UTERINE VOLUME AS A PREDICTOR
OF BIRTHWEIGHT

by

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ABSTRACT

A method for estimating fetal birthweight was studied. The method was developed in the early 1950s by Polous and Langstadt. The method was based on the assumption that there was a close statistical correlation between the volume of the gravid uterus and the birthweight of the fetus. The method was developed from a study of twenty-one subjects and had never been studied independently.

Birthweight was estimated in ten subjects using Polous and Langstadt's method. Various statistical tests and criteria based tests were used to test the accuracy of the method. It was found that Polous and Langstadt's method for estimating fetal birthweight is not sufficiently accurate to form a meaningful basis for clinical judgment related to birthweight.

On the basis of these findings and a review of the literature, it was concluded that neither the method of Polous and Langstadt nor any other method for estimating fetal birthweight is superior to simple abdominal palpation. Since the accuracy of abdominal palpation is known to increase with practice, it is recommended that nurse-midwives and other health care providers who attend laboring women should conscientiously practice this skill to assure that clinical judgments are based on the most accurate assessments possible.

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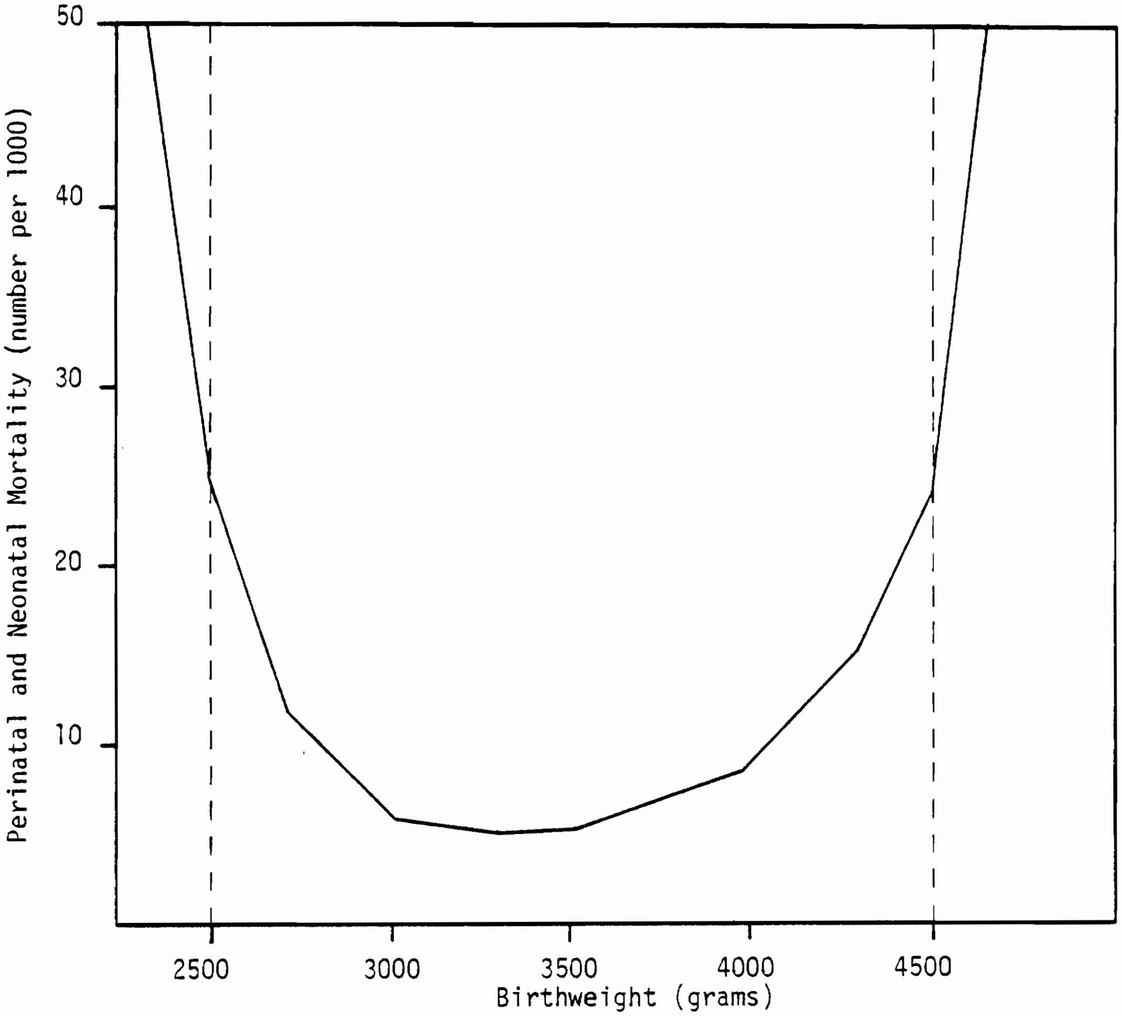
CHAPTER I

