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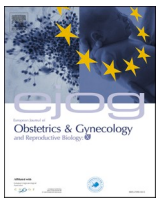

Induction of labor after one previous cesarean: Predictors of vaginal birth☆

Saniyati Badri Bashirudin, Siti Zawiah Omar, Farah Gan, Mukhri Hamdan, Peng Chiong Tan [*,1]

Department of Obstetrics and Gynecology, Faculty of Medicine, University Malaya, Jalan Profesor Diraja Ungku Aziz, Kuala Lumpur 50603, Malaysia

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ABSTRACT

Objective: To identify independent predictors for vaginal delivery after induction of labor after one cesarean (IOLAC).

Study design: In this retrospective cohort study, the electronic medical record of 19064 women who delivered from January 2018–September 2022 in a university hospital in Malaysia were individually searched to identify cases of IOLAC. Preselected data points on characteristics and the outcome of mode of delivery were retrieved. Bivariate analysis was performed to identify predictor characteristics for the dichotomous outcomes of vaginal delivery vs unplanned cesarean delivery. Variables with crude $p < 0.05$ were incorporated into a multivariable binary logistic regression analysis to identify independent predictors of vaginal delivery after IOLAC.

Results: 819 IOLAC cases were identified. There were 465/819 (56.5 %) unplanned cesareans deliveries. Of the 14 selected characteristics, eight had $p < 0.05$ on bivariate analysis. After adjustment, six characteristics, body mass index, height, ethnicity, parity, previous cesarean indication and Bishop score were independently predictive of vaginal birth but not maternal age or method of labor induction. Birthweight, labor induction indication, gestational age, haemoglobin level, diabetes and hypertension in pregnancy were not significant at the level of bivariate analysis.

Conclusion: Obesity, short stature, no prior vaginal delivery, previous cesarean indicated by failure to progress, unfavorable Bishop score and ethnicity were independent predictors for unplanned cesarean after IOLAC. These predictors should help guide women and their care providers in their shared decision-making about IOLAC.

Introduction

The worldwide cesarean rate is 21.1 %, ranging from 5 % in sub-Saharan Africa to 42.8 % in Latin America and the Caribbean, having risen in all regions since 1990 with the greatest increase of 44.9 % in Eastern Asia [1]. National Health Service England maternity statistic data shows induction of labor (IOL) rates have increased from 18.3 % in 1989-90 to 34.4 % by 2020–21 [2]. With the increasing cesarean delivery rate, pregnancy after previous cesarean are also increasing [3]. The IOL rate in trials of labor after cesarean (TOLAC) can be as high as 27–32.7 % [4,5].

IOLAC is a high-risk procedure, causing a scar rupture rate of up to 2.5 % with prostaglandin [6]. Findings of recent IOLAC trials show that the unplanned cesarean rate can be as high as 59 % [7]-69 % [8] compared to 45 % unplanned cesarean rate after TOLAC [9]. Nevertheless, the American College of Obstetricians and Gynecologists (ACOG) guideline accepts IOLAC as an acceptable option [10].

There is limited trial data on IOLAC: A 2016 systematic review on balloon catheters for induction of labor at term after previous cesarean section reported no randomized controlled trial, and data on balloon catheters for labor induction after previous cesarean section are limited by small sample size and retrospective analyses [11]. 2017 Cochrane metanalysis (eight studies with 707 women) on methods (including Foley catheter and dinoprostone) also concluded that evidence is inadequate [12]. Similarly, a 2019 systematic review and metanalysis finds only low to very low certainty evidence for cervical ripening and/or labor induction techniques for vaginal birth after cesarean (VBAC) [13].

Data on maternal characteristics that are predictive of vaginal delivery specifically after IOLAC is sparse. We aim to identify independent predictors for vaginal delivery after IOLAC after an adjusted analysis controlling for confounders.

Abbreviations: IOL, Induction of labor; IOLAC, Induction of labor after one cesarean; TOLAC, Trial of labor after cesarean.

