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BENHA MEDICAL JOURNAL

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Published by Benha Faculty of Medicine

Volume 12 Number 1
Jan. 1995
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Abstract
The purpose of this study was to evaluate fetal sacral length (SL) as a new parameter in gestational age (GA) determination and to establish a normogram of fetal SL throughout the second half of gestation. SL, biparietal diameter (BPD), abdominal circumference (AC) and femur length (FL) were ultrasonographically determined for 220 normal, singleton, pregnant Egyptian women classified into 11 equal groups (each made of 20 women) according to their sure gestational age (From 20th to 41st weeks). Regression analyses were performed on SL, GA, BPD, AC and FL. There was a highly significant linear association between SL and GA. SL (millimeters) as a function of GA (weeks) was expressed by the regression equation: SL = 0.991 GA + 0.355 with a Pearson correlation coefficient of R² = 0.992. Similarly, there was a highly significant linear association between SL and other standard parameters for fetal growth evaluation namely, BPD, AC and FL (R² = 0.995, 0.999 & 0.994 respectively). It is concluded that SL can be used routinely as an additional new accurate ultrasonographic parameter for gestational dating purposes with the same efficacy like other standard parameters.

Introduction
It was recognized that assessment of gestational dates from LMP is fraught with errors. The reason is that LMP remains uncertain in 20% to 40% of gravidas (Dewhurst et al., 1972). Even in women who report LMP with cer-
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tainty, it was found that dates as-
signed by pediatric examination of
the neonate did vary from those
reported antently by 3 or more
weeks in approximately 15% of
gravidas (Sabbagha, 1976).

Besides the need to enhance
clinical estimates of dates and to
prevent iatrogenic prematurity, ob-
jective knowledge of dates is es-
sential in the management of all
pregnancies as the gestational age
forms the X-coordinate of many
graphs pertaining to the evalua-
tion of fetal dates (Sabbagha et al,
1976). For example, interpretation
of the level of α-fetoprotein (AFP)
in maternal serum and amniotic
fluid is dependent on dates
(Cowchock, 1976). Similarly,
placement of a fetus affected by
Rh disease in any of Iiley’s three
zones delineating the severity of
red blood cells hemolysis, de-
pends on correct assignment of
fetal age (Queenan, 1971). Accurate
information about ma-
turity is also essential in allow-
ing the obstetrician to formulate
sound management and decisions
in some high-risk obstetric situa-
tions.

Presently, it may appear that
the most effective way to date
pregnancy is by use of ultrasound.
Several sonographically derived fe-
tal parameters can be used to date
pregnancy including fetal crown-
rump length (CRL), biparietal di-
ameter (BPD), head circumference
(HC), femur length (FL) and ab-
dominal circumference (AC). Also
gestational age can be estimated
by binocular distance or by length’
of humerus. The latter dimen-
sions, however, are less accurate
predictors of fetal age (Jeantyet
al., 1984).

In 1993, Sherer et al reported
that ultrasonic measurement of fe-
tal sacral length could predict ges-
tational age. They postulated that
sacral measurement is easily ob-
tainable during sacral scan which
is a part of the routine antenatal
scanning of fetal spine to exclude
spina bifida. The fact that there
are no other reports to document
the value of sacral measurement
as a new parameter for confirming
fetal age is the stimulus for this
study which was designed to fig-
ure out the possible relationship
between fetal sacral length and
both of gestational age and other commonly used ultrasonic fetal dimensions for gestational age prediction namely BPD, AC and FL.

**Subjects and Methods**

This cross-sectional study was performed on 220 pregnant women who were attending the outpatient clinic of Benha University Hospital or 6th October Insurance Hospital from July 1993 to September 1994. Each pregnant had a sure date of the last menstrual period which was preceded by 3 normal regular periods and gestational age was additionally confirmed by consistent early ultrasonography. Each woman had a singleton pregnancy and any case with detected anomalies, oligohydramnios or growth disturbance (intrauterine growth retardation or macrosomia) was excluded from the study. Women were divided into 11 fetal age groups, each consisted of 20 women (from the 20th to 41st week of gestation).

Each gavida was examined ultrasonographically to measure BPD, AC, FL and SL. BPD was measured as described by Hyghy and Sabbagha (1978), while AC was estimated as described by Campbell and Wilkin (1975). Femur length was measured according to Jeanty et al (1981).

