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Original Article

Effects of amniotomy combined with oxytocin on cervical ripening and neonatal outcome in patients with oligohydramnios in late pregnancy

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Abstract: Objective: To investigate the effects of oxytocin on cervical ripening and neonatal outcome in patients with late-pregnancy oligohydramnios (LPO). Methods: The study retrospectively included 100 patients with LPO using propensity score matching (PSM). The patients were divided into two groups at a 1:1 ratio: the control group (amniotomy alone) and the observation group (amniotomy + oxytocin), with 50 cases in each group. General clinical data, blood and urine test results, imaging examination results, cervical assessment score (CAS), and neonatal Apgar scores were collected and compared between the two groups. Statistical analysis was performed using SPSS 26.0 software. Result: Compared to the observation group, the control group had a lower induction success rate (84.0% vs. 76.0%, χ^2 = 10.0, P = 0.0015), a higher mean CAS (4.08 ± 0.87 vs. 4.76 ± 0.95, t = 2.761, P = 0.008), and a higher proportion of neonates with Apgar score < 9 (2.0% vs. 14.0%, χ^2 = 6.042, P = 0.017). Logistic regression analysis showed that serum ferritin level < 30 μg/L (OR = 4.25, 95% CI: 1.20-15.08, P = 0.025) and fetal chest-to-abdomen ratio (FAR) > 0.85 (OR = 5.95, 95% CI: 1.22-29.03, P = 0.028) were independent risk factors for inadequate cervical ripening. Conclusion: Oxytocin is effective in inducing labor in patients with LPO. Its labor-inducing effect and effect on cervical ripening are influenced by maternal serum ferritin levels and fetal development indices.

Keywords: Oxytocin, the third trimester, cervical assessment score, Apgar score, cesarean section of the lower uterine segment

Introduction

Late-pregnancy oligohydramnios (LPO) refers to a condition in which the amniotic fluid volume falls below the normal range during the third trimester (usually beyond 37 weeks of gestation) [1, 2]. Under normal circumstances, amniotic fluid provides a crucial intrauterine environment for fetal development, offering protection, nutritional support, and facilitating fetal movement [3]. Oligohydramnios not only restricts intrauterine fetal movement but also increases the risk of fetal malformations, pulmonary hypoplasia, and nuchal cord, possibly leading to preterm birth, placental abruption, or fetal distress. The causes of oligohydramnios are multifaceted, including placental insufficiency, fetal urinary system abnormalities, fetal growth retardation, and fetal congenital anomalies [4]. Maternal factors such as hypertension, diabetes, and advanced or very young maternal age are also associated with an elevated risk of oligohydramnios [5].

With the increasing prevalence of clinical risk factors related to LPO, such as advanced maternal age, pregnancy-induced hypertension, and diabetes [6, 7], the incidence of LPO has risen annually, posing great risk to maternal and neonatal safety. Previous studies have shown that LPO is closely related to adverse perinatal outcomes, including placental insufficiency, intrauterine growth restriction (IUGR), prolonged labor, and neonatal distress, as well as significantly increased neonatal intensive care unit (NICU) admission rate [8, 9]. Many studies and optimized labor-induction practices have indicated that standardized induction pathways, optimized incremental oxytocin dosing, and individualized interventions based on cervical maturity may improve labor outcomes and reduce the cesarean section rate in patients

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with LPO [10, 11]. However, current evidence from high-quality studies on the LPO population remains limited.

In clinical practice, labor induction usually adopts synthetic oxytocin [12], which mimics the function of endogenous oxytocin to stimulate uterine contractions and facilitate progression of labor [13]. In LPO cases, the intrauterine environment is typically unfavorable, and continuing the pregnancy may increases risks to the fetus, making labor induction crucial in this population. In patients with LPO, routine oxytocin administration can increase the frequency and intensity of uterine contractions, facilitating the natural progression of labor [14, 15]. However, oxytocin may also cause certain adverse effects. Cervical assessment through palpation is an important indicator for determining the progression of labor [16, 17]. Oxytocin may cause cervical closure or excessive tilt, increasing cervical assessment difficulty and affecting the progress of labor induction and clinical decision-making. Moreover, cervical rigidity thatresults from high uterine contraction intensity or frequency prolongs labor and raises the risk of adverse delivery outcome. The use of oxytocin may also affect the neonatal Apgar score, which evaluates heart rate, respiration, muscle tone, reflexes, and skin color [18, 19]. However, oxytocin-induced strong or frequent uterine contractions may reduce fetal oxygen supply, adversely affecting heart rate and respiration, thereby lowering the Apgar score. It is advised to closely monitor maternal response and fetal condition, adjust the dosage promptly, or discontinue oxytocin administration to ensure maternal and fetal safety.

The application of oxytocin in labor management for LPO patients remains controversial. Reduced amniotic fluid volume may impair uterine contractility and cervical ripening, indirectly reducing the effectiveness of oxytocin-induced labor [20, 21]. Both the dosage and duration of oxytocin administration show close associations with neonatal Apgar scores and maternal outcomes [22]. However, research on oxytocin use in LPO populations and its relationship with labor outcomes is limited, and systematic analytical evidence is lacking.

Therefore, this study focuses on pregnant women with LPO and aims to identify factors influencing cervical assessment and neonatal Apgar scores during oxytocin-induced labor. By determining the key indicators, this study seeks to provide recommendations for clinically optimizing oxytocin administration protocols, improving induction effectiveness, and reducing negative maternal and neonatal outcomes. The novelty of this study lies in its use of multifactorial clinical analytical methods to comprehensively evaluate the correlation between oxytocin dosage, duration of administration, and perinatal outcomes, offering valuable insight for clinical practice.

Materials and methods

Subject screening

Through electronic medical record screening, a total of 215 pregnant women diagnosed with LPO at Zhejiang Xiaoshan Hospital between May 2021 and April 2023 were initially identified. ICD-10 codes for oligohydramnios and related diagnoses were applied to ensure accurate retrieval of medical records.