☆ This study was conducted at University Malaya Medical Center, Kuala Lumpur, Malaysia.

* Corresponding author.
E-mail addresses: pctan@um.edu.my, tanpengchiong@yahoo.com (P.C. Tan).
[1] ORCID: https://orcid.org/0000-0001-8713-6581.

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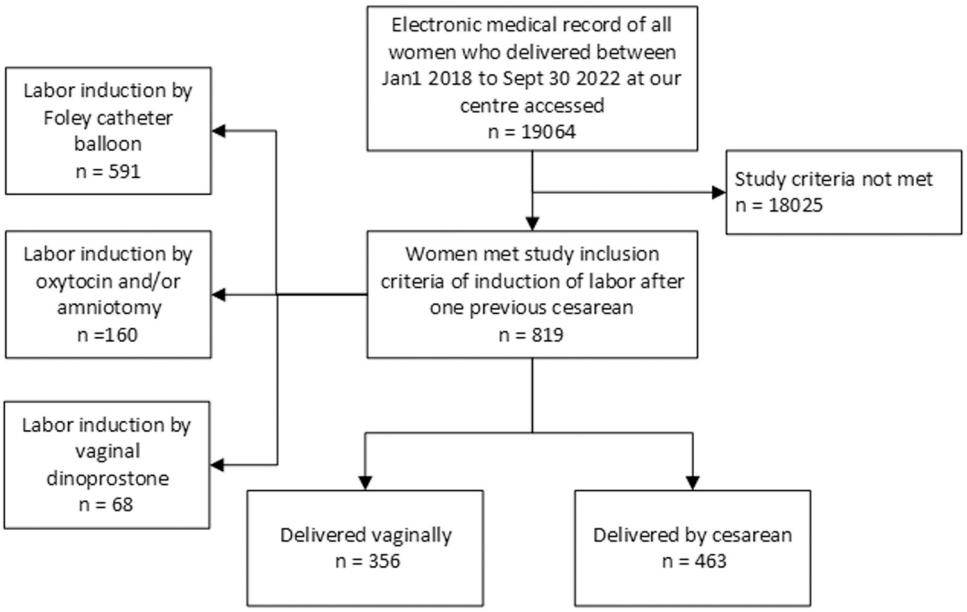

Fig. 1. Flow chart for data retrieval and analysis pathways for a retrospective study on independent predictors of vaginal birth after induction of labor of women with one previous cesarean and comparison of Foley balloon vs vaginal dinoprostone.

Material and methods

This is a retrospective cohort study of data retrieved from individual women's electronic medical record. All 19064 women who delivered at University Malaya Medical Centre (UMMC), Kuala Lumpur, Malaysia from January 1, 2018 to September 30, 2022 had their electronic medical record (hospital chart) individually scrutinized by investigator SBB to identify cases of IOLAC. Data retrieval was extended for another 9 months to September 30 2022 to include the latest data prior to cessation of data collection in October 2022.

UMMC is a tertiary, state-funded, full services hospital located in the capital city of a middle-income multi-ethnic Asian country. Care was provided free of charge or heavily subsidised. The delivery rate was 4–5 thousand births per annum, with a 30–35 % cesarean delivery rate and our IOL rate was 25–30 %.

For IOL in our center, with intact membranes and an unfavorable cervix precluding amniotomy, cervical ripening was predominantly by Foley balloon and sometimes vaginal dinoprostone tablet. With spontaneous membrane rupture and an unfavorable cervix either titrated oxytocin infusion or dinoprostone was used. Concurrent Foley, dinoprostone or oxytocin use was rare. Oxytocin for initiating contractions was usually only after membrane rupture.

The full inclusion criteria for this study were one previous cesarean section only (with or without prior vaginal birth), had induction of labor, term gestation ($\geq$ 37 weeks), singleton, live, and cephalic fetus at induction and maternal age $\geq$ 18 years. In UMMC, planned repeat cesarean was recommended for women with two or more previous cesarean.

