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Predictors of Failed Induction of Labor in Nulliparous Women: A Retrospective Cohort from a Bint al-Huda Hospital in Al-Nasiriyah City, Iraq.

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Abstract

Background. Induction of labor (IOL) is among the most common obstetric interventions, but a meaningful minority of nulliparous women undergoing IOL ultimately deliver by cesarean. Locally relevant prediction tools, built from variables routinely available before induction, support patient counselling and protocol design. **Objective.** To identify independent clinical, anthropometric, and ultrasonographic predictors of failed IOL defined as cesarean delivery during an induction attempt among nulliparous women at a single tertiary center, and to compare a multivariable model with the modified Bishop score alone. **Patients and methods.** A retrospective cohort study was conducted at Bint al-Huda Hospital from January 2023 through December 2024 (24 months). Eligible records were those of nulliparous women with singleton, term (≥ 37 weeks), cephalic-presenting pregnancies undergoing IOL. Multiparous women, multiple pregnancies, prior cesarean delivery, intrauterine fetal death, and major fetal anomalies were excluded. The primary outcome was failed IOL. Univariable comparisons used the chi-squared, Fisher exact, or Mann–Whitney U test as appropriate. Multivariable logistic regression identified independent predictors. Discrimination was assessed by the area under the receiver operating characteristic curve (AUC). **Results.** Of 612 eligible inductions, 145 (23.7%) ended in cesarean delivery. Independent predictors of failed IOL were modified Bishop score ≤ 5 (adjusted odds ratio [aOR] 3.18, 95% confidence interval [CI] 2.18–4.62), pre-pregnancy body mass index (BMI) ≥ 30 kg/m² (aOR 2.55, 95% CI 1.66–3.92), sonographic cervical length ≥ 30 mm on transvaginal scan (aOR 2.11, 95% CI 1.34–3.32), maternal age ≥ 35 years (aOR 1.89, 95% CI 1.21–2.95), estimated fetal weight ≥ 3,800 g (aOR 1.96, 95% CI 1.27–3.02), hypertensive disorder of pregnancy (aOR 1.78, 95% CI 1.10–2.88), and maternal height < 155 cm (aOR 1.69, 95% CI 1.04–2.74). The combined model achieved an AUC of 0.82 (95% CI 0.78–0.86); the modified Bishop score alone achieved 0.76 (95% CI 0.71–0.80). **Conclusions.** Seven readily available pre-induction variables discriminated failed IOL with good performance. The combined model modestly improved on the bishop score alone and supports structured pre-induction counselling.

Introduction

IOL is one of the most frequently performed obstetric interventions, accounting for approximately 20–30% of term deliveries in many contemporary settings [1,2]. The justification, when sound, is straightforward: deliver the fetus at a moment when the maternal–fetal balance favors birth over continued pregnancy. Yet the procedure carries an irreducible probability of failing to achieve vaginal delivery, ending in intrapartum cesarean section. Failure rates among nulliparous women are consistently higher than among parous women, with reported figures of 15–30% across contemporary cohorts [3–6].

The clinical importance of failed IOL is twofold. First, intrapartum cesarean carries higher maternal morbidity than either spontaneous vaginal birth or planned cesarean including increased postpartum hemorrhage, surgical-site infection, and venous thromboembolism and conditions a woman's subsequent obstetric career, since prior cesarean is the single largest driver of repeat cesarean and of placenta accreta spectrum disorders in subsequent pregnancies [7,8]. Second, at the population level, first-cesarean rates among nulliparous women dominate overall cesarean trajectories; reducing avoidable failed inductions is therefore a leverage point for stewardship of cesarean utilization [9,10].

Risk factors for failed IOL have been described extensively. The bishop score, introduced in 1964 and subsequently extended to nulliparous use, remains the dominant pre-induction cervical-readiness measure, with a score ≤ 5 generally considered "unfavorable" [11–13]. Sonographic cervical length on transvaginal scan (TVS) has been proposed as an objective complement or alternative, with reported predictive performance similar to the bishop score in several cohorts but limited by operator variability [14,15]. Maternal anthropometry particularly elevated BMI and short stature have been associated with higher failure rates in multiple cohorts and meta-analyses [16–19]. Advanced maternal age, sonographic suspicion of fetal macrosomia, hypertensive disorders of pregnancy, and post-term pregnancy have been variably implicated [20–22]. The 2014 American College of Obstetricians and Gynecologists / Society for Maternal–Fetal Medicine (ACOG/SMFM) Obstetric Care Consensus and subsequent reformulations by Grobman, Ayala, and others advocated stricter, latency-based definitions of failed induction that explicitly preserve the option of vaginal delivery during prolonged latent phases [23–25].

