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Comparison of pregnancy outcomes between induction of labor at 40 weeks and 41 weeks in low-risk women with Singleton pregnancies: a retrospective cohort study

Hua He[1†], Wei Ren[1†], Shiyu Li[1], Chaoli Chen[1] and Wenpei Zheng[1*]

Abstract

Background The best timing of delivery for term pregnancies has not been determined. This retrospective cohort study compared pregnancy outcomes between induction of labor (IOL) at 40 weeks and 41 weeks in low-risk women with singleton pregnancies and investigated maternal motivations regarding elective IOL.

Methods A total of 603 pregnant women were included in this study, with 342 (56.7%) undergoing IOL at 40–40^{+6} weeks and 261 (43.3%) at 41–41^{+6} weeks. The primary pregnancy outcome was the rate of cesarean section (CS), and the secondary pregnancy outcomes included the rates of neonatal asphyxia and neonatal intensive care unit (NICU) admission. Maternal motivations regarding elective IOL were investigated.

Results The rate of CS was 25.1% in the IOL at 40–40^{+6} weeks group and 33.7% in the IOL at 41–41^{+6} weeks group ($p = 0.021$). The three most prevalent indications for CS in both groups were: (1) non-reassuring fetal heart rate patterns (NRFHRP); (2) meconium-stained amniotic fluid; and (3) failed induction of labor. Compared with the 41-week IOL group, women who underwent IOL at 40 weeks' gestation exhibited higher educational attainment (93.6% vs. 82.0%, $P < 0.001$), a higher proportion of high-income families (91.5% vs. 68.2%, $P < 0.001$), a higher proportion of multiparae (24.0% vs. 16.5%, $P < 0.05$), a lower proportion of ripeness of the cervix (27.5% vs. 37.2%, $P < 0.05$), shorter hospitalization durations (5.84 ± 1.79 vs. 6.17 ± 1.95, $P < 0.05$), and higher hospitalization costs (13627.39 ± 3227.56 vs. 10837.77 ± 3276.73, $P < 0.001$). No significant intergroup differences were observed in the rates of neonatal asphyxia and NICU admission. The most common motivation for elective IOL was concern regarding fetal distress or stillbirth. Parity ≥ 1 and a Bishop score ≥ 6 were protective factors against CS following IOL.

Conclusions IOL at 40 weeks did not result in increased adverse outcomes compared to IOL at 41 weeks. Parturients with higher education and income were more likely to choose elective IOL. Parity ≥ 1 and a Bishop score ≥ 6 were protective factors against CS following IOL. These may provide a new option for clinical decision-making.

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Keywords Time of induction of labor, Pregnancy outcomes, Rate of cesarean section, Maternal motivation

Background

From the initiation of a woman's last menstrual period, the mean pregnancy lasts about 280 days(namely, 40 weeks), but only about 5% give birth on the day of 40 weeks [1]. Labor between 37 and 42 weeks is normal, but adverse perinatal outcomes including stillbirth and maternal complications, increase progressively after 40 weeks and significantly after full term (≥42 weeks) [2]. When the benefits of pregnancy outweigh that of delivery, it is preferable to continue the pregnancy (or equivalently, when the risks are less than continuing the pregnancy, it is preferable to deliver at a given gestational age) [3]. It has been recognized for a long time that gestational age is itself an indicator of risk and can be used as an indication for labor induction [3].

Induction of labor (IOL) is one of the most commonly used obstetric interventions [4]. IOL is recommended only when there are clear indications that the risks to the mother or baby of continuing the pregnancy outweigh the risks of inducing labor [5]. However, as the effectiveness and safety of IOL have improved, randomized trials show that IOL is also beneficial in healthy, uncomplicated pregnancies [6]. Elective inductions are defined as IOL in the absence of medical or obstetrical indications, which are common and contribute to the overall increasing induction rate [7]. While the clinical guidelines issued by the Society of Obstetricians and Gynaecologists of Canada and the Chinese Medical Association recommended IOL start from 41 weeks [8], the American College of Obstetricians and Gynecologists based on the ARRIVE (A Randomized Trial of Induction Versus Expectant Management) trial illustrated that elective IOL at 39 weeks is justified in low-risk nulliparous women [9].

