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Symphysis-Fundal Height Measurements In Estimating Birth-Weight

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Objective: To describe the derivation, accuracy, and limitations of a new formula for estimating birth-weight using symphysiofundal height measurement in centimetres.

Methods: The derivation of the formula was described. The formula was then applied to 2646 consecutive parturients with sure or ultrasonic dates and no clinical or sonographic evidence of uterine fibroids, polyhydramnios, fetal anomalies or death. The symphysiofundal height was measured with the patient supine, the bladder empty and the uterus relaxed. The accuracy of the method was assessed by the mean simple error, the mean absolute error, the mean simple percentage error, the mean absolute percentage error and the percentage of estimates within ± 10% of the actual birth-weights. Possible factors which may affect the accuracy of the formula were assessed using the Student's t-test at the 95% confidence level.

Results: The mean simple error was +44.9 ±377.2g. The mean absolute error was 254.4 ±342g. The simple percentage error [mean ±SD] was 1.7±11.6%. The absolute percentage error [mean ±SD] was 7.7 ±8.9%. 76.5% of estimates were within ±10% of the actual birth-weights. There was a slightly significant tendency of the formula to overestimate birth- weights [p=0.05, one-tailed t-test]. The formula was inaccurate in the estimation of the weights of low birth-weight and extreme premature fetuses.

Conclusion: The symphysiofundal height [SFH] in centimetres inserted into the formula

$$\frac{[SFH]^3}{16}$$

estimates the birth-weight to ±10% of the actual birth-weight in grams in 76.5% of parturients. The limitations of the formula are discussed.

Key Words: Symphysis-Fundal Height, Birth-weight.

INTRODUCTION

Accurate determination of fetal weight is often desired in antepartum clinical decisions regarding the management of breech presentations, previous difficult labour, fetal macrosomia and preterm delivery among others[1-3]. Currently, the two main methods for predicting birth-weight are clinical guesstimation and ultrasonography[4].

Sonographic measurements were expected to yield more accurate estimation of birth-weights than the clinical ones because of the former's greater objectivity and reproducibility. In practice, both methods have generally yielded similar degrees of accuracy with 40-75% of estimates falling within ± 10% of the actual birth-weight[4-9].

However, the accuracy of clinical estimation depends on experience. Furthermore, ultrasonography is unavailable on a 24-hour basis in many parts of Africa so that ultrasonic estimation of fetal weight cannot always be obtained in emergencies. There is therefore the need for a non-experience-dependent, always available, objective non-clinical method for the estimation of fetal weight. A non-elastic tape was consid d an ideal instrument for this estimation.

Earlier attempts at using external uterine measurements to estimate fetal weight[10-12] gave inaccurate results with more than 30% of the measurements being more than ±500g of the actual birth-weight. Only approximately 68% of the estimations fell within ±250g of the actual birth-weight.

In this paper, the derivation, accuracy and limitations of a new formula for he estimation of fetal weight using symphysiofundal height [SFH] measurements obtained with a non-elastic tape are described.

MATERIALS AND METHODS

Derivation of the formula

The estimated birth weight (EBW) of a baby in grams contained in a uterus with a symphysiofundal height [SFH] measurement in centimetres was derived to be: EFW =

$$\frac{[SFH]^3}{16}$$

The details of the derivation are as follows:

It was observed that in a given pregnant woman the SFH[cm] approximated to the widest transverse measurement [cm] of the uterus [Fig 1]. Although ovoid in shape, it was assumed that the pregnant uterus was spherical with the circumference as $2\pi r$ and the volume as: $\frac{4\pi r^3}{3}$

But the SFH or the widest transverse diameter actually measures half the circumference of the uterus [fig 1].

