PRENATAL ULTRASOUND ESTIMATION OF FOETAL WEIGHT

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SYNOPSIS

The accuracy of estimating foetal weight ultrasonographically with the use of three formulae was comparatively analysed in a local population.

166 patients undergoing elective Caesarean section were studied with realtime ultrasound on the eves of the operations. Relevant parameters of the foetus were measured. Estimated foetal weights were calculated using the three formulae, and deviations from the actual birth weights were compared statistically.

It was found that the formulae of Shepard and Campbell-Wilkins were the most accurate overall. The standard deviations were 7.70% and 8.89% respectively and both were not significantly different from zero (by t testing). This compared favourably with studies in Western population.

When the observations were broken down into birth weight strata, it was found that using Shepard's formula, the estimation was good for all weight groups except those in the category of "2500 gms and below." Campbell-Wilkins' formula was equally accurate but for a smaller range. For foetuses of birth weight 2500 gm and below, the best result was obtained with the use of Hadlock's formula.

There was a 6% failure rate in obtaining a good clear image for measuring abdominal circumference and a 11.5% failure rate in obtaining a good midline biparietal diameter.

This prospective study indicated that Shepard's formula (though derived from an American population) could be accurately used to estimate foetal weight in local women except when the foetuses were of low birth weight (< 2500 gm) when Hadlock's formula may be more useful.

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INTRODUCTION

It has been shown without doubt by various workers that foetal weight is a significant predictor of morbidity and mortality in Low Birth Weight infants.(1,2,3) Therefore making its estimation prenatally has become all so important to the obstetricians and paediatricians.(4) This estimation also helps tremendously in the monitoring of foetal growth antenatally. More recently, many obstetricians use the estimated foetal weight as an important factor in deciding the mode of delivery for foetuses presenting with breech, knowing well the higher foetal mortality and morbidity associated in the vaginal delivery of big breeches.

For a long time, obstetricians have attempted various methods in making this estimation. It varies from simple manual palpation of the abdomen to the most detailed ultrasound study and measurement of the foetus and using complicated mathematical calculations.(5,6,7,8,9) With better realtime ultrasound machines now available, the answer probably lies in some form of ultrasonographic measurements of the foetus.

Many workers have employed different ultrasound measurements of the foetus or their combinations and using different formulae for calculating the estimated foetal weights.(6,7,9,12) Much has been claimed by their investigators when used independently. However, few of these formulae and calculations have been tested simultaneously on a studied group of patients to compare their merit and accuracy, with the distinct exception of the study by Deter.(10) Further, there has not been any published data indicating which of these formulae or calculations would best suit the local population.

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Objectives

The aim of this study is two-fold. They are:

1. To comparatively study the accuracy of three commonly used, well accepted and established formulae for estimating foetal weight when they are applied simultaneously on a group of local patients.
2. To evaluate the difficulty and feasibility of measuring by realtime ultrasound the various parameters that are used in the various formulae to estimate foetal weight.

The three formulae selected for comparative study were:

1. Abdominal Circumference (AC) = 21.79 + 6.56 log weight + 3.25 (log weight)^2

   This was derived from Campbell and Wilkins(7). It was very widely used in centres in the United Kingdom and the British Commonwealth. It was relatively simple involving the measurement of only one parameter — abdominal circumference.

2. $\log_{10}$ (Weight) = − 1.7492 + 0.166/(BPD) + 0.046 (AC) − 2.646 (AC × BPD)/1000

   This formula originated from Warsoff's(8) work but subsequently modified by Shepard.(19) It was the most commonly used formula in the American continent and had been described by an American worker, Deter(10), to be more accurate than Campbell and Wilkin's formula. It required the measurement of the biparietal diameter (BPD) in addition to the AC and this sometimes posed a problem in the term foetuses when the heads were very low or engaged and relatively fixed in a position that did not yield a good midline. Moreover, the validity of the measurement of BPD also relied on the shape of the foetal head.