Inclusion criteria: (1) Singleton pregnancy; (2) Gestational age ≥ 37 weeks; (3) Ultrasound-diagnosed oligohydramnios [amniotic fluid index (AFI) ≤ 5 cm]; (4) No severe pregnancy-related comorbidities (such as uncontrolled hypertension, diabetes, heart disease); (5) No severe fetal congenital malformations or chromosomal abnormalities; (6) Complete clinical and follow-up data available.

Exclusion criteria: (1) Presence of absolute contraindications to labor induction (such as placenta previa, placental abruption); (2) Severe maternal diseases (e.g., heart, liver, or kidney dysfunction, immune system diseases); (3) History of classical cesarean section or major uterine surgery; (4) History of cervical surgery or cervical insufficiency; (5) Missing key clinical data (such as gestational age, AFI, mode of delivery).

To control for confounding bias, propensity score matching (PSM) was employed, with "whether to receive oxytocin treatment" as the dependent variable. Covariates including age, gravidity, parity, gestational age, AFI, and pregnancy-related complications were incorporated to calculate the propensity scores. Patients were divided into the observation group (amni-

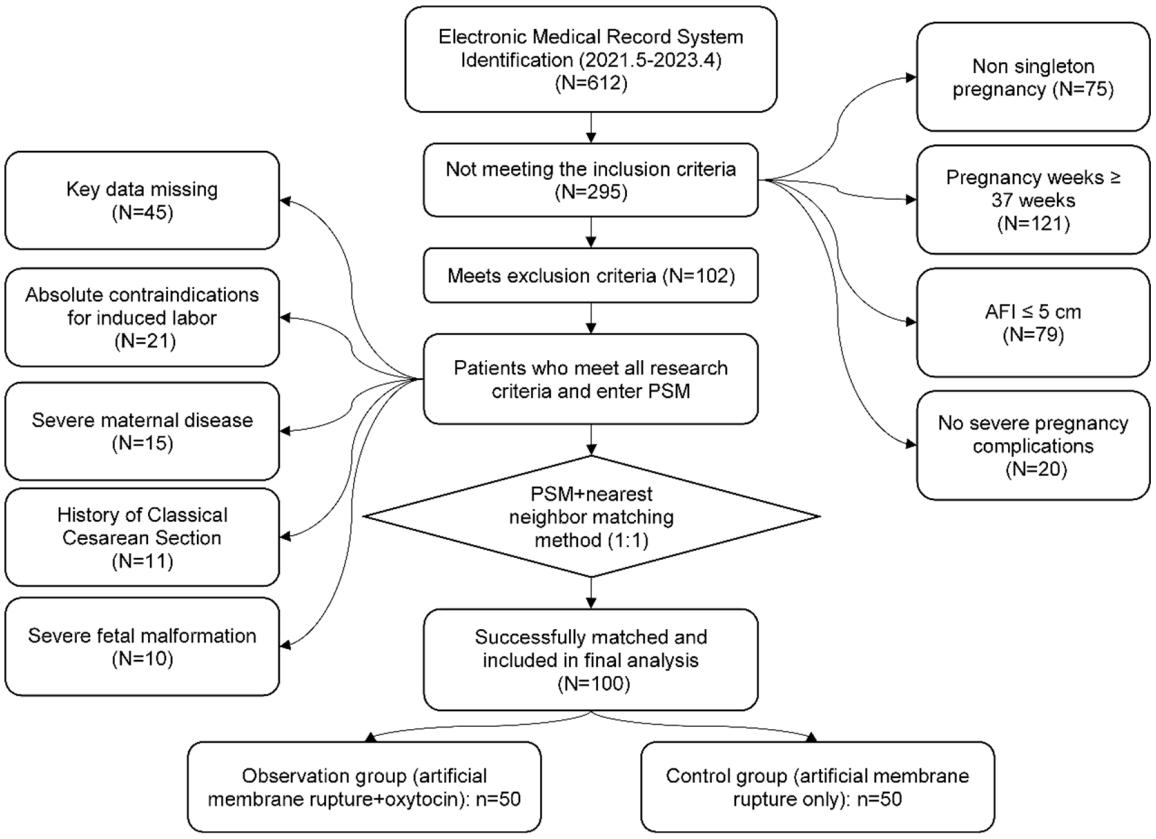

Figure 1. Flowchart of patient screening, inclusion, and allocation.

otomy + oxytocin; n = 50) and the control group (amniotomy only; n = 50), using a 1:1 nearest-neighbor matching method (caliper value = 0.02) (**Figure 1**). After matching, no statistical differences were observed in baseline characteristics between the two groups ($P > 0.05$). This study strictly adhered to the guidelines of the *Declaration of Helsinki* and was approved by the Medical Ethics Committee of Zhejiang Xiaoshan Hospital. Since this study was retrospective and all patient data had been anonymized and de-identified before analysis, the ethics committee waived the requirement for patient informed consent.

Data extraction

Data were retrospectively extracted from the electronic medical record system by two trained obstetricians using a standardized data collection form. The extracted information included:

(1) Maternal demographic and pregnancy information: Basic maternal information included age, gravidity, parity, previous delivery history, pregnancy complications (e.g., gestational diabetes, pregnancy-induced hypertension, thyroid dysfunction), gestational age, and amniotic fluid index (AFI) at admission.

Prenatal laboratory tests were conducted before delivery. Fasting venous blood samples were collected to determine complete blood count, blood glucose, serum ferritin, and lipid levels, which reflect basic health status of the mother. Thyroid function was also evaluated by measuring serum T3, T4, and TSH. When necessary, thyroid ultrasound and radionuclide scanning were employed for a comprehensive evaluation of thyroid morphology, size, and function [23-25]. Serum ferritin reflects the maternal iron reserve, and low ferritin (< 30 μg/L) may contribute to uterine atony and increase the difficulty of labor induction [26].

