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Correlation Between Ultrasonic Manual and Wavelet Based Automatic Measurement of HC and AC

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Abstract

The objective behind this article is to assess the correlation between ultrasonic manual and wavelet based measurements of fetal head and abdominal circumferences. 72 normal pregnant women with gestational ages between 14-40 weeks were included. Three readings of each parameter i.e. head circumference(HC) and abdominal circumference(AC) were taken by both methods. Mean values were calculated and compared using paired sample ”t” test to assess the correlation between ultrasonic manual and Wavelet based automatic measurements. Correlation was found between the mean measurements of the foetal HC and AC by the manual and wavelet based automatic method of calculation. The automatic mode of measurement is a rapid method than the manual calculation, and its use may be encouraged.

Keywords: wavelet, Bi-parietal diameter(BPD), Head-Circumference(HC), Abdominal-Circumference(AC),Ultrasound.

Introduction

Foetal biometry has been in use for the assessment of gestational age and for monitoring foetal growth since the late 1960s when campbell’s first publication on the subject appeared (1).The parameters in common use,are the bi parietal diameter(BPD),head circumference (HC),abdominal circumference (AC) and femur length (FL) (2) (3) (4) (5)**.** Accurate measurements of the head and abdominal circumferences are essential if foetal growth is to be accurately monitored. These can be performed manually by taking two measurements at right angles to each other at an appropriate plane, and the result calculated from the formula for an ellipsoid; it can also be performed on all commercially available ultrasound machines.

Shield J R and co-workers (6), while working on ellipse calculations versus planimetry, expressed that all equations were found to be equally accurate in

calculating HC and AC. Compared to planimetry, the ellipse method is more adequate in calculating circumferences, however, this was not true when calculating their ratios. Similar author,in another study, working on 122 foetal heads and abdomens, reported that the mean of the cephalic index was $79.1\%\pm5.21\%$ and that of the abdominal index was $89.1\%\pm7.0\%$, therefore, the simplest equation, $(D1+D2)\times1.57$, was recommended for calculating AC and HC except in situations of extreme dolicocephaly (7).

The objective of this study was to assess the correlation between ultrasonic manual and automatic wavelet based contour(ellipsoid) measurement (8) (9) of foetal head and abdominal circumferences.

Method

This comparative cross sectional study consisted of a convenient sample of 72 uncomplicated singleton pregnant women, between 14-40 weeks of gestation.Three readings of each parameter,HC and AC were taken using the manual and wavelet based automatic modes. For HC, the mathematical formula used was that for an ellipsoid, viz.

$circumference=0.5\pi(D1+D2)where\pi=3.142$ and D1,D2 are the two diameters at right angle to each other, in this case representing the biparietal diameter(BPD) and the occipito-frontal diameter(OFD) respectively. Thus simplified to $(BPD+OFD)x1.62$

For the automatic measurements of HC,two calipers were placed on BPD and using trackball to reach the outer margins of skull from sinciput to the occiput.

In case of abdominal circumference, the same formula was modified to cater for the more circular abdomen, viz.

$Circumference=(D1+D2)x1.57$, where 1.57 is the correction factor for a circle.

The automatic measurements was taken by placing two calipers on the periphery of the abdominal wall using the trackball to adjust calipers to the outer margins.

The data was analyzed and continuous variables including HC and AC were represented by mean and standard deviation. Paired't' test was applied to compare the difference in measurement of these variables by manual and automatic wavelet based methods. The correlation between manual and automatic measurements was determined through the correlation coefficient(r).

Result

A total of 72 subjects were enrolled in the study.Three readings of each parameters, head and abdominal circumference were taken using manual and automatic wavelet based methods.

Mean HC calculated by the manual method for the foetuses of different gestational ages (14-40 weeks) was found to be $20.11\pm7.04cm$, whereas that measured by the automatic method was $19.46\pm6.82cm$; this difference was statistically significant $p<0.001,95\%C.Iofdifference=0.559,0.731$ as shown in

table 1. There was a positive correlation($r=0.999$) between these mesurements showing the differences were constant. Only two observations of manual HC measurements were found higher than the automatic measurements with a difference of 0.7 and 0.8 cm respectively. Sixteen observations were found equivocal with a difference of $0 to<0.5cm$. While in all remaining 54 observations, automatic HC measurements were found higher than manual HC measurements with a difference of $0.5 to<1.5cm$.

