Research Article

Current Opinion in Gynecology and Obstetrics Intrapartum Ultrasonography for Detecting Fetal Macrosomia

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Abstract

Objective: To compare the accuracy of three ultrasound methods to estimate fetal weight within 48 hours before delivery, in order to recognize macrosomia, defined as birth weight greater than 4000 g.

Methods: A prospective and ultrasonic study was performed on a sample of singleton pregnancies between 37 weeks and 41 weeks plus 6 days of gestation. Fetal weight was evaluated with Estimated Fetal Weight (EFW) formula, with the measurement of the Abdominal Circumference (AC) and with the assessment of the Abdominal Circumference corrected with the constant "c" (ACc).

Results: 1030 patients with single pregnancy were included, 67.28% of them were primiparous, average Body Mass Index (BMI) at birth was 27.37 and macrosomia was found in 77 (8,08%) fetuses. EFW showed a sensitivity of 61.53%, a specificity of 90.72%, a positive predictive value (PPV) of 27.58% and negative predictive value (NPV) of 97.46%, to recognize birth weight of more than 4000 g. AC greater than 375 mm presented a sensitivity of 53.24%, a specificity of 93.21%, a PPV of 41.41% and a NPV of 95.67%, to detect macrosomic fetuses. ACc greater than 375 mm showed a sensitivity of 66.23%, a specificity of 88.65%, a PPV of 34.35% and a NPV of 96.68%, to predict macrosomia. The mean absolute error when the neonatal weight was greater than 4000 g, with EFW was 9,23%, with AC were 11,02% and with ACc was 9,32%.

Conclusions: In this study was shown that either EFW, or AC-only, or ACc are useful tools to detect fetal macrosomia. The measurement of AC and Acc seem to be the easiest methods to learn and to be used every time. During the first stage of labor, ultrasound scan associated to clinic evaluation, provides further elements to physician, to allow a better management of delivery. The finding of a NPV greater than 95% with the three methods, leads to exclude macrosomia with a good approximation, even in case of clinic hypothesis.

Keywords: Fetal weight estimation, Fetal macrosomia prediction, Ultrasound fetal abdominal circumference

Abbreviations: AC: Abdominal Circumference; ACc: Abdominal Circumference corrected; BMI: Body Mass Index; BPD: Biparietal Diameter; EFW: Estimated Fetal Weight; FL: Femur Length; HC: Cephalic Circumference; IUGR: Intrauterine Growth Restriction; NPV: Negative Predictive Value; PPV: Positive Predictive Value; SDP: Single Deepest Vertical Pocket; US: Ultrasound

Introduction

Accurate fetal weight estimation at the end of pregnancy is still a challenge, especially in presence of

macrosomia, defined as birth weight greater than 4000 g or greater than the 90th percentile on growth curves [1]. In a Norwegian study that examined 1,914,544 deliveries, authors found that newborns with birth weight between

4000 g and 4500 g represented 15.75% of the sample and 88,8% of babies with weight greater than 4000 g [2]. Fetal macrosomia is associated with an increased risk of fetal (shoulder dystocia, injuries to the brachial plexus, fractures of the long bones, asphyxia) and maternal (II stage of labor prolonged, increase of operative deliveries, caesarean section, perineal lacerations and postpartum bleedings [3]) adverse outcomes. Up to now, a completely successful method to define fetal weight has not been found yet: “self-made” assessment of pregnant patients, clinical examination by Leopold’s maneuvers and symphysis-fundal measure, or ultrasound (US) evaluation seem to lead to comparable results [4]. However, in case of clinical suspicion of macrosomia, a US assessment should be mandatory and influence the clinical management of labor. The ultrasound study of fetal weight is mainly based on two methods: the abdominal circumference value (AC) and the Estimated Fetal Weight (EFW) which takes into account four biometric parameters: biparietal diameter, head circumference, abdominal circumference and femur diaphysis length [5]. Despite the evaluation of more biometric parameters increases the reliability of the method, estimation of fetal weight becomes less trustworthy with greater fetuses, especially above 4000 g [6]. The purpose of this study was to compare the accuracy of fetal weight estimation with three ultrasound methods: Estimated Fetal Weight (EFW), the abdominal circumference value (AC) and the corrected abdominal circumference measure (ACc), performed within 48 hours before delivery.

