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Establishing normative data on anterior fontanelle size: Associations with gender, mode of delivery, weight at birth, head circumference and gestational maturity

Mohd Irshad[1], Yasmeena Akhter[2], Shahid Hussain Sofi[1], Burhan Shaukat[1], Syed Kaiser Jan[1], Iffat Akbar[1], Ghulam Mohammad Bhat[2], Bashir Ahmad Shah[2]

[1]Department of Pediatrics, Government Medical College Baramulla, [2]Department of Anatomy, Government Medical College Srinagar, Srinagar, Jammu and Kashmir, India.

***Corresponding author:**
Mohd Irshad,
Department of Pediatrics,
Government Medical College
Baramulla, Jammu and
Kashmir, India.

drirshadnabi@gmail.com

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ABSTRACT

Objectives: The anterior fontanelle (AF) is a fibrous gap between skull bones and is most important among all fontanelles in clinical examination of neonates and children in the first 2 years of life. There is a lack of normative data on AF size in our region, and hence, establishing normative data and understanding its associations with various perinatal factors can facilitate clinical evaluations and early diagnosis of potential abnormalities. The study aims to generate normative data on AF size in neonates and investigate its associations with gender, mode of delivery, weight at birth, head circumference and gestational maturity.

Material and Methods: This study was conducted over 3 months in the outpatient department section of the Special Care Newborn unit in an associated hospital of medical college in North India, including normal term neonates born between 37 and 42 weeks. The study excluded pregnancies with antenatal risk factors and neonates with certain defined conditions and measured AF size using the Keisler and Ricer method.

Results: In a study of 217 neonates (114 males and 103 females), the mean AF size was 2.43 ± 0.60, with 97.70% having an AF size between 0.6 and 3.6 cm. No significant gender differences were found in AF size. Neonates born through lower-segment caesarean sections had significantly larger head circumferences compared to those born through normal vaginal delivery. Weak positive correlations were observed between AF size and gestational maturity.

Conclusion: The study shows that AF size is influenced significantly by gestational maturity only and not by weight at birth, head circumference, gender or mode of delivery. These results could help paediatricians in assessments of normal and abnormal fontanelle size in neonates. The high percentage of neonates with good-sized fontanelles between 0.6 and 3.6 cm warrants further investigation to determine if this is due to rampant Vitamin D deficiency of mothers in this part of India or influenced by measurement methods.

Keywords: Anterior fontanelle, Neonate, Gestational maturity, Size, Head circumference

INTRODUCTION

The fontanelles are windows in the bony skull where multiple bones meet and are covered by soft, fibrous, membranous tissues.[1] The word fontanelle is borrowed from the French word 'fontenele', which is a contraction of Fontaine, meaning little spring.[2-4] At birth, there are six fontanelles, including one anterior, one posterior, two mastoids and two sphenoids.[5-7] The largest and easiest to identify is anterior fontanelle (AF), a rhomboid-shaped opening between frontal and parietal bones.[7] AF facilitates faster brain growth relative to calvaria growth.[2,4,8] Clinical examination of AF size as a part of a comprehensive examination in neonates and infants is followed across world in best centres of Neonatology and Paediatrics. Size of AF can be used to follow the development and nutrition of children in the early years of life as it is considered a good index of cranial growth and development in prenatal and postnatal periods.[2,3,5,9] The flat bones of the skull are membranous bones with ossification centres at the centre and are continuously remodelled by a delicate balance between osteoblastic and osteoclastic activity. These bones grow by central resorption and accretion of bone at edges during antenatal and postnatal periods. With the exception of metopic suture, they stay open till brain growth recedes towards end of 2nd year[10] as with fusion of sutures, growth perpendicular to that suture is limited. Therefore, the size of fontanelles is determined by neural growth, dural factors, suture characteristics and osteogenesis.[11,12]