UTERINE VOLUME AS A PREDICTOR OF BIRTHWEIGHT

Introduction

There is a well documented relationship between birthweight and neonatal outcome (Battaglia, Frazier & Hellegers, 1966). The mortality risk for infants weighing less than 2500 g or more than 4500 g is substantially higher than the mortality risk for an infant whose birthweight is within these extremes (refer to figure). Because of the significant mortality risk to these infants, it is important to identify any fetus which will potentially weigh less than 2500 g or more than 4500 g at birth. Early identification of such a fetus can improve its outcome by alerting the health care provider to initiate appropriate management steps. For the certified nurse-midwife, identification of such a fetus may be an indication for medical consultation or referral to a high risk maternal-fetal intensive care unit.

The fetus is not directly accessible for weight measurement; therefore, its birthweight must be estimated. All estimates contain an element of error. The magnitude of the error varies with the method used for estimation. The traditional method for estimating fetal birthweight is to palpate the gravid abdomen and "guess" the weight of the fetus. Ong and Sen studied the accuracy of simple abdominal palpation in 1972. They reported that, for



Perinatal and neonatal mortality by birthweight. Mortality rises steeply for those infants weighing less than 2500 g and more than 4500 g. Based on data from Battaglia, Frazier, & Hellegers, 1966, p. 117.

this method, the degree of error is acceptable for most estimates; however, the estimate becomes critically biased if the fetus weighs less than 2500 g or more than 4500 g. The tendency is to overestimate the birthweight of a fetus weighing less than 2500 g and to underestimate the birthweight of a fetus weing more than 4500 g. This diabolic tendency leads the examiner to estimate falsely a more normal birthweight for these infants. As a result, those infants at greatest risk on the basis of birthweight are the least likely to be identified.

More technologically advanced methods for estimating birthweight do exist. Stockland and Marks (1961) developed a radiologic method which they claim is accurate to within 10% of the actual birthweight in 72% of all cases. Recent concern over the effects of ionizing radiation to the fetus, even in low doses, has made it difficult to justify the procedure for routine application (Brent & Gorson, 1972). McCallum and Brinkley (1979) surveyed several recently developed ultrasonic methods for estimating birthweight. In one such method, the error of the estimation did not exceed 182 g for each kilogram of the actual birthweight in 95% of all cases. Although they are promising, ultrasonic methods require costly and exotic equipment which is not available in all communities, and the examination is too expensive to the consumer for routine screening application. As of March 1979 the cost of an obstetrical ultrasound examination at the University of Utah Medical center was $111.

Summary

Low and high birthweight infants are at substantial mortality risk. Identification in utero of these infants allows earlier initiation of appropriate management by the health care provider. A method for estimating fetal birthweight should ideally: (a) provide accurate and objective results for any size fetus; (b) offer no harm to the gravida and her fetus; (c) be convenient for the client and the examiner; (d) use simple, easily obtained equipment; and (e) be offered at a cost which does not preclude routine screening application. The review of literature examines those methods for estimating birthweight which approach an ideal method.

Review of the Literature

McDonald published his observations about the problem in 1906. He stated that at term the average fundus (measured with a tape measure) is 35 cm above the symphysis pubis and contains a 3300 g fetus. By his simple rule, fetal birthweight varies by 200 g for each centimeter of fundal height over or under 35 cm. Accordingly, a fundal height of less than 31 cm or more than 41 cm would correspond to a birthweight of less than 2500 g or more than 4500 g respectively. McDonald did not substantiate his statement with any data other than his personal testimony.

Johnson and Toshach (1954), working with a series of 200 gravidas, reported findings which differed with McDonald's conclusions. They determined that a fetal birthweight of 3300 g corresponded more closely with a fundal height of 34 cm, rather than 35 cm, and that a 1 centimeter change in fundal height corresponded more closely with a 150 g change in fetal birthweight, rather than

200 g. They introduced a refinement to this method by correcting for descent of the present part into the pelvis and maternal obesity, factors which may distort fundal height. To make the correction, one centimeter is added or subtracted from fundal height if the presenting part is above or below the ischial spines (respectively), and another centimeter is subtracted from fundal height if the mother weighs over 200 pounds. Johnson and Toshach reduced the calculation with all the correction terms to the following equation: $W = 3300 + (F + O - 34)(150)$ where W is the estimated birthweight, F is the fundal height, S is the correction term for station and O is the correction term for obesity. In 1957, Johnson simplified the equation to $W = 155(F + S + O - 12)$ for the same variables. The standard deviation for both equations is 353 g; therefore, the method should predict birthweight with an error of not more than 706 g in 95% of all cases.

