The fetal-pelvic index has minimal utility in predicting fetal-pelvic disproportion

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OBJECTIVE: Our purpose was to evaluate the fetal-pelvic index in our patient population and to determine whether it would be predictive of route of delivery.

STUDY DESIGN: One hundred seventy-six patients with a previous history or clinical findings in the current pregnancy suggestive of fetal-pelvic disproportion participated in this Human Investigation Committee–approved study. All underwent fetal ultrasonographic examinations and modified digital radiography before labor. Fetal head and abdominal circumferences and maternal inlet and midpelvic circumferences were determined, and the fetal-pelvic index was calculated.

RESULTS: Ninety-one patients fulfilled all aspects of the study, including rigorous criteria pertaining to labor management. Thirty of these patients underwent cesarean delivery and 61 were delivered vaginally. The fetal-pelvic index value for the vaginal delivery group was –5.4 ± 5.3, as opposed to –2.4 ± 5.8 in the cesarean delivery group ($P < .02$). Notwithstanding this difference, the fetal-pelvic index had a low overall ability to predict fetal-pelvic disproportion (0.65) and had associated sensitivity and specificity of 0.27 and 0.84, respectively. Predictive thresholds other than zero were tested, but optimal predictive ability, at a fetal-pelvic index cutoff of 2, was only 70% (sensitivity 0.20, specificity 0.95).

CONCLUSION: In our patient population the fetal-pelvic index was only moderately predictive of fetal-pelvic disproportion. Factors other than those assessed by the fetal-pelvic index are probably important in determining the route of delivery. Further studies are indicated. (Am J Obstet Gynecol 1998;179:1186-92.)

Key words: Cesarean delivery, fetal-pelvic disproportion, fetal-pelvic index, pelvimetry

Obstetricians have long desired the ability to accurately predict the presence or absence of fetal-pelvic disproportion and consequently select the optimal route for delivery. Clinical estimates of fetal weight and pelvic capacity have been useful only to a limited degree.[1] Ultrasonographic estimates of fetal weight have lacked discriminatory ability to predict fetal-pelvic disproportion and the ideal method for delivery.[2, 3] Fine et al[4] and Laube et al[5] evaluated the usefulness of x-ray pelvimetry, but neither investigator found radiographs to be of benefit in predicting the route of delivery or in formulating plans for clinical management.

Jagani et al[6] also studied x-ray pelvimetry but also took birth weight into consideration. Unfortunately, they found that pelvic measurements and birth weight "did not provide a predictive tool for delivery outcome in at least 95% of laboring women."[6] They recommended abandoning the term "cephalopelvic disproportion" in favor of "fetopelvic disproportion," emphasized the importance of fetal abdominal dimensions, and predicted that ultrasonographic estimates of fetal size coupled with x-ray pelvimetry might be productive.

Morgan et al[7] immediately understood the importance of the concepts proposed by Jagani et al[6] and explored a novel standardized method to discover fetal-pelvic disproportion by comparing fetal head and abdominal circumferences with the respective maternal inlet and midpelvic circumferences. They termed this the *fetal-pelvic index*.[7] The preliminary report on the fetal-pelvic index was based on a sample of patients at increased risk for fetal-pelvic disproportion and the need for cesarean delivery. The technique was subsequently evaluated by 2 of the original investigators (Morgan and Thurnau) in other patient populations at increased risk, including patients with pregnancies complicated by macrosomia,[8] labor induction,[9] abnormal labor patterns requiring labor augmentation,[10] and vaginal birth after previous ce-

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sarean delivery[11] and also among nulliparous women at high risk for fetal-pelvic disproportion.[12] The authors used a fetal-pelvic index cutoff value of 0 and predicted fetal-pelvic disproportion in patients with a value >0 and absence of fetal-pelvic disproportion in those with a value <0. Overall the test was highly predictive (0.94), and the authors stated, "To confirm these preliminary observations, data from a large number of patients and studies from other investigators are necessary."[8]

In 1993 the cesarean delivery rate at our hospital had increased to 31%, in part because of cesarean deliveries performed without a trial of labor in patients for whom the fetal-pelvic index appeared to demonstrate usefulness. We were therefore anxious to evaluate the fetal-pelvic index at our hospital, yet we had reservations because of the radiation dose associated with x-ray pelvimetry.[13, 14] To assuage our concern about radiation exposure with x-ray pelvimetry, we developed a modified technique of digital radiographic pelvimetry, and by use of thermoluminescent dosimeters we found that we could accurately determine pelvic measurements yet deliver only minimal radiation to the fetus.[15] We then sought to undertake an evaluation of the fetal-pelvic index, as recommended by Morgan and Thurnau.[8] Our purpose in this study was to evaluate the fetal-pelvic index in our patient population and to determine whether it would be predictive of the route of delivery.

