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Original Article

Head circumference and anterior fontanel measurements in newborns

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Abstract

Background Head growth and anterior fontanel (AF) closure are passive processes in response to brain growth. The growth of the brain and skull starts in the third week of intrauterine gestation. Both processes run simultaneously as a part of integral growth, along with increasing gestational age, until post-birth. Measurement of head circumference (HC) and AF in newborns is done to determine if the brain and skull grew normally during the intrauterine period.

Objectives To investigate the differences in HC and AF size between preterm and full-term infants, and the relationship between gestational age (GA) and birth weight (BW) to HC and AF size.

Methods This was a descriptive analytic study on preterm and full-term newborns. Measurement of HC and AF was conducted in three phases: just after birth, 1x24 and 2x24 hours of age. Analysis of HC and AF size differences between preterm and full term subjects was performed, as well as analysis of the correlation between GA and BW to HC and AF size.

Results Two hundred fifty newborns completed the study. There were 180 full-term and 70 preterm subjects. Median HC in full-term and preterm male subjects were 34 cm (range 31-37 cm) and 31 cm (27-34 cm), respectively. Median HC in full-term and preterm female subjects were 33 cm (31-36 cm) and 32 cm (27-35.5 cm), respectively. Median AF in full-term and preterm male subjects were 2.17 cm (1.05-4.6 cm) and 2.22 cm (1.35-4.5 cm), respectively, and in full-term and preterm female subjects were 2.02 cm (1-4.15 cm) and 2.22 cm (0.75-4 cm), respectively. The HC of preterms were significantly lower than the fullterms ($P<0.001$), however the AF size was not different between these 2 groups of newborns ($P=0.28$). Correlation test between GA and BW to HC size revealed a positive correlation ($r=0.620$, $P<0.001$ and $r=0.801$, $P<0.001$, respectively), but not to AF size ($r=-0.06$, $P=0.279$ and $r=-0.049$, $P=0.44$, respectively).

Conclusions We found that the HC size of preterms was significantly lower than the fullterms, but no significant differences in AF size between the two groups. GA and BW were associated with HC size, but not associated to AF size. **[Paediatr Indones. 2012;52:145-51]**.

Keywords: *newborns, anterior fontanel, head circumference, gestational age, birth weight*

Abnormalities in HC and AF size in newborns may reveal clues to assessment of intrauterine brain growth disorders.[1,2] Brain growth disorders may lead to clinical manifestations of impaired growth and development of children in later life.[1,2] The existence of a significant relationship between increased HC and brain growth has led to the implementation of basic neurological examinations in newborns to children aged 2 years, including HC measurement.[3-5] Deviations from normal head growth may provide

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early signs of congenital abnormalities, infections, genetic syndromes, congenital metabolic disorders, or neoplasms.[6] Fontanels and sutures have important roles in brain and skull growth from the intrauterine through the post-birth period, in providing space for the brain and skull bones to grow larger.[7,8]

Normal sized AF in newborns range from 0.6 to 3.6 cm, with an average value of 2.1 cm.[9,10] Abnormal AF size in newborns may indicate possible intrauterine brain growth disorders, calvarial growth failure, or other intracranial disorders.[5,11-13] AF size in newborns may differ among races.[14] AF size in Black infants was reported to be larger than that of White infants, and AF size of Indian newborns was also reported to be greater than that of Caucasians.[14] Adeyemo *et al* concluded that AF size increased with increasing GA, but this correlation was not strong.[15] To date, there has been no global study reporting the incidence of AF abnormalities in infants. Wide variations in AF size may be due to race, sex, chromosomal defects, fetal growth retardation, genetic abnormality associated-syndromes, congenital infections, impaired bone growth, malnutrition, drugs, and toxins.[1,5,12-14,16]

To date, there has been no study in Indonesia to evaluate the average AF size and the incidence of AF abnormalities in newborns. This study was conducted to determine the average HC and AF size in newborns, the AF size differences between full-term and preterm infants, and also any correlation between GA and BW to HC and AF size in newborns.

