Can a customized standard for large for gestational age identify women at risk of operative delivery and shoulder dystocia?

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Abstract

Objective: To determine whether a customized standard for large for gestational age (LGA) identifies undiagnosed women at risk of operative delivery and shoulder dystocia.

Methods: We previously generated customized standards from our institution. We compared the baseline maternal characteristics and neonatal outcomes between LGA and non-LGA births, which were classified by both population-based and customized standards. The risk of operative delivery (vacuum delivery or emergent cesarean section) and shoulder dystocia was compared by logistic regression analysis in LGA pregnancies that were identified by a population-based birth weight standard and a customized standard after adjusting for maternal age, parity, body mass index, and neonatal gender.

Results: Multivariable analysis revealed that the pregnancies identified as LGA by a customized standard were associated with an increased risk of emergent cesarean section [odds ratio (OR), 4.09; 95% confidence interval (CI), 3.00–5.74] and shoulder dystocia (OR, 10.56; 95% CI, 5.52–20.19). However, there was no association between an increased risk of vacuum delivery (OR, 1.45; 95% CI, 0.92–2.30) and pregnancies identified as non-LGA, using both standards. In addition, customized LGA infants were at increased risk of admission to neonatal intensive care unit (OR 1.63; 95% CI, 1.09–2.43).

Conclusion: A customized standard of LGA is useful in identifying previously unrecognized women at risk of emergent cesarean section and shoulder dystocia.

Keywords: Birth weight; customized birth weight standards; large for gestational age.

Introduction

Currently, the number of large for gestational age (LGA) infants is increasing. This phenomenon leads to subsequent increases in adverse maternal complications and neonatal outcomes [3, 20, 23]. It is well known that mothers with LGA infants are at increased risk of prolonged labor, cesarean delivery, postpartum hemorrhage, infection, deep genital tract laceration, and thromboembolic events [6, 13]. LGA infants are also associated with adverse neonatal outcomes, such as stillbirth, birth asphyxia, shoulder dystocia, birth injury, and meconium aspiration syndrome [6, 28, 29]. Therefore, an accurate identification of LGA fetuses is essential for the prediction and the prevention of adverse pregnancy outcomes.

Nevertheless, a clear definition of LGA and a clinical standard of care for LGA fetuses remain uncertain [13]. Because maternal characteristics, such as maternal age, weight, parity, and underlying diseases, such as diabetes, can influence fetal weight, adverse pregnancy outcomes associated with LGA may be different according to the physical constitution of mothers under the same birth weight. Expectedly, the risk of maternal morbidity would be higher in anthropometrically smaller women than in larger women, with the same fetal weight [3].

Accordingly, the customized growth curves that are adjusted to reflect maternal characteristics and fetal sex have been used more frequently, in recent decades [12, 14, 16, 26, 27, 30]. Several reports demonstrated that customized birth standards are useful in detecting undiagnosed fetal growth restriction (FGR) by a population-based standard and to help to manage FGR [2, 8, 10, 12, 26, 32]. However, the clinical significance of identifying LGA by a customized standard, in association with adverse intrapartum outcomes, has been rarely investigated. One report, written by Larkin et al. [23], showed that the customized standard identified a previously unrecognized population that was at increased risk of perinatal morbidity.

With these backgrounds, we hypothesized that the customized standard for LGA can also identify undiagnosed women at risk of vacuum delivery, cesarean section for cephalopelvic disproportion (CPD), and shoulder dystocia. In this study, we compared the baseline maternal characteristics and neonatal outcomes between LGA and non-LGA births, by both population-based and customized standards. Multivariate
analysis was introduced to assess the risk of vacuum delivery, emergent cesarean section for CPD, and shoulder dystocia in LGA pregnancies that were identified by both standards after adjusting for maternal age, parity, body mass index (BMI), and neonatal gender.

**Materials and methods**

We included 8279 singleton pregnant women who delivered from 37 to 41 weeks of gestation. Because maternal diseases, such as diabetes or hypertension, could influence fetal growth or incidence of shoulder dystocia [5], complicated cases with such diseases and congenital abnormalities were excluded. We also excluded cases with non-Korean mothers.

