# Estimating Fetal Age: Effect of Head Shape on BPD

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**Several recent obstetrical sonographic examinations in this department demonstrated that variations in the shape of the fetal skull (e.g., dolichocephaly, brachycephaly) may adversely affect the accuracy of the biparietal diameter (BPD) measurement in estimating fetal age. In each case the cephalic index of the fetal skull (short axis/long axis × 100) was in either the dolichocephalic or brachycephalic range based on established postnatal criteria. Consequently, normal values were determined (mean, 78.3) for the cephalic index in utero based on 316 obstetrical sonographic studies performed at 14–40 weeks. Preliminary experience indicates that a cephalic index greater than 1 SD from the mean (<74, >83) may be associated with a significant alteration in the BPD measurement expected for a given gestational age, and that the head circumference can be used effectively as an alternative means of establishing gestational age.**

The biparietal diameter (BPD) has proven to be a reliable indicator of fetal gestational (menstrual) age [1–3]. In the second trimester of pregnancy, it is accurate to within ±1–1.5 weeks (±2 SD) [2–3], but in the third trimester the reported accuracy is considerably less; a BPD obtained after 28 weeks is accurate only to within ±3 weeks (±2 SD), even if the image meets the criteria for a good BPD [3–4]. The observed variation in the third trimester is undoubtedly multifactorial in etiology, related only in part to technical errors in imaging.

If we assume a technically adequate BPD image, and an accurate measurement, and if we eliminate pathologic causes of variation in fetal head size (e.g., microcephaly, hydrocephaly, growth retardation), there remain two obvious reasons why women with the same last menstrual period may have fetuses with different BPD measurements: (1) genetic variations in head size in fetuses of the same conceptual age and (2) differences in time of ovulation and fertilization with respect to the first day of the last menstrual period.

Our recent experience has suggested that variations in the shape of the fetal skull such as dolichocephaly and brachycephaly may also have a significant effect on BPD measurements. An investigation was therefore undertaken to determine the normal relation between the short and long axis of the fetal skull at the BPD plane, in the hope that it would produce a simple method for detecting variations in the shape of the fetal skull, which may adversely affect the accuracy of the BPD measurement in predicting fetal gestational age.

## Subjects and Methods

We examined 316 consecutive patients using a commercially available dynamic image scanner (Toshiba Medical Systems, Carson, Cal.). The gestational age, based on the BPD measurement, was 14–40 weeks. The widest transverse and longitudinal dimensions of the skull at the level of the BPD [3, 4] were measured from outer margin to outer margin (fig. 1), and the cephalic index [5, 6] (short axis/long axis × 100) was calculated.

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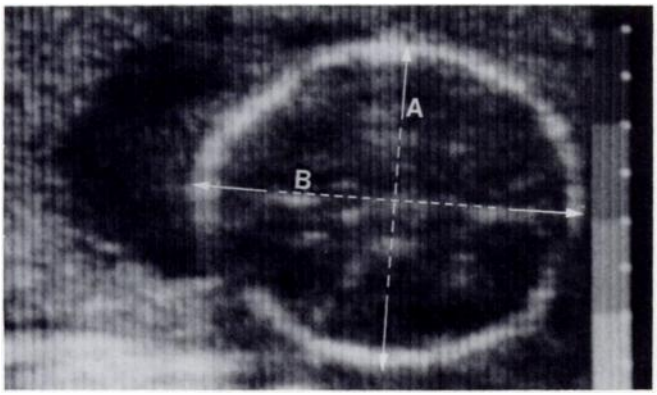



Fig. 1.—Real-time sonographic image of fetal skull at level of biparietal diameter. Cephalic index is A/B × 100.

