Predicting the Spontaneous Onset of Labour in Post-Date Pregnancies: A Population-Based Retrospective Cohort Study

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Abstract

Objective: To estimate the probability of spontaneous onset of labour (SOL) among women with uncomplicated pregnancies who have reached 41+0 weeks and to examine the influence of maternal characteristics on this event.

Methods: We conducted a population-based retrospective cohort study of women with uncomplicated singleton pregnancies in cephalic presentation between 41+0 and 42+0 weeks’ gestation. Detailed clinical information was obtained from the British Columbia Perinatal Data Registry. We determined the time from 41+0 weeks to the exact day and time of SOL, pre-labour Cesarean section, or onset of labour following induction. A Kaplan-Meier curve was created to estimate the probability of SOL. A Cox regression model was used to assess the independent influence of maternal age, parity, BMI, and pregnancy weight gain on the SOL, and to assess the extent to which prediction of SOL could be individualized according to a woman’s characteristics.

Results: Among 15253 women undelivered at 41+0 weeks, there was a 67.6% (95% CI 66.4% to 68.7%) chance of SOL by 41+6 weeks. Although SOL was statistically more likely in younger women, higher parity, lower BMI, and lower weight gain (P < 0.01), the multivariable model’s predictive ability was poor (c-statistic 0.56).

Conclusion: Maternal characteristics were not a strong determinant for successful individualized prediction of SOL in women with uncomplicated pregnancies reaching 41+0 weeks of gestation. Our population-based estimates of the daily occurrence of SOL can be used to inform discussions with women on when to offer induction of labour.

Résumé

Objectif : Estimer la probabilité du travail d’apparition spontanée (TAS) chez les femmes qui connaissent une grossesse exempte de complications atteignant 41+0 semaines et examiner l’influence des caractéristiques maternelles sur cet événement.

Méthodes : Nous avons mené une étude de cohorte rétrospective en population générale qui portait sur les femmes connaissant une grossesse monofœtale exempte de complications en présentation céphalique entre 41+0 et 42+0 semaines de gestation. Nous avons tiré des renseignements cliniques détaillés du British Columbia Perinatal Data Registry. Nous avons déterminé le délai entre 41+0 semaines de gestation et la date et l’heure exactes du TAS, de la tenue d’une césarienne prétravail ou de l’apparition du travail à la suite d’un déclencheur. Une courbe Kaplan-Meier a été tracée pour estimer la probabilité du TAS. Un modèle de régression de Cox a été utilisé pour évaluer l’infériorité indépendante de l’âge maternel, de la parité, de l’IMC et du gain pondéral pendant la grossesse sur le TAS, ainsi que pour évaluer la mesure dans laquelle la prévision du TAS pourrait être personnalisée en fonction des caractéristiques de la patiente.

Résultats : Chez 15 253 femmes n’ayant toujours pas accouché à 41+0 semaines, la probabilité de voir se manifester un TAS d’ici à 41+6 semaines était de 67.6 % (IC à 95 %, 66.4 % - 68.7 %). Bien que le TAS ait été plus probable sur le plan statistique chez les femmes présentant un âge moindre, une parité accrue, un IMC moindre et un gain pondéral moindre (P < 0.01), la valeur de prévision du modèle multivarié était faible (c-statistic : 0.56).

Conclusion : Les caractéristiques maternelles ne constituaient pas un déterminant solide aux fins de la réussite de la prévision personnalisée du TAS chez les femmes qui connaissaient une grossesse exempte de complications atteignant 41+0 semaines de gestation. Nos estimations en population générale quant à la manifestation quotidienne du TAS peuvent être utilisées pour éclairer les discussions menées avec les femmes quant à la détermination du moment propice à l’offre d’un déclenchement du travail.
INTRODUCTION

In the past 20 years, the management of pregnancies beyond 41+0 weeks of gestation (“post-dates”) has favoured induction of labour. Dating of pregnancy using first trimester ultrasound and membrane sweeping at the end of pregnancy have reduced the number of women reaching 41+0 weeks of gestation without delivering, but “post-dates” remains the most frequent indication for induction of labour. This practice is supported by high-quality, randomized trial evidence: a recent meta-analysis of 10 randomized or quasi-randomized trials reported a significant reduction in perinatal mortality in a group of patients in whom labour induction was offered at 41 weeks of gestation compared with those in an expectant management group. In this same meta-analysis, this result was achieved without any increase in the risk of delivery by Caesarean section. In the original large multicentre trial conducted by Hannah et al., induction of labour in post-term women was associated with a decrease in Caesarean section rates. In a systematic review of elective induction of labour versus expectant management of pregnancy, Caughey et al. also showed that there is a significant decrease in Caesarean section rates associated with induction of labour in this setting.