3. Log_{10} Weight = 1.3598 + 0.051 (AC) + 0.1844 (FL) − 0.0037 (AC × FL) where AC was abdominal circumference and FL was femur length

   This formula was adopted from Hadlock et al. Hadlock and his workers realised that the BPD could be difficult to measure and as influenced by shape and therefore favoured the measurement of femur length instead of BPD. Relatively less experience had been recorded on this formula as in comparison to the previous two formulae.

As noted above, the BPD could be difficult to measure. Similarly, measuring abdominal circumference, head circumference and femur length could be difficult and occasionally impossible due to factors like oligohydramnios and position and attitude of the foetus at term. These aspects were looked into and noted in the course of this study.

PATIENTS AND METHODS

Between June 1984 and May 1985, a total of 166 patients admitted to 'A' Unit, Kandang Kerbau Hospital for elective Caesarean Section were routinely scanned by the author personally on the eves of the operations. During the scan as many as possible of the relevant parameters of the foetus were measured (viz biparietal diameter, femur length, abdominal circumference, head circumference, head area and abdominal area). Some of the parameters could not be measured owing to the position of the foetus or the poor quality of the scan.

All the ultrasound scannings were done by one operator using the same machine (Siemens Imager 2380 realtime scanner). All measurements of each parameter were made with electronic calipers on freezed images on the screen of the scanner, and they were repeated at least once to ensure that there were no gross errors in the measurements. The abdominal circumference (AC) was measured as described by Campbell-Wilkins(5).

The parietal diameter (BPD) was measured as described by Warsoff et al(6) and the measurement was made by electronic calipers from the outer edge of the anterior skull to the inner table of the posterior skull.

The femur length (FL) was measured from the greater trochanter to the distal metaphysis as described by Hadlock et al.(15)

All the patients had their Caesarean Sections done within 24 hours of their scanning and the newborns were weighted immediately — within half an hour of birth.

Using the three formulae of Campbell-Wilkins', Shepard's and Hadlock's estimated foetal weights and their deviations (in percentage) from the actual weights were calculated. These percentage deviations were statistically analysed. Calculation was made of mean and standard deviation of the percentage deviations for all observations for each formula as well as for each birth weight strata. Then t tests were performed to see whether mean deviations (both for overall observations and for observations within each birth weight strata) were significantly different from zero.

RESULTS AND DISCUSSION

Practical Difficulties

Out of the 166 patients scanned, 10 were excluded from the study because it was not possible to obtain a clear well-defined correct section of the abdomen. This represented a 6% failure rate which was consistent with the findings of Clement et al.(16) The author agreed with Clement that these patients were "unsuitable" and "should resist the temptation to obtain an approximate measurement."(16)

Of the 156 patients, a good midline BPD was not possible in 18 patients representing a failure rate of 11.5%. A further 3 patients had dolicocephaly. Thus leaving only 135 patients suitable for Shepard's formula which required BPD and AC.

Of the 156 patients who had good AC, measurement of femur length was attempted in 140 patients and in all these patients it was possible to obtain a clearly defined image of the foetal femur for measurement. Thus Hadlock's formula was used on 140 patients.

Results

As shown in Table 1, both Campbell-Wilkins' and Shepard's formulae had deviations not significantly different from zero. They, therefore, would give the best estimated foetal weights. The sd were 8.89% (Campbell-Wilkins) and 7.70% (Shepard's). They were consistent with the reported range of 7% to 10%.(10) Further tests were unable to significantly show which of the two was the more accurate formula.

Table 2 illustrates, in accordance to birth weight strata, the distribution of the x and sd of the percentage deviations of the estimated birth weights.

For all categories except that of 2500 gm and below, Shepard's formula yielded x and sd which were not significantly different from zero, meaning that, the differences between the estimated weight and the actual weight were not statistically significant. Similar assumption was true for Campbell-Wilkins' formula in the categories of "2501 to 3000 gm" and "3001 to 3500 gm." Most babies delivered in the local population have their birth weights lie within these two categories. Therefore, in practical terms, both these formulae were as useful though in theory Shepard's had the edge.