Markers of hepatitis B virus [hepatitis B surface antigen (HBsAg), hepatitis B surface antibody (HBsAb), hepatitis B e antigen (HBeAg), hepatitis B e antibody (HBeAb)] and serum Treponema pallidum antibody (TPAb) were determined

using Enzyme-linked immunosorbent assay (ELISA) according to manufacturer's protocols [27]. Indicators for hepatitis B and syphilis were used to assess the risk of infection during pregnancy and to prevent mother-to-child transmission.

Fetal chest-to-abdomen ratio (FAR) was recorded during prenatal ultrasound examination to assess fetal growth. FAR values were divided into three ranges: < 8, indicative of possible fetal growth restriction or adverse intrauterine environment; 8-8.5, considered within the normal range and indicative of good fetal development; and > 8.5: possibly indicative of excessive fetal growth or metabolic abnormalities.

(2) Cervical and induction-related information: Cervical assessment score (CAS): Transvaginal ultrasound was used to evaluate cervical length (0-3 points), internal os dilation (0-3 points), external os dilation (0-2 points), cervical position (0-1 point), and cervical consistency (0-1 point), yielding a total score of 10 points. The higher the score, the more mature the cervical condition and the lower the risk of preterm birth [28]. A total score of < 6 was generally considered inadequate cervical ripening (abnormal CAS).

Oxytocin use: The total dose and duration of oxytocin use were recorded. Uterine contraction intensity and fetal heart rate changes were monitored.

Induction-related indicators: These included the time from induction to delivery, mode of delivery (vaginal delivery or cesarean section), induction failure rate, and related complications (such as uterine hypercontraction and fetal heart abnormalities).

(3) Neonatal outcome indicators: Basic information: Birth weight, gestational age at delivery, and sex; Apgar score: The 1-min score, with a total of 10 points, was assessed. An Apgar score < 9 indicates incomplete neonatal adaptation to intrauterine or intrapartum stress [29]; Clinical outcomes: Meconium aspiration, NICU admission, and length of hospital stay; Postpartum complications: Respiratory distress, hypoglycemia, jaundice, and other clinical events.

To ensure data accuracy, a second investigator independently re-extracted and cross-checked data from a randomly selected 20% subset of medical records. Any disagreements were resolved through discussion.

Outcome measures

Primary outcomes: (1) Cervical maturity, assessed by the CAS, was measured before labor induction (i.e., before artificial rupture of membranes and/or oxytocin application); (2) Neonatal condition was judged by the 1-min Apgar score and measured at the first minute after birth.

Secondary outcomes: (1) Maternal outcomes included the response to labor induction, delivery modes, induction-to-delivery interval, postpartum blood loss, and the occurrence of fetal heart rate deceleration. Effective induction was defined as eventual vaginal delivery (including spontaneous and instrument-assisted delivery). Delivery modes consisted of vaginal delivery and cesarean section. The induction-to-delivery interval was defined as the duration from artificial rupture of membranes to fetal expulsion. Postpartum bleeding referred to the total blood loss within 24 h after fetal expulsion (mL), and fetal heart rate deceleration was defined as any clinically significant deceleration detected during the induction-to-delivery period obtained through continuous monitoring. (2) Neonatal outcomes included birth weight, composite indicator of adverse outcomes, and length of hospital stay. Weight was measured immediately after birth; adverse outcomes were defined as meconium aspiration or NICU admission from birth to discharge; neonatal length of hospital stay was the total number of days from birth to discharge.

Statistical methods

Statistical analysis was conducted using SPSS 26.0. Measured data were first tested for normality. Data conforming to a normal distribution were expressed as mean ± standard deviation ($\bar{x} \pm s$), and intergroup comparisons were made using the independent samples *t*-test. Data not conforming to a normal distribution were expressed as median (quartiles), and intergroup comparisons were made using the Mann-Whitney U test. Counted data were expressed as frequency and percentage (n, %), and intergroup comparisons were made using χ^2 test or Fisher's exact test, as appropriate.

Table 1. Comparison of baseline characteristics between the two groups

Index	Observation group (n = 50)	Control group (n = 50)	t/χ^2	*P*
Age (years)	29.4 ± 4.1	30.1 ± 3.8	0.878	0.381
Weight (kg)	69.37 ± 15.02	70.33 ± 14.36	-0.311	0.757
Production situation			0.178	0.673
First birth	35 (70%)	33(66%)		
Multiparity	15 (30%)	17 (34%)		
Gravidity (times)	2.1 ± 0.8	2.0 ± 0.9	0.465	0.654
Parity (times)	1.0 ± 0.5	1.1 ± 0.6	0.817	0.424
Previous vaginal delivery (cases, %)	10 (20%)	8 (16%)	0.16	0.683
Previous cesarean section (cases, %)	5 (10%)	6 (12%)	0.108	0.756
Total number of pregnancy complications (cases, %)	12 (24%)	11 (22%)	0.068	0.812
Gestational diabetes (cases, %)	5 (10%)	4 (8%)	0.127	0.727
Pregnancy-induced hypertension (cases, %)	4 (8%)	5 (10%)	0.107	0.732
Thyroid dysfunction (cases, %)	3 (6%)	2 (4%)	0.224	0.654
Gestational age at admission (weeks)	38.6 ± 1.1	38.8 ± 1.0	0.779	0.474
AFI (cm)	4.2 ± 0.7	4.3 ± 0.6	0.495	0.620
FAR			1.194	0.557
< 8 (cases, %)	6 (12%)	7 (14%)		
8-8.5 (cases, %)	36 (72%)	34 (68%)		
> 8.5 (cases, %)	8 (16%)	9 (18%)		

Note: FAR: fetal chest-to-abdomen ratio; AFI: amniotic fluid index.

To explore the effects of oxytocin dosage, induction-to-delivery interval, and related factors on cervical ripening and neonatal Apgar score, a multivariable Logistic regression analysis was conducted. Univariate logistic regression analysis was conducted to identify factors associated with inadequate cervical ripening (CAS < 6), and variables with $P < 0.1$ were selected for inclusion in the multivariate logistic regression model. The regression model used the Enter method, in which all selected variables were entered simultaneously without applying stepwise selection. Results were reported as odds ratios (ORs) with corresponding 95% confidence intervals (CIs). All tests were two-sided, with $P < 0.05$ considered significant.