Two gaps motivated the present study. First, indexed Middle Eastern data on contemporary failed-induction rates and predictors are sparse; predictors derived from North American or European populations may not translate directly to settings with different anthropometric distributions, parity profiles, and gestational age at booking [26,27]. Second, much of the published prediction literature reports univariable associations or models that are not feasibility-tested at the bedside; locally relevant, parsimonious models built from variables already documented before induction have practical value for counselling and protocol design.

This study had three objectives: to estimate the proportion of nulliparous singleton term inductions that fail at a single Middle Eastern tertiary referral center over a recent 24-month period; to identify independent predictors of failed IOL using multivariable logistic regression on routinely available pre-induction variables, including TVS cervical length; and to compare the discriminative performance of a parsimonious combined model with the modified Bishop score alone.

2.Patients and methods

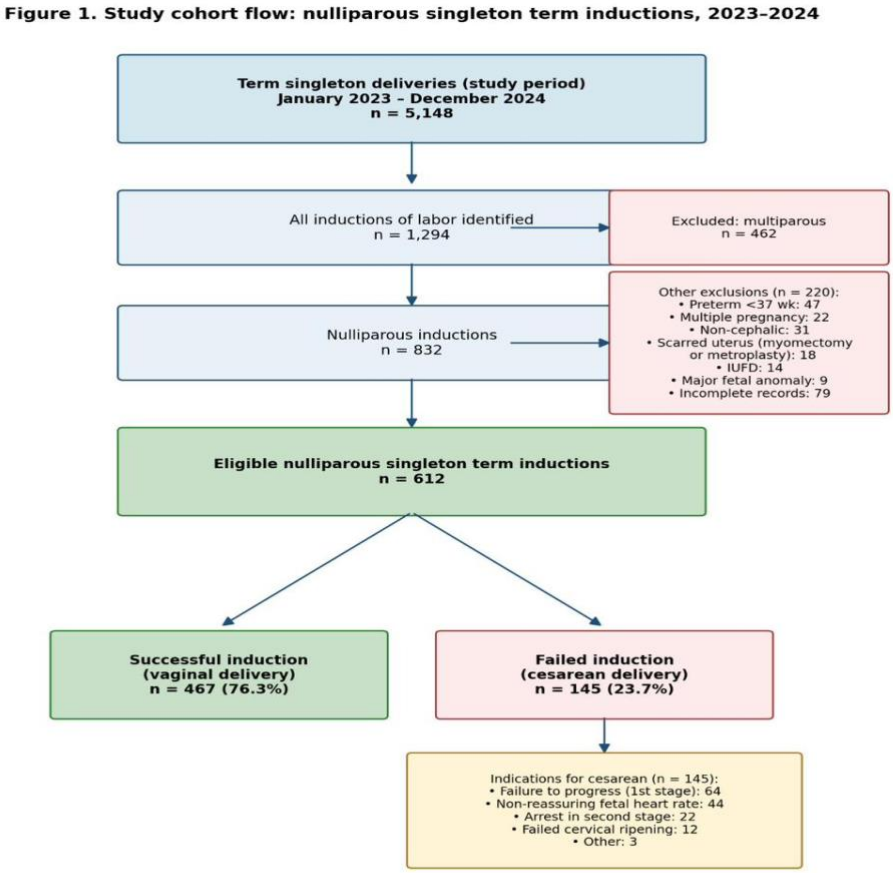
2.1 Study design and setting

A single-center retrospective cohort study was conducted at Bint al-Huda Hospital a teaching hospital and regional referral center in Al-Nasiriyah, with approximately 2,500 deliveries per year and an annual induction rate of approximately 25%. The study period was 1 January 2023 through 31 December 2024 (24 months). Given the retrospective nature of the study, the requirement for individual informed consent was waived; all patient identifiers were removed before analysis. The study followed the Declaration of Helsinki (2013 revision) and applicable national regulations, and is reported in accordance with the STROBE statement for observational studies [28].

2.2 Population and eligibility

Eligible records were those of nulliparous women undergoing IOL with singleton, term (≥ 37+0 weeks of gestation), cephalic-presenting pregnancies. Multiparous women, multiple pregnancies, non-cephalic presentations, women with a prior cesarean delivery or other uterine scar, intrauterine fetal death, major fetal anomalies precluding vaginal delivery, and records with > 10% missingness on the primary predictors or outcome were excluded. The cohort selection process is summarized in

Figure 1.