Material and methods

Between June 1994 and January 1998, 176 patients with a previous history or clinical findings in the current pregnancy suggestive of fetal-pelvic disproportion were invited to participate and accepted. Information pertaining to the study recruitment was distributed to faculty and resident physicians and nurse practitioners who provided obstetric care at the University of Virginia, and these providers were encouraged to prospectively enroll their patients. The study was approved by the Human Investigation Committee at the University of Virginia Health Sciences Center.

Eligibility criteria included cephalic presentation at a gestational age between 37 and 41 weeks with any of the following criteria: (1) history of or suspected macrosomic infant (≥4000 g), (2) small bony pelvis according to clinical examination, (3) history of shoulder dystocia, (4) nulliparity with a gestational age ≥41 weeks and a station of the presenting vertex higher than –2/5; and (5) a history of cesarean delivery for fetal-pelvic disproportion in a patient who wanted a vaginal birth. Patients were not eligible for the study in cases of multiple gestation or nonvertex presentation, if they were not candidates for vaginal delivery (eg, placenta previa or previous cesarean delivery other than low transverse), if they were minors, or if they could not provide informed consent.

Patients enrolled in the study were counseled and informed consent was obtained. Ultrasonography was performed in the department of radiology before active labor by a radiologist who knew only that the subject was a "study patient" but was unaware of the patients' eligibility criteria. Methods previously published were followed in exacting detail to calculate circumferences of the fetal head and abdomen[7] and to determine estimated fetal weights both on the basis of biparietal diameter and abdominal circumference[16] and on the basis of femur length and abdominal circumference.[17]

Table I. Inclusion criteria for patients who could be evaluated

Criterion for inclusion	*No.*
Previous difficult delivery related to shoulder dystocia	3
Previous cesarean delivery for fetal-pelvic disproportion	46
Clinically small pelvis	9
History of macrosomia or suspected macrosomia	13
Nulliparity, ≥41 weeks' gestation, and vertex at –2/5 or higher	20

Modified digital radiographic pelvimetry was performed according to previously developed guidelines[15] in the radiology department within the last 2 weeks of gestation to determine the anteroposterior and transverse diameters of the inlet and midpelvis by means of the bony landmarks reported by Colcher and Sussman.[18] After our initial experience with modified digital radiography we consulted with Dr Gary Thurnau, and at his recommendation we modified the measurement of the anteroposterior diameter of the inlet so that it measured the shortest distance from the posterior aspect of the symphysis pubis to the sacral promontory or sacrum, exactly replicating the measurement technique used by the original investigators.[7] All films were independently reviewed by 3 different authors to ensure accuracy. Labor was managed at the discretion of the patient's faculty physician or of a resident physician under direct faculty supervision. As a condition for the study the Human Investigation Committee recommended that the ultrasonographically determined estimated fetal weight and standard pelvic diameters (anteroposterior and transverse diameters of the inlet and midpelvis) obtained by modified digital radiography be made available to clinicians managing the patient's labor. The clinicians were blinded to the fetal-pelvic index value, which was calculated after discharge by a nurse practitioner (Y.G.N.) who was blinded to the clinical outcome. For inclusion in the study an adequate trial of labor was required, defined as (1) uterine contractions of ≥50 mm Hg in intensity and ≥60 seconds in duration as measured by intrauterine pressure catheter, (2) a frequency of ≥3 contractions in 10 minutes, and (3) cervical dilatation to ≥5 cm for ≥2 hours.[7] Cesarean deliveries were performed on those pa-