The best timing of delivery for term pregnancies has not been determined [9]. Since Dr. Naegele introduced his rule for estimating due dates in 1812, the concept of a 40-week gestation period has become deeply ingrained in obstetric practice. The cumulative proportion of spontaneous labor that started before 40 weeks was 50.3% [10]. Upon reaching the due date, nearly half of pregnant women still show no signs of spontaneous labor. Patients prefer IOL over expectant management after their due date [11].

IOL at 39 weeks has not been universally accepted for both obstetricians and pregnant women in China. Also, few studies from China have discussed related themes. This retrospective cohort study compared pregnancy outcomes between IOL at 40 weeks and 41 weeks in low-risk women with singleton pregnancies and investigated maternal motivations regarding elective IOL.

Methods

Study population

A trained obstetrician conducted a comprehensive review of the electronic medical records (EMR) system at the Maternal and Child Health Hospital of Hubei Province. This study included low-risk pregnant women who underwent IOL and delivered at our hospital between June 30, 2023, and June 30, 2024.

The inclusion criteria were: (1) pregnant women of Han ethnicity aged 18 years or older; (2) singleton pregnancy with head presentation; (3)no signs of spontaneous labor; (4)delivered following IOL; (5)no maternal comorbidities or pregnancy-related complications. The exclusion criteria were: hypertensive disorders of pregnancy, diabetes mellitus/gestational diabetes mellitus, polyhydramnios or oligohydramnios, premature rupture of membranes, history of uterine surgery, fetal growth restriction, and hepatic/renal dysfunction.

The study initially enrolled 1939 pregnant women with intrauterine live singletons who underwent IOL and delivered at our hospital between June 30, 2023, and June 30, 2024. Exclusion criteria were applied as follows: 191 women with hypertensive disorders of pregnancy, 387 with diabetes mellitus/gestational diabetes mellitus, 582 with premature rupture of membranes, 136 with polyhydramnios/oligohydramnios, 29 with history of uterine surgery, 7 complicated by hepatic/renal dysfunction, and 4 cases of fetal growth restriction.

Finally, a total of 603 pregnant women were included in this study, with 342 (56.7%) undergoing IOL at 40–40^{+6} weeks and 261 (43.3%) at 41–41^{+6} weeks, as shown in Figure 1.

The following information was extracted from the EMR system: age, pregestational Body Mass Index (BMI), educational level, annual household income, gravidity and parity, mode of conception, Bishop score, method of IOL, mode of delivery, total duration of labor, indications for cesarean section (CS), neonatal asphyxia, admission to the neonatal intensive care unit (NICU), neonate birth weight, shoulder dystocia, postpartum hemorrhage, episiotomy, Third- and fourth-degree perineal lacerations, hospitalization days and hospitalization costs.

Postpartum hemorrhage was defined as blood loss > 500 mL for vaginal delivery and > 1000 mL for CS within the first 24 h post-delivery. An Apgar score of less than 7 was classified as neonatal asphyxia in this study. Non-reassuring fetal heart rate patterns (NRFHRP) were defined according to the standardized definitions of the American College of Obstetricians and Gynecologists, and the United States National Institute of Child Health and