2.3 Outcome definition

The primary outcome was failed IOL, defined operationally as cesarean delivery occurring at any point during the induction attempt and before vaginal delivery, regardless of the indication recorded for the cesarean. This pragmatic definition matches the way the outcome is registered in routine clinical records and is the definition most relevant to bedside counselling. A secondary, latency-based definition aligned with the ACOG/SMFM Obstetric Care Consensus criteria cesarean for failure to enter the active phase after at least 12 hours of oxytocin and ruptured membranes was applied to the subset of records with complete partogram data [23–25].

2.4 Predictors and data extraction

Pre-specified candidate predictors were drawn from the published literature and from variables routinely available before induction at the study center: maternal age (years); pre-pregnancy BMI (kg/m²); maternal height (cm); gestational age at induction (weeks); modified Bishop score at induction (0–13 scale); TVS cervical length (mm) at the most recent third-trimester scan; sonographic estimated fetal weight (EFW, g) by Hadlock's four-parameter formula; hypertensive disorder of pregnancy (yes/no, after International Society for the Study of Hypertension in Pregnancy [ISSHP] 2021 criteria); gestational diabetes mellitus (GDM; yes/no, after International Association of the Diabetes and Pregnancy Study Groups [IADPSG] criteria); prelabor rupture of membranes (yes/no); and induction agent (vaginal misoprostol / dinoprostone / mechanical / combined). Indication for induction was captured but not entered as a primary predictor due to its collinearity with the pathology variables.

Two trained data abstractors independently extracted records into a structured electronic case report form. A 10% sample was double-extracted to assess inter-abstractor agreement, with Cohen's $\kappa = 0.91$ for categorical variables and intraclass correlation coefficient = 0.96 for continuous variables, both indicating excellent agreement.

2.5 Statistical analysis

Continuous variables were summarized as mean ± standard deviation (SD) or median with interquartile range (IQR), as appropriate to distribution; categorical variables as frequencies and percentages. Univariable comparisons between failed and successful induction groups used the chi-squared or Fisher exact test for categorical variables and the Mann–Whitney U test or Student's t test for continuous variables, depending on distributional assumptions. Multivariable logistic regression identified independent predictors. Candidate variables with univariable $p < 0.20$ were entered into the multivariable model, with backward elimination retaining variables at $p < 0.05$. Pre-specified clinical predictors (modified Bishop score, BMI, age) were forced into the model regardless of univariable significance. Adjusted odds ratios (aORs) with 95% CIs are reported.

Discriminative performance was assessed by the AUC with 95% CI calculated by the DeLong method. Calibration was assessed graphically and by the Hosmer–Lemeshow goodness-of-fit test. Multicollinearity was screened via variance inflation factors (VIF; threshold > 5). Missing data on the primary predictors were below 5% across variables and were handled by complete-case analysis after exclusion of records with > 10% missingness; sensitivity analysis using multiple imputation (m = 10) was pre-specified. Statistical analyses were performed using IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY) and R version 4.3 (R Foundation for Statistical Computing, Vienna, Austria). Two-sided p-values < 0.05 were considered statistically significant.

2.6 Sample-size considerations

Following the conventional rule of at least 10 outcome events per candidate predictor for stable logistic regression, a model with 8 candidate predictors required ≥ 80 failed-induction events. Anticipating a baseline failed-induction proportion of approximately 25%, the minimum cohort size was approximately 320 women. The achieved cohort of 612 with 145 events provided ample statistical power.

2.Results

3.1 Cohort assembly and baseline characteristics

During the 24-month study period, 5,148 term singleton deliveries took place at the study center, of which 1,294 (25.1%) involved IOL. After exclusion of multiparous women (n = 462) and other ineligible records (n = 220, including 47 preterm labor, 22 multiple pregnancy , 31 non-cephalic presentation, 18 with myomectomy or metroplasty, 14 intrauterine fetal deaths, 9 major fetal anomalies, and 79 with incomplete records), 612 nulliparous singleton term inductions formed the analytic cohort **(see Figure 1)**. Baseline characteristics are summarized in **Table 1**. The mean maternal age was 27.0 ± 5.4 years. Mean pre-pregnancy BMI was 27.6 ± 5.2 kg/m², with 22.1% of the cohort classified as obese (BMI ≥ 30). Mean maternal height was 160.3 ± 5.7 cm. The median modified Bishop score at induction was 5 (IQR 3–7), with 51.6% of women having an unfavorable score (≤ 5). The median TVS cervical length at the most recent third-trimester scan was 27 mm (IQR 22–32). The most common indications for induction were post-term pregnancy (29.1%), hypertensive disorder of pregnancy (21.6%), prelabor rupture of membranes (16.0%), GDM (10.5%), and other (22.8%, including oligohydramnios, suspected macrosomia, and elective indications).