Results

Comparison of basic characteristics between the two groups

No significant differences were observed in the distribution of age, weight, gravidity, parity, previous delivery history, or the incidence of pregnancy complications between the two groups (all $P > 0.05$). The gestational age at admission was between 37 and 41 weeks for both groups, with an average AFI of 4.2 ± 0.7 cm for the observation group and 4.3 ± 0.6 cm for the control group ($P = 0.620$), indicating that the baseline conditions of the two groups were comparable (**Table 1**).

Comparison of prenatal laboratory tests between the two groups

Prenatal blood and urine tests showed that the complete blood count, blood glucose, blood lipids, and thyroid function (T3, T4, TSH) of pregnant women in both groups were within the normal range, and no significant differences were observed between the groups ($P > 0.05$). The serological indicators of hepatitis B and syphilis were also well-controlled, with no significant differences between groups, indicating that the basic health status and infection risk of the two groups were comparable (**Table 2**).

Comparison of prenatal fetal indicators between the two groups

Prenatal ultrasound assessment of the FAR showed that the majority in both groups were in the range of 8-8.5, including 36 cases (72%) in the observation group and 34 cases (68%) in the control group. For FAR < 8, there were 6

Table 2. Comparison of prenatal laboratory values between the two groups

Index	Observation group (n = 50)	Control group (n = 50)	t/χ^2	*P*
Complete blood count				
White blood cells ($\times 10^9$/L)	7.2 ± 1.3	7.0 ± 1.2	0.854	0.402
Hemoglobin (g/L)	118.9 ± 10.3	120.3 ± 11.1	1.013	0.312
Platelets ($\times 10^9$/L)	220.3 ± 35.9	225.1 ± 36.3	0.743	0.462
Blood glucose (mmol/L)	4.8 ± 0.5	4.9 ± 0.4	0.821	0.416
Blood lipids (TC, mmol/L)	5.1 ± 0.6	5.0 ± 0.5	0.723	0.473
Serum ferritin (μg/L)	30.6 ± 5.3	31.3 ± 3.6	0.546	0.124
Thyroid function				
T3 (nmol/L)	1.6 ± 0.2	1.6 ± 0.3	0.982	0.456
T4 (nmol/L)	98 ± 12	100 ± 11	0.859	0.405
TSH (mIU/L)	2.1 ± 0.6	2.2 ± 0.5	0.653	0.521
Serological indicators for hepatitis B and syphilis				
HBsAg positive (cases, %)	2 (4%)	1 (2%)	0.494	0.483
HBsAb positive (cases, %)	45 (90%)	46 (92%)	0.179	0.684
HBeAg positive (cases, %)	0 (0%)	0 (0%)	-	-
HBeAb positive (cases, %)	48 (96%)	47 (94%)	0.175	0.680
TPAb positive (cases, %)	0 (0%)	0 (0%)	-	-

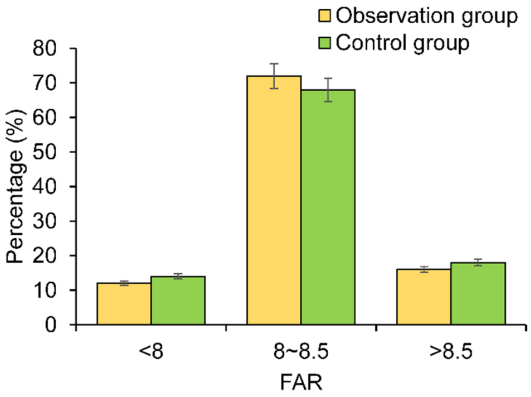

Figure 2. Comparison of prenatal fetal chest-to-abdomen ratio (FAR) between the two groups.

cases (12%) in the observation group and 7 cases (14%) in the control group; for > 8.5, there were 8 cases (16%) in the observation group and 9 cases (18%) in the control group. Statistical analysis showed no significant difference between the two groups in terms of FAR (χ^2 = 1.19, *P* = 0.55) (**Figure 2**).

Comparison of maternal delivery outcomes between the two groups

The success rate of labor induction in the observation group was significantly higher than that of the control group (84.0% vs. 76.0%, χ^2 = *10.000, P = 0.0015*). The observation group also demonstrated a higher mean volume of postpartum blood loss (242.6 ± 25.0 vs. 220.0 ± 20.0 mL, *t* = 2.145, *P* = 0.034), and a higher incidence of fetal heart rate deceleration (46.0% vs. 30.0%, χ^2 = 4.000, *P* = 0.045) compared to the control group. In addition, a significantly higher incidence of adverse outcomes was observed in the observation group relative to the control group (24.0% vs. 8.0%, χ^2 = 5.000, *P* = 0.025). In terms of labor duration, the average delivery time in the observation group was shorter than that of the control group (8 h vs. 8 h 15 min), but the difference was not significant (*t* = 1.325, *P* = 0.188) (**Table 3**).

Comparison of CAS between the two groups

The CAS was 4.76 ± 0.95 in the control group, significantly higher than 4.08 ± 0.87 in the observation group (*t* = 2.761, *P* = 0.008) (**Figure 3**). However, further statistical analysis revealed that in the control group, 38 cases (76%) had abnormal CAS, and in the observation group, 42 cases (84%) had abnormal CAS, with no significant difference between the two groups (χ^2 = 1.33, *P* = 0.249), indicating that the majority of subjects had inadequate cervical ripening.

