

Risk factors for Caesarean delivery after induction of labour among nulliparous women at term

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Objectives: To determine risk factors for Caesarean section after induction of labour (IOL) at term among nulliparous women, and to develop and validate a predictive model.

Methods: We retrospectively reviewed records of all nulliparous women with term, singleton, cephalic pregnancies and induction of labour from 1 January to 31 December 2017 in Queen Elizabeth Hospital. The cervix was examined on admission using the Modified Bishop Score for cervical dilatation, effacement, position, consistency, fetal station. Women with unfavourable cervix received cervical priming. Those with favourable cervix proceeded to induction of labour by combining artificial rupture of membrane and oxytocin infusion. Risk factors for Caesarean delivery were identified using univariable analysis and multivariable logistic regression. A nomogram was constructed using the independent risk factors. A receiver-operating characteristics curve and the area under the curve were generated to assess the discriminative power of the predictive model. An external validation was performed.

Results: A total of 1557 women who were nulliparous and had term, singleton, cephalic pregnancies and induction of labour were included for analysis. 1426 (91.6%) of them were of Chinese ethnicity. Of the 1557 women, 473 (30.4%) underwent Caesarean delivery and the remaining 1084 women delivered vaginally. In the multivariable logistic regression, independent risk factors for Caesarean delivery were maternal age (odds ratio [OR]=1.04, $p=0.005$), baseline height (OR=0.954, $p=0.001$), final body mass index (OR=1.11, $p=0.001$), and need for cervical priming (OR=1.32, $p=0.033$). The discriminative power of the predictive model was assessed by the area under the curve, which was 0.661 for the study cohort and 0.613 for the external validation set of 142 women.

Conclusion: Among Hong Kong nulliparous women with induction of labour at term, independent risk factors for Caesarean delivery were older maternal age, lower baseline height, higher final body mass index, and more need for cervical priming. The predictive model based on these risk factors can calculate the probability of Caesarean section for counselling these women.

Keywords: *Cesarean section; Labor, induced; Nomograms*

Introduction

Induction of labour aims at stimulating uterine contractions to accomplish delivery prior to the onset of spontaneous labour. Induction of labour is advocated to reduce fetal or neonatal morbidity and mortality, to minimise maternal morbidity, or to benefit both¹. There is a trend of rising induction rates. The induction rate was >25% in the United States in 2017² and was 31.4% in 2016 and 33.4% in 2017 in public hospitals in Hong Kong. Nulliparous women have an increased risk of Caesarean delivery after induction of labour^{3,4}. Caesarean section is associated with short-term and long-term complications such as postpartum haemorrhage, morbid adherence of placenta, and uterine rupture in future pregnancies⁵⁻⁷. Risk factors for Caesarean delivery after induction of labour include nulliparity, more advanced maternal age, greater body mass index, hypertension, and diabetes⁸⁻¹². These risk factors have an overall predictive value around 70%^{8,9}. This study aimed to determine risk factors for Caesarean section after induction of labour at term among nulliparous women

in Hong Kong, and to develop and validate a predictive model to help counsel women at risk of Caesarean section.

Materials and Methods

This study was approved by the Kowloon Central / Kowloon East Cluster Research Ethics Committee (Ref: KC/KE-19-0123/ER-3). We retrospectively reviewed records of all nulliparous women with term (≥ 37 weeks of gestation), singleton, cephalic pregnancies and induction of labour from 1 January to 31 December 2017 in Queen Elizabeth Hospital, using the Clinical Data Analysis and Reporting System. In addition, external validation was performed using a validation set of patients recruited using the same inclusion criteria from 1 January to 31 January 2018. Multiparous women or women with previous Caesarean were excluded.

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Data retrieved included maternal age, baseline weight (pre-pregnancy weight or weight at first antenatal visit), baseline height, final body mass index (BMI) before delivery, group B Streptococcus screening result, gestational age on induction, need for cervical priming, and outcome of induction.

The cervix was examined on admission using the Modified Bishop Score for cervical dilatation, effacement, position, consistency, fetal station¹³. The cervix was considered unfavourable if the Modified Bishop Score was <6. Women with unfavourable cervix received cervical priming by vaginal prostaglandin E₂, either 3 mg tablet or 10 mg sustained release system (Propess) or both, in single or multiple doses. The choice of medication was based on patient and physician preference and the Modified Bishop Score. In patients with Modified Bishop Score ≤3, Propess was preferred because of its sustained release nature. Women with favourable cervix proceeded to induction of labour by combining artificial rupture of membrane and oxytocin infusion.