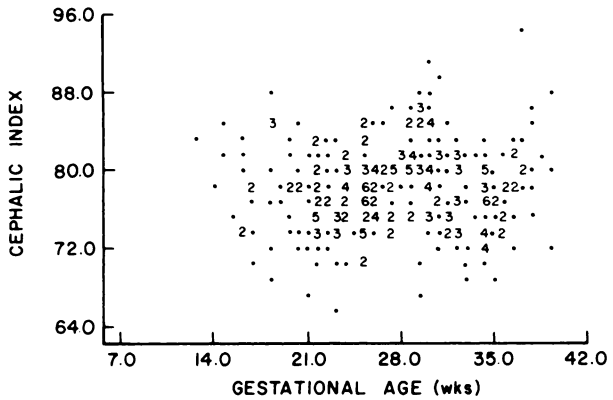



Fig. 2.—Distribution of cephalic index measurements in 316 fetuses at 14–40 weeks.

## Results

The distribution of cephalic index measurements demonstrated no significant change with increasing gestational age (mean, 78.3; SD, 4.4) (fig. 2). Preliminary use of these values has resulted in the detection of 10 fetuses in which the BPD was significantly affected by head shape; eight of these were dolichocephalic and two were brachycephalic. The range of error in predicting the gestational age by the BPD varied from 1.5 weeks in the second trimester to 5.5 weeks in the late third trimester. Our earliest observation of this finding was in an 18 week dolichocephalic fetus whose true gestational age had been established by an early crown-rump length measurement and by documentation of the time of ovulation by measurement of the basal body temperature. However, most of our cases (eight of 10) have been observed in the third trimester. Interestingly, in two cases the BPD and cephalic index changed from normal values to abnormal values over a 6 week period in the third trimester (see case 2 below). Our experience to date suggests that a cephalic index greater than 1 SD from the mean (<74, >83), may be associated with a significant change in the BPD measurement expected for any given gestational age.

## Representative Case Reports

*Case 1*

A 24-year-old woman, gravida 3, para 2, Ab 0, was examined sonographically at 35 menstrual weeks. A single viable fetus was identified. The biparietal diameter was 7.9 cm (32 weeks), which suggested that the fetus was growth retarded or that the menstrual dates were 3 weeks in error. However, the head was noted to be rather elongated (fig. 3) and this was confirmed by a cephalic index [5–6] measurement of 68, which is by definition dolichocephaly [7]. Measurements of the head circumference [8] (32 cm) and abdominal circumference at the level of the umbilical vein (31.8 cm) [9] were both consistent with the patient's menstrual history of 35 weeks amenorrhea. The patient delivered spontaneously 7 weeks later, and the head circumference [8] (36 cm), length [8] (50 cm), weight [8] (3,300 g), and Dubowitz score [10] were all consistent with a 42 week fetus.

*Case 2*

A 27-year-old woman, gravida 5, para 4, Ab 0, was referred for sonography at 30 menstrual weeks to rule out placenta previa. The biparietal diameter of 7.6 cm (30 weeks) was consistent with the menstrual history. A posterior marginal placenta previa was observed, and for this reason a repeat examination was suggested. The second examination was 6 weeks later (36 menstrual weeks), and the placenta was posterior with no evidence of a marginal placenta previa. The BPD on this examination was 8.2 cm (33 weeks), and this was initially believed to represent evidence of growth retardation. However, on reviewing the sonograms (fig. 4) it was obvious that the head shape on the second examination was considerably more elongated than on the first. Additional measurements of the head from the first study demonstrated a cephalic index of 76, which is within the normal range [5–7]; the head circumference was 28 cm, which is at the mean at 30.5 weeks [8]. Additional measurements of the second study demonstrated a cephalic index of 70, which by definition represents dolichocephaly [7], and the head circumference was 32.5 cm, which approximates the mean at 36 weeks [8]. At 3 weeks later the patient spontaneously delivered a 3,630 g boy, which was judged to be a term infant by neonatal examination. The head circumference at delivery was 35 cm, which is appropriate for a term infant [8].