Although in these recent analyses there are significant differences in perinatal mortality and morbidity between the induction and expectant management groups, the differences in absolute numbers remain small. As a result, the number needed to treat for benefit associated with labour induction for post-dates is high: it has been estimated that nearly 500 women need to have labour induced to prevent a single perinatal death. Many women view the spontaneous onset of labour as a positive experience and prefer to avoid intervention; according to Heimstad et al., one in four women would prefer not to undergo induction of labour when they reach 41+0 weeks. Induction at or beyond 41+0 weeks is viewed by women as a loss of the natural delivery process. Labour that is induced does result in satisfaction rates lower than those in women who undergo spontaneous labour. Therefore it is important for women to understand their likelihood of spontaneous onset of labour in the seven days after they reach 41+0 weeks. Women and their care providers must therefore weigh the low but serious risk of stillbirth against the desire to avoid medical intervention in the onset of labour. Knowing the probability that a woman who remains pregnant at 41+0 weeks will go into labour spontaneously over the course of the following days is critical for informing care plan decisions. Although there is knowledge regarding the risk factors for reaching 41+0 weeks of gestation, once this milestone has been reached there is scarce high-quality evidence on the day-specific probability of spontaneous labour during the following week in a population with ultrasound-confirmed estimates of gestational age.

The goals of this study were firstly to calculate the daily probability of spontaneous onset of labour between 41+0 weeks and 42+0 weeks of gestation, and secondly to determine the extent to which the prediction of spontaneous onset of labour can be individualized using maternal characteristics.

METHODS

We reviewed data from women with uncomplicated singleton pregnancies in cephalic presentation with ultrasound confirmed dating who delivered at or beyond 41+0 weeks of gestation in British Columbia between January 2008 and December 2012. We excluded women with comorbidities of maternal diabetes, hypertension, heart disease, or renal disease. We also excluded women whose newborns had congenital anomalies. Women with a previous Caesarean section were not excluded. All data were extracted from the British Columbia Perinatal Data Registry from Perinatal Services British Columbia. The British Columbia Perinatal Data Registry is a quality controlled database containing abstracted medical chart information from over 99% of births in British Columbia.

Women were followed from 41+0 weeks until the day and time (in hours and minutes) of either the spontaneous onset of labour, onset of labour following induction, or delivery by pre-labour Caesarean section. After the occurrence of one of these three events, women were no longer considered “at risk” of spontaneous labour and were removed from the denominator calculation (censored).

A Kaplan-Meier curve was created to estimate the probability of spontaneous onset of labour. This curve was based on a continuous measure of time (time since 41+0 weeks in minutes), calculating the probability of labour at a given moment as a fraction of all pregnancies that remained ongoing at that time. For ease of interpretation, these results were also expressed as day-specific probabilities of spontaneous labour. Kaplan-Meier curves stratified by maternal characteristics were also created, with log-rank tests used to test for statistically significant differences between groups.

Maternal characteristics examined were maternal age (years), parity (nulliparous or para ≥ 1), pre-pregnancy BMI (groups of ≤18.4, 18.5 to 24.9, 25 to 29.9, and ≥30 kg/m²). Finally, gestational weight gain was
calculated by subtracting pre-pregnancy weight from last weight before delivery (within 7 days). Weight gain categories were based on Institute of Medicine BMI-specific recommendations: below, within, or above the BMI-specific recommendation categories. A multivariable Cox regression model was used to assess the influence of maternal age, parity, pre-pregnancy BMI, and gestational weight gain as independent predictors of the spontaneous onset of labour. Maternal age, parity, and BMI were chosen because they have previously been shown to be associated with prolonged pregnancies; we examined whether they remained predictors within the population of women with prolonged pregnancy. Weight gain was a novel predictor that was chosen based on clinical opinion. As recommended, all predictors were included in the model based on a priori substantive grounds. We included an interaction term between pre-pregnancy BMI and gestational weight gain because weight gain recommendations are BMI-specific. Continuous variables (maternal age, pre-pregnancy BMI, and gestational weight gain) were modelled as:

a. linear terms,

b. grouped into categories, and

c. as restricted cubic splines (which allowed non-linear relationships to be assessed).