Niswander, Capraro and Van Coevering (1970) studied the method of Johnson and Toshach to determine its accuracy. Two obstetricians used the method to estimate the birthweights of 1,707 infants. The first examiner overestimated the birthweight by at least 500 g in 77% of all infants weighing less than 2500 g. At the other extreme, the first and second examiner underestimated the birthweight by at least 500 g in 33.3% and 66.6% (respectively) of those infants weighing more than 4500 g. The authors concluded that the method of Johnson and Toshach was no more accurate than simple abdominal palpation.

McSweeny (1958) devised an alternate method for estimating fetal birthweight. The method requires four measurements, two accomplished by caliper and two by tape measure. The caliper is used to measure the fundal height and the widest transverse diameter of the uterus. The tape measure is used to repeat the same measurements. The estimate is based on the sum of the four measurements. Station is corrected by subtracting 3 cm, 2 cm or 1 cm from each measurement if the station of the presenting part is zero, -1 or -2 respectively. Obesity is corrected by measuring the thickness of a fold of abdominal adipose tissue. If the fold of tissue is more than two centimeters thick, the measurement (the double abdominal wall thickness) is subtracted from each of the uterine measurements. McSweeny collected data on 500 subjects and concluded that if the corrected sum of the measurements ranged from 95 to 110 the birthweight could be expected to range from 2590 to 4300 g. Over half of the infants can be expected to weigh less than 2500 g if the corrected sum is less than 95. For the eight subjects in the study where the sum was greater than 110, there were five sets of twins, two infants weighing over 4500 g, and one case of polyhydramnios--clearly a high risk group of infants.

Niswander et al. (1970) tested McSweeny's method on 542 cases. Of those where the corrected sum of the measurements was less than 95, two-thirds weighed more than 2500 g. A sum greater than 110 was found in 23 cases. Contrary to expectation, none of the infants weighed more than 4500 g, yet 13% weighed under 2500 g. These findings seriously challenge the validity of McSweeny's method.

Polous and Langstadt (1953) proposed a method for estimating fetal birthweight. They reasoned that there should be a strong statistical correlation between the volume of the gravid uterus and the birthweight of the fetus. Based on this assumption, they attempted to find a method where birthweight could be accurately estimated by statistical regression from the calculated volume of the gravid uterus.

Polous and Langstadt encountered an immediate problem in determining the best method to measure the dimensions of the uterus and calculate its volume. They approached the problem by calculating the volume of the uterus using four different methods and statistically determining which method yielded the best correlation with fetal birthweight.

Method I

The uterus is assumed to be a prolate spheroid. The volume equation for a prolate spheroid is $V = 1/6(pi)LT^2$ where V is the volume, pi is the mathematical constant 3.141592654, L is the longitudinal diameter. Longitudinal diameter in this case is the fundal height measured by a caliper. Transverse diameter is the widest transverse diameter of the uterus in the frontal plane measured by a caliper. Obesity is corrected by subtracting a correction factor from the transverse diameter. The correction factor is obtained by subtracting two centimeters from the thickness of a fold of abdominal dipose tissue. The equation for calculating uterine volume by method I is $V = 1/6(pi)L[T - (A - 2)]^2$ where V, L, pi and T are defined as above and A is the thickness of a fold of adipose tissue.

Method II

Polous and Langstadt recognized that fundal height does not measure the longitudinal diameter of the uterus along its true longitudinal axis. To measure more accurately the longitudinal diameter of the uterus, they devised a complicated rectal-abdominal technique which measures the uterus along its true axis. Method II differs from Method I only in that the rectal-abdominal technique is used to measure the longitudinal diameter rather than simple fundal height.

Method III

For the third method the uterus is assumed to be a sphere rather than a prolate spheroid. The volume equation for a sphere is $V = 1/6(pi)(D)^3$ where D is the diameter of the sphere. To calculate uterine volume, the value of D is the average of the fundal height and the transverse diameter of the uterus. The equation for calculating uterine volume by method III is $V = 1/6\,(pi)[D - (A - 2)]^3$ where $D = (L + T)/2$.

