A Study in Johnson's Formula: Fundal Height Measurement for Estimation of Birth Weight

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Abstract

The purpose of this study was to determine the degree of positive estimation value of birth weights in Thai pregnancies by using Johnson's formula. There were 400 respondents who were attendants in the delivery room at Bhumibol Adulyadej Hospital between April and October 2002. The data for this study were obtained by interviews, fundal heights, and station level and baby weight measurements by midwives' in the delivery room. The results of this study shown the majority of the respondents' ages were between 21 to 30 years. The body mass index (BMI) of the sample showed nearly half had a BMI less than 19.8, and 55.5% had a BMI from 19.8 to 26.0. The estimating baby weight by using Johnson's formula had a higher percentage in positive estimation value than negative estimation value. The difference between the estimated weight using Johnson's formula was an average of 227 g higher than the actual baby weight. The standard error of weight difference between the estimated weight and actual weight was 9.01, with 95% confidence interval of 209.51 to 244.83. The best cut-off level of an acceptable error was 310 g. It was concluded that there were 72% of the estimated weight predictions within the average 10% of the actual birth weight, while the estimated weight using Johnson's formula had a tendency towards an over estimation of baby weight in all groups of babies.

Keywords: Fetal weight, positive estimation value, negative estimation value, body mass index, estimated weight, actual weight.

Introduction

The complexity of clinical intrapartum practice requires students to learn how to deliver nursing care to pregnant women based on theoretical knowledge and skills relevant to clinical practice situations. In planning and managing care for childbearing families, students frequently have a difficult task in integrating clinical situations and theoretical knowledge, although, there are several guidelines to assist students in their learning such as: McDonald's rule, Leopold's method, the Friedman Curve, and so on. In a predictable labor phase, a deliberate plan for contingencies for clinical experiences when the students have experiential learning, as traditionally, the proceeding three 'Ps': passage (pelvis), passenger (fetus), and powers (contractions) were considered to be the major factors determining the outcome of labor and delivery.

One essential element in which the student faces with the difficult of midwifery training is the estimation of fetal weight in P - passenger (fetus). Because a clinical estimation of fetal size may be inaccurate, the diagnosis of macrosomia is often made until after fruitless attempts at delivery (Cunningham, et al. 1993). Nevertheless, competent clinical examinations should enable experienced examiners to arrive at fairly accurate estimates (in the absence of maternal obesity). Also ultrasounds can identify a group of fetuses with significantly increased risks of macrosomia (Cunningham, et al. 1993; Dickason and Schult 1998).
However, accurate identification of fetal size is an imperfect clinical skill. For example, Hirate, et al. (1990; cited in Cunningham, et al.; 1993) identified 141 fetuses estimated to weight nearly 4,000 g using Leopold’s examinations, and then performed ultrasound examinations to test the accuracy of several reported sonar methods. The actual birth weights were ranged from 2,920 to 5,100 g and 22% of the fetuses weighed less than 4,000 g. They found that the best sonographic estimates of fetal macrosomia were obtained using abdominal circumference and femur length measurements, also ultrasound derived predictions of fetal macrosomia are prone to large inaccuracies. Unfortunately, the suspected macrosomic fetus and the very small or pre-viable fetus that ultrasonic fetal weight estimates are most inaccurate and difficult to obtain (O’Grady and Gimovsky 1995).

Fetal weight is indeed a very important factor based upon decision, must be made with concerns to labor and delivery. Assuming that in large fetuses, dystocia may arise because the head is not only larger, but also harder and less moldable with increasing weight. Cesarean delivery may be necessary if the fetus is too large to travel through the pelvis (fetopelvic disproportion) in an attempt to avoid birth trauma. A large fetus whose size is underestimated may experience trauma to the head as a result of strong contractions, which force the head against the bony structures of the pelvis. Cerebral edema, neurological damage, hypoxia and asphyxia may result. Moreover, shoulder dystocia and fractures of the clavicles and humerus are more common with large infants (Sherwen, et al. 1993). With small fetuses, fetal demise, birth asphyxia, meconium aspiration, and neonatal hypoglycemia and hypothermia are all increased because the fetal organs are not only becomes smaller in size, but also submature in function (Piper, et al. 1996). Therefore, these infants require special care from the health care team. However, extremely overweight infants have a relatively increased prenatal mortality rate. Perinatal mortality doubled from about 3.5 per 1,000 for those overweight infants. Fundal height measurement can be used to estimate fetal weight using Johnson’s formula. Johnson’s formula requires the height of the fundus in cm, and station level to complete the calculation.