The best fit for the final model was established on the basis of the model's Akaike information criterion. Because pre-pregnancy BMI is known to be unrecorded in a moderate proportion of women in our population, we repeated our analyses using multiple imputations to account for missing BMI and gestational weight gain values. As recommended, we included the study outcome (probability of spontaneous onset of labour) as well as other maternal and fetal characteristics in our imputation models. Ten imputed datasets were created, and summary results were produced using “mi estimate” in Stata SE version 11 (StataCorp LLP, College Station, TX).

The coefficients from our multivariable proportional hazards model were used to generate individualized predictions of the probability of spontaneous labour for each woman by 41+6 weeks, given her particular combination of characteristics. We assessed the model's discrimination ability by calculating the model's concordance (c)-statistic. The c-statistic is interpreted in a similar manner as the area under the receiver operating characteristic curve used with logistic regression models, in which a value of 1 represents a perfect ability to predict spontaneous onset of labour and a value of 0.5 suggests that the model's predictions are no more accurate than those expected by chance alone. Statistical analyses were performed using Stata SE version 11 (StataCorp LLP, College Station, TX).

The study was approved by the University of British Columbia/Children’s and Women’s Health Centre of British Columbia Research Ethics Board.

RESULTS

In British Columbia, there were 15 253 singleton pregnancies at or beyond 41+0 weeks between January 2008 and December 2012 that met our study inclusion criteria. The characteristics of these pregnancies are described in Table 1. Most women were nulliparous (62.8%) and of normal pre-pregnancy weight (60.3% among those with available pre-pregnancy BMI). BMI was not recorded in 23.5% of women. A majority of women had a gestational weight gain above the Institute of Medicine recommendations (57.3% among those with available pregnancy weight gain; these data were missing in 37.6%). Nearly one in two women (48.6%) underwent labour induction. Of these, 83.4% were for the indication of “post-dates,” followed by “pre-labour rupture of membranes” (6.5%) and “fetal compromise” (4.0%). There were seven stillbirths in the cohort, confirming that this was a low-risk population. Six stillbirths were

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean ± SD or n (%)</th>
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<tbody>
<tr>
<td>Maternal age, years</td>
<td>30.5 ± 5.4</td>
</tr>
<tr>
<td>Nulliparous</td>
<td>9583 (62.8)</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>24.5 ± 5.1</td>
</tr>
<tr>
<td>Underweight (&lt;18.5 kg/m²)</td>
<td>497 (3.3)</td>
</tr>
<tr>
<td>Normal weight (18.5 to 24.9 kg/m²)</td>
<td>7038 (46.1)</td>
</tr>
<tr>
<td>Overweight (25 to 29.9 kg/m²)</td>
<td>2602 (17.1)</td>
</tr>
<tr>
<td>Obese (≥ 30 kg/m²)</td>
<td>1538 (10.1)</td>
</tr>
<tr>
<td>Missing BMI</td>
<td>3578 (23.5)</td>
</tr>
<tr>
<td>Gestational weight gain, kg</td>
<td>16.0 ± 6.2</td>
</tr>
<tr>
<td>Below IOM recommendations</td>
<td>1287 (8.4)</td>
</tr>
<tr>
<td>Within IOM recommendations</td>
<td>2781 (18.2)</td>
</tr>
<tr>
<td>Above IOM recommendations</td>
<td>5454 (35.8)</td>
</tr>
<tr>
<td>Missing IOM recommendations</td>
<td>5731 (37.6)</td>
</tr>
<tr>
<td>Labour induction</td>
<td>7409 (48.6)</td>
</tr>
<tr>
<td>Caesarean section</td>
<td>4081 (26.8)</td>
</tr>
<tr>
<td>Birth weight, g</td>
<td>3718 ± 451</td>
</tr>
<tr>
<td>Stillbirth</td>
<td>7 (0.6)</td>
</tr>
</tbody>
</table>

IOM: Institute of Medicine
antepartum and distributed evenly across the week. One stillbirth occurred at 41+1 weeks, one at 41+2 weeks, one at 41+3 weeks, two at 41+4 weeks, and one at 42+0 weeks. There was one intrapartum fetal death at 41+3 weeks after SOL.

The probability of spontaneous onset of labour for all women from 41+0 to 41+6 weeks is shown in Figure 1. Because the data on timing of labour were available in hours and minutes, this resulted in a smooth appearance of the Kaplan-Meier curve. Estimates of the cumulative probability of spontaneous labour at the end of each day in this Kaplan-Meier curve are summarized in Table 2. For example, women who remained pregnant at 41+0 weeks had a 47% probability of spontaneous onset of labour by 41+3 weeks of gestation. This increased to 68% by 41+6 weeks of gestation.