Method IV

Method IV differs from method III only in that the rectal-abdominal technique is used in place of fundal height to measure longitudinal diameter.

Polous and Langstadt studied 45 subjects. Each subject was measured twice, once during a contraction and once while the uterus was relaxed. Uterine volume was calculated by all four methods for each subject using both the contracted measurements and the relaxed measurements. This produced eight different calculated uterine volumes. Table 1 summarizes the correlation coefficients between each calculated uterine volume and the birthweight of the infant. The best correlation between volume and birthweight ($r = 0.750 \pm 0.056$) was found when method IV was used to calculate uterine volume while the uterus was contracted.

None of the four methods correct for descent of the presenting part into the pelvis. However, by analyzing the data in more detail, it was found that correlation was improved by measuring the uterus while the presenting part was still above the ischial spines. With the presenting part above the spines the best correlation ($r = 0.883 \pm 0.049$) was found using method IV during a contraction. A smaller but still significant correlation ($r = 0.835 \pm 0.067$) was found if method III was used while the uterus was relaxed.

Polous and Langstadt derived two equations for estimating fetal birthweight based on methods III and IV for calculating uterine volume. Assumptions for the first equation are that (a) the presenting part is above the ischial spines, (b) the longitudinal diameter is measured by the rectal-abdominal technique and (c) the uterus is contracted. The equation is $W = 1570 + 0.12(D)^3$ where W is the estimated birthweight in grams and D is the average of the longitudinal and transverse diameters of the uterus in centimeters minus the correction factor for obesity. The standard deviation for the estimate by the first equation is ± 230 g. On this basis, the

Table 1

Summary of Correlation Coefficients[a]

Method	Uterus Relaxed	Uterus Contracted
Assuming the Uterus to be a Prolate Spheroid		
I	0.561 ± 0.103	0.693 ± 0.078
II	0.584 ± 0.099	0.713 ± 0.074
Assuming the Uterus to be a Sphere		
III	0.616 ± 0.094	0.700 ± 0.077
IV	0.601 ± 0.096	0.750 ± 0.056

[a] Based on data from Table 4, Poulos and Langstadt, 1953, p. 238.

equation should predict birthweight to within ± 460 g in 95% of all subjects. Assumptions for the second equation are that (a) the presenting part is above the ischial spines, (b) the longitudinal diameter is measured by simple fundal height and (c) the uterus is relaxed. The equation is $\underline{W} = 1870 + 0.11(\underline{D})^3$ for the same variables. The standard deviation for the estimate by the second equation is ± 250 g. On this basis, the equation should predict birthweight to within ± 500 g in 95% of all subjects.

No reference was found in the literature to any studies to verify Polous and Langstadt's method for estimating fetal birthweight. Loeffler (1967) has stated that for an estimate to be of any clinical value, it must be accurate to within plus or minus one pound. In rounded metric terms this is equivalent to ± 500 g. Statistically, the method meets this criterion; however, the method is based on data from only 45 cases which included no infants weighing less than 2500 g and only one infant weighing more than 4500 g. The equations for the method are based on only the 21 cases where the presenting part was above the spines. The best accuracy was claimed when the longitudinal diameter of the uterus was measured by the rectal-abdominal technique. Although it is more accurate than measuring fundal height, there are disadvantages to the technique. The patient must be placed in the dorsal lithotomy position; the examination is uncomfortable for the patient and complicated for the examiner. These disadvantages are not outweighed by the gain in accuracy of only ± 40 g at the 95% confidence level when compared to the simpler and more convenient measurement of fundal height.

Summary

Neither the method of Johnson and Toshach nor the method of McSweeny offer any advantage over simple abdominal palpation. The method of Polous and Langstadt is promising. It is objective; it is harmless; the fundal height technique is convenient; the required equipment is simple and easy to obtain, and the examination costs the patient nothing. The claimed accuracy of the method is within acceptable limits, but, the accuracy has not been adequately tested. The extreme birthweights were absent or few in the small sample. If the accuracy of the method was validated on a sufficiently large and unbiased sample, however, it would approach an ideal method for estimating fetal birthweight.

Problem Statement

The purpose of this study was to test the accuracy of Polous and Langstadt's method for estimating fetal birthweight. The study particularly examined the accuracy of the method for infants weighing less than 2500 g or more than 4500 g.

Conceptual Framework

The method of Polous and Langstadt is based on several physical, mathematical and physiological principles.