Statistical analyses were performed using SPSS (Windows version 23; IBM Corp, Armonk [NY], US) and STATA (version 14.2; StataCorp, College Station [TX], US). Risk factors for Caesarean delivery were identified using univariable analysis by Chi-square test for categorical variables and Mann-Whitney *U* test for continuous variables. All *p* values were two-sided. Variables with a *p* value of <0.2 were included in the multivariable logistic regression model to identify independent risk factors. A nomogram was constructed using the independent risk factors¹⁴. A receiver-operating characteristics curve and the area under the curve were generated to assess the discriminative power of the predictive model.

Results

Of 5695 deliveries in 2017 in Queen Elizabeth Hospital, 2105 (37.0%) had spontaneous onset of labour, 2573 (45.2%) had induction of labour, 740 (13.0%) had Caesarean section without labour, and 277 (4.9%) had augmentation of labour. Among the 2573 women with induction of labour, we excluded those with multiparity (*n*=908, 35.3%), preterm gestation (*n*=429, 16.7%), and/or multiple pregnancies (*n*=5, 0.194%). A total of 1557 (60.5%) women who were nulliparous and had term, singleton, cephalic pregnancies and induction of labour were included for analysis (Table 1). 1426 (91.6%) of them were of Chinese ethnicity.

Among the 1557 women included, 473 (30.4%)

Table 1. Indications for induction of labour

Indications	No. (%) of cases (n=1557)*
Hypertension/proteinuria/pre-eclampsia	84 (5.39)
Gestational diabetes/diabetes	129 (8.29)
Maternal disease	13 (0.83)
Past term	272 (17.47)
Antepartum haemorrhage/ persistent show	220 (14.13)
Leaking	462 (29.67)
Abnormal fetal heart	188 (12.07)
Small fetal growth	112 (7.19)
Large fetal growth	77 (4.95)
Meconium stained liquor	15 (0.96)
Polyhydramnios	14 (0.90)
Oligohydramnios	42 (2.70)
Reduce fetal movement	31 (1.99)
Prolonged latent phase	21 (1.35)
Maternal fever	6 (0.39)
Maternal anxiety	6 (0.39)
Others	6 (0.39)

* Total exceed 1557 because some had >1 indication

underwent Caesarean delivery for failed induction (*n*=340, 71.9%), non-reassuring fetal heart status (*n*=74, 15.6%), arrest of first stage of labour (*n*=40, 8.5%), and cord prolapse, prolonged second stage, and failed instrumental delivery (*n*=19, 4.0%). The remaining 1084 women delivered vaginally: 807 (74.4%) spontaneous vaginal delivery, 240 (22.1%) by vacuum extraction, and 37 (3.4%) by forceps delivery.

The Caesarean group and vaginal delivery group were compared in terms of maternal antepartum characteristics. In the univariable analysis, variables with a *p* value of <0.2 were included in the multivariable logistic regression model, namely maternal age, baseline weight, baseline height, final BMI, gestational age on induction, and need for cervical priming (Table 2). In the multivariable logistic regression, independent risk factors for Caesarean delivery were maternal age (odds ratio [OR]=1.04, *p*=0.005), baseline height (OR=0.954, *p*=0.001), final BMI (OR=1.11, *p*=0.001), and need for cervical priming (OR=1.32, *p*=0.033) [Table 3]. A nomogram was constructed using the independent risk factors (Figure 1). The discriminative power of the predictive model was assessed by the area under the curve, which was 0.661 (95% confidence interval=0.629-0.692, Figure 2a).

Table 2. Univariate analysis of risk factors for Caesarean delivery after induction of labour at term in nulliparous women

Characteristics	Caesarean delivery (n=473)*	Vaginal delivery (n=1084)*	p Value
Maternal age, y	31.3±4.4	30.7±4.3	0.078
Baseline weight, kg	56.0±9.8	53.9±8.9	<0.0005
Baseline height, cm	157.4±5.7	159.2±5.7	<0.0005
Final body mass index, kg/m ²	28.2±3.9	26.96±3.4	<0.0005
Positive group B streptococcus status	111 (23.5)	275 (25.4)	0.444
Gestational age on induction, weeks	38.9 (38-40)	39.0 (38-40)	0.037
Need for cervical priming	172 (36.4)	313 (28.9)	0.004

* Data are presented as mean±standard deviation, median (interquartile range), or No. (%) of patients

Table 3. Multivariate analysis of risk factors for Caesarean delivery after induction of labour at term in nulliparous women

Characteristics	Odds ratio (95% confidence interval)	p Value
Maternal age	1.04 (1.01-1.07)	0.005
Baseline weight	1.00 (0.976-1.03)	0.915
Baseline height	0.954 (0.927-0.982)	0.001
Final body mass index	1.11 (1.04-1.18)	0.001
Gestational age on induction	1.09 (0.984-1.21)	0.098
Need for cervical priming	1.32 (1.02-1.71)	0.033