Previously, we analyzed 9052 consecutive deliveries between 28 and 41 weeks, from January 2003 to March 2010 at the Samsung Medical Center, and we generated customized birth weight standards by adjusting for maternal characteristics and neonatal gender. The estimated model for the customized birth weight standards in this study sample was derived from the logistic regression as follows: \( \gamma_{\text{pre}} = \text{In} (\text{BWT}) - 0.442 \text{GA} \) [gestational age, weeks] \(-0.005 \text{GA}^2 + 0.0013 \) Age\(+0.0036\) Gender [0 for girl, 1 for boy] + 0.0047 Maternal weight at delivery \([\text{kg}]+0.0008\) Height \([\text{cm}]-0.022\) Parity \(-0.001\) Pre-pregnancy weight \([\text{kg}] - 8.723\). Using this formula, we obtained the 50th percentile fetal weight according to gestational age, maternal and fetal characteristics, and calculated each percentile birth weight.

The lower \((100\times q)\) th percentile of birth weight is predicted as \(\exp[\gamma_{\text{pre}} + SD\times Z_{(1-q)}]\), and the upper \((100\times q)\) th percentile of birth weight is predicted as \(\exp[\gamma_{\text{pre}} + SD\times Z_{(1-q)}]\), where \(Z_{(1-q)}\) is the 100 \(\times (1-q)\) th percentile of the standard normal distribution and \(SD=0.1526-0.0015\) in GA.

To define the population-based standards, we used average birth weight percentiles from the national birth certificates of all live births in South Korea, from the period of January 2001 to December 2003, with a gestational age from 24 to 44 weeks \((n=1,509,763)\) [25].

Maternal characteristics, including age, parity, and BMI, were investigated. Maternal BMI was calculated using maternal weight at the time of delivery and height. Gestational age was calculated using the last menstrual day and was confirmed by ultrasound assessment in the first trimester. Neonatal outcomes, including birth weight, gender, Apgar score, and admission to neonatal intensive care unit (NICU), were reviewed. Perinatal mortality was defined as a stillbirth of \(\geq 20\) weeks of gestation or a neonatal death before 29 days after birth. We also assessed intrapartum morbidity using the following criteria: **operative delivery** was defined as vacuum delivery or emergent cesarean section for CPD; and **shoulder dystocia** was defined as the delivery that requires additional obstetric maneuvers, such as suprapubic pressure or the McRoberts maneuver to release the shoulders after gentle downward traction has failed [5].

We divided all births into LGA and non-LGA groups, based on the 90th percentile cutoff of population-based and customized standards \((-_{\text{LGA}}\text{ vs. non}_{\text{LGA}}\text{ and }{\text{LGA}}\text{ vs. non}_{\text{LGA}})\). We then compared the baseline maternal characteristics and neonatal outcomes. We also classified the study population into four groups, which used the 90th percentile cutoffs of population-based and customized standards: LGA by both standards \((-_{\text{LGA}}\text{ vs. non}_{\text{LGA}}\text{ and }{\text{LGA}}\text{ vs. non}_{\text{LGA}})\), LGA by population-based standards and non-LGA by customized standards \((-_{\text{LGA}}\text{ non}_{\text{LGA}}\text{ LGA by customized standards and non-LGA by population-based standards (non}_{\text{LGA}}\text{ non}_{\text{LGA}}\text{ LGA by both standards (non}_{\text{LGA}}\text{ non}_{\text{LGA}})\). Then, rates of vacuum deliveries, emergent cesarean section for CPD, and shoulder dystocia were compared using the odds ratio (OR) obtained from logistic regression analysis, with non_{\text{LGA}}\text{ non}_{\text{LGA}}\text{ as the reference after adjusting for maternal age, parity, BMI at delivery, and neonatal gender.}

The Pearson \(\chi^2\) and Fisher’s exact tests were used for categorical variables, and the Student \(t\)-test was used for continuous variables. Multiple logistic regression analysis was performed. All analyses were performed using SPSS 19.0 version 9.1 (SPSS Inc., Chicago, IL, USA).

**Results**

The distribution of the four groups, defined by both standards, is shown in Figure 1. From the total study population, 6.6% and 10.8% of infants were classified as LGA by population-based and customized standards, respectively. Of the 548 infants that were classified as LGA by population-based standards, only 81 infants were re-classified as non-LGA, which was based on customized standards. Of the 896 infants that were classified as LGA by customized standards, 429 infants were re-classified as non-LGA by population-based standards.