The spontaneous onset of labour according to different maternal characteristics is shown in Figures 2 to 5. Women under age 25 and over age 40 had a significantly increased likelihood ($P < 0.001$) of having SOL, although differences between age groups were not marked (Figure 2). Parous women had a significantly increased chance ($P < 0.001$) of having SOL compared with nulliparous women (Figure 3). There was a clear and significant increase ($P < 0.001$) in the probability of SOL with decreasing BMI categories (Figure 4). For example, the probably of SOL by 41+3 weeks was 52.2% among underweight women compared with 38.4% among obese women. With regard to different
Figure 2. Probability of the onset of spontaneous labour according to maternal age among women at or beyond 41+0 weeks’ gestation, in British Columbia, 2008 to 2012

Figure 3. Probability of the onset of spontaneous labour according to parity among women at or beyond 41+0 weeks’ gestation, in British Columbia, 2008 to 2012
Figure 4. Probability of the onset of spontaneous labour according to pre-pregnancy BMI among women at or beyond 41+0 weeks’ gestation, in British Columbia, 2008 to 2012

Figure 5. Probability of the onset of spontaneous labour according to gestational weight gain among women at or beyond 41+0 weeks’ gestation, in British Columbia, 2008 to 2012
weight gain categories, the lower the gestational weight gain, the higher the probability of SOL \( (P < 0.001) \); as shown in Figure 5, women with lower than recommended pregnancy weight gain had a 48.7% probability of SOL by 41+3 weeks, compared with a 42.0% probability among women who gained more weight than recommended.

The independent effects of parity, maternal age, prepregnancy BMI, and gestational weight gain on SOL in these pregnancies are summarized in Table 3. Although all variables were statistically significant predictors, the model’s ability to predict SOL at the individual level was poor, as seen by the c-statistic of 0.56. Therefore, individualizing the probability of SOL on the basis of maternal characteristics was not a meaningful improvement on using the population average values presented in Table 1. There was also no meaningful difference in our results when missing values were filled using multiple imputations (results not shown).

**DISCUSSION**

This population-based study of low-risk pregnancies reaching 41+0 weeks of gestation generated estimates of the daily probability of SOL among women who remained pregnant one week past the expected delivery date. We further assessed the extent to which these characteristics could be combined to produce individualized predictions of SOL. Unfortunately, the c-statistic from our multivariable prediction model was low \( (0.56, \text{ when a value of } 0.7 \text{ is often considered to be the minimum value necessary for successful individualized prediction}) \) and therefore not useful in this manner. As a result, the population-average values shown in Table 2 are most appropriate for use by caregivers and pregnant women to inform decision-making on clinical management. The rate of spontaneous onset of labour in women whose pregnancies remain uncomplicated between 41+0 and 42+0 weeks is 67%. In our study population, approximately 10% of women had a medical indication for delivery, either by induction of labour or pre-labour Caesarean section. According to our findings, we can assume that the rate of SOL is 50% by the end of 41+3 weeks. In delaying induction of labour to this time rather than having a policy of induction at 41+0 weeks, this would allow 6182 women of the 15 253 women at 41+0 weeks to avoid induction. It is interesting to note that a smaller proportion of women have SOL beyond 41+4 weeks. These findings offer justification for patients who prefer having minimal or no intervention to delay induction of labour until further in this week, in order to potentially experience the spontaneous onset of labour.

The strengths of this study lie in its large sample size and the generalizability obtained by use of a population-based sample. Our database is validated yearly and includes over 99% of births in the province of British Columbia. Furthermore, unlike many population-based databases, ours provided access to information on the time in hours and minutes of SOL between 41+0 and 42+0 weeks, ensuring the correct denominator in our calculations (all ongoing pregnancies at the time a given woman went into labour, rather than information only on the day or completed weeks of delivery).

Our database contains data on women’s Bishop scores at the time of admission for delivery, but not at 41+0 weeks of gestation. As the goal of this study was to inform decision-making for women at 41+0 weeks’ gestation, knowing the Bishop score at the time of delivery admission would not be a useful predictor. We demonstrated in this study that individualized prediction at 41+0 weeks based on maternal characteristics was not effective, but further work to evaluate the predictive ability of the Bishop’s score at 41+0 weeks would be valuable. Data on pre-pregnancy BMI and weight gain were missing for a significant proportion of our cohort. Although it seems unlikely that the availability of BMI and weight gain data would affect our predictive ability, and sensitivity analyses using multiple imputations (allowing us to retain women with missing data in the model) were not meaningfully different, we cannot rule out the possibility that the missing data may have influenced our findings.