## Discussion

Previous investigators have established normal values for the cephalic index measured postnatally. In a study of skull radiographs, Haas [5] found a mean value of 81.7 in 52 infants aged 4 weeks to 12 months, with an observed range of 73.5–90.4. He noted that these values might be slightly higher than actual values because the distortion by projection of breadth was greater in his series than that of length. Jordaan [6] measured the cephalic index directly in 50 neonates delivered by cesarean section; he found a mean value of 80.6, with a normal range of 76–85 (±2 SD). Our data, based on a large sample over a wide range of gestational ages (14–40 weeks), demonstrated no significant change in the cephalic index with gestational age. Our mean value of 78.3 is slightly lower than the values observed postnatally. This may be related in part to the greater distortion of the frontal and occipital bones resulting from the sonographic beam passing parallel to these structures

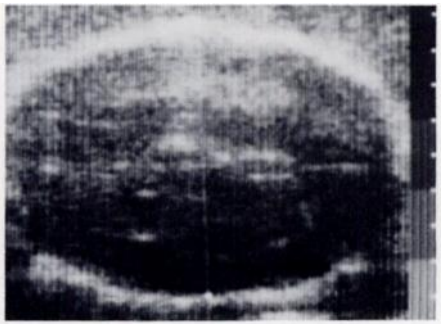
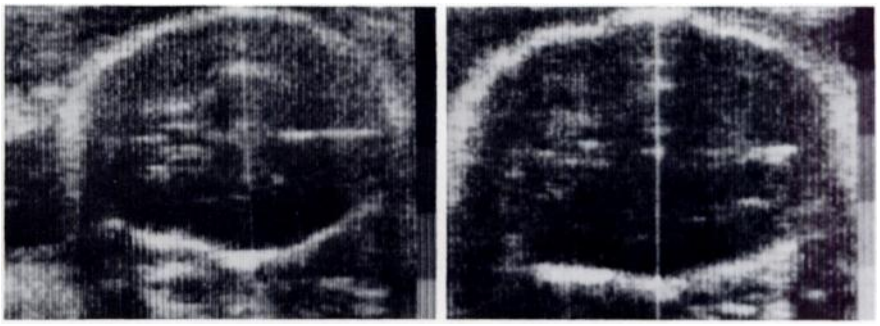


Fig. 3.—Case 1. Real-time sonographic image shows dolichocephalic shaped fetal skull in 35 week fetus. BPD (7.9 cm) suggested gestational age of 32 weeks, while head circumference (32 cm) was appropriate for 35 weeks.



A B

Fig. 4.—Case 2. Real-time sonographic images. **A**, BPD of 7.6 cm (30 weeks) in 30 week normocephalic fetus. **B**, 6 weeks later. More elongated (dolichocephalic) fetal skull; BPD (8.2 cm) suggested gestational age of 33 weeks; however, head circumference (32.5 cm) was appropriate for 36 weeks.

rather than perpendicular. The range of normal (±2 SD) in our series was rather large (70–86), which is very similar to values reported by Haas [5] in a study of 705 adults over the age of 21 years.

Dolichocephaly is defined by a cephalic index below 75.9, while brachycephaly is said to occur when the cephalic index exceeds 81 [7]. Our case reports indicate that such variations in the shape of the fetal skull may adversely affect the accuracy of the BPD in predicting gestational age. When faced with this situation, the sonographer must turn to other parameters of fetal growth in estimating the gestational age. Direct tape measurements of head circumference have been used for years as one postnatal index of age in neonates [8], and recently normal measurements of the fetal head circumference in utero using sonography have been reported [11, 12]. The accuracy of the head circumference measurement in predicting gestational age in the third trimester of pregnancy (±2–3 weeks) [8, 11–12] is comparable to the accuracy using the BPD measurement during this period [3]. In our cases the head circumference measurements have been within ±1 week of the true gestational age based on the menstrual history and/or postnatal evaluation [8, 10]. In addition, normal values for the fetal abdominal circumference (measured at the level of the ductus venosus) as a function of gestational age have been reported recently [9]; this measurement may prove to be a useful adjunct in establishing fetal gestational age in such cases.

We are currently measuring the BPD, head circumference, abdominal circumference, and cephalic index in patients with well established menstrual dates. In this way we hope to define more specifically the boundaries of the cephalic index at which the head circumference is consistently more accurate than the BPD in establishing gestational age, and we hope that the presentation of this data will encourage others to examine the same problem.



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