The case report form's (CRF) data points on potential predictors were guided by known predictors of vaginal delivery after TOLAC [14] which include baseline demographics (maternal age, ethnicity and body mass index), obstetric history (parity, previous vaginal delivery, indication for prior cesarean), index pregnancy factors (gestational age at IOLAC, diabetes in pregnancy and hypertension in pregnancy), IOLAC specifics (indication of induction, Bishop score at induction, method of induction and full blood count at IOLAC), and birth weight. Maternal characteristics, outcomes of mode of delivery and indication of cesarean were abstracted onto the CRF and then entered into a SPSS database.

This study was approved by the Medical Research Ethics Committee of University Malaya Medical Centre (approved February 8, 2022; reference number 202215-10901).

Sample size

Our target sample size was calculated thus: in the study objective for identifying independent predictors of VBAC after IOLAC, trials have reported a VBAC rate of 40–50 % after Foley IOLAC [7,8]. We anticipated a 10 independent variables model for multivariable binary logistic regression analysis. Accounting for the 10 events per variable rule [15,16], we would need at least 100 VBAC which could be expected to be found 100/(0.4–0.5) = 200–250 IOLAC cases. For robust binary logistic regression analysis the minimum sample considered adequate is 500 [17]. Prior audit indicated that there were about 150–200 cases of IOLAC per year at our center. We anticipated that the 4 most recent years (Jan 1 2018 – Dec 31 2021) should comprise at least 620 IOLAC cases.

Statistical analysis

Data were entered into SPSS statistical software (Version 26, IBM, SPSS Statistics). Distribution of continuous data was assessed with the Kolmogorov Smirnov test. Descriptive statistics were performed for the study population.

To identify independent predictors of successful IOLAC, bivariate analyses using the t-test was used to compare means of continuous normally distributed data, the Mann-Whitney U test for ordinal or non-normally distributed data and Chi-square test for categorical data, to vaginal delivery vs unplanned cesarean following IOLAC. Variables with $p < 0.05$ on bivariate analysis were then incorporated into the model for multivariable binary logistic regression analysis to identify independent predictors of vaginal delivery after IOLAC.

To ease interpretation for the six independent predictors, we reduced them into categorical variables: body mass index (BMI) $\geq$ 30 vs $<$ 30 (obese vs non-obese), height $\geq$ 157 cm vs $<$ 157 cm (50th centile cut-off for the study population), and Bishop score $\geq$ 6 vs $\leq$ 5 (conventional cut-off for favorable vs unfavorable cervix). Parity was recategorized to parity 1 (no prior vaginal birth), parity 2 (one prior vaginal birth) and parity $\geq$ 3 (two or more prior vaginal birth) as the number of cases with 3 or more prior vaginal births were not many. Ethnicity was recategorized to three reflecting the main two ethnicities of Malay and Chinese,

Table 1
Characteristics of women who had induction of labor after one previous cesarean.

Maternal demographics	N = 819
Maternal age (years)	32.4 ± 3.9
Body mass index (kg/m^2)	30.9 ± 5.2
Height (cm)	157 [153–160]
Ethnicity	
Malay	593 (72.4 %)
Chinese	73 (8.9 %)
Indian & others	153 (18.7 %)
Indian	94 (11.5 %)
Others[a]	59 (7.2 %)
Obstetric history	
Parity	
Parity 1	530 (64.7 %)
Parity 2	164 (20.0 %)
Parity ≥3	125 (15.3 %)
Previous cesarean indication	
Failure to progress	253 (30.9 %)
Non-reassuring fetal status[b]	341 (41.6 %)
Others[c]	225 (27.5 %)
Diabetes in pregnancy	366 (44.7 %)
Hypertension in pregnancy	58 (7.1 %)
Hemoglobin level pre-delivery (g/dl)	11.8 ± 1.1
Gestational age at induction (weeks)	38.7 ± 1.1
Bishop score at induction	6[5–8]
Indication for induction	
Diabetes in pregnancy	256 (31.3 %)
Non-reassuring fetal status[d]	214 (26.1 %)
Prolonged pregnancy > 39 weeks	125 (15.3 %)
Prelabor rupture of membrane	83 (10.1 %)
Large for gestational age	70 (8.5 %)
Others[e]	71 (8.7 %)
Induction method	
Foley	591 (72.2 %)
Prostaglandin	68 (8.3 %)
Amniotomy and/or oxytocin	160 (19.5 %)
Birth weight (kg)	3.058 ± 0.396