Table 3. Comparison of maternal delivery outcomes between the two groups

Group	Success rate in induction	Postpartum blood loss (mL)	Fetal heart rate deceleration	Incidence of adverse outcomes	Average labor duration
Control group (n = 50)	38 (76%)	220.0 ± 20.0	15 (30%)	4 (8%)	8 h 15 min
Observation group (n = 50)	42 (84%)	242.6 ± 25.0	23 (46%)	12 (24%)	8 h
χ^2/t	10.000	2.145	4.000	5.000	1.325
P	0.0015	0.034	0.045	0.025	0.188

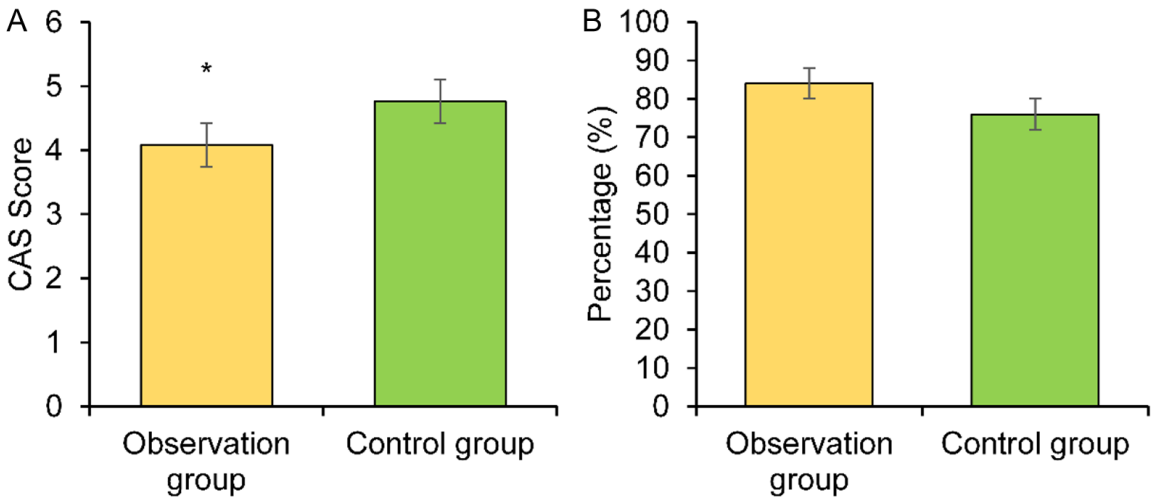

Figure 3. Comparison of CAS between the two groups. A: Total CAS score; B: Abnormal CAS (< 6); *$P < 0.05$, compared to the observation group. CAS: cervical assessment score.

Table 4. Comparison of neonatal outcomes between the two groups

Index	Observation group (n = 50)	Control group (n = 50)	t/χ^2	*P*
Birth weight (g)	3202.3 ± 420.3	3150.9 ± 401.1	0.630	0.530
Gestational age (weeks)	38.6 ± 1.1	38.8 ± 1.0	0.770	0.440
Meconium aspiration (cases, %)	1 (2%)	2 (4%)	*Fisher*	0.520
NICU admission (cases, %)	1 (2%)	3 (6%)	*Fisher*	0.320
Length of hospital stay (days)	4.5 ± 1.2	4.7 ± 1.3	0.770	0.440

Note: NICU: neonatal intensive care unit.

Comparison of neonatal outcomes between the two groups

There were no significant differences in birth weight or gestational age between the two groups of neonates ($P > 0.05$). The average birth weight was (3202.3 ± 420.3) g in the observation group and (3150.9 ± 401.1) g in the control group ($t = 0.630$, $P = 0.530$); gestational age was (38.6 ± 1.1) weeks and (38.8 ± 1.0) weeks, respectively ($t = 0.770$, $P = 0.440$). In the observation group, there was 1 case (2.0%) of meconium aspiration and 1 case (2.0%) of NICU admission, while in the control group, there were 2 cases (4.0%) and 3 cases (6.0%), respectively, with no significant difference ($P > 0.05$). The average length of hospital stay for neonates in the two groups was (4.5 ± 1.2) days and (4.7 ± 1.3) days, respectively ($t = 0.770$, $P = 0.440$) (**Table 4**).

In the control group, 43 neonates (86%) had Apgar scores ≥ 9, and 7 neonates (14%) had Apgar scores < 9; and the numbers in the observation group were 49 (98%) and 1 (2%), respectively. The chi-square test indicated a

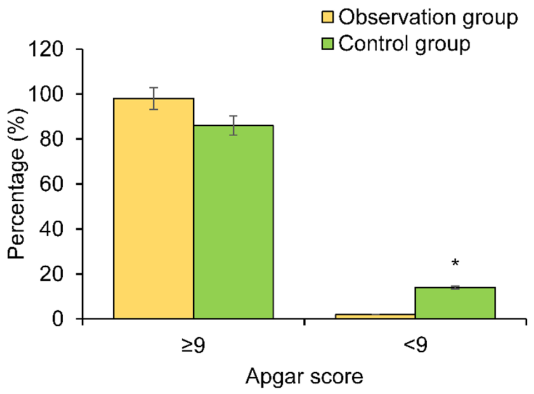

Figure 4. Contrast of neonatal Apgar scores. *P < 0.05, compared to the observation group.

significantly lower proportion of neonates with Apgar scores < 9 in the observation group (χ^2 = 4.000, P = 0.045) (**Figure 4**).

Relationship between Apgar score, CAS, and oxytocin use in the observation group

In the observation group (n = 50), the average dose of oxytocin in mothers of neonates with an Apgar score ≥ 9 was 12.4 ± 3.6 mU/min, with a mean duration of 6.5 ± 1.2 h. There was only one neonate with an Apgar score < 9, whose mother received a dose of 18.0 mU/min for 9.0 h, precluding statistical comparison. Subjects with a CAS < 6 (n = 42) had higher dose and longer duration of oxytocin use at 13.1 ± 3.8 mU/min and 7.0 ± 1.3 h, respectively, compared to those with a CAS ≥ 6 (n = 8, dose 10.2 ± 2.8 mU/min, duration 5.6 ± 1.1 h; dose t = 2.41, P = 0.020; duration t = 2.35, P = 0.024), suggesting that those with inadequate cervical ripening may require a higher dose and longer duration of oxytocin intervention.

Relationship between CAS and oxytocin use in the observation group, and analysis of risk factors

The number of cases with neonatal Apgar score < 9 in the observation group was too small (n = 1) to support a stable multivariate regression analysis, thus, the focus was shifted to exploring the factors affecting cervical ripening (with CAS < 6 as the dependent variable).