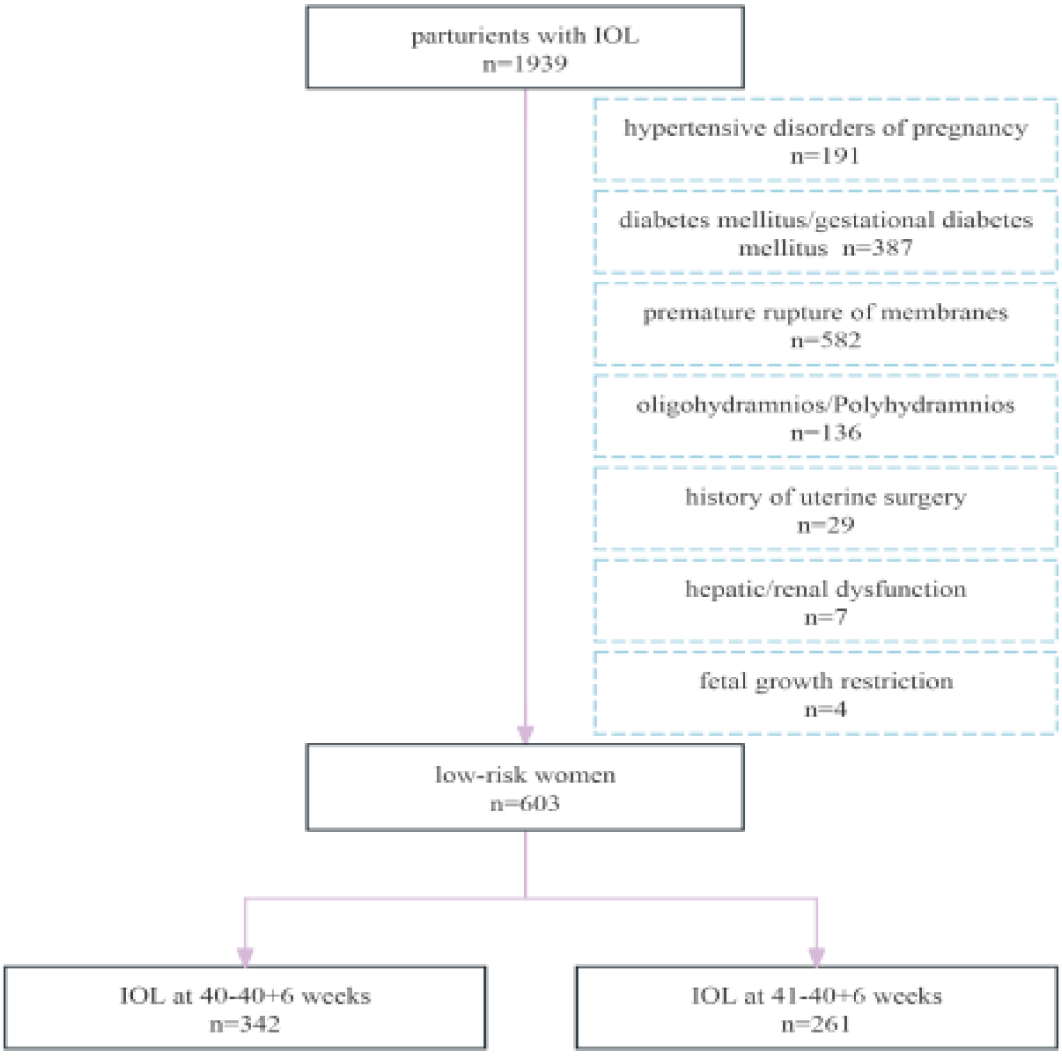

Fig. 1 Study population

Human Development [12]. The unit of Annual household income was yuan.

The primary pregnancy outcome was the rate of cesarean section (CS), and the secondary pregnancy outcomes included the rates of neonatal asphyxia and neonatal intensive care unit (NICU) admission.

Protocol of IOL

Informed consent

According to the latest clinical guidelines issued by the Chinese Medical Association, IOL was recommended for low-risk women with singleton pregnancies reaching 41 weeks of gestation. However, pregnant women residing in remote areas with limited access to hospital facilities might choose to be hospitalized after 40 weeks of gestation due to heightened concerns about potential obstetric emergencies. This practice of hospital admission without evident signs of spontaneous labor reflected a relative lack of medical resources. Furthermore, certain pregnant women chose to be hospitalized voluntarily after 40 weeks of gestation.

In this study, when pregnant women requested IOL at 40 weeks of gestation, obstetricians conducted a systematic evaluation of the clinical indications and provided comprehensive counseling regarding evidence-based risks and benefits to both the pregnant women and their families. When pregnant women persisted in their decision for IOL at 40 weeks following comprehensive counseling, obstetricians implemented the procedure upon verification of valid informed consent documentation.