Johnson’s formula is a formula for the estimation of fetal weight in vertex presentations. The formula is as follows:

\[
\text{Fetal weight (g)} = \left[ \text{fundoal height (cm)} - n \right] \times 155
\]

n = 12, if vertex is above the ischial spines
n = 11, if vertex is below ischial spines.

Considerable demographic variation, in our opinion, has less complexity than anticipated, based on skillful of abdominal exam or ultrasonography interpretations. Johnson’s formula for estimation of fetal weight has been found to be accurate within 375 g in 75% of infants (Sherwen, et al. 1993). These results were collected using White’s pregnancies. Thailand has a smaller demographic ethnicity, so perhaps estimations of Thai fetal weight may not be accurate within normal limits.

Therefore, Johnson’s formula is required in applying estimations of fetal weight in Thai pregnancies. Given the importance of these expectations, one advantage enfolded into the curriculum of clinical intrapartum practice with the quality of educational problems and resulting outcomes scrutinized.

**Purpose of This Study**

The purposes of this study are to:

(i) determine the degree of positive estimation value of Johnson’s formula for the estimation of fetal weight in Thai pregnancies who were attended in the delivery room at Bhumibol Adulyadej Hospital.

(ii) determine the degree of negative estimation value of Johnson’s formula for the estimation of fetal weight in Thai pregnancies that were attended in the delivery room at Bhumibol Adulyadej Hospital.

(iii) determine the degree of error for Thai fetal weight in grams, using Johnson’s formula.
Research Methodology

Population Samples

The samples used in this study were 400 Thai pregnancies, which met the eligibility criteria and were attended in the delivery room at Bhumibol Adulyadej Hospital between April and October 2002.

Inclusion Criteria

The following criteria were employed to include the samples:
1. Pregnancy, a singleton fetus
2. Presentation, preferably vertex
3. Station should not be located at 0 levels (level of the ischial spines)
4. Maternal height and pregnancy weight within 26.0 (BMI ≤ 26.0)

Exclusion Criteria

The following criteria were employed to exclude the samples:
1. Pregnancy, complicated chronic disease
2. Pregnancy, diagnosed oligohydramnios or polyhydramnios
3. Death, fetus in uterine or abortion
4. Pregnancy, uterine and/or abdominal mass

Instrumentation

The survey instrument used for this study consisted of six components, subdivided into three parts namely: (i) demography, (ii) obstetrical history, abdominal examination, pelvic examination, and (iii) newborn record and fetal weight calculation by Johnson’s formula which it was conceptualized by the researcher. The six components were developed from the concepts of labor assessment, AU Faculty of Nursing Science. The content validity for this instrument was further strengthened by three university professors, two administrative nurses and one executive obstetrician specializing in this area. Their opinions and suggestions were included for the improvement, clarity and utility of this instrument.

Research Procedure

Data for this study were obtained in three ways:

1. Through the completion of survey instruments via interviews.
2. Through fundal height and station level examines by midwives.
   2.1 Fundal height measurement: The bladder should be empty, then the fundal height is measured in cm using a tape measure. Placing the tip on the upper border of the maternal symphyses pubis, over the midline of the abdomen, to the top of the uterine fundus is an accurate method of measuring.
   2.2 Station identification: A five level method is used for designating the station. When conducting a vaginal examination, the lowermost portion of the presenting fetal part is at the level of ischial spines. It is designated as being at zero (0) station. Levels above the spines are designated in centimeters by negative values, -1, -2, -3 stations. Levels below the spines are designated by positive value, +1, +2, +3 stations, down to the pelvic floor.
3. Through fetal outcome (weight) measurement: Weight is performed in the delivery room. The baby is placed unclothed in the center of a properly balanced scale. The weight is then recorded in grams.

