Influence of Fetal Birth Weight on Caesarean Section Rate and Fetal Outcome After Induction of Labor

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Abstract. Aim: The aim of the present study was to provide information for better obstetric counselling by analyzing the impact of fetal birth weight on the caesarean section rate and fetal outcome after induction of labor. Materials and Methods: In this retrospective study from January 2010 to December 2013, 1,474 singleton deliveries with labor induction at or greater than 37 gestational weeks were analyzed for their impact of fetal birth weight on delivery outcome. The normal birth weight group was defined as 2,500 g to less than 4,000 g. For comparison, further birth weight groups were defined as: group 1 <2,500 g, group 2 4,000 to <4,250 g; group 3 ≥4,250 g. The primary outcome was the caesarean section rate; secondary outcome measures were fetal complications monitored by pH and base excess (BE) of the umbilical cord artery, Apgar score after 5 min (Apgar-5) and postpartum transfer to the Neonatal Care Unit. The set of controlling variables included maternal body mass index and age, gestational age, neonatal sex, maternal diabetes, maternal hypertension disorder, parity and method of induction of labor. Results: Second-stage caesarean section is significantly more likely when fetal birth weight is below 2,500 g (42.9% vs. 24.2% in the normal birth weight group, odds ratio=3.11, 95% confidence interval=1.48-6.51, p=0.003). A birth weight of 4,000 g or more did not have a significant influence on the caesarean section rate. Only the mean Apgar-5 for group 1 was significantly lower (p=0.044). The non-parametric tests and regression analyzes of pH and BE of the umbilical cord and of the Apgar-5 for adverse fetal outcome (pH<7.05, BE<−12 or Apgar-5 <7) showed no significant differences in the three birth weight groups when compared to the normal group. Neonates were significantly more often transferred to the Neonatal Care Unit after delivery when birth weight was below 2,500 g (odds ratio=9.68, 95% confidence interval=4.33-21.65, p<0.001) or above 4,250 g (odds ratio=2.68, 95% confidence interval=1.34-5.36, p=0.005). Conclusion: Although a fetal birth weight of under 2500 g and a birth weight over 4,250 g are associated with some risks, there is no general contraindication against performing induction of labor in regards to fetal birth weight.

Induction of labor has been continually rising over the past decades and constitutes a large group of childbirths today (1-3). Common medical reasons for induction of labor vary from post-term pregnancy, premature rupture of membranes, diabetes, suspected fetal macrosomia, oligohydramnios, suspected intrauterine growth restriction to maternal hypertensive disorders (4). In addition to these medical reasons, in some cases, induction of labor is performed at the request of the mother or even the obstetrician (5, 6). However, this differentiation between medical and elective induction of labor poses a dilemma (7). For many supposedly medical reasons, the evidence justifying an induction of labor is still lacking (4). Nevertheless, we are faced today with a large collective of women delivering after induction of labor and consider it a success whenever the pregnancy results in a vaginal birth with no adverse outcome for the newborn. In times when caesarean section rates are still rising (8), special interest has been drawn to the mode of delivery after the induction of labor, with more recent studies suggesting a lowered rate of caesarean section through induction of labor, especially for pregnancies at or beyond term (9-12). As fetal birth weight is one of the important factors to consider with regards to delivery mode (13, 14), the aim of the present study was to analyze the impact of fetal birth weight on successful vaginal birth and fetal outcome after induction of labor.
Materials and Methods

In this retrospective study, we included cases of induction of labor at or after 37 weeks from January 2010 through December 2013 at the University Medical Centre Mannheim, Heidelberg University. Cases with previous caesarean section, breech presentation, major malformations, as well as multiple and stillbirths were excluded. The induction of labor was performed either by application of oral or vaginal misoprostol, prostaglandin E2 vaginal gel, oxytocin, a double balloon catheter, or a combination of these.