Method of IOL

The Bishop score was used to assess the readiness of the cervix and the method of induction. It evaluated four components of cervical status (length, consistency, dilatation, position) and the position of the fetal head in relation to the ischial spine. The total score ranged from 0 to 13, a score greater than or equal to 6 was defined as

cervical ripening. Conversely, a score less than 6 was defined as cervical immaturity. Vaginal examinations to evaluate the cervix was required prior to and during IOL to confirm the best mode of induction and to observe and evaluate progress [10].

In our study, for cases with a prepared ripened cervix (Bishop score ≥ 6), IOL was initiated with intravenous oxytocin infusion. In contrast, when Bishop score < 6, the methods of induction involved the pharmacological method (dinoprostone vaginal insert, Propess®) or mechanical approach (double-balloon Cook catheter, DBC). The selection between these cervical ripening modalities was guided by a comprehensive evaluation of individual patient characteristics, including obstetric history, cervical status assessment, cost-effectiveness analyses, and risk stratification for potential complications. As shown in Figure 2.

The DBC was left for about 15 hours and then removed (or expulsed), followed by an assessment to determine the Bishop score [13]. If the score was greater than or equal to 6 without regular uterine contractions, the next step was intravenous oxytocin infusion. For the few cases still with a score less than 6, according to Queensland Clinical Guidelines: Induction of Labour V9 [14], Propess was inserted. Reinsertion of DBC after 24 h' rest was not a standard practice in our hospital.

Propess was left no more than 24 h. In cases of hypercontractions, premature rupture of membranes, or non-reassuring fetal heart rate patterns (NRFHRP), Propess should be removed [13]. After an interval of 30 min, if there were no regular uterine contractions or cervical dilation, the next step was intravenous oxytocin infusion.

Statistical analyses

Normally distributed data were presented as mean ± standard deviation (SD), and the unpaired Student's t-test was applied to compare differences among groups. For qualitative data, the Chi-square test was applied. Logistic regression models were applied to estimate the odds ratios (ORs) and 95% confidence intervals (CIs) for CS following IOL at different gestational weeks. The statistical analyses were performed by SPSS 25.0 version (IBM