Data expressed as mean ± standard deviation, median [interquartile range] and number (%).

[a] Includes Malaysian native tribes, Indonesian, Thai, Burmese, Bangladeshi, Sri Lankan, Yemeni, Sudanese and Nigerian.

[b] Includes abnormal fetal heart rate tracing, fetal growth restriction and abnormal dopplers.

[c] Includes non-cephalic presentation, hypertension in pregnancy, placenta previa, large for gestational age, maternal request, teenage pregnancy.

[d] Includes small for dates, small for dates or growth restriction, oligohydramnios, suspicious dopplers, reduced fetal movement but fetal heart rate tracing must be reassuring at induction.

[e] Includes fetal anomaly, thrombocytopenia in pregnancy, gestational proteinuria, cholestasis at term.

and others (a combination of diverse ethnic minorities within our population which had similar vaginal delivery rates after IOLAC within our study). Indication of prior cesarean was organized to contrast failure to progress (inclusive of cephalopelvic disproportion, labor dystocia and failed induction that were likely recurrent) with non-reassuring fetal status (plausibly recurrent) and pre-labor cesarean sections (including non-cephalic presentation, placenta previa that were likely non-recurrent) categories. Two-sided $p < 0.05$ was taken as the level of significance.

Results

Fig. 1 depicts the participants' flow through the study. Over the study period of January 1, 2018 to September 30, 2022, 19,064 deliveries were recorded in our center. 819 women who had IOLAC were identified. Their IOL method and mode of delivery are shown. There were 563/819 (56.5 %) unplanned (emergency) cesarean after IOLAC.

Table 1 shows the characteristics of the 819 IOLAC cases with regards to demographics, obstetric history and information on the index pregnancy.

Table 2 lists the 14 selected variables for bivariate analysis. Eight of these variables, maternal age, body mass index, height, ethnicity, parity, prior cesarean indication, Bishop score and IOL indication were significantly correlated with vaginal delivery after IOLAC, with bivariate analysis $p < 0.05$. After adjusted analysis, the six independent predictors were non-obese BMI < 30 AOR 0.62 (95 % CI 0.45–0.86) $p = 0.003$, height ≥ 157 cm AOR 1.37 (95 % CI 1.002–1.97) $p = 0.049$, Chinese (referent group) > Malay AOR 0.42 (95 % CI 0.24–5.49) $p = 0.002$ > other minority ethnicities AOR 0.25 (95 % CI 0.13–0.47) $p < 0.001$, higher order parity AOR 3.65 (95 % CI 2.4205.49) for parity 2 and AOR 7.45 (95 % CI 4.39–12.67) for parity ≥ 3, $p < 0.001$, prior cesarean not indicated by failure to progress AOR 1.42 (95 % CI 0.98–2.07) $p = 0.067$ for non-reassuring fetal status and AOR 1.77 (95 % CI 1.17–2.68) $p = 0.007$ for other indictions, and Bishop score ≥ 6 AOR 1.74 (95 % CI 1.22–2.50) $p = 0.002$. Maternal age and IOL indication were not significant after adjusted analysis.