The primary outcome measure was the caesarean section rate. Secondary outcome parameters were fetal complications. The recorded fetal outcome was monitored by pH and base excess (BE) of the umbilical cord artery, the Apgar score after 5 minutes (Apgar-5) and postpartum transfer to the Neonatal Care Unit. In order to discriminate severe cases of adverse fetal outcome, we used the following indicators: pH<7.05, BE<-12 and Apgar-5 <7. The medical records were incomplete for 165 individuals, for whom maternal age, maternal body mass index (BMI) gestational age, indication for labor induction, neonatal sex, PH, BE or Apgar-5 score were missing for 19, 13, 1, 78, 7, 6, 36 and 5 individuals, respectively. Rather than excluding these 165 individuals from this study completely, the remaining information of these individuals was used for various statistical analyzes.

The neonates were divided into four groups according to their birth weight recorded in grams. If the birth weight was from 2500 g to less then 4000 g, the newborns were assigned to the normal group. Other groups were categorized as follows: group 1: birth weight <2,500 g, group 2: birth weight from 4,000 to less than 4,250 g, and group 3: birth weight ≥4,250 g.

Statistical analysis. We performed the two-sample t-test (parametric) and the two-sample Kolmogorov–Smirnov test (non-parametric) to assess significant differences between groups 1 to 3 and the normal group, as well as multivariate logistic regression to control for confounding variables. The null hypothesis of the t-test was that the population means of two samples were equal. This type of test was conducted for the continuous variables pH, BE and the Apgar-5. The Kolmogorov–Smirnov test was performed to verify whether two samples differed significantly in terms of the probability distribution. This test could be applied to all variables of interest. Test statistics with a value of \( p \leq 0.05 \) were considered significant. Multivariate logistic regression was performed to control for possible confounders; effect estimates were expressed as odds ratios. The control variables included in the multivariate logistic regression analyzes were maternal BMI and age, gestational age, neonatal sex, maternal diabetes, maternal hypertension disorder, parity and method of induction of labor. The statistical analysis was carried out using STATA 13 (StataCorp. LP, College Station, TX, USA).

Results

In total, 1,474 cases were amenable for analysis. These 1,474 neonates were categorized by birth weight into four groups, resulting in the following distribution: group 1 with 35 neonates, normal group with 1,265 neonates, group 2 with 108 neonates and group 3 with 66 neonates. Lower birth weight was associated with female neonate gender, lower maternal age and a higher occurrence of maternal diabetes, maternal hypertension disorder, parity and method of induction of labor. The statistical analysis was carried out using STATA 13 (StataCorp. LP, College Station, TX, USA).

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Table I. Baseline demographics and pregnancy characteristics of all groups.