Table II. Patient characteristics

	Cesarean delivery (n = 30)	*Vaginal delivery (n = 61)*	*Statistical significance**
Age (y)	25.3 ± 5.8	23.2 ± 5.6	NS
Parity	0.47 ± 0.7	0.9 ± 0.9	NS
Gestation (wk)	40.3 ± 1.4	40.1 ± 1.4	NS
Maternal weight† (lb)	213.5 ± 38.7	198.4 ± 41.3	NS
Weight gain‡ (lb)	38.3 ± 35.0	38.7 ± 56.7	NS
Race			NS§
White	26	42	
Black	4	19	

Values are mean ± SD. *NS,* Not significant.
*By independent group *t* test.
†Values are derived from different sample sizes because weight within 1 week of delivery was unavailable for 2 patients in each group (n = 28 for cesarean delivery and n = 59 for vaginal delivery).
‡Values are derived from different samples because overall weight gain was not available for 9 patients in cesarean delivery group and 15 in vaginal delivery group (n = 21 for cesarean delivery and n = 46 for vaginal delivery).
§By χ^2 test, 1 degree of freedom.

Table III. Labor characteristics

	Cesarean delivery (n = 30)	*Vaginal delivery (n = 61)*
Type of labor		
Spontaneous	2	23
Induced	21	28
Augmented	7	10
Maximum oxytocin dose (mU/min)	6.6 ± 5.5 1	10.4 ± 4.6*
Epidural (No.)	28	50

*P = .0001 by independent group *t* test.

tients when these criteria were met but there was no progress in labor and fetal-pelvic disproportion was clinically determined.[7]

After delivery, fetal and bony measurements were used to calculate head circumference and abdominal circumference of the fetus and inlet circumference and midpelvic circumference of the maternal pelvis according to the precise methods reported by Morgan et al.[7] On the basis of the 4 circumference differences between the fetus and the maternal pelvis (cephalopelvic differences of head circumference minus inlet circumference and head circumference minus midpelvic circumference and abdominopelvic differences of abdominal circumference minus inlet circumference and abdominal circumference minus midpelvic circumference), a fetal-pelvic index was derived from the sum of the 2 most positive differences in circumference (a positive number indicates presence of fetal-pelvic disproportion and a negative number indicates absence of fetal-pelvic disproportion).[7] For comparative data we also analyzed the ability of ultrasonographically derived estimated fetal weight[16, 17] and modified digital pelvimetry according to the Colcher-Sussman criteria[18] and Mengert's criteria[19] to predict fetal-pelvic disproportion.

Data analyses were performed by means of the χ^2 analysis, the Fisher exact test, and the Student *t* test with the SAS system (SAS Institute Inc, Cary, NC). Sensitivity, specificity, positive and negative predictive values were calculated in the standard fashion. The performance of the fetal-pelvic index was also investigated by means of a variety of cutoff scores other than the value of zero reported by Morgan et al.[7]

Results

Of the 176 patients who enrolled in the study, 85 were excluded for the following reasons: 29 for failure to obtain ultrasonographic or computed tomographic pelvimetric measurements before labor, 49 (with ultrasonographic and pelvimetric measurements obtained) for cesarean delivery performed by the physician with inadequate or no trial of labor, 6 for incomplete penetration of digital radiographic pelvimetry as a result of obesity, and 1 as a result of incorrect pelvimetry technique. Inclusion criteria for the 91 patients who could be evaluated are depicted in Table I.

Patient characteristics are shown in Table II. There were no significant differences in age, parity, gestation, maternal weight, maternal weight gain during pregnancy, or race between patients who underwent cesarean delivery and those who were delivered vaginally. Most patients were moderately obese and 25% were African American.

Table III describes the type of labor and use of epidural treatment during labor in the cesarean and vaginal delivery groups. In the cesarean delivery group labor inductions were performed for the following reasons: postdate pregnancy (n = 15), suspected macrosomia (n = 3), pregnancy-induced hypertension (n = 1), and spontaneous rupture of membranes at term without labor (n = 2). In the vaginally delivered group inductions were performed for the following reasons: postdate pregnancy (n = 16), suspected macrosomia (n = 5), pregnancy-induced hypertension (n = 3), history of shoulder