The extremes of fontanelle size may be a hallmark of both diseases within the bony skull or outside.[13-15] A very small fontanelle may be due to slowed brain growth, craniostenosis[16] or hyperthyroidism.[13] A large fontanel with normal intracranial pressure is seen in variety of disorders[17] such as bone dysplasias,[14] developmental disorders of clavicles,[18] osteogenesis imperfecta,[19] chromosomal aneuploidy,[17] hypothyroidism[15] or intrauterine malnutrition.[20] In view of these associations, AF dimensions are vitally important for the early identification of these disorders indicating the importance of measurements of AF. The size of AF may be defined as the average of the anteroposterior and transverse dimensions or by surface area.[14,21] The fontanelle size at birth varies from 0.6 cm to 3.6 cm.[14]

The development of fontanel is determined by brain growth, attachments of dura, suture development and osteogenesis.[15] Like other parameters of neonatal anatomy, AF size is affected by gestational maturity, gender, birth weight and may be other environmental, genetic and racial factors. The present study was undertaken to study the dimensions of AF in selected neonates born at our hospital over a period of 3 months to find normal size range due to scarcity of same in our area and to compare it with results from various studies and find correlation with various demographic characteristics.

MATERIAL AND METHODS

A cross-sectional study over a period of 3 months was conducted from March 2024 to May 2024 in the neonatal outpatient section of the Special Care Newborn unit in the department of paediatrics in an associated hospital of a medical college in north India after proper ethical clearance. A total of 217 normal-term neonates born between 37 weeks and 42 weeks and 0 days were included in our study after consent from one of the parents. The sample size was calculated using the following formula $N = Z^2 SD^2/d^2$ where:

N= sample size required

Z= standard normal variate set at 1.96 corresponding to confidence interval of 95% and 0.05% level of significance.

SD = Standard deviation from previous studies which are equal to 2.

d= precision level taken as 0.3 cm above and below the expected mean.

Taking the attrition rate of 15% as many females with healthy babies asked for discharge within 24 h, the final sample size came around 200.

Pregnancies with any associated antenatal risk factors like gestational diabetes, pregnancy induced hypertension, infections affecting foetal growth, maternal smoking, drug abuse, use of teratogenic drugs or postnatal complications such as excessive moulding, cephalhematoma, subgaleal bleed, caput succedaneum, and head injuries were excluded from the study. Similarly, neonates with facial dysmorphism, obvious congenital anomalies, intrauterine growth retardation, macrocephaly or microcephaly and babies with weight which is too large for their gestational age were also excluded from the study. Gestational age was determined from earliest antenatal ultrasonography supplemented by taking meticulous menstrual history and confirmed by new Ballard's score done at the time of measurements. The AF was measured by the Keisler and Ricer method by two examiners between 12 and 24 hrs. One examiner palpated for bony edges of AF and moved ahead to find the meeting point called the anterior vertex of the fontanelle which was marked with washable ink by the second examiner. Similarly, all other vertices were marked. The anteroposterior and transverse diameter were measured by measuring tape to an accuracy of ±0.1 cm and size of AF was calculated as under:

Size of AF = (AP) diameter + Transverse diameter (TD)/2.

The weight of the neonate was taken by digital beam balance in grams with an accuracy of ±100 g. The head circumference was taken by non-stretchable tape just above the supraorbital ridges anteriorly and the most prominent point on occiput posteriorly and recorded to accuracy of 1 mm. The procedure of measurements and data collection was done by one 2nd year national board of examinations (NBEMS) diploma candidate, one senior medical officer and a junior resident working in special newborn unit after the principal investigator trained them and their ability to take measurements was assessed by taking a pilot study before the main study.

The data were recorded in predesigned pro forma, which included gestational age, mode of delivery, gender, weight at birth, head size, AP diameter of AF, transverse diameter of

AF and AF size and data were subjected to standard statistical analysis.

As per previous studies, the size of AF varies from 0.6 to 3.6 with a mean of 2.1.[14] The anterior fontanel is classified as small if <0.6 cm; normal if it is 0.6–3.6 cm and large fontanelle if >3.6 cm.[1]

RESULTS

Out of 217 neonates enrolled in our study, 114 were male and 103 were female. The extreme and mean values of gestational age, weight at birth and head size are shown in Table 1.

The mean anteroposterior diameter was 2.79 ± 0.61 cm, and the mean transverse diameter was 2.08 ± 0.89 cm. The mean AF size was 2.43 ± 0.60, indicating that on average, the AF size was in the range as per the classification criteria used as in Table 2.