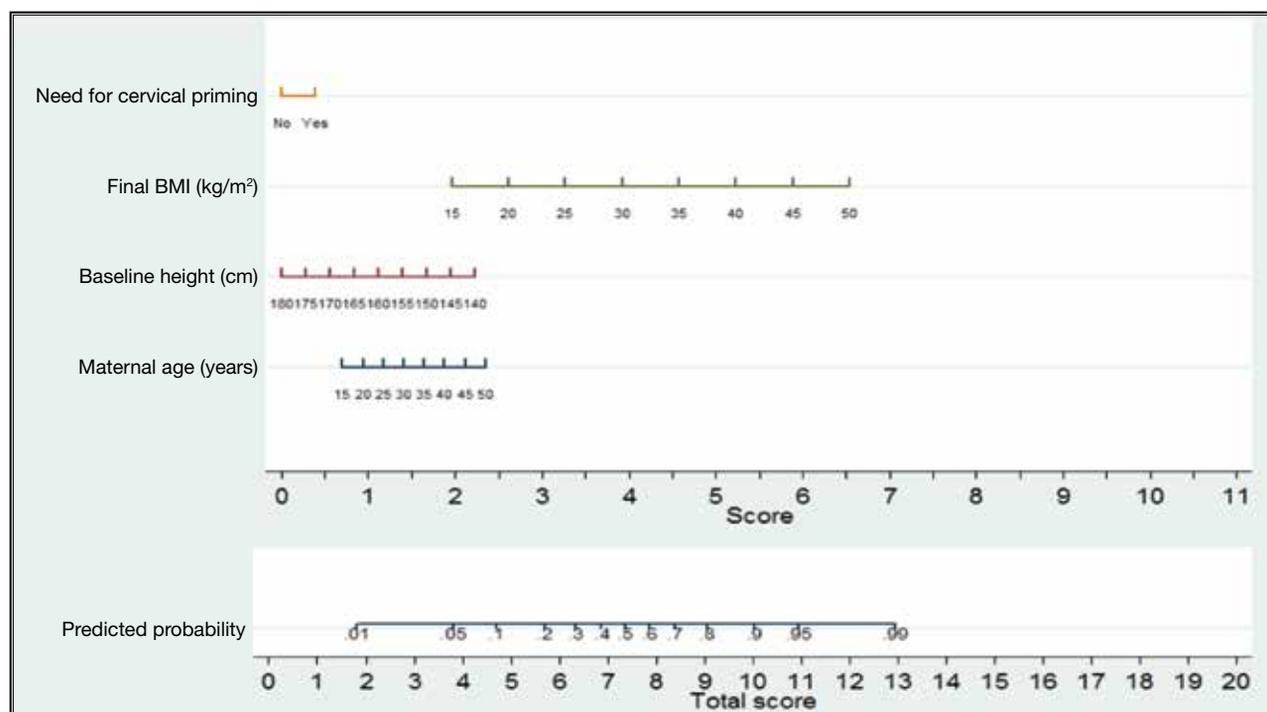


Figure 1. A nomogram predicting the probability of Caesarean delivery for nulliparous women with induction of labour at term based on the independent risk factors (maternal age, baseline height, final body mass index (BMI), and need for cervical priming).