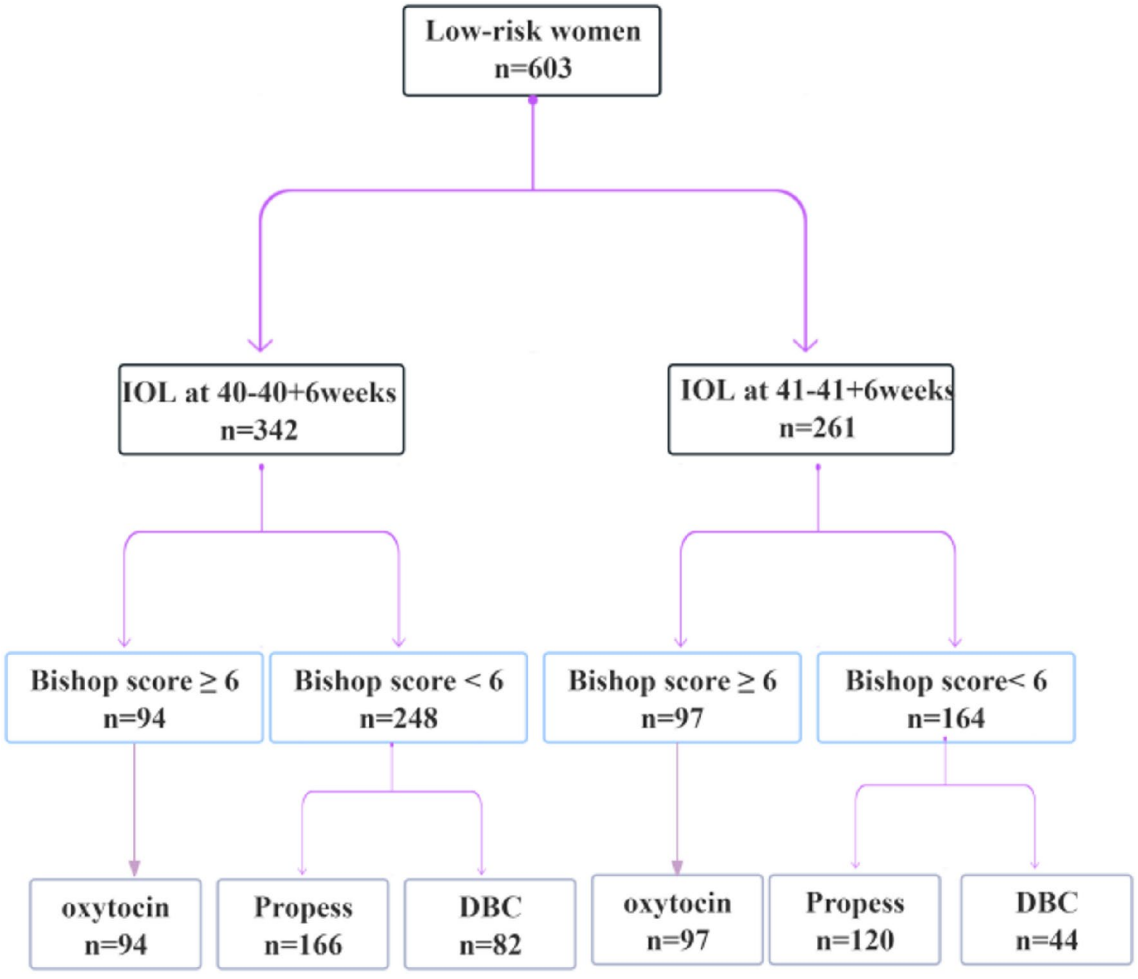

Fig. 2 Group of the study population

Corp, Armonk, NY, USA). $P<0.05$ was considered as statistically significant.

Results

Maternal characteristics

The maternal characteristics of the 603 parturients (342 (56.7%) undergoing IOL at 40–40^{+6} weeks and 261 (43.3%) at 41–41^{+6} weeks) were summarized in Table 1. No significant intergroup differences were observed in maternal age, pre-pregnancy BMI, or mode of conception. Compared with the 41-week IOL group, women who underwent IOL at 40 weeks' gestation exhibited higher educational attainment (93.6% vs. 82.0%, $P<0.001$), a higher proportion of high-income families (91.5% vs. 68.2%, $P<0.001$), a higher proportion of multiparae (24% vs. 16.5%, $P<0.05$).

Labor details

The rate of elective IOL (undergoing IOL at 40–40^{+6} weeks in this study) was 17.6% (342/1939). The rate of CS was 25.1% in the 40-week IOL group and 33.7% in the 41-week IOL group ($p=0.021$). The three most prevalent indications for CS in both groups were: (1) NRFHRP; (2) meconium-stained amniotic fluid; and (3) failed induction of labor. Notably, the 40-week IOL group exhibited 4 adverse outcomes: 2 instances of placental abruption, 1 fetal presentation conversion from cephalic to breech, and 1 umbilical cord prolapse. In comparison, the 41-week IOL group presented with a single case of fetal presentation conversion from cephalic to breech.

Furthermore, the 40-week IOL group demonstrated a lower proportion of ripeness of the cervix (27.5% vs. 37.2%, $P<0.05$), shorter hospitalization durations (5.84 ± 1.79 vs. 6.17 ± 1.95, $P<0.05$), and higher hospitalization costs (13627.39 ± 3227.56 vs. 10837.77 ± 3276.73, $P<0.001$). No significant intergroup differences were observed in total duration of labor, postpartum hemorrhage, or Third- and fourth-degree perineal lacerations. Notably, neither group experienced any instances of maternal or infant mortality, hysterectomy, or shoulder dystocia during the study period. As shown in Table 2; Figure 3.

Neonatal outcomes

Neonatal outcomes were demonstrated in Table 3. No significant intergroup differences were observed in neonatal outcomes, including the incidence of birth asphyxia, NICU admission rates, and birth weight percentiles.