Table IV. Fetal and maternal measurements

	Cesarean delivery (n = 30)	*Vaginal delivery (n = 61)*	*Statistical significance**
Birth weight (g)	3792 ± 440	3555 ± 474	*P* = .02
Ultrasonography			
Fetal head circumference (cm)	34.3 ± 2.3	33.6 ± 4.6	NS
Fetal abdominal circumference (cm)	35.2 ± 2.3	34.3 ± 4.9	NS
Digital radiographic pelvimetry			
Maternal pelvic inlet circumference (cm)	40.8 ± 2.6	39.9 ± 5.9	NS
Maternal midpelvic circumference (cm)	36.4 ± 2.4	36.8 ± 5.4	NS
Fetal-pelvic index	–2.4 ± 5.8	–5.4 ± 5.3	*P* = .02

Values are mean ± SD. *NS,* Not significant.
*By independent group *t* test.

Table V. Test performance

	Cesarean delivery (No.)	*Vaginal delivery (No.)*	*Sensitivity*	*Specificity*	*Predictive power*	*Statistical significance**
Ultrasonographic estimated fetal weight			0.17	0.90	0.66	NS
>4100 g	5	6				
<4100 g	25	55				
DR pelvimetry (Colcher-Sussman)			0.07	1.0	0.7	NS
Contracted	2	0				
Adequate	28	61				
DR pelvimetry (Mengert)			0.10	0.98	0.7	NS
Contracted	3	1				
Adequate	27	60				
Fetal-pelvic index			0.27	0.84	0.65	NS
Positive	8	10				
Negative	22	51				

NS, Not significant; *DR,* digital radiographic.
*By χ^2 test, 1 degree of freedom.

dystocia (n = 3), and suspected intrauterine growth restriction (n = 1). Thus the overall cesarean section rate for this study was 33% compared with 26% for the institution during the same interval.

In Table IV actual birth weights are compared between patients who underwent cesarean delivery and those who were delivered vaginally. As might be expected, birth weight of babies born by cesarean delivery was larger (by 238 g) than that of babies delivered vaginally ($P < .02$). There was no significant difference in the fetal head or abdominal circumference or maternal pelvic inlet or midpelvic circumference between babies born by cesarean delivery and vaginally delivered babies. The fetal-pelvic index value demonstrated a significant difference, with the vaginally delivered group having a more strongly negative (predictive of absence of fetal-pelvic disproportion) value ($P < .02$). There were 2 cases of shoulder dystocia in this study; each resolved with appropriate maneuvers without neonatal sequelae. One of these patients had a negative fetal-pelvic index value and a 4850-g infant; the other had a positive fetal-pelvic index value and a 3665-g infant.

We also compared estimated fetal weights obtained by the femur length/abdominal circumference and biparietal diameter/abdominal circumference ratios to the actual birth weights. Both predictive formulas were highly correlated with actual birth weight ($r = 0.73$) and with each other ($r = 0.86$). Differences between predicted and actual birth weights were in the range of –30 to –70 g.

Table V shows the performance of the fetal-pelvic index as a predictor of cesarean versus vaginal delivery. Table V also shows the performances of an estimated fetal weight threshold of 4100 g and of previously used parameters of pelvic contraction.[18, 19] As can be noted, none of the indexes demonstrated high levels of accurate prediction. In particular, sensitivity values for all indexes were low, indicating that most cesarean deliveries were not accurately predicted by the indexes.

Next we assessed the performance of the fetal-pelvic index with predictive cutoffs other than the value of zero employed by Morgan et al.[7] Results are shown in Fig 1, which illustrates changes in the overall predictive power of the index for all possible thresholds. Predictive power increases to about 70% (sensitivity 20%, specificity 95%) at a fetal-pelvic index value of 2 and declines again for values >7.