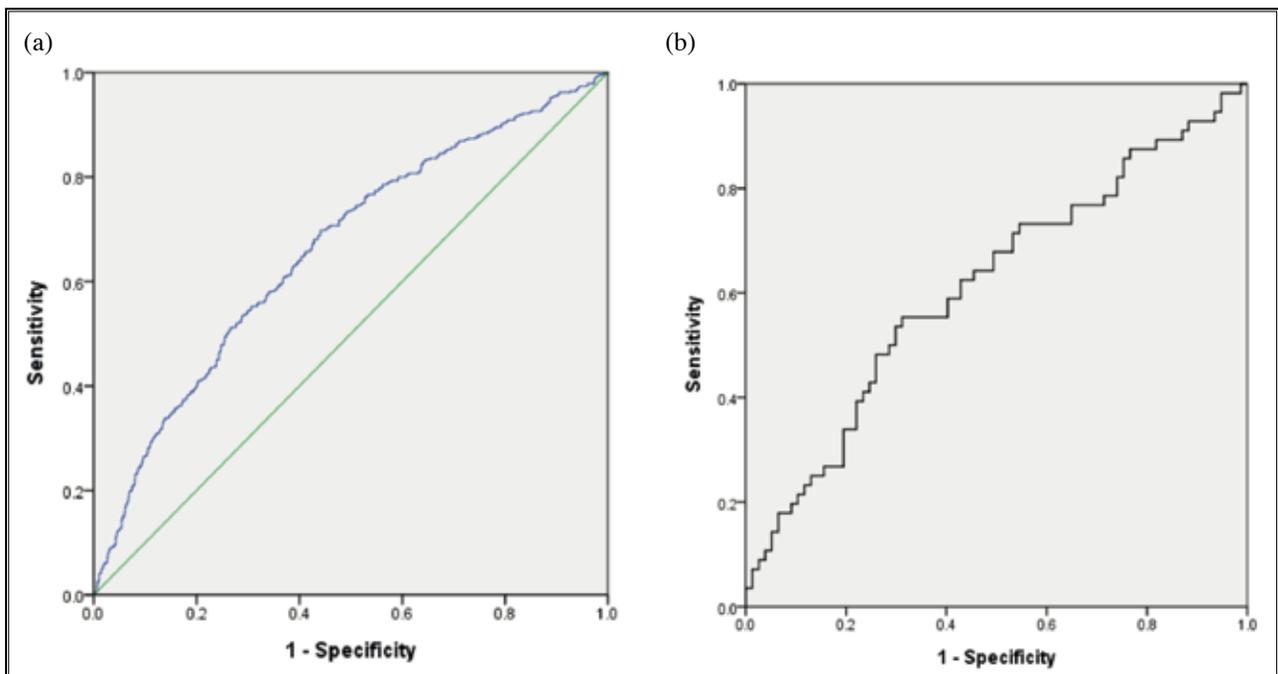


Figure 2. The area under the receiver operating characteristic curve was (a) 0.661 (95% CI=0.629-0.692) for 1557 nulliparous women with induction of labour at term and (b) 0.613 (95% CI=0.515-0.711) for the external validation set of 142 women.. Perpetrator of abuse

An external validation was performed using a validation set of 142 women recruited using the same inclusion criteria from 1 January to 31 January 2018. Of the 142 women with induction of labour, 60 (42.3%) underwent Caesarean delivery for failed induction ($n=37$, 61.7%), non-reassuring fetal heart status ($n=16$, 26.7%), arrest of first stage of labour ($n=3$, 5%), and cephalopelvic disproportion or prolonged second stage ($n=4$, 6.7%). The remaining 82 women delivered vaginally: 65 (79.3%) spontaneous vaginal delivery, 14 (17.1%) by vacuum extraction, and 3 (3.7%) by forceps delivery. The nomogram was applied to the external validation set, and the area under the curve was 0.613 (95% confidence interval=0.515-0.711, Figure 2b).

Discussion

Among Hong Kong nulliparous women with induction of labour at term, independent risk factors for Caesarean delivery were older maternal age, lower baseline height, higher final BMI, and more need for cervical priming. The risk factors identified in our study were consistent with those reported in studies on Western populations⁹⁻¹². We aimed to develop and validate a predictive model to help counsel local nulliparous women with induction of labour at term at risk of Caesarean section whose antepartum characteristics (especially height, weight, and body mass index) may differ from Western populations. Previous studies have also included

other risk factors such as ultrasound cervical length and birth weight in the prognostic model¹⁰⁻¹². We included only four readily available antepartum risk factors to the predictive model; it is more user-friendly for obstetricians in patient counselling. In addition, the predictive model was externally validated to ensure the discriminative power and reproducibility¹⁵.

Nonetheless, the predictive model and nomogram were limited to nulliparous women with induction of labour at term and cannot be generalisable to multiparous women, preterm deliveries, or those with previous Caesarean deliveries. We included only nulliparous women because they accounted for most of Caesarean deliveries after induction of labour. Although the model was externally validated, the validation set was from the same institute and the sample size was small. External validation with a larger sample from multiple centres can increase the generalisability. The discriminative power of the predictive model was only 0.661; other antepartum or intrapartum factors (such as indications for induction of labour, Modified Bishop Score, and presence of diabetes/hypertension) should have been evaluated to generate a more powerful predictive model^{18,16-20}.

The predictive model should be used in conjunction with the overall clinical information. It should not be used

alone for decision making on the mode of delivery. There is no threshold above which a direct Caesarean section is indicated instead of induction of labour. For example, in a 17-year-old nulliparous woman with a height of 155.4 cm, final BMI of 23.98 kg/m², and favourable cervix, her risk score is $0+0.8+1.4+3.2=5.4$, and the predicted probability of Caesarean delivery is 18%. The patient can expect a higher chance of achieving vaginal delivery, hence proceeding to induction of labour if clinically indicated. In another example, in a 25-year-old nulliparous woman with a height of 149 cm, final BMI of 38.74 kg/m², and unfavourable cervix, her risk score is $0.4+1.6+5+1.2=8.2$, and the predicted probability of Caesarean delivery is 68%. The patient can be counselled for short trial of induction

of labour or direct Caesarean section based on clinical indications.

Conclusion

Among Hong Kong nulliparous women with induction of labour at term, independent risk factors for Caesarean delivery were older maternal age, lower baseline height, higher final BMI, and more need for cervical priming. The predictive model based on these risk factors can calculate the probability of Caesarean section for counselling these women.

Declaration

The authors have no conflict of interest to disclose.

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