Table 1 shows baseline maternal characteristics, neonatal outcomes, and intrapartum morbidities between LGA and non-LGA births by population-based standards. We confirmed that mothers of \(-_{\text{LGA}}\text{ were older and had higher BMIs, higher rates of multiparity, and more male births than mothers with non-LGA infants. The NICU rate of admission was increased in}_{\text{LGA} infants. The mothers of LGA infants showed a higher rate of emergent cesarean section for CPD and shoulder dystocia. In contrast, no differences in maternal characteristics between LGA and non-LGA births were observed with customized standards, indicating that these maternal characteristics were thoroughly adjusted (Table 2). Similar to population-based standards, the customized LGA infants were associated with higher rates of NICU admission. The mothers of LGA infants by customized standards were

![Figure 1](https://example.com/figure1.png)

**Figure 1** The distributions of the four groups defined by both birth weight standards: LGA by both standards \((-_{\text{LGA}}\text{ LGA})\), LGA by population-based standards only \((-_{\text{LGA}}\text{ non}_{\text{LGA}}\text{ LGA})\), LGA by customized standards only \((\text{non}_{\text{LGA}}\text{ non}_{\text{LGA}}\text{ LGA})\), and non-LGA by both standards \((\text{non}_{\text{LGA}}\text{ non}_{\text{LGA}}\text{ LGA})\). LGA=large-for-gestational-age (above the 90th percentile of birth weight).
Table 1  Comparison of baseline maternal characteristics, neonatal outcomes, and intrapartum morbidities between LGA and non-LGA births classified with population-based birth weight standards.

<table>
<thead>
<tr>
<th>Maternal characteristics</th>
<th>pop LGA (n=548)</th>
<th>Non pop LGA (n=7731)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)*</td>
<td>32.2±3.7</td>
<td>31.5±3.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>GAD (days)*</td>
<td>275.2±7.6</td>
<td>275.4±7.7</td>
<td>0.554</td>
</tr>
<tr>
<td>GAD (weeks)*</td>
<td>39.7±1.1</td>
<td>39.8±1.1</td>
<td>0.240</td>
</tr>
<tr>
<td>Maternal BMI*</td>
<td>28.2±4.0</td>
<td>26.0±3.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Nulliparity (%)</td>
<td>224 (40.9)</td>
<td>3997 (51.7)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Neonatal outcomes

| Birth weight (kg)*       | 4.00±0.2        | 3.2±0.3              | <0.001  |
| Male (%)                 | 360 (65.7)      | 3892 (50.3)          | <0.001  |
| Apgar score below 7 (%)  | 1 (0.2)         | 14 (0.2)             | 0.868   |
| Admission to NICU (%)    | 31 (5.7)        | 301 (3.9)            | 0.042   |
| Duration of NICU stay (day)* | 0.3±1.5 | 0.2±1.5      | 0.197   |
| Stillbirth (%)           | 0 (0.0)         | 0 (0.0)              | 1.000   |
| Neonatal death (%)       | 0 (0.0)         | 0 (0.0)              | 1.000   |

Intrapartum morbidity

| Vacuum delivery          | 27 (10.8)       | 448 (9.4)            | 0.439   |
| Emergent c/s for CPD     | 94 (27.3)       | 575 (10.8)           | <0.001  |
| Shoulder dystocia        | 19 (7.6)        | 39 (0.8)             | <0.001  |

*Mean±SD. LGA=large for gestational age, GAD=gestational age at delivery, BMI=body mass index, NICU=neonatal intensive care unit, c/s=cesarean section, CPD=cephalopelvic disproportion, emergent c/s for CPD=emergency c/s for non-CPD and elective c/s were excluded, shoulder dystocia=the nominator is total vaginal delivery, vacuum delivery=the nominator is total vaginal delivery.

Table 2  Comparison of baseline maternal characteristics, neonatal outcomes, and intrapartum morbidities between LGA and non-LGA births classified by customized birth weight standards.