The mean AC calculated by manual technique was $16.79\pm6.24cm$, and that measured by automatic technique was $16.74\pm6.11cm$. This was not statistically significant($p=0.44,95\%C.Iofdifference=0.07,0.161$) as shown in table 1;correlation between these measurements($r=0.997$) was positive. In case of AC, 31 manual measurements were found less than automatic wavelet based measurements (8) (9) with a difference ranging from 0.1 to 0.6 cm. Thirty three observations were equivocal where the difference was $0 to<0.5cm$ and in the remaining 8 observations, the automatic AC was found higher than the manual AC measurements with a difference of 0.5 to 3.0 cm.

Table 1: Comparison of Mean $\pm$ SD values (in cm) by manual and automatic modes of measurement.

Ultrasonic Parameters	Number (n)	Manual Measurement	Automatic Measurement	Level of Significance
		Mean $\pm$ SD (in cm)	Mean $\pm$ SD (in cm)	
Head Circumference	72	20.10 ± 7.0	19.46 ± 6.8	$p=0.44$
Abdominal Circumference	72	16.79 ± 96.2	16.74 ± 6.1	$p<0.001$

Discussion

Sonographic measurements of foetal ultrasound parameters form the basis of acurate determination of gestational age, monitoring of foetal growth, and detecting growth abnormalities (10). .some selected parameters are used to estimate foetal weight (11) (12) (13).

The shape of the foetal head is ovoid, whereas that of the upper abdomen is more circular. Various mathematical formulas are used to measure the circumference, the one is common use for head circumference being the one for an ellipsoid, $Circumference=0.5\pi(D1+D2)$ where $\pi=3.142$ and D1 and D2 are the two diameters at right angle to each other and 1.57 is the correction factor of a circle. This equation is commonly used for the calculation of AC. However, the same equation has been claimed to be accurate for the HC, except in situation of extreme dolicocephaly (12).

The formula for ovals or ellipses like the head is $HC=BPD+OFDx1.62$ Where, 1.62 is the correction factor for ellipses. A more rigorous formula for ellipses is

$$Circumference = 0.325\sqrt{D1^2+D2^2}$$

The modern ultrasound machines are equipped with the facility to estimate the circumferences technically using calipers and trackball for both circles and ellipses. In this study an attempt was made to find the correlation between manually measured head and abdominal circumferences making use of traditional formula compared with the wavelet based automatic mode. There was a statistical difference between the mean values of HC obtained by the two techniques; the difference being of the order of $0.6cm(20.11\pm7.04cmVs19.46\pm6.82cm)$ which forms 3% of the value of 20.1 cm. This may not be clinically significant; i.e. the value of HC at 22 weeks of gestation ranges from 17.4 cm to 22.3 cm(5th and 95th centiles) (13) (14)**.** Therefore, it can be suggested that the difference obtained by two methods, although statistically significant ($p=0.001$), may not be clinically significant.

According to Lu W et al (16) , the difference between automatic and sonographer's manual measurements were 0.12% for BPD and -0.52% for HC. The 95% CI of the agreements were -3.34% , 3.58% for BPD and -5.50% , 4.45% for HC.The result demonstrated that the two measurements were consistent and accurate (16)**.**

In our study, regarding measurement of AC, there was no statistical difference between the values obtained by the two methods($p=0.44$). Similar results were obtained by Watson et al (17) who,while working on AC in 235 cases demonstrated that the directly measured AC was found to be greater than the calculated value($p=0.00014$). The magnitude of the difference however, was only $1.3\pm2.2\%$, which is smaller than the average inter-observer measurement error. The study further stated that although statistically significant, the difference between these two measurement methods is not clinically significant, suggesting that either method is acceptable to determine foetal AC. This discussion suggests that the automatic measurement is a more rapid method than the manual, and is recommended for the measurement of the head and abdominal circumferences.

Conclusion

The measurements of the head circumference by the manual and the wavelet based automatic methods were statistically significant; however, the difference may not be clinically significant, as it would fall within the standard deviation of approximately 4 days allowed for the HC. There was strong positive correlation($r=0.999$).

As regards the measurement of AC by the two methods, there was no statistical difference between the two,however, there was strong positive correlation between the two methods($r=0.997$).Wavelet based automatic measurement (8) (9) may be routinely used for the measurement of head and abdominal circumferences.

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