There is a well known relationship in physics between weight and volume in a homogeneously dense mass. The relationship is expressed in mathematical terms by the equation $W = DV$ where W is weight, D is density and V is volume. Weight and volume in a homogeneous mass are directly proportional because an increase in volume is always accompanied by a proportional increase in weight. The relationship between weight and volume in a homogeneous mass is such that weight can be calculated if the volume is known and vice versa.

If volume is plotted on the X-axis and weight is plotted on the Y-axis of a Cartesian graph for various volumes of a homogeneously dense substance, the graph will be a straight line. For any straight line graph in a Cartesian system, the value of X is related to the value of Y in the following manner: $Y = b + mX$ where b is the point where the line crosses the Y-axis (the Y-intercept), and m is the slope of the line (Beckenback, Drooyan & Wooton, 1973). An advantage to adopting this mathematical convention (the slope-intercept form of the linear equation) is that weight can be calculated directly from the relationship between weight and volume without having to know density.

The slope-intercept form of the linear equation was used by Polous and Langstadt to derive their equations for estimating birthweight. By plotting calculated uterine volume on the X-axis and birthweight on the Y-axis of a cartesian graph, a linear regression was obtained by the least squares method (Ingram, 1974). The regression line is described by the following linear equation:

$$W = 1870 + 0.21(V). \qquad [1]$$

The equation is in the slope-intercept form where 1870 is the Y-intercept and 0.21 is the slope of the regression line. Volume is calculated from the equation for a sphere:

$$V = 1/6(pi)(D)^3 \qquad [2]$$

By substituting the right hand term of equation 2 for V in equation 1 and performing elementary algebraic transformation, Polous and Langstadt derived their equation for estimating birthweight:

$$W = 1870 + 0.11(D)^3 \quad . \qquad [3]$$

For the relationship between weight and volume to remain constant, it is necessary to have a relatively homogeneous mass. The fetus is composed of many different types of tissue and is not a homogeneous mass. In terms of density, however, almost 80% of the fetus is water and its lungs are not inflated. Morrison and McLennen studied the question of density homogeneity of the fetus in 1976. They examined the densities of various fetal tissues and concluded that for practical purposes the fetus is a homogeneously dense mass.

A final conceptual consideration is the shape of the uterus. For their study, Polous and Langstadt made the assumption that the uterus was approximately the shape of a prolate spheroid. Ultrasound studies have recently confirmed that the gravid uterus is a prolate spheroid (Phillips, Goodwin, Thomason & Dempsey, 1977). The known shape of the uterus is inconsistent with the finding that the spherical equation for volume produced better correlations with birthweight. The finding may be a simple statistical artifact induced by a small sample. The spherical equation gives a greater calculated volume than the equation for a prolate spheroid. The extra volume may "accidently" provide a correction factor to the method which is needed but not recognized.

Summary

The method of Polous and Langstadt is based on well established scientific and mathematical rationale. The slope-intercept equation derived from the linear regression line simplifies the computations. The fetus may be considered a relatively homogeneous mass. The uterus approximates the shape of a prolate spheroid; yet, the best correlations were obtained when uterine volume was calculated using the volume equation for a sphere.

Research Questions

1. Is the method of Polous and Langstadt accurate for normal infants?

2. Is the method accurate for infants weighing less than 2500 g?

3. Is the method accurate for infants weighing more than 4500 g?

4. Is the method reliable enough to base clinical judgement on?

CHAPTER II

METHODOLOGY

Statistical Model

The purpose of this study was to determine if the method of Polous and Langstadt for estimating fetal birthweight is sufficiently accurate to form a basis for clinical judgment in laboring women. A measurement is accurate if it yields a value which is close to the true value within an acceptable margin of error. The statistical model for such a study is one which compares the estimate obtained by the method with the actual birthweight of the infant.

Pearson's Coefficient of Correlation

This statistic examines the strength of the linear relationship between two variables. If a relationship is to be applied to groups, a Pearson's coefficient of 0.60 or greater may be significant. In this study, a relationship was applied to individuals and was expected to form the basis of clinical judgment. A Pearson's coefficient of at least 0.95 is appropriate in these circumstances for a level of significance.

Reliability Coefficient

This statistic examines the issue of how consistently the estimated value is close to the true value. As with the Pearson coefficient, a significant value could not be less than 0.95 for a study of this nature.