<table>
<thead>
<tr>
<th>Maternal characteristics</th>
<th>cust LGA (n=896)</th>
<th>Non cust LGA (n=7383)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)*</td>
<td>31.6±3.7</td>
<td>31.5±3.6</td>
<td>0.399</td>
</tr>
<tr>
<td>GAD (days)*</td>
<td>274.5±7.8</td>
<td>275.5±7.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>GAD (weeks)*</td>
<td>39.6±1.1</td>
<td>39.8±1.1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Maternal BMI*</td>
<td>26.2±3.4</td>
<td>26.2±3.7</td>
<td>0.697</td>
</tr>
<tr>
<td>Nulliparity (%)</td>
<td>451 (50.3)</td>
<td>3770 (51.1)</td>
<td>0.680</td>
</tr>
</tbody>
</table>

Neonatal outcomes

| Birth weight (kg)*       | 3.8±0.3         | 3.2±0.3              | <0.001  |
| Male (%)                 | 459 (51.2)      | 3793 (51.4)          | 0.934   |
| Apgar score below 7 (%)  | 1 (0.1)         | 14 (0.2)             | 0.685   |
| Admission to NICU (%)    | 49 (5.5)        | 283 (3.8)            | 0.019   |
| Duration of NICU stay (day)* | 0.3±1.8 | 0.2±1.5      | 0.053   |
| Stillbirth (%)           | 0 (0.0)         | 4 (0.1)              | 1.000   |
| Neonatal death (%)       | 0 (0.0)         | 4 (0.1)              | 1.000   |

Intrapartum morbidity

| Vacuum delivery          | 49 (12.2)       | 426 (9.2)            | 0.052   |
| Emergent c/s for CPD     | 148 (27.0)      | 521 (10.2)           | <0.001  |
| Shoulder dystocia        | 25 (6.2)        | 33 (0.7)             | <0.001  |

*Mean±SD. LGA=large for gestational age, GAD=gestational age at delivery, BMI=body mass index, NICU=neonatal intensive care unit, c/s=cesarean section, CPD=cephalopelvic disproportion, emergent c/s for CPD=emergency c/s for non-CPD and elective c/s were excluded, shoulder dystocia=the nominator is total vaginal delivery, vacuum delivery=the nominator is total vaginal delivery.
also associated with increased risk of intrapartum morbidities, including vacuum delivery, emergent cesarean section for CPD, and shoulder dystocia.

Furthermore, we performed statistical comparisons, which use a multivariable analysis adjusting for maternal age, parity, BMI at delivery, and neonatal gender with the non\_\text{popLGA-non\_custLGA} group as a reference group (Figure 2). Multivariable analysis showed that the non\_\text{popLGA-custLGA} group is associated with increased risk of emergent cesarean section for CPD [OR, 4.09; 95% confidence interval (CI), 3.00–5.74] and shoulder dystocia (OR, 10.56; 95% CI, 5.52–20.19) compared to the non\_\text{popLGA-non\_custLGA} group. The pop\_\text{LGA-custLGA} group also showed increased risk of vacuum delivery (OR, 1.65; 95% CI, 1.06–2.55), emergent cesarean section for CPD (OR, 3.85; 95% CI, 2.77–5.35), and shoulder dystocia (OR, 11.20; 95% CI of 5.19–24.14). The pop\_\text{LGA-non\_custLGA} group was not associated with increased risk of vacuum delivery (OR, 1.25; 95% CI, 0.42–3.67) and emergent cesarean section for CPD (OR, 1.35; 95% CI, 0.57–3.20), but was associated with shoulder dystocia (OR, 7.58; 95% CI, 2.30–24.94).

In our study population, the total rate of admission to the NICU was 4.0% (332/8275 excluding stillbirth) and the indications of admission were as follows: birth asphyxia, feeding intolerance, jaundice, respiratory problems, and infection. Notably, non\_\text{popLGA-custLGA} infants were also associated with increased risk of admission to the NICU when compared to non\_\text{popLGA-non\_custLGA} infants (OR, 1.63; 95% CI, 1.09–2.43). However, the remaining two groups did not show any significant differences.

**Figure 2** Adverse outcomes of pregnancies that were identified as LGA by both standards (pop\_\text{LGA-custLGA}), LGA by population-based standards only (pop\_\text{LGA-non\_custLGA}), and LGA by customized standards only (non\_\text{popLGA-custLGA}). (A) Vacuum delivery. (B) Cesarean delivery. (C) Shoulder dystocia. (D) NICU admission. LGA = large for gestational age (above the 90\textsuperscript{th} percentile of birth weight).