Discussion

This study aimed to identify independent predictors for vaginal delivery after IOLAC after an adjusted analysis controlling for confounders. From a study population of 819 women who underwent IOLAC over the most recent 5-year period, the vaginal delivery rate after IOLAC was 43.5 %, compared to the 54.8 % vaginal delivery rate after TOLAC from a 2023 report [9]. This mode of delivery results was achieved whereby 80.5 % of the cases needed cervical ripening, in 64.7 % their only prior delivery was the cesarean, 53.5 % were obese and the median height was 157 cm (5 feet 1.8 in.).

We identified six independent predictors for vaginal delivery after IOLAC. Five of the six independent predictors we found, namely maternal BMI, Bishop score, minority ethnicity, increasing parity (more prior vaginal births) and previous cesarean indicated by failure to progress coincided with factors predictive for vaginal delivery after TOLAC identified in a meta-analysis [14]; the meta-analysis were largely derived of association studies without adjustment for confounders. BMI, cervical status and parity are also well known factors influencing vaginal delivery in general cases of IOL [18].

A systematic review and meta-analysis comments that "The belief that induction of labor is associated with an increased risk of cesarean delivery is based on the results of retrospective studies comparing induction with spontaneous labor at the same gestational age" [19]. Another meta-analysis reports that a policy of induction compared with expectant management was associated with a reduction in the risk of cesarean section [20] which has been confirmed by a large 2018 randomized trial report [21]. These findings indicate the need to separately evaluate risk factors for failed TOLAC which have been studied extensively [14] from that for failed IOLAC for which data is far sparser.

Additionally, we found maternal height to be an independent predictor. Consideration of ethnicity or race in predictive modelling of VBAC is controversial as often minorities are disadvantaged [22].

Maternal age, diabetes, hypertension complicating pregnancy, macrosomia and fetal malpresentation are also significant factors for vaginal delivery after TOLAC [14]. In our bivariate analysis, maternal age was significant as was IOL indication, but these were no longer significant after adjustment. On bivariate analysis, we did not find successful IOLAC to be associated with diabetes or hypertension in pregnancy, or birthweight.

Strengths and limitations

As to strength, we presented data on IOLAC from a contemporary cohort of IOLAC cases, sufficiently large for robust adjusted analysis [16,17]. The predictors of VBAC after IOLAC are likely to robust as they are consistent with hypothesis generated from the predictors of vaginal delivery after TOLAC [14]. The IOLAC cases were systematically

Table 2
Bivariate and multivariable binary logistic regression analysis on characteristics of women who had induction of labour after one previous caesarean dichotomised to women who had vaginal birth or caesarean section.