Thus:

$$\text{Circumference } [C] = 2\pi r \text{ and}$$

$$SFH = ½C = 2\pi r/2 = \pi r$$

Therefore $\pi r = SFH$

$$r = SFH/\pi$$

Volume of the assumed spherical uterus =

$$\frac{4\pi r^3}{3} = \frac{4\pi}{3}\frac{[SFH]^3}{\pi}$$

$$= \frac{4\pi[SFH]^3}{3 \quad \pi^2}$$

$$= \frac{[SFH]^3}{[7.5]^{cm^3}}$$

Since approximately 60% of the human body is composed of water[13], it was assumed that 1 cubic centimetre of calculated uterine volume weighed 1g. From previous work in our population, the mean SFH at 40 weeks was 38cm[14] while the mean birth-weight at the same gestation in 1998 was 3350g[15].

Applying the above derived formula, the total uterine weight at 40 weeks was therefore

$$\frac{[38]^3}{[7.5]}\text{grams} = 7316$$

Subtracting the mean fetal weight of 3350g left 3966g [composed of the weights of the placenta (600)[16], liquor (800g)[16], uterus alone (1000g)[16] and error term (E) due to inclusion of anterior abdominal wall (1566g). (This error term is explained below). The formula $[SFH]^3/7.5$ therefore over-estimated the fetal weight by 3966/3350x100 = 118.4% due to the above reasons. To correct for this overestimation, the denominator 7.5 was increased by 118.4% (8.88) to obtain 16.38 (approximately 16) as the denominator.

The final formula was thus:

$$\frac{[SFH]^3}{16}$$

as described at the beginning.

The error term (E) arose from the inclusion of the anterior abdominal wall (fig 2). It is evident from Fig 2 that the radius (R) included in the calculation was more than the actual radius (r) of the uterus. The difference (R-r) is the error term (E). From 100 consecutive measurements taken at caesarean section (unpublished) the term averaged 3cm in our population.

Application of the formula.

The formula was tested prospectively on 2646 consecutive parturients with sure or ultrasonic dates and no clinical or sonographic evidlence of uterine fibroids, poyhydramnios, fetal anomalies or death. Those with uterine fibroids, polyhydramnios, fetal anomalies or death were excluded. Apart from these, there were no other exclusion criteria.

The study took place at the University of Nigeria Teaching Hospital, Enugu, Eastern Nigeria from 1st September 1998 to 31st March 2000. As soon as a parturient meeting the above criteria was admitted for vaginal or abdominal delivery, the admitting resident doctor measured the distance from the top of the fundus to the top of the symphysis pubis three times to the nearest cm using a non-elastic tape with the centimetre side of the tape facing down, the patient supine, her urinary bladder empty and uterus relaxed. The mean of the three readings was then obtained to the nearest cm. One of us (PON) did approximately half of the symphysiofundal height measurements while the rest were done by three other residents. The birth-weight of the baby was measured in grams by the midwife on duty within 6 hours of delivery using a weighing scale (Waymaster model). Neither the residents (including PON) nor the midwives knew the formula during the period of the study.

The accuracy of the method was assessed by (1) mean simple error (estimated minus the actual birth-weight, g) (2) mean absolute error (absolute value of simple error, g) (3) mean simple percentage error [(estimated minus actual birth-weight)/actual birth-weight] x 100 (4) absolute percentage error [(absolute value of estimated minus actual birth-weight)/actual birth-weight] x 100 (5) percentage of estimates within 10% of the actual birth-weights. Tests of statistical significance were carried out using the t-test at the 95% confidence level. The results were compared with other published clinically and ultrasonically estimated birth-weights.

RESULTS

Two thousand, six hundred and forty six (2646) out of the 2789 parturients who delivered during the study period satisfied the inclusion criteria and were studied. The mean maternal age was 29.3±5.5 years (range 17 -42 years). The mean parity was 2.6±2.2 (range 0-8). The mean gestational age was 38.5±2.6 weeks with a range of 30 - 42 weeks. Two hundred and thirty one pregnancies (8.7%) were under 37 weeks' gestation, 1988 (75.1%) 37-40 weeks', and 427 (16.1%) at or beyond 41 weeks' gestation. Out of the 2646 deliveries there were 2767 babies whose mean birth-weight was 3225±608g (range 1150 - 5050g). Two hundred and fifty four (9.2%) babies weighed less than 2500g, 2195 (79.3%) weighed 2500 - 3999g while 318 (11.5%) weighed 4000g or more. In further analysis, the combined weights of the multiple fetuses have been used as single entries.