About 97.70% of neonates have an AF size between 0.6 and 3.6 cm. About 2.3% of neonates have an AF size >3.6 cm, suggesting that a significant portion of the population studied has AF size within the range of 0.6–3.6 cm. This high percentage of neonates with good-sized AFs may be due to several factors such as genetic, racial, ethnic, measurement technique, or sample characteristics or due nutritional status of mothers with rampant Vitamin D deficiency. The AF size in males (2.38 ± 0.61 cm) is slightly smaller than in females (2.49 ± 0.59), but this difference is not statistically significant (*P* = 0.161), as shown in Table 3.

Neonates born through lower segment caesarean section have significantly larger head circumferences (33.41 ± 1.77 cm) compared to those born through normal vaginal delivery (32.75 ± 1.32 cm), with *P* = 0.015, making this a statistically significant finding, as shown in Table 4. This could be because babies born through vaginal delivery may experience some head moulding during birth.

No significant difference is observed between the AF size of neonates born through normal vaginal delivery (2.35 ± 0.53 cm) and those born through lower segment caesarean section (2.46 ± 0.62 cm) with (*P* = 0.254), as shown in Table 4. A positive and statistically significant correlation (r = 0.255, *P* = 0.001) is observed between gestational age and AF size, as shown in Table 5. This suggests that as gestational age increases, the AF size tends to increase slightly. A weak non-significant positive correlation (r = 0.081 *P* = 0.233) is found between weight at birth and AF size, indicating that babies with higher birth weights tend to have slightly larger fontanelles. No significant correlation is found between head and AF sizes (r = 0.068, *P* = 0.316), suggesting that head size does not strongly influence the size of the AF.

Table 1: Descriptive statistics for various neonatal measurements.

Parameter	Minimum	Maximum	Mean ± SD
Gestational age	37	40	38.73±1.16
Birth weight	2.5	4.5	3.15±0.45
Head circumference	25.0	38.9	33.26±1.70
Anteroposterior diameter	1.1	5.0	2.79±0.61
Transverse diameter	0.9	8.0	2.08±0.89
Anterior fontanelle size	1.0	5.3	2.43±0.60

SD: Standard deviation

Table 2: Distribution of neonates according to anterior fontanelle size.

Anterior fontanelle size	No.	%
Small (<0.6 cm)	0	0
Normal (0.6–3.6 cm)	212	97.70
Large (>3.6)	5	2.30
Total	217	100

Table 3: Association of various neonatal measurements with gender.

Parameter	Male (*n*=114)	Female (*n*=103)	*P*-value
Gestational age	38.61±1.15	38.86±1.17	0.114
Birth weight	3.14±0.48	3.16±0.43	0.779
Head circumference	33.31±1.71	33.2±1.69	0.632
Anteroposterior diameter	2.75±0.65	2.83±0.55	0.349
Transverse diameter	2.01±0.87	2.16±0.92	0.208
Anterior fontanelle size	2.38±0.61	2.49±0.59	0.161

Table 4: Association of various neonatal measurements with mode of delivery.

Parameter	NVD (*n*=50)	LSCS (*n*=167)	*P*-value
Gestational age	38.68±1.15	38.75±1.17	0.716
Birth weight	3.07±0.45	3.18±0.45	0.162
Head circumference	32.75±1.32	33.41±1.77	**0.015***
Anteroposterior diameter	2.76±0.64	2.80±0.60	0.704
Transverse diameter	1.94±0.68	2.12±0.95	0.199
Anterior fontanelle size	2.35±0.53	2.46±0.62	0.254

*Statistically significant, NVD: Normal vaginal delivery, LSCS: Lower segment cesarean section. Bold value: Meaning that there is very low probability of observing data you did if the null hypothesis (no effect) is true ,concluding that there is significant effect present from this data.

DISCUSSION

As AF is the most relevant in the clinical evaluation of young children and considering that cranial bones are membranous, the borders of AF, being the edges of cranial bones, serve as

Table 5: Correlation of anterior fontanelle size with gestational age, birth weight and head circumference among neonates.