	Vaginal birth	Caesarean	p-value	RR (95 % CI)	AOR (95 % CI)	p-value
	(n = 356)	(n = 463)				
Maternal demographics						
Maternal age (years)	33.3 ± 4.2	32.31 ± 3.7	<0.001		0.97 (0.93–1.01)	0.167
Body mass index (kg/m^2)	29.4 [26.9–32.7]	31.2 [27.9–34.2]	<0.001			
BMI ≥30	164 (46.1)	274 (59.2 %)	<0.001	0.74 (0.64–0.87)	0.62 (0.45–0.86)	0.003
Height (cm)	157 [153–161]	156 [153–160]	0.006			
Height ≥157 cm	196 (55.1 %)	221 (47.7 %)	0.038	1.14 (1.01–1.28)	1.37 (1.002–1.97)	0.049
Ethnicity			<0.001			<0.001
Malay	273 (76.7 %)	320 (69.1 %)			0.42 (0.24–5.49)	0.002
Indian and Other	38 (10.7 %)	115 (24.9 %)			0.25 (0.13–0.47)	<0.001
Indian	22 (6.2 %)	72 (15.6 %)				
Other	16 (4.5 %)	43 (9.3 %)				
Chinese	45 (12.6 %)	28 (6 %)			[1]	
Obstetric history						
Parity			<0.001			<0.001
Parity 1	161 (45.2 %)	369 (79.7 %)			[1]	
Parity 2	101 (28.4 %)	63 (13.6 %)			3.65 (2.42–5.49)	<0.001
Parity ≥3	94 (26.4 %)	31 (6.7 %)			7.45 (4.39–12.67)	<0.001
Previous caesarean indication			<0.001			0.023
Failure to progress	82 (23.0 %)	171 (36.9 %)			[1]	
Non-reassuring fetal status	153 (43.0 %)	188 (40.6 %)			1.42 (0.98–2.07)	0.067
Other	121 (34.0 %)	104 (22.5 %)			1.77 (1.17–2.68)	0.007
Index pregnancy						
Diabetes in pregnancy	156 (43.8 %)	210 (45.4 %)	0.661	0.97 (0.83–1.13)		
Hypertension in pregnancy	22 (6.2 %)	36 (7.8 %)	0.378	0.86 (0.62–1.21)		
Haemoglobin at IOL (g/dl)	11.9 [11.1–12.6]	11.8 [11.1–12.6]	0.751			
Gestation at IOL (weeks)	38.4 [37.9–39.6]	38.7 [37.9–39.9]	0.061			
IOL indication			0.116			
Non-reassuring fetal status	109 (30.6 %)	105 (22.7 %)				
Diabetes in pregnancy	101 (28.4 %)	155 (33.5 %)				
Prolonged pregnancy	50 (14.0 %)	75 (16.2 %)				
PROM	38 (10.7 %)	45 (9.7 %)				
Large for gestational age	32 (9 %)	38 (8.2 %)				
Others	26 (7.3 %)	45 (9.7 %)				
Bishop score at induction	6[5–8]	6[5–7]	<0.001			
Bishop score ≥6	264 (74.2 %)	272 (58.7 %)	<0.001	1.33 (1.18–1.49)	1.74 (1.22–2.50)	0.002
Induction method			0.018			0.666
Foley	239 (67.1 %)	352 (76 %)			0.91 (0.61–1.37)	0.649
Prostaglandin	34 (9.6 %)	34 (7.3 %)			1.16 (0.59-.29)	0.665
Oxytocin or amniotomy	83 (23.3 %)	77 (16.6 %)			[1]	
Birth weight (kg)	3.04 ± 0.40	3.07 ± 0.40	0.263			

Data are expressed as mean ± standard deviation, median [interquartile range] or number (%). The normality of data distribution of continuous data was assessed with the Kolmogorov Smirnov test. Student t-test was used for analysis of continuous normally distributed data, Mann Whitney U test used for ordinal and non-parametric data and Chi Square test used for categorical or nominal data. Multivariable binary logistic regression was performed incorporating variables with $p < 0.05$ on bivariate analyses to identify independent predictors of vaginal birth after caesarean. 2-sided $P < 0.05$ was taken as the level of significance.
[1] Referent group

identified and verified, and data methodically abstracted from the review of the entire electronic medical record of the individual case by a single clinician-investigator (SBB).

We were limited by being a retrospective chart review, even if from electronic medical records, as such data was still more likely to be inaccurately or incompletely documented compared to prospectively collected data on prespecified data fields.

Conclusion

Obesity, shorter stature, no previous vaginal delivery, previous cesarean indicated by failure to progress in a trial of labor and an unfavorable Bishop score are independent predictors of unplanned cesarean after IOLAC. These predictors should inform care providers and women in their shared decision-making about IOLAC. The method of cervical ripening is not contributory.

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CRediT authorship contribution statement

SBB: Data curation, Formal analysis, Investigation, Methodology and Writing – original draft. **SZO**: Funding acquisition, Supervision, Writing – review & editing and minor role in Methodology and Formal analysis. **FG:** Data curation, Project administration, Writing – review & editing and minor role in Formal analysis. **MH:** Resources, Supervision, Writing – review & editing and minor role in Methodology and Formal analysis. **PCT:** Conceptualization, Formal analysis, Methodology, Project administration, Visualization, and Writing – original draft.

Declaration of Competing Interest

All authors report no conflict of interest.

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