Table 1 summarises the symphysio-fundal height measurements (cm), the corresponding estimated birth-weights(g), and the mean ± SD of the actual birth-weights(g). There was a tendency for the formula to predict birth-weights towards the mean for a given SFH. The standard deviations of the actual birth-weights were least when the SFH measured 33-39 cm. Below 33 cm and above 39 cm, the standard deviations were wide as is also evident in Fig 3 which is a scatter diagram of the symphysiofundal height (SFH) versus estimated (EBW) and actual (ABW) birth-weights with the best fitting curves for the two sets of data. Of the first, second and third order polynomials fitted into the SFH versus ABW data, the best fitting curve was described by the second order polynomial: $ABW = 258.1 - 62.9(SFH) + 3.8(SFH)^2$. The estimated birth-weight and the mean of the actual birth-weights almost coincide for the range of SFH 33-39cm. Beyond 39cm the two curves diverge. Fig 4 is a scatter plot of the EBW versus ABW with the best fitting curve. The R^2 statistic was 0.82. The mean simple error was +44.9 ± 377.2g. The mean absolute error was 254.4 ± 342g. The simple percentage error (mean ± SD) was +1.7 ± 11.6%. This was just significantly different from zero (p = 0.05, one-tailed t-test) suggesting a systematic overestimation of birth-weight by the formula. The absolute percentage error (mean ± SD) was 7.7 ± 8.9%.In

76.5% , estimates were within 10% of the actual birth-weights.

Table 1: Symphysiofundal height (SFH), the corresponding estimated birth-weights (EBW), and the mean ± SD of the actual birth-weights (ABW).

SFH(cm)	EBW(g)	ABW(g) Mean	SD
28	1372	1462	152
29	1524	1610	451
30	1688	1633	561
31	1862	2138	125
32	2048	2336	571
33	2242	2369	274
34	2457	2554	324
35	2680	2689	218
36	2916	2810	271

SFH(cm	EBW(g)	ABW(g) Mean	SD
37	3166	3142	214
38	3430	3472	239
39	3707	3790	270
40	4000	3860	397
41	4308	3989	534
42	4631	4350	294
43	4969	4580	490
44	5324	4628	698
45	5695	5123	752
46	6048	5406	554
47	6489	5696	650
48	6912	5994	758
49	7353	6300	810
50	7813	6613	457
51	8291	6934	370
52	8788	7263	790

Table 2 shows the effects of gestational age and birth-weight on the predictive accuracy of the formula. Seventy observations were made at 34 weeks gestation and below. The accuracy of the for..ula increases with gestational age, being most a curate at 37 weeks gestation and above and least accurate at 34 weeks gestation and below. Two hundred and three singleton pregnancies weighed less than 2500g. The formula was very inaccurate in the estimation of these low birth-weight babies; more accurate in the estimation of babies in the ≥ 400g group and most accurate in the 2500-3999g group. The mean simple percentage error results for the 3 birth-weight categories suggest a tendency for the formula to grossly overestimate low birth-weight babies. The accuracy of the formula for the 2500-3999g and ≥ 400g weight groups was not statistically different ($p>0.05$).

Table 2: Effects of gestational age and birth-weight on the predictive accuracy of the formula.

		Estimated birth-weight		
Gestational age(wks)	No	MSPE*± SD	MAPE** ± SD***	± 10%
≤34	70	+9.5 ± 28.1	21.4 ±19.5	40.0%
35-36	161	+1.3 ±11.0	7.9 ±7.5	72.2%
37-40	1988	+1.7 ±11.0	7.6 ±8.6	82.2%
≥41	427	+0.3 ±8.3	6.0 ±5.8	81.3%
Actual birth-weight,g				
<2500	203	+6.9 ±22.3	17.9 ±14.6	18.2%
2500-3999	2072	+1.2 ±9.5	6.4 ±7.1	85.6%
≥4000****	371	+1.3 ±13.6	9.[illegible]±10.0	80.6%

*MSPE = Mean simple percentage error
**MAPE = Mean absolute percentage error
***SD = Standard deviation
**** The combined weights of all the multiple fetuses are included under this.