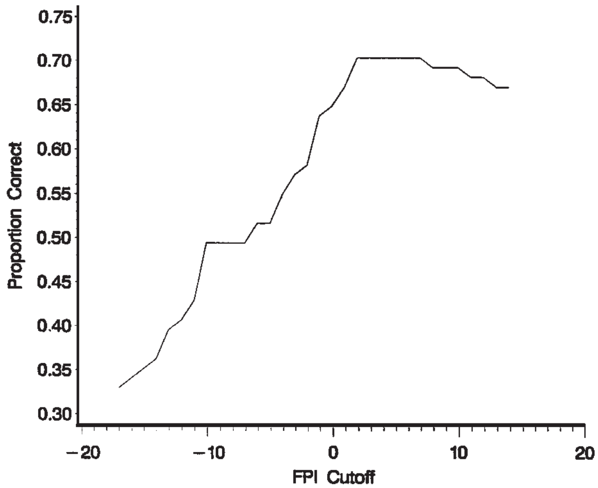

Fig 1. Total proportion of correct predictions of cesarean and vaginal delivery for different cutoffs of the fetal-pelvic index *(FPI).* Maximum predictive power of 70.5% was achieved for cutoffs ranging from a fetal-pelvic index of 2 to a fetal-pelvic index of 7.

Comment

In this study we prospectively evaluated the fetal-pelvic index and its ability to predict fetal-pelvic disproportion. Our data confirmed previous reports[2-12] in which it was shown that estimated fetal weight and measurements of pelvic bony diameters have low sensitivities for the detection of fetal-pelvic disproportion when used alone. The poor performance of estimated fetal weight and bony measurements alone should not be unexpected, because these measures take into account only the "passenger" and the "passage," respectively, ignoring the corresponding variable and, in both instances, the "power." The fetal-pelvic index does take into account aspects of both the passenger and the passage; however, we did not find the fetal-pelvic index to be as accurate in predicting fetal-pelvic disproportion as did Morgan and Thurnau.[7-12] In their studies the fetal-pelvic index was highly sensitive (range 0.72-0.92) and specific (range 0.71-1.0) and had positive and negative predictive powers between 0.67 and 1.0 and between 0.81 and 0.95), respectively, in determining cesarean versus vaginal (operative and spontaneous) delivery.

To investigate whether differences between our results and those of Morgan and Thurnau[7-10, 12] and Thurnau et al[11] may have been influenced by sampling error, we constructed bootstrap confidence intervals around our results using methods described by Efron and Tibshirani.[20] Five hundred random samples of size n = 91 were drawn with replacement from our sample. Sensitivity, specificity, and predictive power were computed in each random sample. The distribution of these parameters across samples estimates their sampling distrubtion and can be used to construct empiric confidence intervals around our estimates. The 95% confidence interval around our estimate for total predictive power was 57%-73%; the corresponding interval for sensitivity was 14%-47%, and for specificity it was 76%-93%. These intervals suggest that the relatively poorer performance of the fetal-pelvic index in our sample is not the result of random differences in sampling.

The reason for the limited success reported here for the fetal-pelvic index in prospectively identifying fetal-pelvic disproportion is not known with certainty. We followed the study design and conduct of the original reports as accurately as possible, as can be recognized from our inclusion and exclusion criteria; our definition of adequate labor; the formulas used to calculate the fetal and pelvic circumferences, estimated fetal weight, and fetal-pelvic index; and all other aspects of the study. The fetal-pelvic index was unknown to clinicians managing the patient's care and was in fact calculated only after delivery and patient discharge. Ultrasonographically derived estimated fetal weights and pelvimetric measurements were determined by radiologists who were unaware of the patient's study criteria and plan of management. Although the estimated fetal weight and pelvic diameters were made available to the physicians managing the labor, it is unlikely that this information would have affected labor management or study outcome, because inclusion in our analysis required patients to undergo the prescribed rigorous trial of labor. We believe that we faithfully replicated the original studies and performed a thorough and unbiased evaluation of the fetal-pelvic index technique in our patient population.

Interestingly, when the actual birth weights, head circumferences, and abdominal circumferences of the fetuses in the cesarean and vaginal delivery groups from this study were compared with those of the appropriate groups as reported by Morgan et al,[7] they were found to be almost identical. In our study the inlet and midpelvic circumferences were not different when the cesarean delivery group was compared with the vaginally delivered group. In the initial study by Morgan et al,[7] however, both the inlet and midpelvic circumferences of the cesarean group were slightly but significantly smaller than the corresponding measurements of the group who were delivered vaginally. Smaller pelvic circumferences in the cesarean delivery group would make the fetal-pelvic index value more likely to be positive and thus indicate fetal-pelvic disproportion. One possible explanation for the limited success of the fetal-pelvic index we report could therefore relate in part to the pelvic measurements (or actual dimensions) of patients in this study compared with those in the previous studies. Refuting this as the total explanation, however, is the finding in 2 subsequent trials by Morgan and Thurnau[8, 9] of no significant difference in the inlet pelvic circumferences between cesarean and vaginally delivered patient groups yet persistent predictability by the fetal-pelvic index.

