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ORIGINAL ARTICLE

Sonographic measurement of subarachnoid space and ventricular width in premature and mature newborns

Mehmet Ozturk

Diyarbakir Children's Hospital, Department of Radiology, Diyarbakir, Turkey

Abstract

Aim: We aimed to measure the subarachnoid space and ventricular width with transfontanel sonography in premature and mature newborns and to identify the subarachnoid space/ventricular width ratio.

Material and method: This prospective study included 123 premature and 121 mature newborns, totally 244 cases. All cases had sonographic investigation from the anterior fontanel with 4.8-11.0 MHz linear transducer. The subarachnoid space/ventricular width ratio was calculated. Analysis of variables was completed with SPSS 22.0 program; and independent samples T test was used for the comparisons between the groups.

Results: The birth week, head circumference, weight and height values of mature newborns were higher compared to the premature newborns ($p<0.001$, for each). The subarachnoid space and ventricular width values for mature and premature newborns were 3.13±0.39 mm, 1.79±0.45 mm, and 3.45±0.47 mm and 2.02±0.54 mm, respectively ($p<0.001$, for each). The subarachnoid space/ventricular width ratios were 0.90±0.02 and 0.89±0.05 in mature and premature newborns with no difference identified between the groups ($p=0.432$). The result of Receiver Operating Curve analysis was that the threshold values for premature-mature distinction were 2.29 mm for subarachnoid space and 2.49 mm for ventricular width; and the sensitivity and specificity for both values were found to be 100% ($p<0.001$, for each).

Conclusion: Subarachnoid space and ventricular width values vary according to the birth week of newborns, though the subarachnoid space/ventricular width ratio is not different. Transfontanel sonography is a useful imaging method for measurement of cerebrospinal fluid spaces in newborns.

Keywords: Ultrasound; Newborn; Subarachnoid Space; Ventricular Width.

INTRODUCTION

Cerebrospinal fluid (CSF) carries metabolites, neurotransmitters and nutritional material to different regions of the central nervous system. The majority of CSF is produced in the ventricles of the choroid plexus and passes through the subarachnoid cavity via the basilar cisterns. Finally it empties into the dural venous system through the arachnoid villi (1,2).

In babies, the subarachnoid cavity has been assessed with imaging methods such as computed tomography, magnetic resonance imaging and ultrasonography (3-5). Expanded subarachnoid spaces may occur with atrophy, external hydrocephalus or a variation of normal development. This situation causes interpretation problems in healthy babies.

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Corresponding Author
Mehmet Ozturk, Diyarbakir Children's Hospital, Department of Radiology, Diyarbakir, Turkey
E-mail: drmehmet2121@gmail.com

The most commonly used and chosen imaging method to assess CSF spaces in newborns is transfontanel ultrasonography (TFUS).

The most important advantages are that it does not include ionizing radiation, is cheap and repeatable (5).

The aim of this study is to measure the subarachnoid space (SAS) and ventricular width (VW) with TFUS in premature and mature newborns to identify the SAS/VW ratio.

MATERIALS and METHODS

Study design

This prospective study assessed a total of 247 newborn cases, 125 premature and 122 mature, with TFUS from October 2015-November 2016 after receiving permission from the local Clinical Research Ethics Committee. Before assessment, "informed consent" was obtained from the parents of all cases accepted into the study.

Patients

To calculate gestasional age of cases, last menstrual cyclus or if known new Ballad scoring was used. TFUS investigation was performed within the first 3 days after

birth. No medication was used for sedation. Cases with head circumference, weight and height below the 5th percentile or above the 95th percentile, with additional pathology (microcephaly, macrocephaly, sepsis, congenital anomalies, etc.) and history of steroid use were not included in the study. During investigation, 2 premature cases with intraventricular hemorrhage and 1 mature newborn with corpus callosum agenesis were excluded from the study.

Ultrasound Investigation

Sonographic assessment used a 4.8-11.0 MHz linear transducer with Aplio™ 500 (Toshiba Medical Systems Co. Ltd, Otawara, Japan) ultrasound device and was completed by a pediatric radiology expert (5 years experience of pediatric radiology) in supine position on the anterior fontanel. Measurements were taken on the coronal plane at the level of the foramen monro. SAS measurements were the mean of three measurements of the bilateral shortest craniocortical (CC) space (Figure 1). VW measurements were the mean of three measurements from the frontal horns of the right and left lateral ventricles (Figure 2). Finally the SAS/VW ratio was calculated.