For babies less than 2500 gm, only Hadlock's formula had a test not significantly different from zero. It was therefore tempting to infer that for low birth weight newborns in the local population, this formula seemed to give the best estimates of birth weights. Babies of this category in the study consisted of low birth weights at or near term when elective Caesarean sections were performed. They were therefore assumed to be small not from prematurity but from some degree of poor grwoth in utero.

The author was surprised by the finding that Hadlock's formula (using femur length and abdominal circumference) was not accurate for all categories and yet was accurate for those of "2500 gm and below" (even better than Shepard's). This implied that the femur length was a more important function than the BPD in estimating weights of Low Birth Weight infants due to poor growth in utero.

CONCLUSION

The results of this study, when translated into practical terms, could help the obstetrician choose the right formula for estimating weight of a foetus. If the foetus was expected to be of low birth weight (2500 gm and below) then Hadlock's would be the best. For the average-sized foetus, both Shepard's and Campbell-Wilkins' formulae would be equally accurate. However, one may have difficulty in obtaining a good midline BPD (11.5%) or a good AC (6%). In the event that the BPD was poor (or the head dolichocephalic) then Campbell-Wilkins' formula would be best as it only used AC values. If it was not possible to obtain a good section of the abdomen, none of the studied formulae could be used and at the present knowledge no other ultrasonographic method could give a more accurate estimate without making an abdominal measurement (be it AC or APTD × TTD or abdominal area).

TABLE 1
ANALYSIS OF THE ESTIMATED WEIGHTS AND THEIR PERCENTAGE DEVIATIONS OVERALL OBSERVATIONS

Formulae	Campbell-Wilkins (AC alone)	Shepard's (BPD & AC)	Hadlock's (AC & FL)
x	0.4815	− 0.0955	− 2.2606
sd	8.8916	7.7004	7.3366
n	156	135	140
t(p)	− 0.676 (0.5)	− 0.144 (0.9)	− 3.646 (<0.001)

x : mean deviation
sd: standard deviation
n : sample size
t : t test for significant difference from zero
p : p value for significance

TABLE 2
ANALYSIS OF THE ESTIMATED WEIGHTS AND THEIR PERCENTAGE DEVIATIONS OBSERVATIONS CATEGORISED INTO BIRTH WEIGHT STRATA

Birth Weight Strata	Campbell-Wilkins'	Shepard's	Hadlock's
⩽ 2500			
x	8.0846	6.715	0.4167
sd	9.5523	5.6999	6.7374
n	13	12	12
t	3.052 (0.01)	4.081 (0.015)	0.214 (0.85)
2501 – 3000			
x	1.0976	− 0.5758	− 1.7005
sd	9.9087	7.5848	8.1579
n	50	43	42
t	0.783 (0.45)	0.498 (0.65)	− 1.357 (0.2)
3001 – 3500			
x	− 0.5	0.35	− 1.8375
sd	6.5926	7.5905	6.1298
n	61	55	57
t	− 0.592 (0.55)	0.342 (0.8)	− 2.263 (0.035)
3501 – 4000			
x	− 5.0417	− 2.1713	− 3.65
sd	5.7760	5.4588	7.3152
n	29	23	26
t	− 4.701 (≪ 0.001)	− 1.908 (0.05)	− 2.544 (0.02)
⩾ 4000			
x	− 19.4633	− 19.01	− 16.8067
sd	4.6953	3.6345	2.9614
n	3	2	3
t	− 7.180 (≪ 0.001)	− 7.490 (0.02)	− 9.830 (0.015)

While these conclusions were a fair derivation from the results of this study, it must be remembered that the pregnancies studied were at or near 38 weeks. Therefore similar conclusions may not hold true for foetuses who would be premature when the proportions of the head and body could be very dissimilar. A prospective study of these formulae on foetuses who were delivered pre-term would certainly help to complete the picture.

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