Table 3 shows the effect of head descent and membrane rupture on the accuracy of the formula. Contrary to expectation, the formula was more accurate in the 462 cases in which the presenting part was engaged than in the 2184 cases in which it was not although the difference was not statistically significant ($p>0.05$). Also contrary to expectation, the state of the membranes had no effect on the accuracy of the results ($p>0.05$). This was however true only in cases of recent membrane rupture ($n=805$). In 28 cases with prolonged membrane rupture (>24 hours), the accuracy was greatly diminished with none of the estimates falling within 10% of the actual birth-weight.

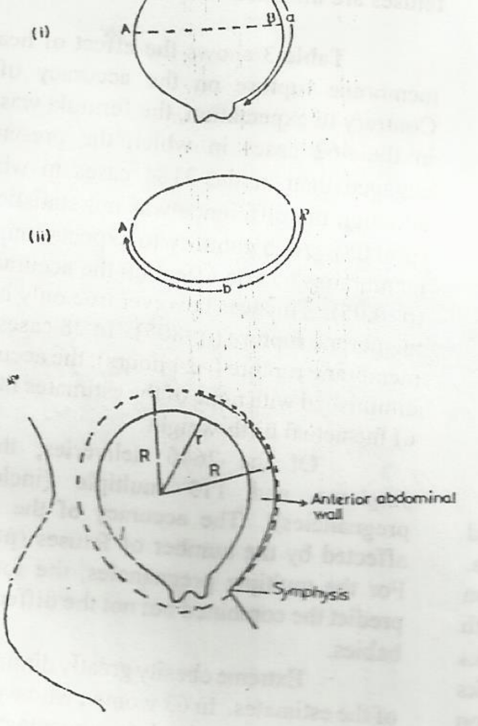
Of the 2646 deliveries, there were 2531 singleton and 115 multiple (including 6 triplet pregnancies). The accuracy of the formula was not affected by the number of fetuses ($p>0.05$) (Table 3). For the multiple pregnancies, the formula could only predict the combined but not the different weights of the babies.

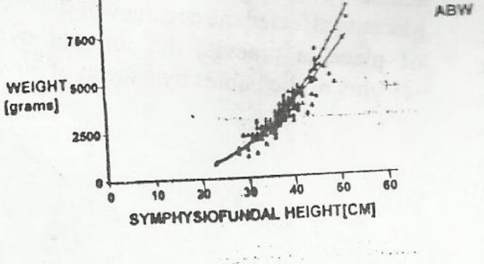
Extreme obesity greatly diminished the accuracy of the estimates. In 63 women who weighed greater than 100kg, the mean absolute percentage error was 27.9 ± 10.6% with none of the estimates within 10% of the actual birth-weights. Similarly, the location of the placenta affected the accuracy of the results. In 41 cases of placenta praevia, the formula over-estimated the wieghts of the babies by a mean of 30%.

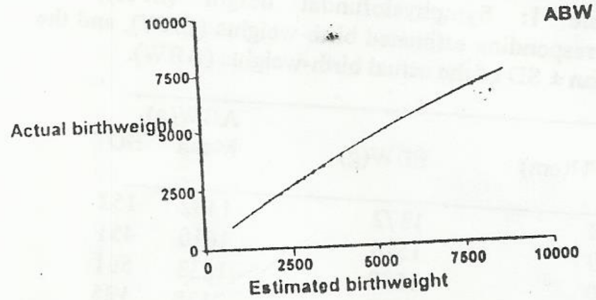
Table 3: Effects of head descent, membrane status and the number of fetuses on the predictive accuracy of the formula

	Estimated birth-weight			
	No	MSPE*± SD	MAPE** ± SD***	±10%
Head descent 0/5,1/5,2/5	462	+1.1 ±10.8	6.3 ±8.9	84.4%
3/5,4/5,5/5	2184	+1.8 ±11.8	8.0 ±8.8	78.8%
Membrane Status				
Intact	1813	+1.2 ±11.9	8.2 ±8.7	78.5%
Ruptured	833	+2.8 ±11.0	6.8 ±9.2	79.1%
No of fetuses				
Sigleton	2531	+1.1 ±10.2	7.0 ±7.1	80.1%
Multiple	115	+3.7 ±9.7	6.4 ±6.0	77.8%

*MSPE = Mean simple percentage error
**MAPE = Mean absolute percentage error
***SD = Sdandard deviation.