Methods

This study was performed at the Cipto Mangunkusumo Hospital from February to May 2011 on preterm (GA 33-37 weeks) and full-term (GA 38-41 weeks) newborns, who were delivered by Caesarian section, spontaneously, or vaginally with vacuum extraction. We excluded newborns who were small for gestational age, had intrauterine growth retardation, or had a history of congenital anomalies known since the prenatal period, such as congenital hydrocephalus, meningocele or skull bone defect-related syndromes.

We recruited 270 subjects consecutively who fulfilled the study criteria, but only 250 subjects completed the study. Subjects' demographic and clinical data were obtained from history-taking, physical examination, and medical records. Measurements of HC and AF were conducted at three different times: just after birth, at 1x24 and 2x24 hours of age. HC measurement was performed at the largest occipito-frontal diameter. Results of HC measurements were plotted in HC growth curves of Nellhaus and Fenton.[9] AF measurement method was the average value of the anteroposterior and transverse diameters. Measurement of HC and AF at the three different times was performed by the same method and examiner. HC and AF size differences between preterm and full-term infants was analyzed, as well as the correlation between GA and BW to HC and AF.

Data was analyzed using SPSS for Windows version

Table 1. Subjects' characteristics

Characteristics	Preterm subjects n = 70	Full-term subjects n = 180
Gestational age, n (%)		
33-34 weeks	20 (28.6)	
35-37 weeks	50 (71.4)	
38-41 weeks		180 (100.0)
Gender, n (%)		
Male	32 (45.7)	99 (55.0)
Female	38 (54.3)	81 (45.0)
Manner of birth, n (%)		
Spontaneous	24 (34.3)	87 (48.3)
Caesarian section	45 (64.3)	86 (47.8)
Vaginal with vacuum extraction	1 (1.4)	7 (3.9)
Mean birth weight, g	2370	3145
Birth weight by grouping, n=250		
<2500 g, n (%)	49 (19.6)	
2500-4000 g, n (%)	192 (76.8)	
>4000 g, n (%)	9 (3.6)	

Preterm: mean GA=35.7 weeks; Full-term: mean GA=38.9 weeks

17.0 and P<0.05 was considered to be statistically significant. This study was approved by the Medical School Ethics Committee, University of Indonesia.

Results

We recruited 250 subjects for this study, consisting of 180 full-term and 70 preterm infants; male to female ratio was 1:1.1. There were 111 subjects delivered spontaneously, 131 subjects delivered by Caesarian section and 8 subjects delivered vaginally with vacuum extraction **(Table 1)**.

Median HCs in full-term and preterm male subjects were 34 cm (range 31-37 cm) and 31 cm (range 27-34 cm), respectively. Median HCs in full-term and preterm female subjects were 33 cm (range 31-36 cm) and 32 cm (range 27 -35.5 cm), respectively. Median AFs in full-term and preterm male subjects were 2.17 cm (range 1.05-4.6 cm) and 2.22 cm (range 1.35-4.5 cm), respectively. Median AFs in full-term and preterm female subjects were

Table 2. Median HC and AF in preterm and full-term male and female subjects (n=250)

	Males	Females	P value, male vs. female	P value, preterm vs. full-term
Median head circumference, cm (range)				
Preterm	31 (27-34)	32 (27-35.5)	0.369	
Full-term	34 (31-37)	33 (31-36)	0.093	<0.001
Median anterior fontanel, cm (range)				
Preterm	2.22 (1.35-4.50)	2.22 (0.75-4.00)	0.728	
Full-term	2.17 (1.05-4.60)	2.02 (1-4.15)	0.120	0.280