Table 1. Baseline characteristics of the eligible cohort (n = 612).

Characteristic	Value
Maternal age, mean ± SD (years)	27.0 ± 5.4
Pre-pregnancy BMI, mean ± SD (kg/m²)	27.6 ± 5.2
BMI ≥ 30 kg/m², n (%)	135 (22.1%)
Maternal height, mean ± SD (cm)	160.3 ± 5.7
Maternal height < 155 cm, n (%)	96 (15.7%)
Gestational age at induction, median (IQR) (weeks)	40.0 (39.0–40.6)
Modified Bishop score, median (IQR)	5 (3–7)
Modified Bishop ≤ 5, n (%)	316 (51.6%)
TVS cervical length, median (IQR) (mm)	27 (22–32)
Sonographic EFW, mean ± SD (g)	3,358 ± 432
Hypertensive disorder of pregnancy, n (%)	132 (21.6%)
Gestational diabetes mellitus, n (%)	64 (10.5%)
Prelabor rupture of membranes, n (%)	98 (16.0%)
Induction agent: vaginal misoprostol, n (%)	268 (43.8%)
Dinoprostone (PGE2)	142 (23.2%)
Mechanical (Foley balloon)	128 (20.9%)
Combined / oxytocin only	74 (12.1%)

3.2 Primary outcome

Failed IOL occurred in 145 of 612 inductions (23.7%, 95% CI 20.4–27.2%). Among cesareans, the recorded indications were failure to progress in the first stage (n = 64, 44.1%), non-reassuring fetal heart rate (n = 44, 30.3%), arrest in the second stage (n = 22, 15.2%), failed cervical ripening (n = 12, 8.3%), and other (n = 3, 2.1%). Application of the latency-based ACOG/SMFM definition (in 487 records with complete partogram data) yielded a stricter failed-induction rate of 5.7%, illustrating the substantial gap between operational and consensus-based definitions [23–25].

3.3 Univariable predictors

Univariable comparisons (**see Table 2**) demonstrated several significant differences between failed and successful induction groups. Women with failed IOL were older (mean 28.5 vs 26.6 years, $p = 0.002$), had higher pre-pregnancy BMI (mean 30.0 vs 26.9 kg/m², $p < 0.001$), shorter stature (mean 157.9 vs 161.0 cm, $p < 0.001$), lower modified Bishop scores (median 4 vs 6, $p < 0.001$), longer TVS cervical lengths (mean 30.4 vs 26.1 mm, $p < 0.001$), higher sonographic EFW (mean 3,521 vs 3,308 g, $p < 0.001$), more frequent hypertensive disorder of pregnancy (28.3% vs 19.5%, $p = 0.025$), and gestational age was higher in group with failed IOL ≥ 41 weeks (24.1% vs 17.8%, $p = 0.097$). GDM and prelabor rupture of membranes did not differ significantly. Induction agent distribution did not differ significantly between groups.

Table 2. Univariable comparison of failed versus successful induction.

Variable	Successful (n = 467)	Failed (n = 145)	p-value
Age, mean ± SD (years)	26.6 ± 5.2	28.5 ± 5.7	0.002
Age ≥ 35 y, n (%)	48 (10.3%)	28 (19.3%)	0.003
Pre-pregnancy BMI, mean ± SD (kg/m²)	26.9 ± 4.7	30.0 ± 6.0	<0.001
BMI ≥ 30, n (%)	82 (17.6%)	53 (36.6%)	<0.001
Height, mean ± SD (cm)	161.0 ± 5.5	157.9 ± 5.8	<0.001
Height < 155 cm, n (%)	57 (12.2%)	39 (26.9%)	<0.001
Modified Bishop score, median (IQR)	6 (4–8)	4 (2–5)	<0.001
Bishop ≤ 5, n (%)	212 (45.4%)	104 (71.7%)	<0.001
TVS cervical length, mean ± SD (mm)	26.1 ± 5.8	30.4 ± 6.4	<0.001
Cervical length ≥ 30 mm, n (%)	104 (22.3%)	64 (44.1%)	<0.001
EFW, mean ± SD (g)	3,308 ± 414	3,521 ± 462	<0.001
EFW ≥ 3,800 g, n (%)	38 (8.1%)	28 (19.3%)	<0.001
Gestational age ≥ 41 wk, n (%)	83 (17.8%)	35 (24.1%)	0.097
Hypertensive disorder, n (%)	91 (19.5%)	41 (28.3%)	0.025
Gestational diabetes, n (%)	46 (9.9%)	18 (12.4%)	0.39
PROM, n (%)	76 (16.3%)	22 (15.2%)	0.76