	Pearson correlation coefficient (r)	*P*-value
Gestational age	0.255	0.001*
Birth weight	0.081	0.233
Head circumference	0.068	0.316

*Statistically significant

important indicators of bone growth determined by their time of closure.[14]

The mean AF size in our study was 2.43 ± 0.60 cm with maximum and minimum of 1.00 cm and 5.30 cm, similar to studies done by Perera *et al.*[22] in Sri Lankan neonates (2.55 cm), Shajari *et al.*[5] (2011) in Iranian neonates (2.54 ± 1.33), Esmaeili *et al.*[7] (2015) in Iranian neonates (2.55 ± 1.92) and Chang and Hung[23] in Chinese neonates (2.67). The mean AF size in our study was smaller than reported by Chakrabarti[24] from India, who found AF size of 3.80 ± 1.95 cm in 130 neonates from hilly region and 3.35 ± 1.07 cm in 110 neonates from non-hilly areas, by Mathur *et al.*[25] from East India (3.37 ± 0.06 cm), by Adeyemo *et al.*[26] from Nigerian Ibadan (4.0 ± 1.0) and by Tirpude *et al.*[4] from Indian Nagpur (4.24 ± 2.2). Smaller mean AF sizes were reported in studies by Srugo and Berger[27] from Israel (2.06 cm), Jackson *et al.*[28] (2.25 cm) from Hispanic neonates, Duc and Largo[29] (2.01) from Switzerland, El-Mougi *et al.*[30] (2.20) from Egypt and Brandt *et al.*[31] from Germany (2.00 cm). The possible reason for such varying AF in different studies may be due genetic, ethnic, geographical and possibly climatic factors which demands more studies.

The AF size was 2.38 ± 0.61 cm and 2.49 ± 0.59 cm in male and female neonates, which were not statistically significant ($P = 0.161$), which agrees with studies done by Faix [32] Lyall *et al.*[33] and although some studies have found significant differences between genders, like Mir and Weislaw[34] The insignificant difference in AF size between genders in our study may be due racial, ethnic and geographical factors nullifying effect of gender on AF size.

The AF size in neonates born through normal vaginal delivery and lower segment caesarean section in our study is 2.35 ± 0.53 cm and 2.46 ± 0.62, respectively, with $P = 0.254$, which is not statistically significant such as studies done by Esmaeili *et al.*,[7] Pedroso *et al.*[21] and Shajari *et al.*[5]

Direct correlation (weak positive) was found between gestational maturity and AF size with Pearson correlation coefficient of r = 0.255 and $P = 0.001$. Direct correlation (very weak positive) was also found between AF size and weight at birth with a Pearson correlation coefficient of 0.081 and $P = 0.233$. This was in agreement with studies done by Shajari *et al.*,[5] Oumer *et al.*,[35] G/meskel *et al.*,[3] Jackson *et al.*[28] and Lyall *et al.*[33] Our study is probably one of few studies which reported a direct correlation between gestational maturity and AF size like the one reported by Volpe JJ *et al.*[36] Only Shajari *et al.*[5] found a significant negative correlation between AF size and infant's weight (r = 0.10, $P = 0.04$). No important correlation was reported between AF size and infant's weight by similar studies in Nigeria and Turkey by Malas and Sulak[9] and Adeyemo *et al.*[26] No notable association was found between head circumference and AF size in studies done by Malas and Sulak[9] Shajari *et al.*[5] and Jackson *et al.*[28]

A very strong association was found between the mode of delivery and head circumference (32.75 ± 1.32 cm in neonates born through normal vaginal delivery and 33.41 ± 1.77 cm in neonates born through lower segment caesarean section) with $P = 0.015$. This may be due to excessive moulding during normal delivery and higher chances of caesarean section in mothers with larger head sizes.

CONCLUSION

The study shows that AF size is influenced by gestational age and birth weight but not by head circumference, gender or mode of delivery. These results could help guide paediatricians in assessments of normal and abnormal fontanelle size in neonates. The high percentage of neonates with large fontanelles may warrant further investigation to determine if this is population-specific or influenced by measurement methods. The main limitation of our study was that measurements were obtained within the first 24 hrs of life as most babies are discharged after 24 hrs from the hospital and moulding sustained during the birth process might have affected our results.

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