(1) Results of univariate analysis: In **Table 5**, there were no significant differences between the two groups in terms of age, gravidity, parity, pregnancy complications, gestational age at admission, AFI, or most laboratory indicators (P > 0.05). However, the level of serum ferritin before delivery in the group with CAS < 6 was significantly lower than that of the group with CAS ≥ 6 [28.5 μg/L (22.0, 35.8) vs. 38.0 μg/L (33.3, 45.5), P = 0.012]. The proportion of FAR > 0.85 in the group with CAS < 6 was significantly higher than that in the group with CAS ≥ 6 [9 (21.4%) vs. 0 (0.0%), P = 0.047]. Univariate logistic regression further indicated that serum ferritin < 30 μg/L (OR = 4.05, 95% CI: 1.18-13.89, P = 0.026) and FAR > 0.85 (OR = 5.34, 95% CI: 1.09-26.19, P = 0.034) were significantly associated with inadequate cervical ripening.

(2) Results of multivariate logistic regression analysis: To further identify the independent influencing factors of insufficient cervical ripening (CAS < 6), the variables with P < 0.1 in the univariate analysis (serum ferritin level, FAR > 0.85, total dose of oxytocin, duration of oxytocin use) were included in the multivariate Logistic regression model (**Table 6**). After adjusting for the effects of the total dose and duration of oxytocin use, a serum ferritin level of < 30 μg/L (OR = 4.25, 95% CI: 1.20-15.08, P = 0.025) and FAR > 0.85 (OR = 5.95, 95% CI: 1.22-29.03, P = 0.028) were identified as independent risk factors for insufficient cervical ripening (CAS < 6). The total dose of oxytocin (OR = 1.07, 95% CI: 0.97-1.18, P = 0.175) and the duration of its use (OR = 1.10, 95% CI: 0.92-1.32, P = 0.283) lost statistical significance in multivariate analysis.

Discussion

In recent years, with the popularization of ultrasound technology and prenatal diagnosis, the incidence of oligohydramnios has risen to about 5% [22]. Oligohydramnios poses certain risks to both maternal and fetal health and often requires labor induction [30, 31]. Oxytocin, a commonly used uterotonic drug, can facilitate childbirth [12, 13]. However, its efficacy and safety in LPO still need careful assessment.

Our results showed that, compared with amniotomy alone, the combination of amniotomy and oxytocin could significantly increase the success rate of labor induction (84% vs. 76%) and decrease the incidence of low Apgar scores in newborns (2% vs. 6%). This finding is consis-

Table 5. Comparison of baseline data between patients with different CAS in the observation group

Index	CAS < 6 (n = 42)	CAS ≥ 6 (n = 8)	*t/Z*	*P*
Maternal basic information				
Age (years)	29.5 ± 4.2	28.9 ± 3.5	0.378	0.707
Gravidity (times)	2.2 ± 0.8	1.8 ± 0.7	1.324	0.192
Parity (times)	1.0 ± 0.5	1.1 ± 0.4	-0.507	0.615
Previous cesarean section (cases, %)	4 (9.5%)	1 (12.5%)	6.351	0.584
Prenatal laboratory tests				
Serum ferritin (μg/L)	28.5 (22.0, 35.8)	38.0 (33.3, 45.5)	-2.264	0.012
Hemoglobin (g/L)	118 ± 11	119 ± 9	-0.228	0.821
Prenatal fetal indicators				
FAR > 0.85 (cases, %)	9 (21.4%)	0 (0.0%)	7.541	0.047
AFI (cm)	4.1 ± 0.7	4.5 ± 0.6	-1.512	0.137

Note: CAS: cervical assessment score; FAR: fetal chest-to-abdomen ratio; AFI: amniotic fluid index.

Table 6. Multivariate logistic regression analysis of factors affecting insufficient cervical ripening (CAS < 6)

Variate	Assignment in regression analysis	B coefficient	Wald χ^2	Adjusted OR	95% CI	*P*
Serum ferritin < 30 μg/L	1 = Yes, 0 = No	1.447	5.012	4.25	1.20-15.08	0.025
FAR > 0.85	1 = Yes, 0 = No	1.784	4.830	5.95	1.22-29.03	0.028
Total dose of oxytocin (mU/min)	Continuous variable (original value)	0.068	1.837	1.07	0.97-1.18	0.175
Duration of oxytocin use (h)	Continuous variable (original value)	0.095	1.157	1.10	0.92-1.32	0.283

Note: CAS: cervical assessment score; FAR: fetal chest-to-abdomen ratio.

tent with a previous study that using oxytocin 24 h after amniotomy, rather than immediately, significantly increased the vaginal delivery rate while reducing neonatal acidosis and ICU admissions, thereby demonstrating its role in enhancing labor induction success and neonatal outcomes [32]. However, the average CAS in the observation group was lower than that in the control group (4.08 vs. 4.76), and further analysis within the group showed that the majority of subjects (84%) had insufficient cervical ripening (CAS < 6). This is consistent with a previous report that cervical ripening is a key factor affecting the success of labor induction, with patients having a Bishop score < 6 showing a significantly lower success rate of labor induction, an increased rate of cesarean section, and prolonged duration of labor [33]. These results suggest that, although oxytocin is generally effective in inducing labor, its role in improving cervical ripening is still limited for LPO patients with insufficient cervical ripening, and it is necessary to formulate individualized labor induction strategies in combination with cervical ripening assessment in clinical practice.