Student's t-test

This is the small sample statistic for comparison of means. Most often the researcher hopes to reject a null hypothesis which states that two means do not differ significantly (H_0: $m_a = m_b$), thereby accepting the alternate hypothesis that two means do differ significantly (H_A: $m_a \neq m_b$). For this study the inverse null hypothesis applies, that is the null hypothesis is H_A: $m_a \neq m_b$ or that the mean of the estimate differs significantly from the mean of the actual birthweight. The alternate hypothesis is that these means do not differ significantly. The alpha risk was set at 0.05. The null hypothesis was rejected if the value of *t* *did not* exceed the critical value of *t* at the 0.05 level for the appropriate degrees of freedom.

Criteria Based Reliability

For this test, criteria are established and the measure is tested against the criteria at a designated confidence level. Loeffler (1967) stated that for an estimate to be of any clinical value it must be within ± 500 g of the actual birthweight. A confidence level of at least 95% is desirable.

Sample

All data were collected by the principle investigator at the University of Utah Medical Center Obstetrical Unit between January 1980 and March 1980. The sample was one of convenience because of time limitations on the part of the principle investigator. To be included in the study all subjects met the following criteria: (a) They were in active labor; (b) the primary care provider gave consent; (c) the subject gave informed consent; (d) the fetus was in a longitudinal lie, cephalic presentation; (e) the pregnancy was singleton; and (f) the estimated gestation was more than 29 weeks.

Definitions

Birthweight. The mass in grams of the infant obtained not more than three hours after its birth.

Corrected average diameter. The arithmetic mean of the fundal height and the transverse diameter of the gravid uterus less the correction term for obesity.

Double abdominal wall thickness. The thickness of a fold of abdominal adipose tissue measured by a caliper midway between the symphysis pubis and the umbilicus.

Fetal lie. The relationship of the fetal axis to the maternal axis. A longitudinal lie means that the fetal axis is parallel to the maternal axis.

Fundal height. The distance in centimeters from the pubic crest to the most superior point of the uterine fundus.

Station. The distance in centimeters of the vertex above or below the level of the ishial spines. Negative station indicates distance above the spines while positive station indicates distance below the apines.

Transverse diameter. The widest diameter of the uterus perpendicular to the maternal axis in the frontal plane measured in centimeters.

Equipment

Caliper

The caliper used in the study was designed by the principle investigator and made by David Dicky. To assure accuracy it was used in the following manner: The blades were held in place spanning the diameter to be measured; the blades were locked by tightening a wingnut; the blades were removed from the diameter, and the distance between the blades was measured with a tape measure.

Tape Measure

A steel tape measure was used for the study to avoid problems with stretching or shrinking. It was manufactured by Lufkin and was calibrated in inches and centimeters.

Informed Consent

Since the subjects were being attended by the faculty, residents, and certified nurse-midwives of the University of Utah, the permission of the appropriate care provider was sought prior to approaching the subject. Informed consent as approved by the University of Utah Committee for Research with Human Subjects was obtained from each subject prior to data collection.

Procedure

1. Obtain consent of health care provider.

2. Obtain informed consent of subject.

3. Perform Leopold's maneuvers to determine fetal lie and position.

4. Perform vaginal examination to determine station of the presenting part and the status of the membranes (the method was found to work better if the presenting part was above the spines). To reduce potential risks and unnecessary discomforts to the subject, this examination was conducted as part of a routine examination deemed necessary by the care provider for the safe conduct of the labor.

5. Palpate the pubic crest and mark the skin over this point with a washable pen.

6. Palpate and mark the most superior point of the uterine fundus.

7. Find and mark the endpoints of the widest transverse diameter of the uterus.

8. Using the marks for reference, measure the fundal height and transvers diameter of the uterus with the caliper while the uterus is relaxed.

9. Repeat step 8 during a contraction.

10. Repeat steps 8 and 9 using a tape measure instead of a caliper.

11. Measure the double abdominal wall thickness.

12. Calculate the corrected average diameter of the uterus with the equation: $\underline{D} = (\underline{L} + \underline{T})/2 + (2 - \underline{A})$ where $\underline{D}$ is the corrected average diameter, $\underline{L}$ is the longitudinal diameter, $\underline{T}$ is

the transverse diameter and $\underline{A}$ is the double abdominal wall thickness.

13. Calculate the estimated birthweight using Polous and Langstadt's equation: $\underline{W} = 1870 + 0.11(\underline{D})^3$ where $\underline{W}$ is the estimated birthweight and $\underline{D}$ is the corrected average diameter of the uterus.