Multivariable logistic regression analysis for CS following IOL

Multivariable logistic regression models were applied to estimate the odds ratios (ORs) and 95% confidence intervals (CIs) for CS following IOL at different gestational

Table 1 Maternal characteristics

	IOL at 40-40^{+6} weeks (n=342)	IOL at 41-41^{+6} weeks (n=261)	$\chi 2$ /t	P value
Age (year)	29.97±3.25	29.10±3.08	3.34	0.38
Pre-pregnancy BMI (kg/m2)	21.21±2.68	20.78±2.61	1.96	0.05
Education(years)				
<12	22(6.4%)	47(18.0%)	19.572	<0.001
≥12	320(93.6%)	214(82.0%)		
Annual household income(RMB)				
<100000yuan	29(8.5%)	83(31.8%)	53.234	<0.001
≥100000yuan	313(91.5%)	178(68.2%)		
Gravidity				
1	194(56.7%)	166(63.6%)	3.185	0.023
2	90(26.3%)	61(23.4%)		
≥3	58(17.0%)	34(13.0%)		
Parity				
Nulliparae	260(76.0%)	218(83.5%)	5.069	0.024
Multiparae	82(24.0%)	43(16.5%)		
Mode of conception				
natural conception	332(97.1%)	253(96.9%)	0.01	0.92
assisted reproduction	10(2.9%)	8(3.1%)		

Table 2 Labor details

	IOL at 40-40^{+6} weeks (n=342)	IOL at 41-41^{+6} weeks (n=261)	$\chi 2$ /t	*P* value
Bishop score				
<6	248（72.5%）	164（62.8%）	6.408	**0.011**
≥ 6	94（27.5%）	97（37.2%）		
Method of induction				
Propess	166(48.5%)	120(46.0%)		
DBC	82(24.0%)	44(16.9%)		
oxytocin	94(27.5%)	97(37.1%)		
Mode of delivery				
vaginal delivery	250(73.1%)	169(64.8%)	5.296	**0.021**
forceps delivery	6(1.8%)	4(1.5%)		
cesarean section	86(25.1%)	88(33.7%)		
Total duration of labor (minutes)	471.74±196.32	441.09±202.20	1.567	0.118
Shoulder dystocia	0(0.0%)	0(0.0%)		
Postpartum haemorrhage	25(7.3%)	18(6.9%)	0.038	0.845
Episiotomy	35(13.7%)	34(19.7%)	2.736	0.098
Third- and fourth-degree perineal lacerations	2(0.8%)	0(0.0%)	0.196	0.658
Indications for CS				
NRFHRP	32(37.2%)	45(51.1%)		
Meconium-stained amniotic fluid	13(15.1%)	21(23.9%)		
Failed induction of labor	13(15.1%)	7(8.0%)		
Fever in labor	9(10.5%)	2(2.3%)		
Maternal request	9(10.5%)	5(5.7%)		
Failure to progress in labor	6(6.9%)	7(8.0%)		
Placental abruption	2(2.3%)	0(0.0%)		
Fetal presentation conversion	1(1.2%)	1(1.0%)		
Umbilical cord prolapse	1(1.2%)	0(0.0%)		
Hospitalization days (days)	5.84±1.79	6.17±1.95	-2.19	**0.02**
Hospitalization costs(RMB)	13627.39±3227.56	10837.77±3276.73	10.42	**<0.001**

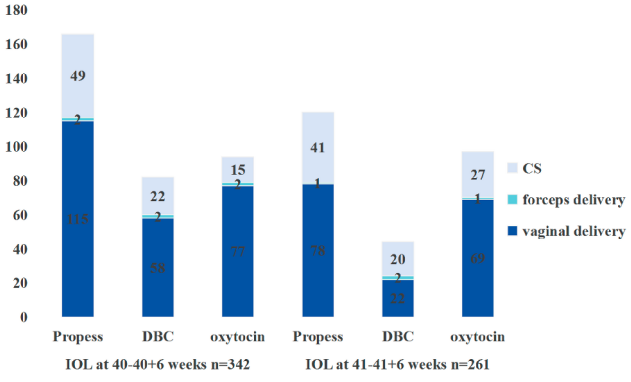

Fig. 3 Mode of delivery

weeks, adjusted for age, pregestational BMI, educational level, annual household incomes, gravidity, and mode of conception.