Materials and Methods

From 2014 to 2018 women with single and low risk pregnancy between 37th week and 41st week plus 6 days of gestation (Table 1), who delivered in the Division of Obstetrics, ASST of Lodi (Italy), were enrolled. All pregnancies had been dated through an ultrasound scan before the 12th week. The ultrasound examination to calculate fetal weight was performed with a transabdominal Convex variable band probe, within 48 hours before the delivery, to minimize the time between the estimated weight and the real weight measured at birth. The weight appraisal was obtained using the Hadlock’s formula [3], the method of Campbell and Wilkin [6] and AC corrected with factor “c” (Table 2).

In order to identify macrosomic fetuses with weight greater than 4000 g, fetuses with known intrauterine growth restriction (IUGR) were excluded. The Hadlock’s formula (EFW) and the Campbell method were used in case of AC greater than 375 mm otherwise the ACc was

used with a threshold of 375 mm. Values obtained in mm through AC and ACc measures were multiplied by ten to obtain weight in grams. Results obtained with all the three methods were compared. We also studied whether the body mass index (BMI) or the amniotic fluid volume influenced the weight evaluation. Particular attention has been put to macrosomic suspected fetuses whose birth weights were expected to be between 4000 g and 4500 g. In this study they represent the 93.4% of the whole macrosomic sample.

Results

1030 patients were included, 60.9% of them were Caucasian, 16.6% Asian, 11.9% African, 10% Latin American. Patients had a mean age of 31.8 years and 67.28% was primiparous (Table 1). The average duration of pregnancy was 39 weeks and 3 days (Table 3) [7].

In 90% of cases, differences between neonatal weight and estimated weight were in the range between -453 g and + 635 g when measured with EFW (Figure 1);

Figure 1: Gaussian distribution of estimated fetal weight with EFW.

Between -520 g and + 520 g when measured with AC (Figure 2);

Between -542 g and + 504 g when evaluated with ACc measurement (Figure 3).

Figure 2: Gaussian distribution of estimated fetal weight with AC.

Figure 3: Gaussian distribution of estimated fetal weight with ACc.

EFW had a mean absolute error of 8,37% and when the newborn weighed more than 4000 g of 9,23% (Table 4).

Measuring the only AC, mean absolute error was 7,48% and rose to 11.02% when the baby weighed more than 4000 g (Table 5).

Evaluating the ACc, mean absolute error was 7,47% and increased to 9,32% when the baby weighed more than 4000 g (Table 6).

Figure 4: Polynomial 4 trend curve. (- - - neonatal weight, ... estimated fetal weight with EFW)

That compares the birth weight and the estimated fetal weight EFW, is reported a polynomial 4 trend curves, similar to birth weights curve, with only a slight tendency of underestimation in weight greater than 4000 g.

With the AC (Figure 5),

Figure 5: Polynomial 4 trend curve. (--- neonatal weight, ... estimated fetal weight with AC)

The polynomial 4 trend curve crosses the line of neonatal weights at about 3500 g with an angle of about 20°, which is greater than the angle of polynomial trend curve of ACc (Figure 6).

Table 1: Women with single and low risk pregnancy.

Total patients	1030 women	Caucasian 628 (60.9%), Asian 172 (16.6%), African 123 (11.9%), Latin American 103(10%), other 4(0.38%)
Multiparous	337 women	32.72%
Primiparous	693 women	67.28%
Mean age	31.8 years	
average height	164.51 cm	
average weight at delivery	73.79 kg	
average weight at the beginning of pregnancy	61.36 kg	
average weight increase	12.428 kg	
B.M.I. at the beginning of pregnancy	22.67	
B.M.I. at delivery	27.37	

Table 2: The method of Campbell and Wilkin and AC corrected with factor "c".