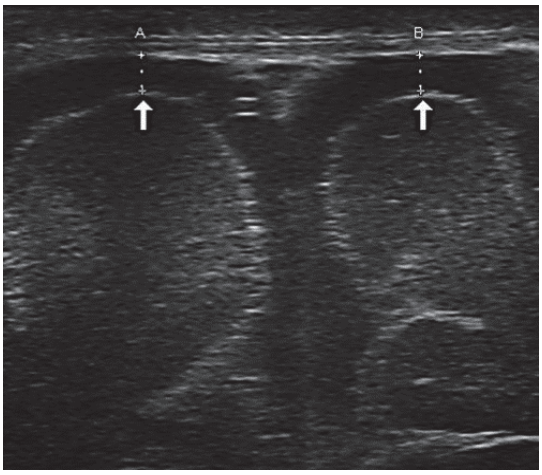

Figure 1. Measurement of subarachnoid space in coronal plane (arrows and between +'s, right (A) and left (B) craniocortical width)

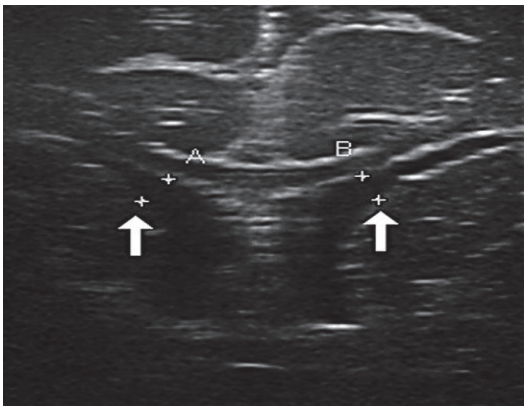

Figure 2. Measurement of ventricular width in coronal plane (arrows and between +'s, right (A) and left (B) anterior ventricular horns width

Statistical Analysis

Analysis of variables used the SPSS 22.0 (IBM Corporation, Armonk, New York, United States) program. Normal distribution of data was assessed with the Shapiro-Wilk test, while variance homogeneity was assessed with the Levene test. For comparison of quantitative data in two independent groups, the Independent-Samples T test Bootstrap results were used along with the Mann-Whitney U test Monte Carlo results. For comparison of categorical variables, the Fisher Exact test was used. For variables in the groups, the correlation of the classification based on the calculated cut-off value with true classification was investigated using sensitivity, specificity, positive and negative prediction rates in ROC (Receiver Operating Curve) analysis. Quantitative data are given as mean ± standard deviation (SD) and median ± interquartile range (IQR) in tables. Categorical variables are given as n (%). Variables were investigated at the 95% confidence level and p values less than 0.05 were accepted as statistically significant.

RESULTS

The birth week, head circumference, weight and height values for mature newborns were higher than those of premature newborns. Demographic data are summarized in Table 1.

Table 1. Baseline descriptive data of the study population.

Group	Birth week (weeks) Median±IQR	Head Circumference (mm) Median±IQR	Weight (kg) Mean±SD	Height (cm) Median±IQR
Premature (n=123)	33.00±4.80	30.20±5.00	2.434±602.10	44.05±5.20
Mature (n=121)	40.25±1.90	34.15±2.30	3.297±385.49	48.45±3.10
p value	<0.001*	<0.001*	<0.001*	<0.001*

SD. Standard Deviation - IQR: Interquartile range (Abbreviation *: statistically significant).

The SAS and VW values for mature newborns were 3.13±0.39 mm and 3.45±0.47 mm, premature newborns were 1.79±0.45 mm and 2.02±0.54 mm, respectively (Table 2).

Table 2. The Cerebrospinal fluid space size according to age groups (Abbreviation *: statistically significant

Group	SAS (mm)	VW (mm)	SAS/VW
Premature (n=123)	1.79±0.45	2.02±0.54	0.89±0.05
Mature (n=121)	3.13±0.39	3.45±0.47	0.90±0.02
p value	<0.001*	<0.001*	0.432

The SAS/VW ratios were 0.90±0.02 and 0.89±0.05 in mature and premature newborns with no difference identified between the groups (Figure 3). The results of ROC analysis was that the threshold values for premature-mature differentiation were 2.29 mm for subarachnoid space and 2.49 mm for ventricular width with sensitivity and specificity of both values found to be 100%. The area under both ROC curves was 1 with positive and negative prediction rates calculated as 100% (Figures 4, 5).

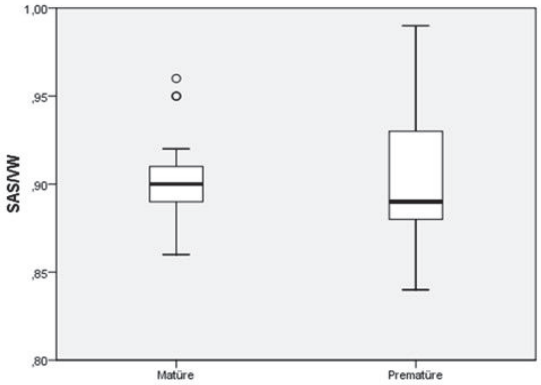

Figure 3. The mean SAS/VW values for both groups.