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th>Normal Group</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth weight</td>
<td>&lt;2,500g</td>
<td>2,500 to</td>
<td>4,000 to</td>
<td>≥4,250 g</td>
</tr>
<tr>
<td>No. of neonates</td>
<td>35</td>
<td>1265</td>
<td>108</td>
<td>66</td>
</tr>
<tr>
<td>Mean maternal age , years</td>
<td>26.91</td>
<td>29.56</td>
<td>30.67</td>
<td>30.72</td>
</tr>
<tr>
<td>Mean maternal BMI, kg/m²</td>
<td>28.01</td>
<td>30.38</td>
<td>30.95</td>
<td>33.67</td>
</tr>
<tr>
<td>Median no. of pregnancies</td>
<td>1 (1-2)</td>
<td>1 (1-2)</td>
<td>2 (1-3)</td>
<td>2 (1-3)</td>
</tr>
<tr>
<td>Median parity</td>
<td>0 (0-1)</td>
<td>0 (0-1)</td>
<td>1 (0-1)</td>
<td>0 (0-1)</td>
</tr>
<tr>
<td>Mean gestational age, days</td>
<td>270.21</td>
<td>279.82</td>
<td>284.03</td>
<td>285.00</td>
</tr>
<tr>
<td>Median Bishop score</td>
<td>3 (1-3)</td>
<td>3 (2-4)</td>
<td>3 (2-4)</td>
<td>3 (2-5)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>5.7%</td>
<td>14.9%</td>
<td>16.7%</td>
<td>16.7%</td>
</tr>
<tr>
<td>Hypertension disorders</td>
<td>14.3%</td>
<td>4.2%</td>
<td>5.6%</td>
<td>6.1%</td>
</tr>
<tr>
<td>Mode of delivery</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vaginal birth</td>
<td>45.7%</td>
<td>63.2%</td>
<td>59.3%</td>
<td>65.1%</td>
</tr>
<tr>
<td>Vaginal operative delivery</td>
<td>11.4%</td>
<td>12.6%</td>
<td>15.7%</td>
<td>7.6%</td>
</tr>
<tr>
<td>Caesarean section</td>
<td>42.9%</td>
<td>24.2%</td>
<td>25.0%</td>
<td>27.3%</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>31.4%</td>
<td>50.0%</td>
<td>64.8%</td>
<td>63.6%</td>
</tr>
<tr>
<td>Female</td>
<td>65.7%</td>
<td>48.9%</td>
<td>32.4%</td>
<td>31.8%</td>
</tr>
<tr>
<td>Mean pH</td>
<td>7.25</td>
<td>7.24</td>
<td>7.24</td>
<td>7.23</td>
</tr>
<tr>
<td>pH &lt; 7.05</td>
<td>0.0%</td>
<td>0.9%</td>
<td>0.9%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Mean BE</td>
<td>–3.8</td>
<td>–4.4</td>
<td>–4.4</td>
<td>–4.4</td>
</tr>
<tr>
<td>BE &lt; –12</td>
<td>2.9%</td>
<td>0.8%</td>
<td>0.9%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Median Apgar-5</td>
<td>10 (9-10)</td>
<td>10 (9-10)</td>
<td>10 (9-10)</td>
<td>10 (9-10)</td>
</tr>
<tr>
<td>Apgar-5 &lt; 7</td>
<td>5.7%</td>
<td>0.8%</td>
<td>0.0%</td>
<td>3.0%</td>
</tr>
<tr>
<td>Abnormal cardiotocography</td>
<td>37.1%</td>
<td>28.0%</td>
<td>21.3%</td>
<td>18.2%</td>
</tr>
<tr>
<td>Epidural anesthesia</td>
<td>20.0%</td>
<td>28.4%</td>
<td>34.3%</td>
<td>25.8%</td>
</tr>
<tr>
<td>Oxytocin during labour</td>
<td>34.3%</td>
<td>43.2%</td>
<td>47.2%</td>
<td>53.0%</td>
</tr>
<tr>
<td>Meconium-stained</td>
<td>20.0%</td>
<td>14.2%</td>
<td>23.2%</td>
<td>33.3%</td>
</tr>
<tr>
<td>amniotic liquor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postpartum transfer to neonatal care unit</td>
<td>60.0%</td>
<td>9.7%</td>
<td>11.1%</td>
<td>19.7%</td>
</tr>
</tbody>
</table>

BE, Base excess; Apgar-5, Apgar score after 5 min. Median values are followed by 25th and 75th percentile reported in parentheses.

Table II. Indication for induction of labor.

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th>Normal Group</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth weight</td>
<td>&lt;2,500g</td>
<td>2,500 to</td>
<td>4,000 to</td>
<td>≥4,250 g</td>
</tr>
<tr>
<td>Post-term pregnancy</td>
<td>8.6%</td>
<td>30.1%</td>
<td>50.0%</td>
<td>53%</td>
</tr>
<tr>
<td>Premature rupture of membranes</td>
<td>14.3%</td>
<td>29.4%</td>
<td>12.0%</td>
<td>12.1%</td>
</tr>
<tr>
<td>Diabetes</td>
<td>0%</td>
<td>8.5%</td>
<td>11.1%</td>
<td>10.6%</td>
</tr>
<tr>
<td>Maternal request</td>
<td>8.6%</td>
<td>6.3%</td>
<td>3.7%</td>
<td>4.6%</td>
</tr>
<tr>
<td>Oligo-/anhydramnios</td>
<td>0%</td>
<td>4.1%</td>
<td>0.9%</td>
<td>3.9%</td>
</tr>
<tr>
<td>Hypertension disorders</td>
<td>14.3%</td>
<td>3.4%</td>
<td>2.8%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Placental insufficiency</td>
<td>31.4%</td>
<td>2.9%</td>
<td>0.9%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Abnormal cardiotocography</td>
<td>2.9%</td>
<td>2.9%</td>
<td>1.9%</td>
<td>1.5%</td>
</tr>
<tr>
<td>Suspected fetal macrosomia</td>
<td>0.0%</td>
<td>1.4%</td>
<td>9.3%</td>
<td>7.6%</td>
</tr>
</tbody>
</table>
hypertensive disorders. When the birth weight exceeded 4,250 g, the maternal BMI as well as the occurrence of maternal diabetes were higher. Descriptive statistics for these four groups are presented in Table I.