To measure the sacrum, we chose the anterior aspect of vertebral body (central) ossification as the point of reference as the neural arch of the fetal sacral spine fails to demonstrate ossification before 22 weeks gestation (Filly et al., 1987).

The distal vertebral body ossification center of the spinal column visualized in gestation truely represents S5 and accordingly the last five vertebral body ossification centers represent the sacrum (Fig. 1). Slight lordosis of the fetal lumbar spine produces an angulation at the sacral promontory, confirming and assisting identification of the sacrum (Sherer et al., 1993). Sacral measurements were performed by two independent observers to insure accurate data. The fetal sacrum was most easily visualized with the occiput anterior or in vertex-presenting fetuses or sacrum anterior in breach-
presenting fetuses. At times, when the fetal spine was posterior and adjacent to the uterine wall, measurements might be difficult. Waiting for few minutes or having the patient return after a short interval often permitted the appropriate visualization.

Simple linear regression analysis was performed to ascertain the form of the relationship between the different measurements determined in this study.

Fig. 1: Ultrasonographic scan showing sacral length and femur length of a fetus of 36 weeks gestation.

Results

Estimates of the mean (+SD) of SL, BPD, AC and FL for each gestational age group are shown in table (1). These parameters were found to increase progressively by age till reaching a maximum at full term.

Growth of the fetal sacral length (SL) was found to be linear during the second half of pregnancy (From 20 to 41 week). The linear regression equation of sacral le-
ngth in millimeters as a function of gestational age (GA) in weeks is as follows: \( SL = 0.991 \text{GA} + 0.355 \).

The Pearson correlation coefficient of this regression is \( R^2 = 0.992 \) indicating highly strong relationship between sacral length and gestational age. Figure 2 represents this linear regression equation with squares indicating data means. Moreover, ultrasonographic measurement of fetal sacral length was found to be easily obtainable as the sacrum was visualized and measured in 94.8% of cases (220 out of 232 cases). Only when the fetal spine was in posterior position, sacral measurement was difficult to be obtained.

The linear regression equations representing the form of the relationship between sacral length and each of the three established parameters of fetal growth (BPD, AC & FL) are shown in figures 3-5. There was highly significant linear association demonstrating a good fit between sacral length and each of these standard parameters (\( R^2 = 0.995 \), 0.999 and 0.994 respectively).

**Table 1: Means (+ SD) BPD, AC, FL, and SL for each gestational age (GA) group.**

<table>
<thead>
<tr>
<th>GA (Weeks)</th>
<th>BPD (mm)</th>
<th>AC (cm)</th>
<th>FL (mm)</th>
<th>SL (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 - 21</td>
<td>45.8 + 2.29</td>
<td>15.11 + 3.23</td>
<td>31.72 + 2.97</td>
<td>20.32 + 0.70</td>
</tr>
<tr>
<td>22 - 23</td>
<td>53.81 + 2.81</td>
<td>17.05 + 0.76</td>
<td>36.56 + 1.97</td>
<td>22.25 + 0.58</td>
</tr>
<tr>
<td>24 - 25</td>
<td>59.63 + 2.70</td>
<td>19.19 + 0.88</td>
<td>45.6 + 2.95</td>
<td>24.13 + 0.89</td>
</tr>
<tr>
<td>26 - 27</td>
<td>65.93 + 2.90</td>
<td>21.86 + 0.27</td>
<td>51.71 + 2.23</td>
<td>26.71 + 0.61</td>
</tr>
<tr>
<td>28 - 29</td>
<td>71.67 + 2.29</td>
<td>23.66 + 1.53</td>
<td>54.27 + 2.12</td>
<td>28.73 + 0.76</td>
</tr>
<tr>
<td>30 - 31</td>
<td>77.13 + 2.33</td>
<td>25.95 + 1.80</td>
<td>59.31 + 3.09</td>
<td>30.63 + 0.62</td>
</tr>
<tr>
<td>32 - 33</td>
<td>80.38 + 2.75</td>
<td>28.12 + 1.84</td>
<td>64.50 + 1.41</td>
<td>32.69 + 0.79</td>
</tr>
<tr>
<td>34 - 35</td>
<td>85.20 + 1.70</td>
<td>29.42 + 1.32</td>
<td>68.07 + 2.02</td>
<td>34.60 + 0.83</td>
</tr>
<tr>
<td>36 - 37</td>
<td>89.29 + 1.20</td>
<td>31.54 + 1.26</td>
<td>71.93 + 2.56</td>
<td>35.93 + 1.00</td>
</tr>
<tr>
<td>38 - 39</td>
<td>93 + 2.51</td>
<td>34.17 + 0.63</td>
<td>76.07 + 1.10</td>
<td>38.00 + 0.76</td>
</tr>
<tr>
<td>40 - 41</td>
<td>95.6 + 1.35</td>
<td>35.50 + 0.82</td>
<td>77.53 + 1.06</td>
<td>39.67 + 0.49</td>
</tr>
</tbody>
</table>
Fig. 2: Sacral length plotted against gestational age.