Table 3. Preterm subjects' mean HC and AF by gender

	Males	Females
Mean head circumference, cm (± 2 SD)		
GA		
33 weeks	29.6 (26.6-32.6)	29.1 (26.6-31.6)
34 weeks	30.3 (27.6-33.0)	30.2 (27.8-33.0)
35 weeks	31.3 (28.5-34.1)	31.7 (29.3-34.0)
36 weeks	32.2 (29.5-34.8)	32.3 (29.8-34.7)
37 weeks	33.0 (30.4-35.6)	33.0 (30.6-35.4)
Mean anterior fontanel, cm (± 2 SD)		
GA		
33 weeks	1.9 (1.12-2.72)	2.1 (1.5-2.7)
34 weeks	2.0 (0.8-3.1)	1.9 (1.1-2.95)
35 weeks	2.0 (0.6-3.4)	1.9 (0.7-3.1)
36 weeks	2.1 (0.75-3.3)	2.1 (0.7-3.8)
37 weeks	2.1 (0.9-3.3)	2.2 (0.8-3.6)

Table 4. Full-term subjects' mean HC and AF by gender

	Males	Females
Mean head circumference, cm (± 2 SD)		
GA		
38 weeks	33.6 (31-36)	33.2 (30.8-35.5)
39 weeks	34.1 (31.7-36.5)	33.4 (31.2-35.6)
40 weeks	34.5 (32.2-36.8)	33.6 (31.3-35.8)
41 weeks	34.8 (32.6-37)	33.8 (31.6-36)
Mean anterior fontanel, cm (± 2 SD)		
GA		
38 weeks	2.2 (0.8-3.6)	2.2 (1.1-3.2)
39 weeks	2.3 (0.7-3.9)	2.1 (1.3-2.9)
40 weeks	2.3 (1.2-3.3)	2.1 (1.3-2.8)
41 weeks	2.3 (1.5-3.1)	2.0 (1.2-2.8)

2.02 cm (range 1-4.15 cm) and 2.22 cm (range 0.75-4 cm), respectively **(Table 2).**

There was a significant difference in HC size between full-term and preterm infants (P<0.001), but not in AF size (P=0.280). Further analysis of the full-term subjects revealed that HC or AF size in male subjects did not differ significantly from those of female subjects (P=0.093 and P=0.120, respectively). Similar results were seen in preterm subjects, where there were no significant differences in HC or AF size between male and female subjects (P=0.369 and P=0.728, respectively). Furthermore, there was no significant change in HC or AF size from the early stage to last stage measurements (P=0.593 and P=0.633, respectively).

A correlation test of GA and BW to HC size revealed positive correlations (GA: r=0.620, P<0.001 and BW: r=0.801, P<0.001). However, no correlation