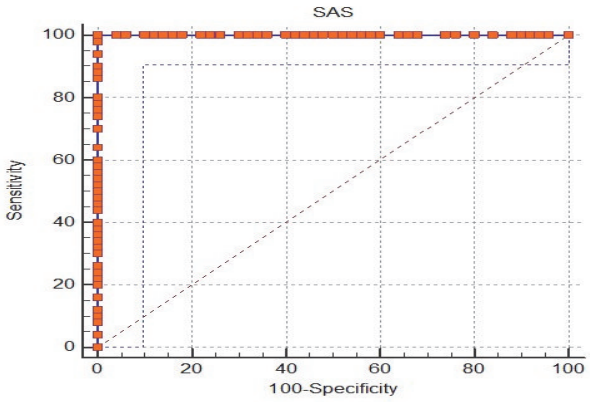

Figure 4. ROC analysis for critical SAS. The optimal cut-off value was 2.29. The area under curve was 1.

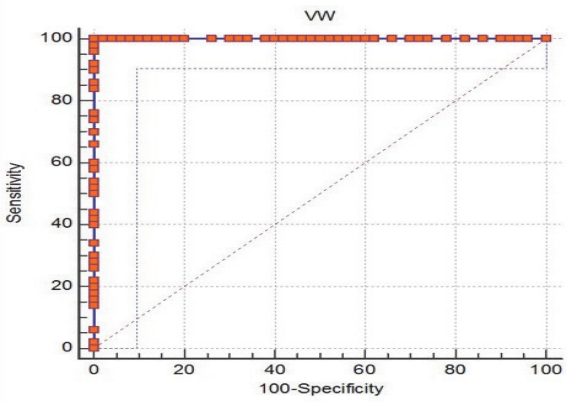

Figure 5. ROC analysis for critical VW. The optimal cut-off value was 2.49. The area under curve was 1.

DISCUSSION

This study completed measurements of the anterior fontanel with TFUS with the aim of identifying the normal SAS and VW values in the newborn period and revealed important results. The first is that SAS and VW values changed in newborns based on birth week, while the SAS/VW ratio did not change. Second, the values determined are important in terms of threshold values for diagnosis of pathologies causing expansion of the CSF space in newborns. Thirdly, TFUS is a cheap, repeatable and useful imaging method for CSF space measurements in newborns.

Previous studies have varied in terms of imaging methods used and measured distances for SAS in healthy mature newborns and infants, with values varying from 1.9 to 5.7 mm (4, 6-9). Two different studies measuring the CC interval with TFUS found SAS values of 3.3 and 3.5 mm with the upper limit for the 95th percentile recommended as 3 mm (5, 6). In our study, the distance of the CC of the SAS was measured between 2.74-3.52 mm in mature newborns and was similar to previous studies.

A study of 230 term newborns by Narlı et al. found SAS values on CC measurements were 1.261±0.784 mm, with an increase identified with weight, height and head circumference (10). Another study of 278 newborns and infants aged from 1 day to 12 months showed an increase in SAS in the first month with age; however they reported a reduction in this over time (11).

A study by Armstrong et al. measured SAS and head circumference weekly in premature newborns from birth until 36 weeks. The initial mean SAS value was 1.56 mm, with mean at 36 weeks 1.94 mm and a weekly increase of 0.02 mm reported (12). In this study, the distance of the CC of the SAS was measured between 1.34-2.22 mm in premature newborn and was similar to previous studies. The mean difference between the pre- mature newborns was 1.3 mm and the weekly SAS change was not evaluated.

Two different studies on lateral ventricular frontal horn width reported the mean VW values as 4.5-8 mm and 1.3-5 mm (8, 9). Measurements at the foramen monro level accepted the upper limit for lateral ventricular width as 10 mm (13). In this study, frontal horn VW is between 1.48 and 2.56 mm in prematurity and between 2.98 and 3.92 mm in mature, similar to the literature.

As reported in previous studies, there is no standard value for SAS and VW in premature and mature newborns. As a result, Okur et al. defined the SAS/VW ratio and reported it as 0.9 ± 0.3 in mature newborns and infants. They proposed that this ratio may be used as a standard measurement in healthy babies (9). In our

study the ratios for mature and premature newborns were 0.90±0.02 and 0.89±0.05, with no difference identified between the groups. This is similar to the literature. Additionally in our study, to ease the premature-mature differentiation in SAS and VW values, a threshold value was determined with ROC analysis.

A previous study proposed that brain and gyral pattern development was accompanied by expansion of the SAS around these structures, with this situation explained by increased CSF production in response to growing brain parenchyma (14). Two different studies found a close correlation between head circumference and brain development; however they reported that SAS measurements may be more valuable than head circumference measurements (12, 15). In our study the SAS and VW values of mature-premature newborns were in accordance with head circumference values and larger in mature newborns. It is important that measurements were made within the first three days after birth in terms of reflecting intrauterine brain development and CSF production.

A study reporting corticosteroids reduced brain development in preterm rats stated that steroids may cause bad neurodevelopmental process in preterm babies (16). As a result, newborns receiving corticosteroid treatment after birth were excluded from the study. Among the limitations of our study are the relatively low number of cases and that TFUS investigation was completed by a single user.

CONCLUSION

In conclusion, measurements with TFUS on the anterior fontanel of newborns found SAS and VW values vary with birth week, with no difference identified in SAS/VW ratio. TFUS is a cheap, repeatable and beneficial imaging method to assess central and peripheral CSF spaces in newborns.

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