This study further identified through multivariate analysis that serum ferritin < 30 μg/L and FAR > 0.85 were independent risk factors for inadequate cervical ripening. Iron has been linked to the function of the uterine muscle. For example, iron deficiency may lead to reduced uterine contractility [34]. As a reflection of the body's iron reserve status, serum ferritin has been closely associated with uterine atony [26]. It may interfere with cervical remodeling and the coordination of contractions by affecting the energy metabolism and oxygenation capacity of uterine smooth muscle cells, which is consistent with the lower CAS scores observed in the low-ferritin group in this study. In addition, FAR is an important indicator for assessing fetal growth and development. Pasquo et al. [35] suggested that an elevated FAR may indicate abnormal fetal development or metabolism, increasing the complexity of labor and cervical ripening. Another study

found that fetal growth restriction was closely related to inadequate cervical ripening, suggesting that abnormal fetal development may affect the cervical maturation process, possibly mediated by placental insufficiency [36]. The association between elevated FAR and inadequate cervical ripening observed in this study may indicate that abnormal fetal development impedes fetal descent and cervical mechanical dilation, providing a new perspective for interpreting variability in oxytocin efficacy under different fetal development conditions. Future research may further explore the molecular mechanisms of iron metabolism pathways and cervical connective tissue remodeling, as well as the comprehensive effect of fetal morphologic indicators and maternal pelvic adaptability on the labor induction process.

Our findings emphasize the need for comprehensive prenatal assessment, including maternal iron status and fetal biometry, to identify high-risk patients who may have poor responses to labor induction. These results are consistent with previous literature, highlighting the importance of individualized labor induction strategies [37, 38]. For patients with low serum ferritin, iron supplementation may improve uterine responsiveness; for cases with abnormal fetal biometry, enhanced fetal monitoring and preparation for surgical delivery should be implemented.

This study also has some limitations. First, its retrospective design may have introduced information bias, with some confounding factors (such as the nutritional status and lifestyle of the parturient) not being fully controlled. Second, the relatively limited sample size may have affected the generalizability and statistical power of the results, especially for some subgroup analyses (such as the small number of cases with neonatal Apgar < 9). In addition, this study only focused on short-term neonatal outcomes and lacks long-term follow-up data. Future studies should prioritize larger-scale prospective cohorts to further verify the efficacy and safety of oxytocin in the LPO population and explore other potential factors that may affect the effectiveness of labor induction and cervical ripening (such as inflammatory markers, cervical elastography indicators). Moreover, constructing predictive models combining multicenter data will help to more accurately identify high-risk populations for labor induction failure in the prenatal period, thereby enabling earlier intervention and more individualized management.

Conclusion

Oxytocin is generally effective for labor induction in LPO patients. However, to achieve optimal treatment outcome, individualized assessment and treatment are essential, particularly with regard to serum ferritin and FAR. Incorporating these indicators allows for a comprehensive understanding of maternal-fetal conditions and substantiates the development of an individualized plan to foster the success and safety of labor induction.

Disclosure of conflict of interest

None.

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References

[1] Leytes S, Kovo M, Weiner E and Ganer Herman H. Isolated oligohydramnios in previous pregnancy is a risk factor for a placental related disorder in subsequent delivery. BMC Pregnancy Childbirth 2022; 22: 912-912.

[2] Bao Y, Pan X, Pan S, Zhuang D, Li H, Mu Q and Yan L. Enlarged multicystic dysplastic kidneys with oligohydramnios during infancy caused by NPHP3 gene mutation. Zhonghua Yi Xue Yi Chuan Xue Za Zhi 2022; 39: 510-513.

[3] Jabeen Z, Bacha R and Iyaz RM. Hemodynamic changes in umbilical artery and middle cerebral artery with oligohydramnios in third trimester of pregnancy. J Diagn Med Sonogr 2022; 38: 147-153.

[4] Egagifo O, Omo-Aghoja LO and Adeyinka AT. Correlation of perinatal outcomes with amniotic fluid assessment techniques in high-risk pregnancies in a Tertiary Hospital in Southern Nigeria. Afr Health Sci 2021; 21: 1310-1320.

[5] Simonyi A, Eros FR, Hajdu J and Beke A. Effectiveness of fetal ultrasound diagnostics in cardiac malformations and association with polyhydramnios and oligohydramnios. Quant Imaging Med Surg 2021; 11: 2994-3004.

[6] Ishida A, Minamiguchi S, Yamada Y, Nakagawa R, Chigusa Y, Kondoh E, Mandai M and Haga