ACc for fetuses with AC greater than 350 mm
$ACc = [350 + (AC - 350) \times c]$
"c" = 1,5
ACc for fetuses with AC less than 350 mm
$ACc = [350 - (350 - AC) \times c]$
"c" = 1,5

Table 3: The average duration of pregnancy.

Average pregnancy duration	39 week 3 day	
PROM (premature ropture of membrane)	148 women	14.36%
SDP Single Deepest vertical Pocket (Kehl S)	44.7 mm	
Babies with weight > 4000	77	8.08%
Average EFW weight estimated	3449 gr (average neonatal weight 3323 gr)	Difference + 126 gr
Average AC weight estimated	3421 gr (average neonatal weight 3357 gr)	Difference + 64 gr
Average ACc 1.5 weight estimated	3382 gr (average neonatal weight 3357 gr)	Difference + 25 gr

Table 4: EFW.

	Difference between estimate and neonatal weight. Average absolute error gr	Average absolute error %	Average neonatal weight
overall 236 pz	278.37	8.37	3323.14
if new born ≥ 4000 gr	394.69	9.23	4274.61
if new born < 4000 gr	271.56	8.31	3267.43
If SDP ≤ 2	271.36	8.52	3184.81
if SDP ≥ 5	295.48	8.64	3418.92
if BMI ≤ 24.9	290.8	8.99	3233.21
if BMI ≥ 30	312.23	9.02	3459.31

Table 5: AC.

	Difference between estimate and neonatal weight. Average absolute error gr	Average absolute error %	Average neonatal weight
overall 952 pz	251.27	7.48	3357.96
If new born ≥ 4000 gr	467.35	11.02	4226.88
If new born < 4000 gr	232.26	7.07	3281.49
if SDP ≤ 2	273.92	8.41	3254.65
if SDP ≥ 5	238.52	6.93	3439.96
If BMI ≤ 24.9	268.73	8.26	3250.82
if BMI ≥ 30	246.65	7.09	3477.69
if BMI ≤ 24.9 e AFI ≤ 2	316.59	9.96	3178.48
if BMI ≥ 30 e AFI ≥ 5	244.62	6.84	3572.73

Table 6: Acc.

	Difference between estimate and neonatal weight. Average absolute error gr	Average absolute error %	Average neonatal weight
overall 952 pz	250.9	7.47	3357.96
If new born ≥ 4000 gr	394.31	9.32	4226.88
If new born < 4000 gr	238.28	7.26	3281.49
if SDP ≤ 2	257.74	7.96	3234.28
If SDP ≥ 5	245.91	7.14	3439.96
if BMI ≤ 24.9	257.31	7.91	3250.82
if BMI ≥ 30	265.96	7.64	3477.7
if BMI ≤ 24.9 e AFI ≤ 2	311.84	9.81	3178.48
if BMI ≥ 30 e AFI ≥ 5	270.75	7.57	3572.73

Figure 6: Polynomial 4 trend curve. (--- neonatal weight, ... estimated fetal weight with ACc)

That it is about 10°. Both lines show a tendency to overestimate weight inferior to 3500 g of neonatal weight and to under estimate weight major of 3500 g.

In line charts (Figures 7, 8, 9),

Figure 7: Polynomial 4 trend curve. (--- neonatal weight, ... estimated fetal weight with EFW)

It is evident that the estimation of the weight calculated with AC and ACc tends to overestimate the fetal weight below 3500 g and to underestimate the fetal weight above 3500 g; while the estimation made with EFW has

an inclination similar to the birth weight line.

Figure 8: Polynomial 4 trend curve. (... neonatal weight, ... estimated fetal weight with AC)

Figure 9: Polynomial 4 trend curve. (--- neonatal weight, ... estimated fetal weight with ACc), linear distribution.

Figure 10: ROC curve of EFW.

Figure 11: ROC curve of AC.

Figure 12: ROC curve ACc.