**Discussion**

To avoid possible complications associated with LGA, it seems rational to intervene, either with induction or cesarean delivery, if the fetus is suspected of being macrosomic. However, several observational studies and a randomized trial have not shown a benefit of induction for LGA [9, 15, 19, 24]. Furthermore, a systemic meta-review concluded that the prenatal suspicion of LGA would not help to decrease the risk of vacuum delivery, emergent cesarean section, and shoulder dystocia [31]. On the contrary, a recent retrospective cohort study demonstrated that induction of labor might reduce the risk of cesarean delivery [7]. The optimal management of LGA has not been established. Therefore, the application of customized growth curves, which have been introduced in clinical management of FGR [12, 14, 16, 17, 22, 23, 25, 27, 30], could be also quoted in the assessment of the risk of LGA. In fact, it was suggested that elective induction or cesarean section would be useful after applying customized standards that adjusted maternal characteristics and fetal gender [23].

With these backgrounds, in this study, we have recently generated our own customized birth weight standard and assessed the intrapartum morbidity, which was associated LGA infants. As a result, we found that the customized standard for LGA can identify undiagnosed women at risk of emergent cesarean section for CPD and shoulder dystocia. These findings are similar to those of a previous report that customized LGA pregnancies, which showed association with increased risk of shoulder dystocia, third- or fourth-degree
laceration, and cesarean section for CPD [23]. Intriguingly, we also found that customized LGA infants were found to be significantly higher with the risk of NICU admission in this study group. Although we could not elucidate the exact reason for this finding, several researchers already showed that LGA infants were known to be associated with increased risks for perinatal asphyxia, meconium aspiration, respiratory distress syndrome, assisted ventilation, low Apgar scores, and hypoglycemia [4, 13, 28]. Moreover, our data support that a mother of an LGA infant by population-based standards had different maternal characteristics and neonatal gender from the non-pop LGA group. This finding confirmed the necessity of customization when defining LGA.

It is notable that we discovered nearly 50% of customized LGA pregnancies were undiagnosed by conventional population-based standards in our study group. Our population showed similar proportion of popLGA-cust LGA group compared to Larkin’s study (5.6% vs. 5.0%), but the proportion of non-popLGA-cust LGA was relatively higher (5.2% vs. 1.3%) and the proportion of popLGA-non pop LGA was lower (1.2% vs. 4.6%) [23]. One of the possible explanations of these findings may be derived from the difference in each population-based standard, which was used in the two studies. We admit the population-based standard in our study was not gender specific [25], but that used in Larkin’s study was gender specific [1]. Therefore, adjustment of fetal gender in generating customized birth weight standard could have more of an impact on our study group. Another reason for these findings may be derived from ethnic differences in the two study groups. Recently, Gethaun et al. reported that primary cesarean section rates due to dystocia were significantly higher for women of Asian/Pacific Islander ethnicity, compared with that for white women, after adjusting maternal age, education, prenatal care, and smoking during pregnancy [18]. It indicates that birth weight of Asian population might be relatively large to their figures and therefore the necessity of a customized birth weight standard might be emphasized in our population.

Through this study, we suggested that a customized birth weight standard for LGA could predict the risk of emergent cesarean section for CPD and shoulder dystocia. However, because of the limitation of retrospective study design, we could not represent the optimal management or delivery mode for the non-popLGA-cust LGA group. For clinical utility of the customized birth weight standard in the management of LGA, further randomized controlled trials are needed. Because it is possible that the inaccuracy of ultrasound in estimating fetal weight by large intra- and interobserver variability [11] may misclassify grown fetuses as LGA and thus induce improper obstetrical intervention, the accurate measurement of fetal biometry and estimation of fetal weight seems important for introducing customized birth weight standard in the management of LGA. The second limitation is that this study had a relatively small study population. In fact, there were only four cases of stillbirth or neonatal death from the total study population, which restricts statistical analysis. Meanwhile, it is worth mentioning that we excluded all maternal medical diseases, which could affect fetal growth, including diabetes and hypertension. Our data support the notion that LGA pregnancies without maternal diabetes have increased risks for adverse perinatal outcomes, which was indicated by a previous report [13]. Interestingly, it was recently reported that the use of customized standard in a diabetic population identified a greater percentage of neonates with abnormal fetal growth compared to the use of population-based standards [21].

In conclusion, the customized birth weight standard for LGA could predict the risk of emergent cesarean section for CPD and shoulder dystocia. However, further randomized trials are needed to demonstrate how to use customized birth weight standard in a clinical situation.

References


The authors stated that there are no conflicts of interest regarding the publication of this article.