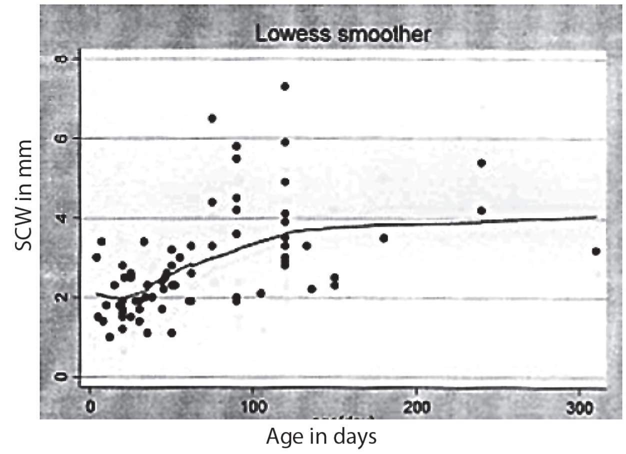

Fig 3. Lowess regression test for correlation of age by SCW.

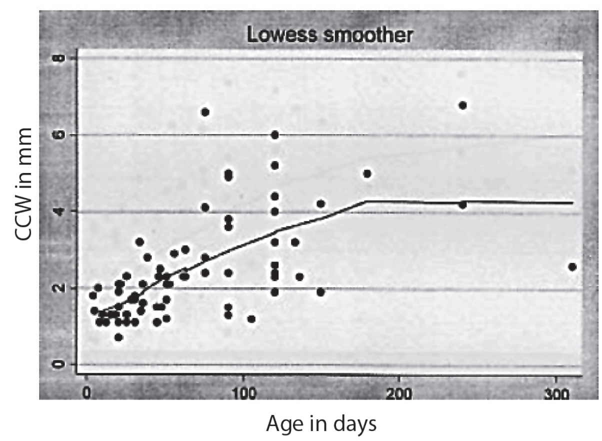

Fig 4. Lowess regression test for correlation of age by CCW.

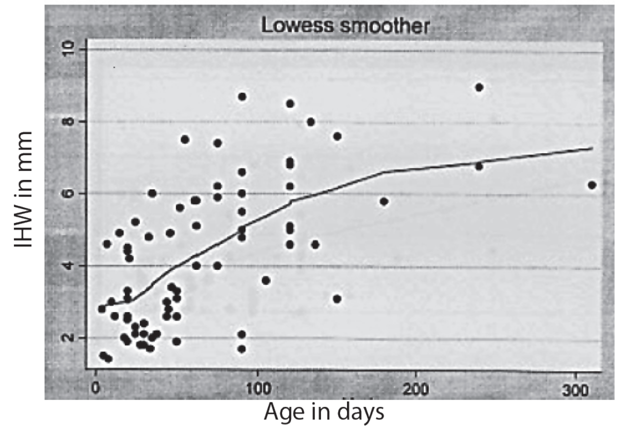

Fig 5. Lowess regression test for correlation of age by IHW.

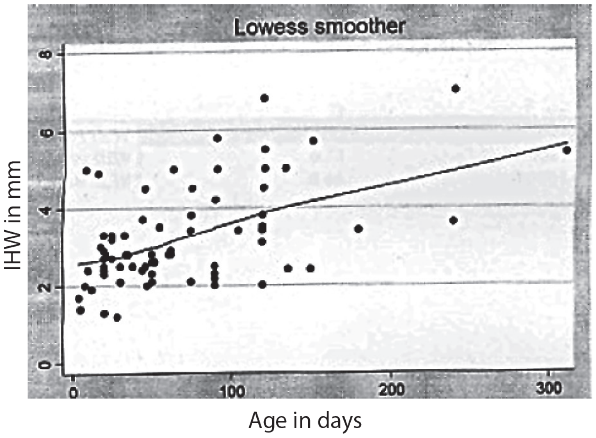

Fig 6. Lowess regression test for correlation of age by FHW.

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