Although we are unaware of studies examining determinants of spontaneous onset of labour among women who have reached 41+0 weeks, our findings are in agreement with studies establishing determinants of remaining pregnant until post-term. In a large, population-based study in Sweden, increasing pre-pregnancy BMI was associated with an increased risk of post-term pregnancy and a longer duration of pregnancy.\(^{(15)}\) This study also found that a greater increase in BMI during pregnancy (BMI at

<table>
<thead>
<tr>
<th>Maternal characteristic</th>
<th>Hazard ratio (95% CI)</th>
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<tr>
<td>Parity ≥ 1 (vs. nulliparous)</td>
<td>1.33 (1.24 to 1.41)</td>
</tr>
<tr>
<td>Maternal age (per 5 years)</td>
<td>0.95 (0.92 to 0.99)</td>
</tr>
<tr>
<td>Maternal pre-pregnancy BMI (per 5 kg/m(^2))</td>
<td>0.88 (0.85 to 0.91)</td>
</tr>
<tr>
<td>Gestational weight gain (per 5 kg)</td>
<td>0.96 (0.91 to 0.98)</td>
</tr>
<tr>
<td>Interaction term for weight gain and BMI</td>
<td>1.00 (1.00 to 1.00)</td>
</tr>
</tbody>
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delivery minus pre-pregnancy BMI) was also associated with longer duration of pregnancy. A study of the Danish Birth Cohort also found an increased risk of post-term pregnancy with increasing pre-pregnancy BMI (adjusted odds ratios of 1.24 [95% CI 1.15 to 1.34] among women with a pre-pregnancy BMI of 25 to 29 kg/m², 1.37 [95% CI 1.22 to 1.54] with a BMI of 30 to 34 kg/m², and 1.52 [95% CI 1.28 to 1.82] with a BMI of 35 kg/m² and above). Our study results are supported by these previous findings. In the Danish Birth Cohort, there was a significantly increased risk among nulliparous women of reaching post-term (adjusted odds ratio of 1.35), but no statistically significant or clinically meaningful association between maternal age and risk of post-term pregnancy. This lends validity to our findings that among women who remain pregnant at 41+0 weeks, the chance of SOL increases with increasing parity, decreasing BMI, and decreasing weight gain. Again, our study focused on relevant risk factors for SOL after reaching 41+0 weeks, not risk factors for reaching 41+0 weeks, although they are supported by the latter. More research is needed in women with higher BMI and higher weight gain on the onset of parturition.

It was not the intent of this study to review the perinatal morbidity and mortality of inductions of labour compared with conservative management with fetal assessments, as this has been reported in a recent revision of a Cochrane review. There is a well-known gradual increase in stillbirth rates during the interval studied, although the actual rates remain low. Furthermore, a recent meta-analysis has demonstrated that a policy of offering labour induction for women at ≥ 41+0 weeks of gestation would decrease perinatal mortality without affecting Caesarean section rates. The most recent Canadian guideline supports this view but the precise day of intervention at or beyond 41+0 weeks of gestation at which ideal outcomes would be encountered is unknown. Our study provides information on the number of women who will go into spontaneous labour within this time period; this should inform resource planning implications (number of inductions and number of women requiring fetal surveillance) associated with policies for routine induction at different gestational ages within the week (e.g., routine induction at 41+0 weeks vs. routine induction at 41+3 weeks).

We also did not intend to review the costs of delaying induction of labour from 41+0 to 42+0 weeks of gestation. This would require a comparison of the cost of resources to conduct adequate fetal assessments in the interval studied with the cost of carrying out increased numbers of labour inductions early in the week, and consideration of the costs of an increased or decreased number of Caesarean sections in each group.

CONCLUSION

In uncomplicated singleton pregnancies reaching 41+0 weeks of gestation with a cephalic presentation, women were more likely to have SOL if they were younger, parous, had a lower pre-pregnancy BMI, or had a lower gestational weight gain. However, these characteristics were not sufficient to be able to predict the SOL accurately on an individual level. As a result, the population level estimates of the probability of SOL on a specific day presented here are the most appropriate for supporting clinical decision making and counselling of these pregnant women.

ACKNOWLEDGEMENTS

Jennifer Hutcheon is supported by New Investigator Awards from the Canadian Institutes of Health Research and the Michael Smith Foundation for Health Research.

REFERENCES

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