Statistical Analyses

Part I

To determine the personal data, frequencies, percentages and means (where appropriate) were computed.

Part II and III

Percentages, means and standard deviations were first computed. Then, positive estimation value, negative estimation value and degree of error were administered for Johnson’s formula in calculation of Thai (baby) fetal weight.
Results

The results of this study were divided into three parts: (i) demography (ii) obstetric details, and (iii) differences between estimated weight and baby weight.

Demography

The majority of the respondents’ ages were in the range of 21 to 30 years old (55.25%). One hundred and thirty-nine respondents had completed Grade 9 education. Many of the women were employees, nearly 60% earned incomes less than Baht 10,000 per month. The body mass index of the sample, nearly half had body mass index less than 19.8 and half had body mass index between 19.8-26.0.

Obstetric Details

There were 85.75% (n = 235) primigravida and 41.25% (n = 165) multigravida in the sample, with gestation age ranged from 34 to 42 weeks (mean = 39.14, SD = 1.668). The total pregnancy weight gain varied from 4 to 34 kg. (mean = 14.39, SD = 5.351). The height of fundus ranged from 27 to 44 cm (mean = 33.22, SD = 2.39), more than 85% had station minus (above ishial spines) and around 14% had station plus (below ishial spines).

The Difference Between Estimated Weight and Baby Weight

Of the 400 babies delivered, 209 were male (52.25%) and 191 female (47.75%), actual baby weight ranged from 1,900 g to 5,300 g (mean = 3,175.57; SD = 414.67). The estimated weight values obtained ranged from 2,325 g to 4,960 g, with a mean of 3,318.16 ± 351.72 g. The difference between the estimated weight and actual baby weight ranged from -750 to +530 g, with a mean of 227.17 ± 180.38 g (Table 1). The standard error was 9.010 g., with a 95% confidence interval (CI) of 209.51 to 244.83 g (Table 2). Positive estimation values of baby weight at critical cut-off points of 200 and 310 g, and 10% of actual baby weight, were 241 (60.25%), 287 (71.75%), and 286 (71.5%) of 400 cases, respectively (Table 3).

Table 1. Range, mean and standard deviation by height of fundus, baby weight (BW), estimated weight (EW), and difference between EW and BW

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Range</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height of fundus (cm)</td>
<td>27–44</td>
<td>33.22</td>
<td>2.39</td>
</tr>
<tr>
<td>Baby weight (g)</td>
<td>1900–5300</td>
<td>3175.57</td>
<td>414.67</td>
</tr>
<tr>
<td>Estimated weight (g)</td>
<td>2325–4960</td>
<td>3318.16</td>
<td>351.72</td>
</tr>
<tr>
<td>Difference between EW and BW (g)</td>
<td>(-750)–530</td>
<td>227.17</td>
<td>180.38</td>
</tr>
</tbody>
</table>

Table 2. Range, mean, standard deviation, standard error, confidence intervals (CI) and P value by estimation error

<table>
<thead>
<tr>
<th>Estimation error (g)</th>
<th>n</th>
<th>mean</th>
<th>SD</th>
<th>SE</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>(-750)–530</td>
<td>400</td>
<td>227.71</td>
<td>180.38</td>
<td>9.01</td>
<td>209.51 to 244.83</td>
</tr>
</tbody>
</table>

Table 3. Frequency and percentage by positive estimation value (PEV) and negative estimation value (NEV) at the level of acceptable error