We used modified digital radiographic pelvimetry to measure the bony pelvis to minimize radiation exposure to the fetus. Our previous work indicated that radiation exposure was significantly less to the fetus after modified digital radiography (55 ± 24 mrad)[15] than that expected from standard x-ray pelvimetry (885 ± 111 mrad).[21, 22] Additionally, digital radiographic pelvimetry has been shown to have an accuracy in bony mensuration of ± 1%, versus ± 10% for x-ray pelvimetry.[23] Gimovsky et al[24] also evaluated digital radiographic pelvimetry in comparison with x-ray pelvimetry, and they likewise reported that x-ray pelvimetry was not as accurate as digital radiography and that x-ray pelvimetry appeared to overestimate bony pelvic measurements in comparison. It is noteworthy that the inlet and midpelvic circumferences we report in the group delivered vaginally are nearly identical to those in the vaginally delivered group reported on by Morgan et al,[7] indicating overall comparability of measurement techniques and further demonstrating accuracy. In the studies of Laube et al[5] and Jagani et al,[6] patients at risk for fetal-pelvic disproportion were studied with x-ray pelvimetry. These investigators found, as did we, that there was no significant difference in any pelvic diameter between patients who were delivered vaginally and those who were delivered abdominally. We therefore believe that the differences in bony measurements and the possible consequent effect of the calculated fetal-pelvic index are more likely to be reflective of inherent differences in patient populations. For instance, it is well known that different races have different pelvic types. Racial proportions in studies were not reported on by Morgan et al,[7-12] and they may well have differed between our study and those previously reported, thus contributing to the difference in test performance.

To examine possible differences between our sample and those employed by Morgan et al,[7] we restricted our sample to only those patients receiving negative fetal-pelvic index scores, indicative of absence of fetal-pelvic disproportion. Among this selected sample we compared patients who were delivered vaginally, in accordance with fetal-pelvic index–based predictions, with patients who underwent cesarean delivery, contrary to fetal-pelvic index predictions. The groups were compared on all patient characteristics, labor variables, and fetal and maternal measurements listed in Tables II, III, and IV. The only variables on which these 2 groups differed significantly were parity (vaginal delivery patients were more parous) and age (vaginal delivery patients were younger).

Additional factors that may affect the probability of fetal-pelvic disproportion, route of delivery, or both could likewise differ between study populations. These factors could include force of uterine activity, maternal weight, maternal weight gain during pregnancy, fetal sex, parity, age, vaginal and pelvic soft-tissue resistance or obstruction, epidural use, ambulation during labor, moldability of the fetal head, and minor and major degrees of malposition and asynclitism. In our patient population, and perhaps in others,[5, 6] these factors may be more of a determinant for the route of delivery than are those quantified by the fetal-pelvic index, thus explaining how the fetal-pelvic index could be useful in a given population of patients yet not in another. Further support for this viewpoint derives from clinical experience and from reports documenting fetal-pelvic disproportion and the need for cesarean delivery in an initial pregnancy followed by successful vaginal delivery of fetus of equal or greater size in a subsequent gestation.[6, 25, 26]

We sought to determine the role of the fetal-pelvic index in our patient population. Apart from reports by the original investigators, we could find no additional studies evaluating the fetal-pelvic index. In this initial corroborative trial we found the fetal-pelvic index to be only moderately predictive of fetal-pelvic disproportion and the need for cesarean delivery in our patient population. The fetal-pelvic index did perform better than either estimated fetal weight or bony measurements alone, indicating the need to evaluate the fetus with respect to the maternal bony pelvis. We believe that additional trials with digital radiographic pelvimetry or magnetic resonance imaging should be undertaken by other investigators to further evaluate the concept and the predictive value of the fetal-pelvic index. In such trials other factors also known to affect the route of delivery should be carefully evaluated to determine their contributions relative to those represented by the fetal-pelvic index.

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