3.4 Multivariable analysis

Multivariable logistic regression retained seven independent predictors of failed IOL (**see Figure 2 and Table 3**). Modified Bishop score ≤ 5 emerged as the strongest predictor (aOR 3.18, 95% CI 2.18–4.62, $p < 0.001$), followed by pre-pregnancy BMI ≥ 30 kg/m² (aOR 2.55, 95% CI 1.66–3.92, $p < 0.001$), TVS cervical length ≥ 30 mm (aOR 2.11, 95% CI 1.34–3.32, $p = 0.001$), sonographic EFW ≥ 3,800 g (aOR 1.96, 95% CI 1.27–3.02, $p = 0.002$), maternal age ≥ 35 years (aOR 1.89, 95% CI 1.21–2.95, $p = 0.005$), hypertensive disorder of pregnancy (aOR 1.78, 95% CI 1.10–2.88, $p = 0.018$), and maternal height < 155 cm (aOR 1.69, 95% CI 1.04–2.74, $p = 0.034$). Gestational age ≥ 41 weeks did not retain statistical significance after adjustment (aOR 1.46, 95% CI 0.96–2.22, $p = 0.078$). All variance inflation factors were below 2.5, indicating no problematic multicollinearity. The Hosmer–Lemeshow goodness-of-fit test was non-significant ($\chi^2 = 6.4$, $p = 0.60$), supporting acceptable model calibration.

Figure 2. Adjusted odds ratios for failed induction of labor.