In order to evaluate the diagnostic tests in terms of sensitivity and specificity, we decided to perform the ROC (Receiver Operating Characteristic) analysis. As shown in figures 10,11,12, we defined ROC curves for EFW, AC, ACc and successively we compared them (Figure 13). We chose to put cut-off value of estimated weight at 4000 g for EFW and 375 mm for AC and ACc. In fact, according to our opinion, a threshold of 350 mm realized by AC and ACc would have caused a significative increase in false positive results. Even considering the rising of the EFW threshold to 4250 g, it was recorded a little variation in terms of sensitivity and specificity. This is the reason why we confirmed the cut-off at 4000 g.

Table 7 is shown how sensitivity to identify a fetus with weight greater than 4000 g, when the AC and ACc are greater than 375 mm, varies from 53% to 66%; specificity varies from 88% to 93%; PPV varies from 27% to 41% and

NPV varies from 95% to 97%.

Figure 13: ROC curves.

Moreover, to identify a fetus with weight greater than 4250 g using EFW, AC and ACc greater than 375 mm, sensitivity varies between 53% and 75%, specificity varies between 85% and 93%, PPV between 11% and 17%, NPV between 98% and 99% (Table 8).

Discussion

Fetal weight is an important parameter in the clinical evaluation of labor. Above all, when the weight exceeds 4000 g, it is associated with both maternal and fetal complications. In a study counting a sample of 12,393 women, the rise in both the cephalic circumference and the abdominal circumference were correlated with increased risk of obstetric interventions; shoulder dystocia seems to be related only to the abdominal circumference [8]. However, some studies report that the recognition of macrosomia does not improve maternal and fetal prognosis [9,10].

Anyway, at the end of pregnancy, fetal weight result is still a challenge, because there is not a method yet to accurately calculate it.

Subjective evaluation of multiparous patients, the symphysis-fundal height, the Leopold's maneuvers and ultrasound study, seem to lead to similar results [4]. However, if macrosomia is clinically suspected, an ultrasound evaluation is required in order to obtain objective elements, even if they are not determinant for the management of labor.

In fact, a successful outcome of birth is the result of

multiple variables that depend on fetus and mother characteristics, on the presence of well trained personnel at delivery and on the availability of an advanced equipment in case of adverse events. Even considering the accurate fetal weight unknown until birth, an ultrasound estimate of the weight confirming the suspicion of macrosomia allows alerting the staff to be ready to deal with possible complications.

In literature, lots of studies have been based on ultrasonography, taking into account different fetal parameters: the only abdominal circumference (AC) [11,12], biparietal diameter associated with abdominal circumference (BPD and AC) [13], cephalic circumference associated with abdominal circumference (HC and AC) [14], biparietal diameter, cephalic circumference, abdominal circumference and femur length (BPD, HC, AC and FL) [15]. All ultrasound weight estimations have an average absolute error of about 10%, that increases at fetal weight rising.

During labor, fetal biometry is difficult to be studied even for expert physician. Maternal adiposity, amniotic fluid restriction and engagement of fetal presenting part could reduce the accuracy of the measurements. In particular, the measurement of the cephalic part is difficult or even impossible when deeply engaged in the pelvic cavity.

The measurement of AC seems to be the single most important parameter in the evaluation of fetal weight, both because the technique is easy to learn, and because it is always detectable. In a Franco-Belgian study on about 20,000 births, authors found a sensitivity of 54% to recognize macrosomic fetuses (> 4000 g) when the AC exceeded 363 mm [16].

In the current study it was not always possible to accurately obtain cephalic measure and the mean absolute error with EFW and AC were similar.

In our study, with the measure of AC, an overestimation of fetal weight for fetuses attended to weight less than 3500 g was revealed. Similarly, it was also described an underestimation for those expected to be heavier than 3500 g. In order to reduce the slope of weight estimation's line, we corrected the value with the constant "c" equal to 1.5. This operation partially compensated the slope, maintaining the mean absolute error for fetuses with weight greater than 4000 g at 9.32%, similarly to 9.23% described using EFW. In fact, when babies weighed more

Table 7: Identify a fetus with weight greater than 4000 g.

Weight estimation $\geq$ 4000 gr	Sensitivity	Specificity	PPV	NPV
EFW	61.53%	90.72%	27.58%	97.46%
AC (350 mm)	92.20%	65.73%	19.50%	98.94%
AC (375 mm)	53.24%	93.21%	41.41%	95.67%
ACc (350 mm)	92.20%	65.61%	19.45%	98.94%
ACc (375 mm)	66.23	88.65%	34.35%	96.68%

Table 8: Identify a fetus with weight greater than 4250 g.

