Ponderal index of large-for-gestational age infants: comparison between infants of diabetic and non-diabetic mothers

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SUMMARY: Armangil D, Yurdakök M, Korkmaz A, Yiğit Ş, Tekinalp G. Ponderal index of large-for-gestational age infants: comparison between infants of diabetic and non-diabetic mothers. Turk J Pediatr 2011; 53: 169-172.

Ponderal index (PI) is a weight-height related parameter that is mainly used to assess the pattern of fetal growth in small-for-gestational age infants. We aimed to use PI for large-for-gestational age (LGA) infants who were born to diabetic or non-diabetic mothers, in order to predict the fetal growth pattern. One hundred sixty-six LGA infants born at the Department of Obstetrics, Hacettepe University Hospital, Ankara, Turkey were included in the study. The PI was calculated by using the following formula: PI = weight (g) x 100/(height, cm)^3. Sixty-seven (40%) of these infants were born to diabetic mothers. Maternal age, maternal weight and maternal weight gain during pregnancy were similar in the diabetic and non-diabetic groups. Mean birthweight, height and head circumference were similar in both groups, but median PI of infants of diabetic mothers was significantly higher than of infants of non-diabetic mothers (3.02 and 2.89, respectively, $p<0.05$). Fetal growth was different between LGA infants of diabetic and non-diabetic mothers, and PI provided useful information on the proportionality of fetal growth in LGA infants.

Key words: large-for-gestational age infants, ponderal index.

Fetal growth depends on a series of mechanisms, with transplacental fuel transport, uteroplacental flow, hormones of the fetoplacental unit, and genetic factors being considered the most important[1]. In healthy pregnant women, characteristic changes in maternal metabolism provide nutrients for fetal growth in addition to maternal and fetal energy requirements[2].

Maternal diabetes is an important risk factor that is associated with fetal overgrowth and macrosomia. Macrosomia is defined as a birth weight >4000 g[3] and is associated with important neonatal morbidity, such as birth trauma, neonatal hypoglycemia, other neonatal complications, and mortality[4,5]. However, most of the large-for-gestational age (LGA) and macrosomic infants are born to non-diabetic mothers[3,4].

There is an increased incidence of macrosomia, not only in pregnant women who equal or exceed the threshold values defining gestational diabetes on an oral glucose tolerance test, but also among women exhibiting lower degrees of glucose intolerance[6]. The ponderal index (PI) is generally used to determine "proportionality" in small-for-gestational age infants. Early intrauterine adverse insults leading to fetal growth restriction or genetic disorders usually result with proportionately small fetuses. In these infants, head circumference, length and weight are all proportionately reduced for gestational age. However, adverse intrauterine insults in late pregnancy usually result in a disproportionally small fetus with reduced birth weight and relatively normal height and head circumference[7]. However, to our knowledge, no study has focused on PI values of LGA infants with and without maternal diabetes.

The purpose of this investigation, therefore, was to calculate PI values in LGA infants with and without maternal diabetes to determine any correlation between them.

Material and Methods

One hundred and sixty-six LGA infants born in Hacettepe University Hospital, Ankara, Turkey

were included in the study. LGA infants were divided into two groups as: Group 1, infants of non-diabetic mothers and Group 2, infants of diabetic mothers. Infants with congenital and chromosomal anomalies were excluded. Birth weight chart of Fenton was used for this study[8]. Birth weight, length and head circumference were measured with the same digital scale and standard tape measures by the same investigator. Gestational ages were recorded as completed weeks. The PI was calculated according to the formula[9]:

PI: birth weight (g) x 100 / [length (cm)]^3

The presence of maternal diabetes (pregestational or gestational) and any neonatal morbidities, such as hypoglycemia, hyperbilirubinemia, polycythemia, respiratory distress syndrome, and shoulder dystocia, and hospital stay were recorded for each infant.