H. Histological distribution pattern of hemosiderin deposition on the chorionic plate and fetal membrane of diffuse chorioamniotic hemosiderosis related to chronic abruption oligohydramnios sequence. Placenta 2021; 105: 1-6.
[7] Mohammed SS and Ahmed AA. Prevalence rate, probable causes, and perinatal outcomes in women with oligohydramnios in labor. Cureus 2024; 16: e61290.
[8] Molla M, Mengistu Z, Tsehaye W and Sisay G. Magnitude and associated factors of adverse perinatal outcomes among women with oligohydramnios at 3rd trimester at University of Gondar comprehensive specialized hospital, North West Ethiopia. Front Glob Womens Health 2023; 3: 958617.
[9] Dutta I, Suman S and Pan T. Maternal and fetal outcomes in idiopathic oligohydramnios vs. normal amniotic fluid index after 34 weeks: a case-control study in Eastern India. Niger Med J 2025; 66: 637-645.
[10] Lutgendorf MA, Northup M, Budge J, Snipes M, Overbey J, Taylor A and Simsiman A. Pregnancy outcomes after implementation of an induction of labor care pathway. AJOG Glob Rep 2023; 4: 100292.
[11] He H, Ren W, Li S, Chen C and Zheng W. 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. BMC Pregnancy Childbirth 2025; 25: 586.
[12] Kandemir C. Effect of oxytocin added into sperm on artificial insemination in sheep. Arch Anim Breed 2023; 66: 61-69.
[13] Wan Y, Li H and Lin X. Additional granisetron does not alter uterine contraction following oxytocin: a prospective randomized controlled clinical trial. Asian J Surg 2023; 46: 1147-1148.
[14] Mcadow M, Stark E, Cassello N and Son M. Salivary oxytocin concentration correlates with plasma oxytocin concentration in patients undergoing induction of labor. Am J Obstet Gynecol 2023; 228: S547-S548.
[15] Diel de Amorim M, Bramer SA, Rajamanickam GD, Klein C and Card C. Serum progesterone and oxytocinase, and endometrial and luteal gene expression in pregnant, nonpregnant, oxytocin, carbetocin and meclofenamic acid treated mares. Theriogenology 2023; 198: 47-60.
[16] Chen HX, Wen HX and Li SL. New progress in predicting premature birth by cervical ultrasound evaluation. J Med Ultrasound 2021; 18: 501-507.
[17] Tu WJ. The value of ultrasound evaluation of cervical morphology in mid to late pregnancy in predicting pregnancy outcomes. Med Equip 2020; 33: 22-23.
[18] Onen BC, Semulimi AW, Bongomin F, Olum R, Kurigamba G, Mbiine R and Kituuka O. Surgical Apgar score as a predictor of outcomes in patients following laparotomy at Mulago National Referral Hospital, Uganda: a prospective cohort study. BMC Surgery 2022; 22: 433-433.
[19] Muhammad S, Sheshe AA, Naaya HU, Suleiman IE and Bello UM. Predicting major complications following laparotomy for gastrointestinal conditions using surgical Apgar score: A prospective analysis in a Nigerian population. J West Afr Coll Surg 2022; 12: 24-29.
[20] Wax JR and Pinette MG. The amniotic fluid index and oligohydramnios: a deeper dive into the shallow end-reply to Magann et al. Am J Obstet Gynecol 2023; 228: 598.
[21] Alayu S, Talie A and Bishaw KA. Vaginal delivery following induction and associated factors among laboring women at South Wollo Zone Public Hospitals of Ethiopia, 2023. Sci Rep 2024; 14: 25255.
[22] Brüggemann C, Carlhäll S, Grundström H, Ramö Isgren A and Blomberg M. Cumulative oxytocin dose in spontaneous labour-adverse postpartum outcomes, childbirth experience, and breastfeeding. Eur J Obstet Gynecol Reprod Biol 2024; 295: 98-103.
[23] Xiong ZY and Wu JN. Establishment of a SAT diagnostic scoring scale without thyroid nuclide scanning. Jiangsu Med J 2021; 47: 400-403.
[24] Zhang Q, Li XQ and Zhao YQ. The application value of contrast-enhanced ultrasound parameters in the diagnosis and evaluation of thyroid cancer. Chin J Health Eng 2023; 22: 534-536.
[25] Zhang LC, Zi SX. Parthenolide inhibits cell viability and induces apoptosis in melanoma through inhibition of PI3K/AKT signaling. J Biol Regul Homeost Agents 2022; 36: 1781-1788.
[26] Agus A, Tahir M, Bangsawan N, Chalid M, Lukas E and Lisal L. The relationship between ferritin levels and uterine inertia in labor women. Indonesian J Obstet Gynecol Sci 2023; 6: 212-219.
[27] Shu Y, Wang ZG and Luo XD. Clinical value of E-Cervix elastography in evaluating cervical maturity in term pregnancy and predicting vaginal delivery. J Clin Ultrasound Med 2022; 24: 44-47.
[28] Xu Y, Huang L, Han J and Zhou Y. Effects of EPO combined with mild hypothermia on oxidative stress and neuroprotection in neonates with hypoxic-ischemic encephalopathy. Cell Mol Biol (Noisy-le-Grand) 2022; 68: 36-45.
[29] Zhao Y. Common causes of oligohydramnios in late pregnancy. Jiangsu Health Care 2022; 09: 33.
[30] Wang GW, Li D. Clinical study on the effect of oligohydramnios detected by ultrasound in

late pregnancy on perinatal maternal and fetal outcomes. Hebei Med J 2022; 44: 1382-1384+1388.

[31] Wang J. The therapeutic effect of Huangqi Daicha Yin combined with Compound Danshen Injection on oligohydramnios in late pregnancy. Inner Mongol Tradit Chin Med 2021; 40: 46-47.

[32] Jan M, Guérin S, Yanni MA, Robin A, Lassel L, Bhandari Randhawa S, Béranger R and Lous ML. Induction of labor in late-term pregnancy: amniotomy plus early oxytocin perfusion versus amniotomy plus oxytocin perfusion delayed by 24 h. J Gynecol Obstet Hum Reprod 2025; 54: 102875.

[33] Hasan NA, Hong JGS, Teo IH, Zaidi SN, Hamdan M and Tan PC. Early versus delayed amniotomy with immediate oxytocin after Foley catheter cervical ripening in nulliparous labor induction: a randomized trial. Int J Gynaecol Obstet 2022; 159: 951-960.

[34] Ibsen CP, Scavenius C, Frederiksen KD, Wonsbek L, Ammitzbøll ILA, Vojdeman FJ, Glenthøj A, Noer MC, Lauenborg J, Mandrup CM and Clausen TD. Impact of second trimester iron deficiency on maternal and infant outcomes: a Danish cohort study. Eur J Obstet Gynecol Reprod Biol 2025; 311: 114004.

[35] Di Pasquo E, Morganelli G, Volpe N, Labadini C, Zegarra RR, Abou-Dakn M, Mappa I, Rizzo G, Dall'Asta A and Ghi T. The sonographic measurement of the ratio between the fetal head circumference and the obstetrical conjugate is accurate in predicting the risk of labor arrest: results from a multicenter prospective study. Am J Obstet Gynecol MFM 2022; 4: 100710.

[36] Villalain C, Quezada MS, Gómez-Arriaga P, Simón E, Gómez-Montes E, Galindo A and Herraiz I. Prognostic factors of successful cervical ripening and labor induction in late-onset fetal growth restriction. Fetal Diagn Ther 2020; 47: 536-544.

[37] Jiao J, Li L, Liu L and Huang C. Clinical study on preventive treatment of postpartum hemorrhage with carboprost tromethamine combined with oxytocin and misoprostol. Pak J Pharm Sci 2025; 38: 1023-1027.

[38] Su P. Clinical efficacy of ergometrine and oxytocin in the treatment of postpartum hemorrhage and their impact on coagulation function. Syst Med 2022; 7: 182-185+190.