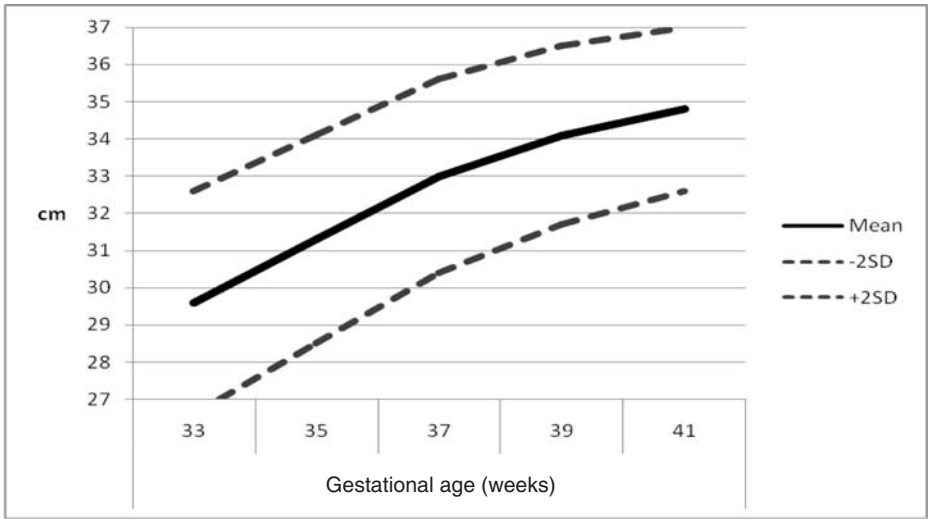

Figure 1. Head circumference of male subjects according to gestational age

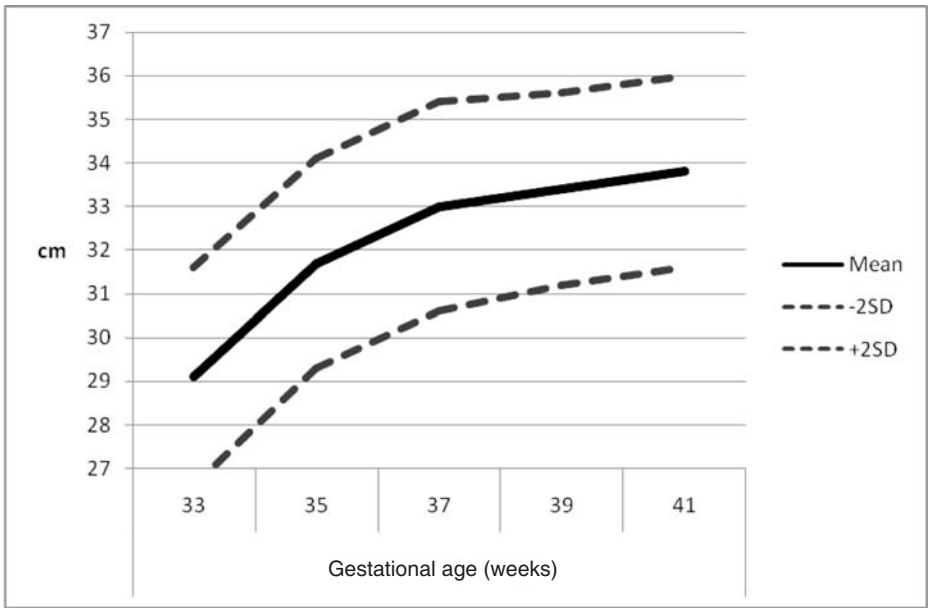

Figure 2. Head circumference of female subjects according to gestational age

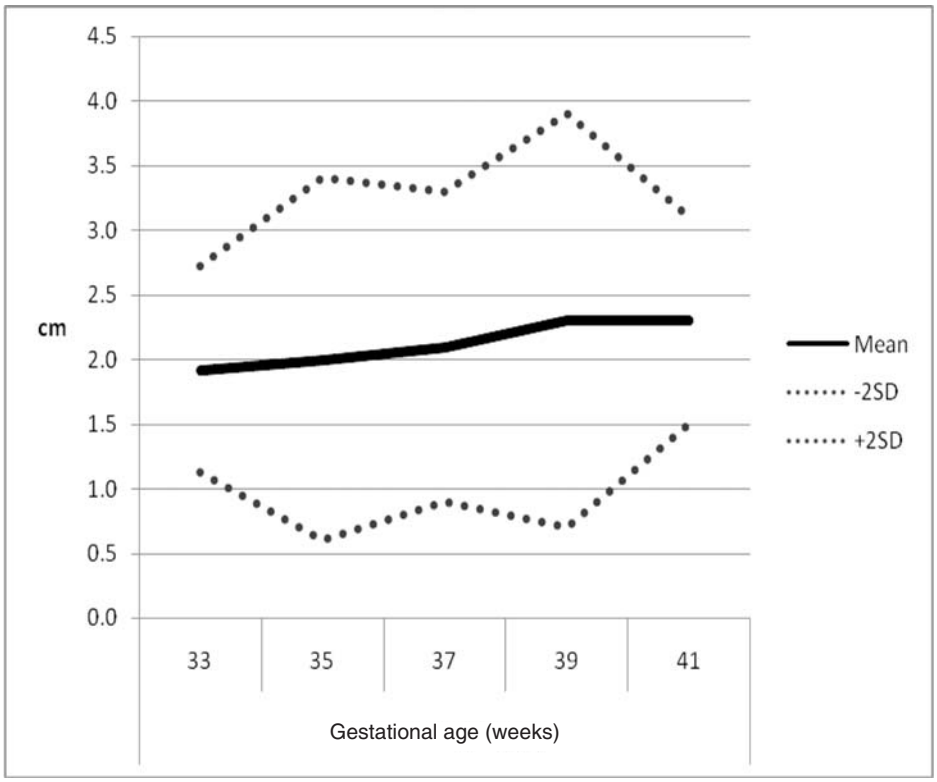

Figure 3. Anterior fontanel size of male subjects according to gestational age

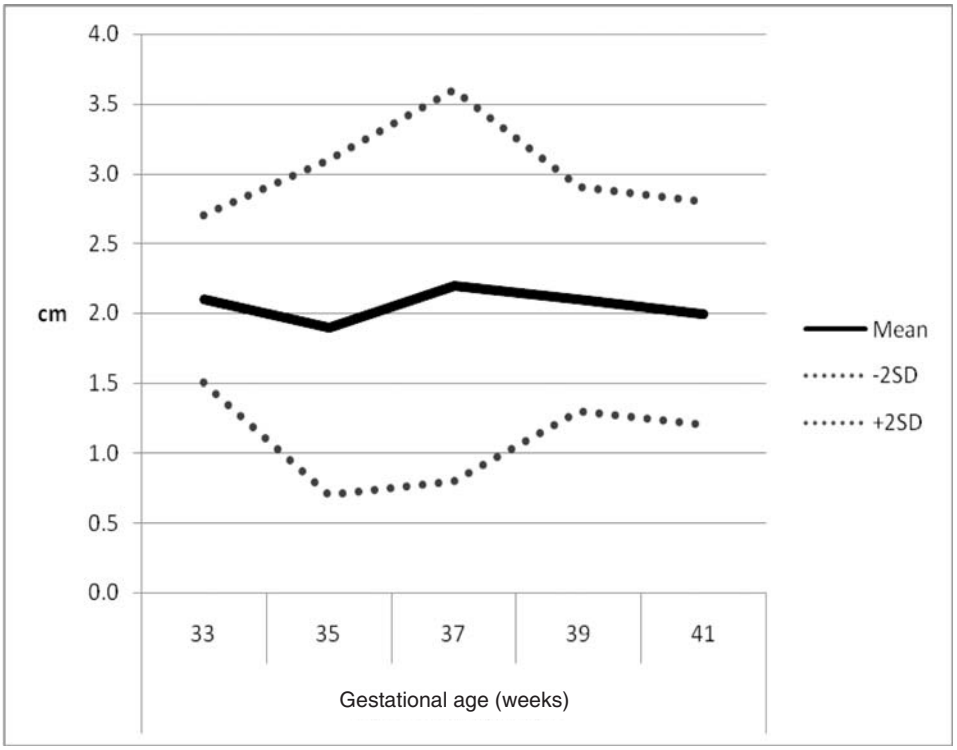

Figure 4. Anterior fontanel size of female subjects according to gestational age

was observed for either GA or BW to AF size (GA: r=-0.06, P=0.279 and BW: r=-0.049, P=0.44). Furthermore, there was no correlation between HC and AF size (r=- 0.061, P=0.338). Mean HC and AF in preterm subjects (GA 33-37 weeks) and full-term subjects (GA 38-41 weeks) according to gender are shown in **Tables 3** and **4**. HC and AF according to GA and gender are shown in **Figures 1-4.**