DISCUSSION

In two previous studies, 55.3%[4] and 71.5%[5] of the clinically predicted birth-weights were within ± 10% of the actual birth-weights while the corresponding values for ultrasonic estimation were 58.?%[4] and 68.7%[5], respectively. With 76.5% of the estimates in the present study falling within 10% of the actual birth-weights, the present formula holds a great promise in fetal weight estimation. Its higher accuracy than ultrasonic estimation may be because only a single parameter is measured while in ultrasonography several parameters are measured, an error in each of which can decrease the accuracy of the predicted weight. Similarly, its higher accuracy than clinical guesstimation is probably because the accuracy of guesstimation depends on experience while the accuracy of symphysiofundal height measurement does not[17]. The accuracy, simplicity, affordability, reproducibility, objectivity and easy availability of the method makes it particularly of value in developing countries where the majority of parturients are cared for by paramedical staff and where ultrasonography is available in only a few centres for a limited part of the day.

The much lower accuracy (18-40%) of the formula than ultrasonic and clinical guesstimation (45-63%) [4,5] in the estimation of birth-weights of babies of low birth-weight and those below 34 weeks' gestation is rather disappointing. This may be because the assumptions underlying the derivation of the formula applied to 40 weeks; gestation. It is probably that the relative contributions of the uterus, liquor, placenta, and baby to the total uterine weight at less than 34 weeks' gestation differ from what they are at 40 weeks. Secondly, most deliveries at 34 weeks' gestation and below are usally a consequence of pathological pregnancies in which the relative contributions of the uterine components may again differ from the initial assumptions. At present, this decreased accuracy may be of little clinical significance for most parts of Africa because of the low salvage rate of the low birth-weight and extreme premature babies in Africa owing to lack of good neonatal units.

In contrast to the case of low birth-weight babies, the accuracy (80.6%) of the present formula in predicting macrosomic babies to within 10% of their actual birth-weights is much higher than the 53.1 - 61.3% for clinical and 58.8 - 62.0% for ultrasonic estimates of such babies reported by other workers[4,5]. This is of particular importance in African countries with their high incidence of fetopelvic disproportion and consequent obstructed labour[2]. In this regard, the high accuracy (77.8%) in predicting the combined weights of multiple fetuses will aid in the practical management of multiple pregnancies, although ultrasonography has the advantage of predicting the individual weights of the fetuses.

In obese women, the gross over-estimation of the birth-weight by the formula is due to the large size of the error term (E) from the very thick subcutaneous layer. In placenta praevia, the presenting part is displaced superiorly thereby falsely increasing the SFH. This again results in the over-estimation of the birth-weight. The fact that engagement of the presenting part and membrane did not affect the accuracy of the formula was surprising. A probable explanation is the tendency of the formula to systematically over-estimate the birth-weight. A slight decrease in the symphysiofundal height due to membrane rupture or head descent may compensate for this over-estimation with little or no effect on accuracy.

Although the present formula was derived from an Igbo ethnic obstetric population in Enugu, Eastern Nigeria, it has the potential for application in other populations. If the formula is not found suitable in a given population, a slight adjustment of the denominator can be carried out to reflect local birth-weights. However, this may not be necessary as a derivatiion of the formula using birth-weights from Aberdeen[18], USA[19], and Enugu, Nigeria[15] showed the approximate denominator of 16.

It is concluded that the symphysiofundal height in centimetres when inserted into the formula described in this paper estimates the birth-weight to ± 10% of the actual birth-weight in 76.5% of parturients. The formula is of limited value in low birth weight babies, obese women and in cases of placenta praevia. The application of the formula to other populations needs further evaluation.

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