14. Inform the subject of the estimated birthweight.

15. Obtain the infant's birthweight from the medical record after birth.

CHAPTER III

RESULTS AND CONCLUSIONS

Description of Sample

A total of 10 subjects were studied. They ranged in age from 19 to 34 with an average of 25.4 years. There were three nulliparas, four primiparas and three secundiparas. Gestation ranged from 35 to 42 weeks with an average of 38.7. Cervical dilatation ranged from 1 to 6 with a rounded average of 4 centimeters. Station ranged from -3 to 0 for a rounded average of -1. Membranes were ruptured in 30% of the subjects. Fundal height (by tape measure) ranged from 28 to 41 averaging 35.2 centimeters.

Raw Data

The estimate, birthweight and difference between the estimate and birthweight are listed for each case in Table 2. The estimates ranged from 3439 g to 4840 g with an average of 4177 g and a standard deviation of 379 g. The birthweights ranged from 2070 g to 4310 g with an average of 3353 and a standard deviation of 807. The difference ranged from 40 g to 1847 g averaging 824 g with a standard deviation of 575 g.

Statistical Analysis

The data were analyzed utilizing an Apple II Plus computer.

Table 2

Summary of Estimates, Birthweights
and Differences
(in grams)

Number	Estimated	Birthweight	Difference
1.	3976	3690	286
2.	4416	3960	456
3.	4158	3520	638
4.	3439	2110	1329
5.	3917	2070	1847
6.	4350	4310	40
7.	4035	2950	1085
8.	4484	4220	264
9.	4158	2940	1218
10.	4840	3760	1080

Programming for the analysis was written by the principle investigator in the computer language UCSD Pascal II.1 (Apple Computer Inc., 1979).

Pearson's Coefficient of Correlation

Comparing the two variables estimate and birthweight, a value of 0.6831 was obtained for Pearson's *r*. This value is less than 0.95, the specified level of significance.

Reliability Coefficient

This statistic is calculated as the dividend of the variance of the birthweight and the variance of the estimate. The calculated value was 0.2206 which was far short of the specified level of significance.

Student's t-test

The value of *t* for the paired two tailed test was 4.52. At the 0.05 alpha risk level for 9° of freedom the critical value of *t* was 2.26 (Polit & Hungler, 1979, p. 647). Since the critical value of *t* was exceeded, the null hypothesis could not be rejected.

Criteria Based Reliability

Four out of 10 estimates met the criteria of falling within ± 500 grams of the birthweight. By converting to a standard *Z*-score, a confidence interval of 0.2877 was obtained (Selby, 1967). The value was far below the specified confidence level of 0.95.

Conclusions Relative to Research Questions

1. The uniform failure of the method to pass even one of the statistical tests indicates that Polous and Langstadt's method is inaccurate for estimating the birthweight of normal infants.

2. Subjects four and five weighed less than 2500 g. Data on Table 2 indicate that the greatest error in the estimates occurred in these two subjects. The error in subject number five exceeded 4 pounds. The magnitude of the errors in these two subjects casts considerable doubt on the accuracy of the method particularly as it pertains to those infants weighing less than 2500 g.

3. None of the infants studied weighed more than 4500 g, however, two of the infants weighed more than 4000 g. For these infants the smallest error was encountered. In subject eight the error was 264 g while in subject six the error was only 40 g. The apparent accuracy of the method in large infants may be a probabilistic fluke. The average estimate was 4177 g while the average birthweight was 3353 g. Since the estimates all tended to be high, it is more probable that the estimates would be closer in the larger babies.

4. The many inaccuracies revealed in the method render it too unreliable to form a basis for clinical judgment.

Limitations of the Study

The primary limitation is the small sample size. Part of this limitation is resolved by the use of the *t*-test, a small sample statistic. The absence of any infants weighing more than

4500 g limits the inferences which can be made regarding that group of infants. All of the observations were made by the principle investigator, the use of only one observer has a positive effect on the internal validity of the study, but a negative effect on the external validity of the study.