Weight estimation $\geq$ 4250 gr	Sensitivity	Specificity	PPV	NPV
EFW	75.00%	93.72%	17.64%	99.52%
AC (375 mm)	53.84%	90.61%	14.14%	98.55%
ACc(375mm)	65.38%	85.54%	11.48%	98.85%

than 4000g the mean absolute error with EFW and ACc was lower compared with the only AC. Even with this correction, being the mean absolute error of 9.32%, the difference in weight can exceed of 400 g in macrosomic fetuses. All methods showed a mean absolute error that increased at the rising of birth weight, especially above 4000 g; EFW has a tendency to underestimate the fetal weight above 4000 g, the AC and ACc have a tendency to overestimate the weight below 3500 g and underestimate it above 3500 g.

In contrast with other studies [17], the amniotic fluid volume calculated with the single deepest vertical pocket (SDP) [18] and the Body Mass Index (BMI) (Tables 4-6), do not seem to affect the weight estimation with EFW; whereas, the measurement with AC and with ACc revealed a lower mean absolute error when SDP was equal or greater than 50 mm and when BMI at delivery was equal or greater than 30 (Tables 4-6). The error was higher when SDP was equal or less than 20 mm and also when BMI at delivery was equal or lower than 24.9.

Sensitivity, specificity, PPV and NPV do not change significantly within the three methods (Tables 7 and 8), both to find out fetuses with an estimated weight greater than 4000 g and to identify fetuses whose weight is supposed to be greater than 4250 g. Seeing as our findings reported low VPP values, while NPV values were above 95%, we could affirm that macrosomia should be excluded with reasonable certainty when the estimated weight appears inferior to 4000 g through EFW method and when AC and ACc are inferior to 375 mm.

In fact, as shown by Bayes' theorem: 1 - in case of low prevalence, (that's to say in case of low possibility to find

out macrosomia), the positive predictive value of the test decreases; 2- in case of low test specificity, the positive predictive value of the test decreases; 3- in case of low prevalence and low specificity, the negative predictive value of the test increases. This means that the test becomes mainly useful to exclude macrosomia.

The predictivity of the test is proportional to the prevalence of macrosomia in pregnant women studied. In order to reduce false positive values, prevalence should be increased selecting pregnant patients that had fetuses with growth curves greater than 75th percentile at 30 weeks through a pre-test. This would allow to perform a confirmation test at delivery on previously selected women. In this way the test would have an high predictivity of macrosomia because it should be used applied on a population characterized by an high prevalence of macrosomia.

Conclusions

The ultrasound examination performed during labor, has proved to be objective and useful to estimate fetal weight, compared with self-evaluation and measurement of uterine bottom-pubic symphysis. The evaluation should be conducted by properly trained personnel and would have a better predictivity if applied on a population whose fetuses present biometric values above the 75th percentile of growth at 30 weeks of pregnancy; so that increasing the prevalence with a pre-test, the predictability of the birth test should increase.

When the operator can collect cephalic parameters, EFW method should be preferred. Both AC and ACc are equally valid, fast and easy to perform in all circumstances; however, we noted that both an SDP equal or lower than

20mm and BMI at delivery equal or lower than 24.9 increase the mean error values.

The estimate performed with a EFW cut-off of 4000 g and an AC/ACc cut-off of 375 mm seem to have an acceptable number of false positive results. However, it is interesting to note that in case of low prevalence and low specificity, there is a high negative predictive value of the test. In our case this result is useful to exclude macrosomia and to reduce the alertness of the delivery room staff as well as the patient anxiety.

In the end, our study has shown once more the importance of ultrasound assessment in labor and in particular ultrasonic weight estimation, but the methods still need improvements that research and new technologies will certainly find out.

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Declarations

The authors declare that they have no competing interests.

The patients were agree with sharing their ultrasound data while maintaining anonymity.

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