As demonstrated in Table 4, both parity and the Bishop score exhibited negative correlations with CS following IOL. Notably, parity ≥ 1 and a Bishop score ≥ 6 emerged as protective factors against CS in this context, with parity demonstrating powerful protective effects.

Maternal motivations regarding elective IOL

Among the participants, 248 cases (72%) chose elective IOL due to concerns regarding fetal distress or stillbirth, rather than awaiting spontaneous labor onset or delaying induction until 41 weeks. 62 women (18%) elected elective IOL out of macrosomia concerns, fearing continued fetal growth might complicate vaginal delivery. 17 participants (5%) requested elective IOL after staying in hospitalization for more than 3 days due to diminishing patience with expectant management. Notably, 9 cases (3%) scheduled delivery to coincide with culturally significant dates such as International Children's Day or National Day. Additionally, 6 women (2%) underwent elective IOL after oxytocin challenge tests. As shown in Figure 4.

Discussions

Rates of induction surpass 20% in some high-income countries and are also vastly used in lower-income countries [15]. However, there has been controversy about when to induce labor in overdue pregnancies for ages [16]. Induction of labor also causes the risks of rare adverse events, including maternal and neonatal morbidity and mortality [17]. Therefore, identifying the optimal time of labor induction is of great significance for both

Table 3 Neonatal outcomes

	IOL at 40-40^{+6} weeks n=342	IOL at 41-41^{+6} weeks n=261	$\chi 2$ /t	*P* value
Neonatal asphyxia	1（0.3%）	1（0.4%）	0.000	1.000
Admission to the NICU	7(2%)	10(3.8%)	1.721	0.19
neonate birth weight (g)				
2500-3999	324(94.7%)	244(93.5%)	0.423	0.515
≥4000	18(5.3%)	17(6.5%)		

Table 4 Multivariable logistic regression analysis for CS following IOL

	OR	95%CI	*P* value
Age	1.176	0.425-3.257	0.755
Gravidity	1.112	0.719-1.718	0.634
Parity	0.151	0.068-0.335	**<0.001**
Bishop score	0.607	0.402-0.916	**0.017**
Elective IOL	0.730	0.506-1.053	0.092

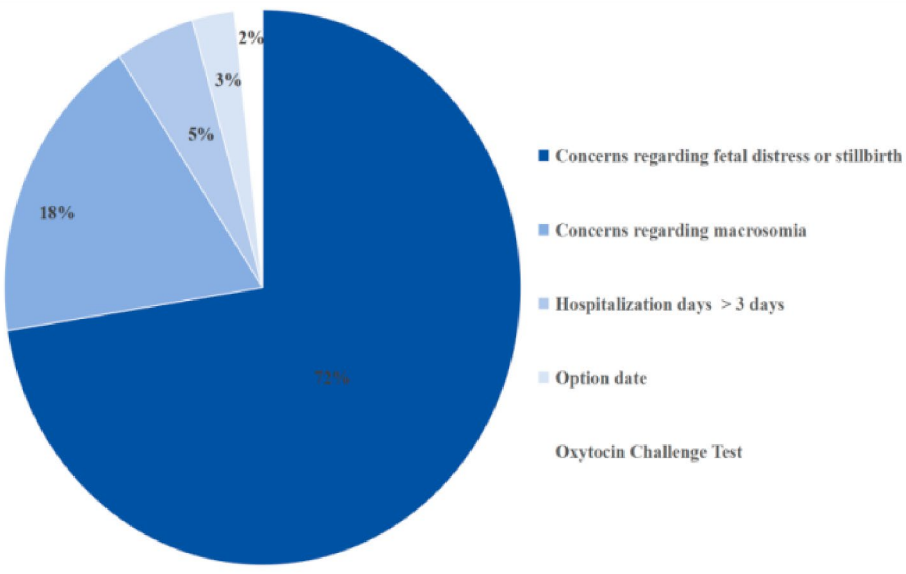

Fig. 4 Maternal motivations regarding elective IOL

women and infants. With the ARRIVE trial, the permissibility of IOL for both women and clinicians has increased [17]. A number of obstetricians in the United Kingdom have already induced labor at 40 weeks [18]. Our findings indicated that IOL at 40 weeks did not result in increased adverse outcomes compared to IOL at 41 weeks.