CHAPTER IV

DISCUSSION, RECOMMENDATIONS, AND IMPLICATIONS

Many methods for estimating fetal birthweight have been examined. Simple abdominal palpation is inadequate because subjectivity in the form of wishful thinking tends to bias the estimate towards normalcy. McSweeny's method and Johnson and Toshach's method have not stood up to testing, and now Polous and Langstadt's method has been shown to be inaccurate. The reasons for this inaccuracy are not entirely clear. It is possible that there are more variables involved in the calculation of uterine volume than are readily apparent. Variations in measurement, volume of amniotic fluid, placental mass and other factors may be so great as to undermine the basic assumptions of the method. The greatest inaccuracies were found in the smallest infants. One possible explanation may be that the volume of amniotic fluid steadily decreases as a pregnancy approaches term. Therefore, the ratio of amniotic fluid to fetus is greater in premature infants than in term infants. The transverse measurement of the uterus may be contributing to the error. A large portion of this measurement consists of fetal small parts, amniotic fluid and maternal soft tissue. The error introduced by these extraneous items in the measurement is compounded by the equation for the estimate because the transverse measurement is effectively squared. The equations developed by Polous and Langstadt were based on a selected sample of 21 subjects which contained no infants weighing less than 2500 g. The absence of small infants in their sample may have been a source of error in the equation.

Attempts were made to correct Polous and Langstadt's equation to make it more accurate. Polous and Langstadt did not include a means to correct for descent of the fetus into the maternal pelvis. Both the method of McSweeny and the method of Johnson and Toshach included such a correction term. A computer program was written to recalculate the birthweight to include a correction term for station. However, it failed to improve the accuracy of the estimate. An attempt was made to correct the estimate by basing the uterine volume calculation on the equation for a prolate spheroid rather than the equation for a sphere. As Polous and Langstadt found, this maneuver only made the estimates less accurate.

Other variables were examined to determine if they were in any way related to the accuracy of the estimate. Maternal age, weight gain, obesity, parity, cervical dilatation, effacement, station and status of membranes were all unrelated to the accuracy of the estimate. The only variable related to the accuracy of the estimate was the birthweight of the fetus. In general, the more the fetus weighted, the more accurate was the estimate.

Polous and Langstadt's method was compared with other methods for accuracy. Recalculating the estimate using McDonald's rule (1906) yielded quite surprising results. Eighty percent of the estimates obtained by this method fell within ± 500 g of the birthweight. Converting to standard *Z*-scores, a confidence interval of 89% (0.8932) was obtained! The average error between the estimate and the birthweight was -121 g with a standard deviation of 286 g. An estimate calculated by Johnson and Toshach's method yielded similar results with a confidence interval of 86%. On the basis of this sample, McDonald's elegantly simple method appears to be remarkably accurate, particularly when compared to Polous and Langstadt's method.

Recommendations

It is recommended that studies continue into methods for accurately estimating fetal birthweight. Such methods should be simple, convenient, require no highly specialized equipment, offer no harm to the gravida and her fetus and be accurate enough to form a reasonable basis for clinical judgment. Future researchers testing Polous and Langstadt's method may wish to consider that the transverse diameter of the uterus is given an inordinate amount of weight in the calculation. A possible approach might be to apply pressure to the uterus while it is being measured transversely so that the measurement more accurately reflects a measurement of the fetus rather than amniotic fluid or maternal soft tissue.

Nursing Implications

Nurse-midwives and nurses caring for laboring women must make management decisions on the basis of their assessments. Estimating fetal birthweight by abdominal palpation can be misleading, yet, none of the methods examined have proven to be superior to this time honored technique. Loeffler (1967) demonstrated that care providers can improve the accuracy of their abdominal palpation estimates by practicing. In his study, a log book was used to record all estimates of birthweight. The care providers were encouraged to compare their estimates with the birthweights of the infants. Over the course of time, it was observed that the estimates became more accurate. Therefore, every nurse and nurse-midwife involved in the care of laboring women should practice this vital assessment skill so that their estimates become accurate enough to form a meaningful basis for clinical judgment.

APPENDIX

Data Collection Sheet

Name ______________________ Age _____ Parity __________________

Admission Weight _____ Weight Gain _____ Height _________________

Birthweights of previous children #1 _____ #2 _____ #3 _____ #4 ____

#5 _____ #6 _____ #7 _____ Estimated gestation ___________________

Abdominal evaluation: Lie ____________ Position ________________

Vaginal Examination: Dilatation_____ Effacement_____ Station_______

Suspect multiple gestation? yes _____ no _____

Selected for study? yes _____ no _____ membranes _________________

Measurements

	Contracted	Relaxed
Caliper		
Longitudinal	_______cm	_______cm
Transverse	_______cm	_______cm
Tape Measure		
Longitudinal	_______cm	_______cm
Transverse	_______cm	_______cm

Double abdominal wall thickness _____

Corrected average diameter $D = (L + T)/2 + (2 - A)$ ________________

Estimated birthweight $W = 1870 + 0.11(D)^3$ _________________________

Recorded birthweight ______________________

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