Maternal diabetes was categorized into pregestational diabetes mellitus (PGDM) and gestational diabetes mellitus treated with diet alone (GDOD) or with insulin (GDOI).

All pregnants except pregestational diabetic women underwent 50 g glucose screening test at 24-28 weeks of pregnancy. Diagnostic oral glucose tolerance test was performed in those with serum glucose level >140 mg/dl at the first hour of the screening test. Gestational diabetes was diagnosed in those mothers who had values at least two higher than threshold on the above-mentioned test.

A LGA neonate is defined as an infant with a birth weight of more than 2 standard deviations above the mean birth weight for gestational age or above the 90th percentile on the growth charts[8,9]. This allows for preterm, term and postterm neonates to be designated as LGA. Another common definition is a birth weight of 4000-4500 g or >90% for gestational age after correcting for neonatal sex and ethnicity. Term LGA neonates weighing >4000 g can be described as macrosomic[9-12].

Hypoglycemia was diagnosed in the case of plasma glucose concentrations of ≤45 mg/dl in clinically symptomatic infants[13]. Newborns with serum total bilirubin levels of ≥5 mg/dl and an increase in serum total bilirubin concentration of >0.5 mg/dl/h in the first 24 hours, ≥12 mg/dl on day 2, ≥15 mg/dl on day 3, and ≥17 mg/dl on days 4 and 5 were defined to have significant hyperbilirubinemia[14]. Hematocrit was measured in all neonates at the sixth hour of life and neonatal polycythemia was defined as venous hematocrit >65%[15]. Shoulder dystocia was defined as a failure of delivery of fetal shoulder(s), whether anterior, posterior or both, that required a special maneuver for the delivery of shoulders other than downward traction of the fetal head[16]. The diagnosis of respiratory distress syndrome was defined by the presence of typical radiologic and clinical signs including tachypnea, grunting, cyanosis, and retractions[17].

The Statistical Package for Social Sciences (SPSS version 11.5) for Windows was used for calculations. Measurements were compared statistically with t-test, and PI values were tested by Mann-Whitney U test.

Results

A total of 166 LGA infants were included in the study. Ninety-nine of the mothers were healthy while the remaining 67 were diabetic.

Table I. Comparison of Demographic and Clinical Characteristics of LGA Infants of Non-Diabetic (Group 1) and Diabetic Women (Group 2)

	Group 1 n=99	Group 2 n=67	p
Maternal age, year	31.2 ± 4.8	31.8 ± 5.1	>0.05
Maternal body weight, kg	79.6 ± 11	80.6 ± 10.8	>0.05
Maternal BMI, kg/m^2	29.3	29.9	>0.05
Gestational age, week	38.3 ± 1.5	38.2 ± 1.8	>0.05
Birthweight, g	3927 ± 210	3940 ± 165	>0.05
Height, cm	51.4 ± 3.2	51.0 ± 3.5	>0.05
Head circumference, cm	35.7 ± 2.5	35.4 ± 2.8	>0.05
Ponderal index, g x 100/cm^3	2.89	3.02	<0.05

LGA: Large-for-gestational age. BMI: Body mass index.

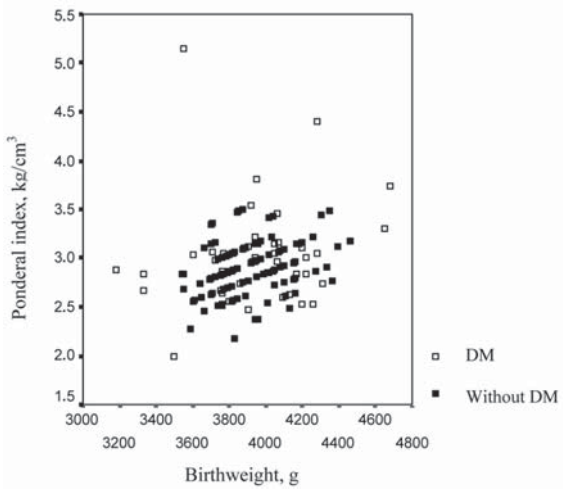

Fig. 1. The distribution of ponderal index and birthweight in LGA infants with (white boxes) and without (black boxes) maternal DM.