<table>
<thead>
<tr>
<th>Level of acceptable error (g)</th>
<th>Positive estimation value</th>
<th>Negative estimation value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Percent</td>
</tr>
<tr>
<td>≤ 200</td>
<td>241</td>
<td>60.25</td>
</tr>
<tr>
<td>≤ 310</td>
<td>287</td>
<td>71.75</td>
</tr>
<tr>
<td>≤ 10% of birth weight</td>
<td>286</td>
<td>71.50</td>
</tr>
</tbody>
</table>
From Table 4, positive estimation values of baby weight at critical cut-off points of 200 and 310 g, and 10% of actual baby weight by baby weight category: (i) less than 2,500 g, were only 2 (15.38%), 3 (23.08%), and 2 (15.38%); (ii) 2,500-4,000 g were 232 (61.87%), 276 (73.02%), and 275 (72.75%); and (iii) greater than 4000 g were 6 (66.67%), 8 (88.89%), and 9(100%), respectively.

Table 4. Frequency and percentage by positive estimation value (PEV) and negative estimation value (NEV) in baby weight classification.

<table>
<thead>
<tr>
<th>Baby weight classification (g)</th>
<th>Acceptable of 200 g</th>
<th>Acceptable of 310 g</th>
<th>Acceptable error of 10% birth weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PEV</td>
<td>NEV</td>
<td>PEV</td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>&lt; 2,500</td>
<td>2</td>
<td>15.38</td>
<td>11</td>
</tr>
<tr>
<td>2,500-4,000</td>
<td>232</td>
<td>61.87</td>
<td>145</td>
</tr>
<tr>
<td>&gt; 4,000</td>
<td>6</td>
<td>66.67</td>
<td>3</td>
</tr>
</tbody>
</table>

Discussion

Estimation of fetal weight by symphysis fundal height (SFH) measurement has been reported by various authors including Edwards (2001), Bothner et al. (2000), Mongelli and Gardosi (1999), Promvijit et al. (2000) conducted a study to determine the measurement of fundal heights in labor as a means of estimating birth weight in singleton pregnancies. As a diagnostic test they reported fundal height useful on an individual basis and recommended that individual biometry or sonographic measurement more useful in assessing the growth of an at risk fetus. Probably a combination of SFH and biometry is an appropriate compromise of estimation of fetal weight.

According to a recent study of 400 singleton pregnancies, results shown that estimating baby weight by Johnson’s formula had a higher percentage of positive estimation value than negative estimation value. The best cut-off level of acceptable error was 310 g. Consequently, the statistical average baby weight should be concerned with determining baby weight at birth. The average estimated weight by using Johnson’s formula was 227.17 g higher than the actual baby weight, whereas at 95% confidence interval was between 209.51 to 244.83 g. Similarly, Mhaskar, et al. (2002) found the estimated weight by using Johnson’s formula of an average 310 g higher than the actual weight.

There were serious problems with calculating and reporting an estimated fetal weight. The main problems related to the calculation of estimated fetal weight using Johnson’s formula was not sufficiently accurate in small gestation age babies (weight less than 2,500 g). Also, the results indicated that estimated fetal weight using Johnson’s formula had a tendency toward over estimation of baby weight in all groups of babies, particularly in low birth weight cases. Therefore, sonographic estimation is essential to enhance accuracy. Low birth weight for gestation is a main cause of perinatal morbidity and mortality especially in developing countries. Thus, close monitoring during labor should be done for estimated low birth weight fetuses.

Overall, 72% of the estimated weight predictions were within an average and 10% of the actual birth weight. In support of the idea of symphysis fundal height (SFH) measurement to determine baby weight, this researcher believes that SFH has adequate precision and accuracy for preparturition estimation of baby weight.

The present study reveals that estimating fetal height intrapartally is crucial to enable the nurse-midwife and/or nursing student to:
(i) create a decision regarding the mode of delivery,
(ii) anticipate problem during labor and hence close monitoring of labor could be obtained particularly for small gestation infants,
(iii) anticipate possible shoulder dystocia and hence notify for availability of a senior competent nurse-midwife and/or obstetrician at the time of delivery, and
(iv) predict individual birth weights and/or special resources requirement except a tailor measuring tape that its advantages are spread, economy and general applicability.

References

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