Reasons for induction of labor differed between the different birth weight groups (Table II). In the normal group, the three most often named reasons for induction of labor were post-term pregnancy, premature rupture of membranes and maternal diabetes. When the birth weight was below 2,500 g, placental insufficiency, maternal hypertensive disorders and premature rupture of membranes were the main reasons. When birth weight exceeded 4,000 g, suspected fetal macrosomia was the fourth common reason for induction of labor.

The rate of caesarean section in the normal group was 24.2%. Although the neonates with a birth weight <2,500 g had an almost doubled rate of caesarean section (42.9%), the difference was not significant in the non-parametric test (Table V). However, in the regression analysis, the rate of caesarean section was significant (p=0.003) for neonates with a birth weight <2,500 g (Table IV). A birth weight of 4,000 g or more did not have a significant influence on the delivery mode in our analysis (Tables III and IV).

The mean pH and mean BE of the umbilical cord artery did not show any significant difference between the three groups. Only the Apgar-5 for the neonates with a birth weight <2,500 g was significantly lower (p=0.044) (Table V). The non-parametric tests of pH and BE of the umbilical cord and of the Apgar-5 for adverse fetal outcome (pH<7.05, BE<−12 or Apgar-5 <7) showed no significant differences in the three birth weight groups when compared to the normal group (Table VI).

A multivariate analysis of the effect of birth weight on caesarean section rate and neonatal outcome adjusted for maternal BMI and age, gestational age, neonatal sex, maternal diabetes, maternal hypertension disorder, parity and method of induction of labor is presented in Table IV. As mentioned above, the multivariate analysis showed a higher caesarean section rate for newborns with a birth weight <2,500 g (odds ratio=3.11, 95% confidence interval=1.48-6.51, p=0.003). Additionally, neonates were significantly more often transferred to the Neonatal Care Unit after delivery when birth weight was <2,500 g (odds ratio=9.68, 95% confidence interval=4.33-21.65, p<0.001) or >4,250 g (odds ratio=2.68, 95% confidence interval=1.34-5.36, p=0.005).

Discussion

This study aimed to provide data on the relation between birth weight and caesarean section rate, as well as fetal outcome, after induction of labor. In our study, we showed
that after labor induction, a fetal birth weight <2,500 g is particularly associated with a higher caesarean section rate. The Apgar-5 score was significantly lower and the newborn was significantly more often admitted to a Neonatal Care Unit after birth when compared to the normal group. When fetal birth weight exceeded 4,000 g, there was no significant difference concerning a successful vaginal delivery when compared to the normal group. All neonates over 4,000 g had a comparable fetal outcome, with no evidence of any risk (pH and BE of the umbilical cord artery, as well as the Apgar-5 score, showed no significant difference in all statistic tests). Only postpartum admission to the Neonatal Care Unit was significantly higher when birth weight exceeded 4,250 g.

Neonates with a birth weight <2,500 g at term constitute a risk group, especially when the birth weight is low due to fetal growth restriction (15, 16). With a rate of 42.9% for caesarean section after induction of labor for newborns with a birth weight <2,500 g, we report a much higher rate than given in previous investigations [14% reported by Boers et al. (17), and 22.5% by Walsh et al. (14)]. In our collective, the occurrence of placental insufficiency, as well as maternal hypertensive disorders, was very high for the pregnancies, resulting in a newborn with a birth weight <2,500 g. Such risk factors were either much lower or not reported in the aforementioned studies. The fetal outcome showed no major significant differences compared to the newborns between 2,500 g and 4,000 g (the mean Apgar-5 score was only significantly lower in the parametric test, all other tests showed no significance). The high rate of postpartum transfers to a Neonatal Care Unit is partly due to the mentioned risk factors but also linked to a very strict policy of the neonatologist to admit a newborn with a birth weight <2,500 g for observation and monitoring. Consequently, even considering the high caesarean rate in this collective, induction of labor with the chance of vaginal delivery is still a valid option. Boers et al. found no important differences in women with suspected fetal growth restriction at term between induction of labor and expectant monitoring. They stated that it is rational to choose induction to prevent possible neonatal morbidity and stillbirth (17).