Fig. 4: Sacral length plotted against abdominal circumference.

Fig. 3: Sacral length plotted against biparietal diameter (BPD).

Fig. 5: Sacral length plotted against femur length.
Discussion

The fetal sacrum is a consistently identifiable structure and landmark that provides a reproducible plane for measurement. The lower spine is usually visualized at length to document anatomical integrity and to rule out structural congenital anomalies that occur in this region, such as spina bifida, sacrococcygeal teratoma, and caudal regression syndrome. Sacral vertebrae can be visualized as early as 15 weeks as by this time they show ossification centers in a staged manner starting by that of vertebral body as do other vertebrae (Sherer et al., 1993).

The present study defines normal limits of sacral length throughout the second half of gestation (table 1, Fig. 2). The Pearson coefficient (R2) of the regression analysis between SL and GA documents the presence of a strong linear relationship between them (Fig. 2), a result which is consistent with that of Sherer et al., (1993) who reported similar linear relationship in both normal and abnormal (dysmature or macrosomic) fetuses throughout pregnancy (from 15 to 41 weeks). It is of interest to note in the present study that the mean sacral length in millimeters almost equals the gestational age in weeks as demonstrated in table 1. Thus sacral length may serve as a handy way to determine gestational age accurately.

Two previous reports (Li and Woo, 1985; Birnholtz, 1986) studied ultrasonographic documentation of axial growth of the fetal spine; however, neither of these studies address sacral growth. Birnholtz (1986) reported data obtained from 128 normal fetuses between 11 and 41 weeks gestation and measured average lumbar spacing calculated from the distance between centers of four lumbar bodies. This distance increased linearly throughout the second and third trimesters. Li and Woo (1985) defined the fractional spinal length as the distance of the longitudinal axis between T10 and L5. This distance was measured in 218 normal fetuses and was found to correlate strongly with femur length. However, in the present work we found that in order to measure
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lumbar vertebral length one must verify all vertebrae (cervical, thoracic, lumbar and sacral) to identify lumbar vertebrae, while the sacrum is represented by the last five caudal ossification centers, indicating that SL measurement is much easier in addition to its documented accuracy.

The present study additionally showed that Pearson coefficients ($R^2$) obtained from regression analysis of sacral length with BPD, AC and FL demonstrate the relative strength of sacral length measurement as compared with these standard parameters of gestational age and fetal growth determination (Fig. 3, 4, 5). This indicates that sacral length measurement can go hand by hand with the commonly used standard parameters for gestational age evaluation.

Inspite of the fact that this study was performed on only normal pregnancy, however it is logic that sacral length are not affected by abnormal intrauterine fetal growth like femur length does not (Abramowicz et al, 1989) as asymmetrical fetal growth retardation and macrosomia will affect mainly soft tissue contents of the fetus. However, further studies are recommended to verify sacral length efficacy in determining gestational age in cases with abnormal intrauterine growth.

In conclusion, the results of this study and the technical ease with which sacral measurement is obtained indicate that sacral length can be used routinely as an additional new accurate ultrasonographic parameter for gestational dating purposes and it is especially useful in cases in which gestational age is unknown and traditional ultrasonographic parameters such as BPD are unobtainable because of fetal positioning or an abnormal cephalic index in fetuses with brachycephaly or dolichocephaly.

References