In our study, we observed that parturients with higher education were more likely to choose elective IOL, echoing findings from Nigerian research [19]but contrasting with those from Norway [20]. While the divergent outcomes may be partially explained by differences in control group composition, this trend highlights the critical role of women's empowerment and health literacy in

facilitating informed decision-making regarding reproductive healthcare.

In addition, our study revealed that the elective IOL group comprised a greater percentage of multiparae. While the statistical analysis suggested a reduced CS rate within the elective IOL group, parity considerations precluded us from reaching a definitive conclusion.

Although elective IOL at 40 weeks appears to be a reasonable management option for term pregnancies, the practice of IOL at 41 weeks should not be discarded entirely. The 41-week IOL group exhibited a statistically higher rate of cervical ripeness, indicating a reduced need for obstetric interventions. Furthermore, our research revealed the 41-week IOL group experienced lower hospitalization costs but longer hospitalization days, with the former factor being a crucial consideration for families with limited income. Indeed, the hospitalization costs encompassed the hospital bed charge, with wards categorized into single and multi-occupancy. It was worth noting that the charge for a single-room bed surpasses the ward bed fee by over tenfold. The 40-week IOL group had a higher annual household income, which enabled them to afford single rooms, resulting in increased hospitalization costs.

To our knowledge, few studies have discussed maternal motivations regarding IOL in the absence of maternal or fetal indications after one's due date. A prospective observational study found that 10% of the inductions were elective, among the elective inductions, the four most common indications were maternal request (35%), history of a difficult delivery experience/obstetric history (19%), maternal fatigue/tiredness in pregnancy (17%) and anxiety (15%) [20]. In France, 13.9% of induced labors were elective [7]. The rate of elective IOL in our study seems to be slightly higher than in other countries. Consequently, investigating the maternal motivations behind this trend was crucial. The most common motivation for elective IOL in our study was concern about fetal distress or stillbirth. This finding underscores the critical need to integrate structured psychological evaluation into routine prenatal care protocols, thereby enabling early identification and preventive management of antenatal anxiety disorders through systematic clinical interventions. To be clear, the oxytocin challenge test and hospitalization days exceeding 3 days as indications for induction were infrequent occurrences. An intriguing question arises: why not 1 day or 2 days, but specifically 3 days? In Chinese culture, the number 3 carries rich symbolic and structural significance in various traditional rules and practices.

The primary limitations of this study stem from its non-randomized design and the single-center nature of the data collection, which may impact the generalizability of the findings. Another limitation is that women who experienced spontaneous onset of labor without IOL at or beyond 40 weeks' gestation were not included in the analyses. Prospective randomized controlled trials are needed to better inform evidence-based clinical practice. The long-term prognosis for the infant after labor induction should be a weighty consideration in clinical decision-making [17]. Further research on short- and long-term results is needed to review future risk prevention strategies [21].

Conclusions

IOL at 40 weeks did not result in increased adverse outcomes compared to IOL at 41 weeks. Parturients with higher education and income were more likely to choose elective IOL. Parity ≥ 1 and a Bishop score ≥ 6 were protective factors against CS following IOL. These may provide a new option for clinical decision-making.

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Author contributions
WZ and WR designed and conducted the study. HH collected the data and wrote this manuscript. CC and SL checked the data, and WZ performed the data analysis. All authors read and approved the final manuscript.

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Not applicable.

Data availability
The data from this study are not publicly available to protect individual privacy, as mandated by the Institutional Ethics Committee of the Maternal and Child Health Hospital of Hubei Province.

Declarations

Ethics approval and consent to participate
This study involving participants was reviewed and approved by the institutional review board of the Maternal and Child Health Hospital of Hubei Province and was based on the principles of the Declaration of Helsinki. All subjects provided written Informed consent for participation.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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