In our collective, a fetal birth weight exceeding 4000 g after labor induction was not related to a significantly higher caesarean section rate compared to childbirths with a fetal birth weight of 2,500 g to <4,000 g. These results are in line with another analysis by our group of a larger collective independent of labor induction (13). The question of whether fetal macrosomia is linked to a higher caesarean rate after induction of labor, and if induction should be performed when macrosomia is suspected, remains very controversial as some trials found higher rates (18, 19) and others did not (20, 21). Most reviews do not recommend labor induction in presence of suspected fetal macrosomia.

<table>
<thead>
<tr>
<th>Table V. p-Values for mean comparison tests (significance level p≤0.05)</th>
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<tbody>
<tr>
<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td>Normal group (2,500 to &lt;4,000 g)</td>
</tr>
<tr>
<td>Group 1 (&lt;2,500 g)</td>
</tr>
<tr>
<td>Group 2 (4,000 to &lt;4,250 g)</td>
</tr>
<tr>
<td>Group 3 (≥4,250 g)</td>
</tr>
</tbody>
</table>

BE, Base excess; Apgar-5, Apgar score after 5 min.

<table>
<thead>
<tr>
<th>Table VI. p-Values of Kolmogorov-Smirnov tests (significance level p≤0.05)</th>
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<tbody>
<tr>
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<tr>
<td></td>
</tr>
<tr>
<td>Normal group (2,500 to &lt;4,000 g)</td>
</tr>
<tr>
<td>Group 1 (&lt;2,500 g)</td>
</tr>
<tr>
<td>Group 2 (4,000 to &lt;4,250 g)</td>
</tr>
<tr>
<td>Group 3 (≥4,250 g)</td>
</tr>
</tbody>
</table>

BE, Base excess; Apgar-5, Apgar score after 5 min.
(22). In a recent publication, Walsh et al. concluded that the frequency of caesarean delivery increased with each 500 g increase in neonatal weight above 3,000 g, especially after induction of labor (14). However, the collective analyzed in their study considered only nulliparous women and did not report the rates of maternal risk factors such as diabetes or hypertensive disorder. We did not find any adverse fetal outcome in our collective, however, the postpartum transfer of the newborn to a Neonatal Care Unit occurred significantly more often for these over 4,250 g. The reason for transfer was not noted in our data but considering the high rate of maternal obesity and diabetes in this group, fetal metabolic disorders, for example, that would occur independently of the mode of delivery, seem to be very probable. Our study did not suggest any elevated risk in any terms of delivery mode and the fetal outcome for macrosomic newborns after induction of labor.

However, it is known that shoulder dystocia is more common when the birth weight is more than 4,250 g (13). This clinical end-point was not assessed in this investigation.

The continuous rise of the caesarean section rate constitutes a major problem (23-25). According to the Federal Statistic Office, the overall caesarean rate in Germany was as high as 31.8% in 2013. In some situations, we have a strong indication for performing a caesarean section, but in many cases there are risk factors present without an absolute indication for performing a caesarean section. In these cases, clinicians are often faced with the decision whether to perform an induction of labor, an elective caesarean section, or expectant management. Especially when the gestational age rises, there is good evidence that induction of labor reduces the caesarean section rate (12, 26). One of the factors to consider when making the decision whether to induce labor is the fetal birth weight. The reported caesarean rate in our induced collective was overall higher (for example 24.2% for fetal birth weight 2,500 g to <4,000 g) than reported before in a larger collective, considering all deliveries where vaginal birth was attempted at our hospital from 2006 to 2011 (15.5% for fetal birth weight 2,500 g to <4,000 g) (13). In this trial, the caesarean section rate was high for newborns with a birth weight below 2,500 g, but nevertheless almost 60% were delivered vaginally after induction of labor with no adverse fetal outcome overall. This underlines that primary caesarean section would not have been justified.

**Conclusion**

The fetal birth weight is an important factor to consider when induction of labor is performed. Although a fetal birth weight under 2,500 g and a birth weight over 4,250 g are associated with certain risks, induction of labor is still a valid option compared to primary caesarean section.

**References**


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