Mean maternal age, parity and maternal weight were similar in the two groups. There were no significant differences between the two groups in gestational age and birth weight, height, and head circumference. The median PI of infants of diabetic mothers was significantly higher than that of infants of non-diabetic mothers (3.02 and 2.89, respectively; $p<0.05$) (Table I).

Among diabetic mothers, 10 were PGDM, 23 were GDOI, and the remaining 34 were GDOD. There were no statistically significant differences in PI and neonatal morbidities between these diabetic subgroups. The distribution of PI and birthweight in the LGA infants is given in Fig. 1.

There were significantly higher complications, including hypoglycemia and respiratory distress syndrome, in infants of diabetic mothers ($p<0.05$). The incidences of other neonatal morbidities (such as polycythemia, hyperbilirubinemia and shoulder dystocia) and hospital stay were similar in the two groups ($p>0.05$) (Table II).

Discussion

Maternal hyperglycemia, which is characteristic of diabetes, stimulates the fetal pancreas to produce insulin, which causes excessive growth, or macrosomia, and LGA infants due to maternal diabetes are at higher risk than LGA infants without maternal diabetes for neonatal complications[18].

The incidence of LGA infants is 1-10% of all pregnancies[15]. An unadjusted analysis of mean birth weight and proportions of LGA births and births of ≥4500 g found that the incidence of LGA births rose by 23% during a period of 10 years in Sweden[19]. Researches in North America and Europe show a similar pattern for LGA (>4000 g) related respectively to a decrease in maternal smoking and an increase in body mass index, specifically obesity[20,21].

Fetal mortality is increased when the birth weight is ≥4250 g in nondiabetic patients and ≥4000 g in diabetic patients[22].

The PI provides information on the proportionality of body growth. As such, it allows the estimation of stunting, wasting and overgrowth that have occurred either *in utero* or postnatally[23]. The PI has been shown to vary with the gestational age of the infant[24] and is useful for the identification of growth-retarded infants who are at risk for neonatal morbidities especially in small-for-gestational age neonates[25,26]. However, PI has been never used to assess body growth for LGA neonates. In this study, we found that PI values were greater in LGA infants of diabetic mothers than in non-diabetic LGA infants. We suggest the possibility that insulin may affect birth weight more than length in this population, but further studies are needed to demonstrate this finding.

We observed that PI may also be used for LGA infants to determine additional morbidities such as hypoglycemia, polycythemia and related problems. Because some LGA infants have no clear history or follow-up about maternal diabetes, we recommend evaluating them using the PI; high PI values may inform clinicians about possible neonatal complications related to maternal diabetes. As observed in our findings, LGA infants with maternal diabetes are at high risk of neonatal complications.

In conclusion, we suggest that PI may be used for assessing body proportion in LGA infants and it may estimate higher rates of postnatal complications in the infants of diabetic mothers. The fetal effects of insulin may explain higher PI values in infants of diabetic mothers. Insulin may accelerate the growth of muscle and fat tissues more than bone in the fetus, thus leading to disproportionate LGA infants.

Table II. Neonatal Morbidities in LGA Infants

	Group 1 (n=99)	Group 2 (n=67)	p
Hypoglycemia	22 (22%)	45 (67%)	<0.05
Polycythemia	4 (4%)	6 (8%)	>0.05
Hyperbilirubinemia	19 (19%)	23 (34%)	>0.05
Shoulder dystocia	2 (2%)	3 (4%)	>0.05
Respiratory distress syndrome	5 (5%)	8 (11%)	<0.05
Hospital stay (day)	3.2 ± 2.5	4.8 ± 2.0	>0.05

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