Discussion

There has been no study to date in Indonesia on the average AF size in newborns. Characteristics of subjects in several previous studies on AF size in newborns have been quite diverse, though some studies involved only subjects with mean BW above 2500 grams.[10,14,16-18] Several previous studies reported that AF size varies widely in both newborn males and newborn females, leading experts to conclude that factors other than race may impact AF size in newborns. These factors include gestational age, gender, manner of birth, chromosomal defects, fetal growth retardation, genetic abnormality associated-syndromes, congenital infections, calvarial growth disorders, malnutrition, drugs and toxins.[17-22] Our results were similar to several previous studies, in that we also observed a wide variation of AF size in our newborn subjects.[10,14,15,18-20, 23]

Many studies have been done globally to study the effect of race on AF size differences in newborns.[10,14,15,19,23] In our study, median AF in full-term subjects was 2.1 cm (1-4.6 cm), while that of preterm subjects was 2.22 cm (0.75-4.5 cm). These results were similar to those obtained by Popich *et al* [10] and Adeyemo *et al*.[15] We found the median HC in full-term and preterm subjects were 34 cm (31-37 cm) and 31 cm (27-35 cm), respectively, similar to results from Nellhaus[24] and Fenton.[25]

Duc *et al*[26] and Pedroso *et al*[27] found no significant differences in AF size between full-term and preterm newborns. GA and AF size were significantly correlated in preterm newborns only at birth, but there was no significant correlation between AF size and gender.[26] AF size tends to be greater in male than in female infants, especially in the first 6 months to one year of life.[10,26,27] However, we found that GA and gender did not affect AF size differences in newborns. These results may be due to the limited number of preterm subjects, compared to the number of full-term subjects in our study. The mean GA for preterm subjects was also 35 weeks, close to full-term GA. AF size in male infants tended to be larger than that of female infants, but the difference was not statistically significant. However, HC size between preterm and full-term infants differed significantly.

We observed a significant correlation between GA and BW to HC size, as HC size increased with increasing GA and BW. These results were similar to those obtained by Duc *et al*[26], Popich *et al*[10] and Pedroso *et al*[27] However, we noted no significant correlation between GA and BW to AF size, similar to previous studies,[10,26,27] as there were wide variations in AF size in newborns.

In the full-term subject group, AF size for -2 SD to +2 SD was 1.5 to 3.2 cm. Based on these results, there were 29 subjects with AF sizes larger than 3.2 cm, and 33 subjects with AF size smaller than 1.5 cm. In the preterm subject group, AF size for -2 SD to +2 SD was 1.3 to 2.7 cm. This group had 19 subjects with AF sizes larger than 2.7 cm (> +2 SD) and 4 subjects with AF size smaller than 1.3 cm (<-2 SD). Further evaluation needs to be done in patients who have AF size > +2 SD and <-2 SD with the idea that AF size should not be more than 2.5x3.0 cm. Further assessment on these patients is needed for monitoring and early detection of possible developmental disorders associated with suspected intrauterine brain growth disorders. Based on our results, AF measurement should be done routinely, along with measurements of HC, while noting that given the wide AF size variations in the normal population, smaller or larger fontanel sizes may not always be accompanied by HC abnormalities.

HC measurements in full-term and preterm subjects were similar to those of previous studies.[24,25] The mean HC in full-term male subjects was 34 cm (31.6 to 36.4 cm), while the mean HC in full-term female subjects was 33.5 cm (31. 3 to 35.7 cm).

A limitation of this study was its cross-sectional design. There was no follow-up over time. Therefore, we could not make conclusions about subsequent changes in HC and AF size during the first year of life. Determining the normal size of AF in newborns,

as well as determining the number of newborns with AF size abnormalities could not be done in this study. Another limitation was the sampling carried out without "matching" GA, so that by the end of our study, we found considerable differences in numerous full-term and preterm infants.

In conclusion, GA and BW were associated with the size of HC, but not significantly associated with AF size. AF size between preterm and full-term infants also was not significantly different.

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