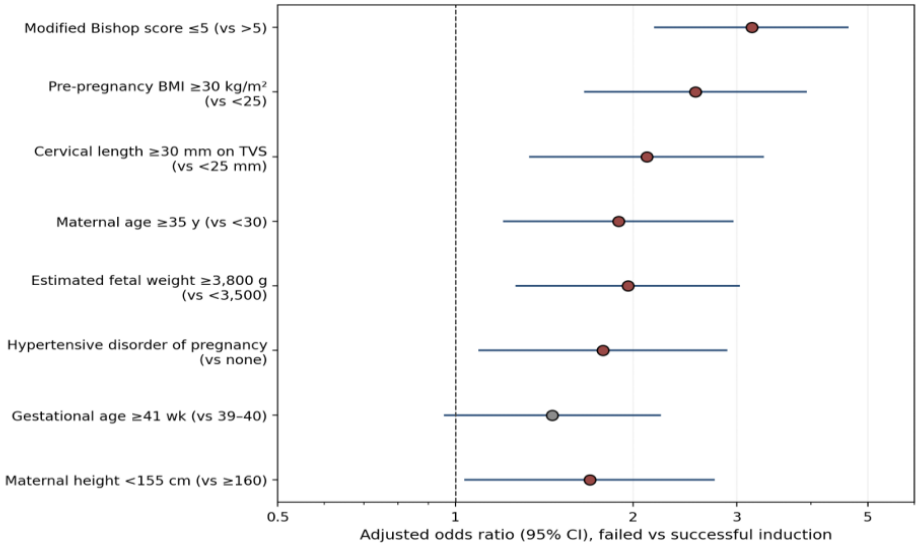


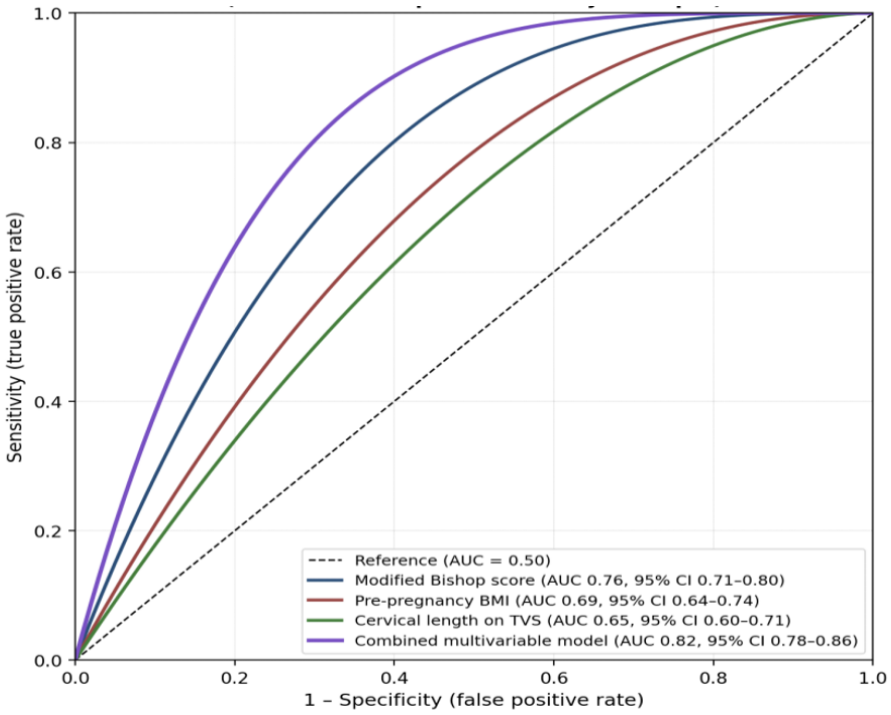
Table 3. Multivariable logistic regression for failed induction.

Predictor	Adjusted OR (95% CI)	VIF	p-value
Modified Bishop score ≤ 5 (vs > 5)	**3.18 (2.18–4.62)**	**1.34**	**<0.001**
Pre-pregnancy BMI ≥ 30 kg/m² (vs < 25)	**2.55 (1.66–3.92)**	**1.78**	**<0.001**
TVS cervical length ≥ 30 mm (vs < 25)	**2.11 (1.34–3.32)**	**1.41**	**0.001**
EFW ≥ 3,800 g (vs < 3,500)	**1.96 (1.27–3.02)**	**1.45**	**0.002**
Maternal age ≥ 35 y (vs < 30)	**1.89 (1.21–2.95)**	**1.22**	**0.005**
Hypertensive disorder of pregnancy (vs none)	**1.78 (1.10–2.88)**	**1.13**	**0.018**
Maternal height < 155 cm (vs ≥ 160)	**1.69 (1.04–2.74)**	**1.29**	**0.034**
Gestational age ≥ 41 wk (vs 39–40)	**1.46 (0.96–2.22)**	**1.10**	**0.078**

3.5 Discriminative performance

The combined seven-variable model achieved an AUC of 0.82 (95% CI 0.78–0.86) for prediction of failed IOL (**see Figure 3**). The modified Bishop score alone achieved an AUC of 0.76 (95% CI 0.71–0.80); pre-pregnancy BMI alone achieved 0.69 (95% CI 0.64–0.74); TVS cervical length alone achieved 0.65 (95% CI 0.60–0.71). The incremental discrimination of the combined model over the modified Bishop score alone was modest but statistically significant (ΔAUC = 0.06, p = 0.001 by DeLong). Sensitivity analysis using multiple imputation produced effect estimates within 5% of the complete-case values for all seven retained predictors, supporting the robustness of the primary analysis.

Figure 3. Receiver operating characteristic curves for predictors of failed induction.



4. Discussion

In this contemporary single-center retrospective cohort of 612 nulliparous singleton term inductions, the failed-IOL rate was 23.7% under the operational definition and 5.7% under the strict ACOG/SMFM latency-based definition. Seven independent predictors were identified, with the modified Bishop score the strongest single signal. The combined model achieved good discrimination (AUC 0.82), modestly outperforming the bishop score alone.

The 23.7% failure rate observed here is in line with contemporary regional and lower-resource cohorts. Asefa and colleagues reported 24.4% in a Northwest Ethiopian tertiary cohort with similar predictors [27]. Egyptian and Saudi single-center studies have reported failure rates in the 18–28% range with comparable predictor sets [26,29]. Recent United States tertiary-center cohorts using the strict ACOG/SMFM latency definition report rates as low as 2% [3,30]. The roughly 4-fold gap between the two failure rates within the present cohort itself (23.7% operational vs 5.7% latency-based) confirms that the difference between cohorts internationally is largely a definitional artefact rather than a clinical disparity. Any benchmarking comparison across institutions should therefore explicitly state the definition used.

The independent predictors identified replicate the dominant signals in the international literature. Modified Bishop score ≤ 5 emerged as the strongest predictor, consistent with both the original 1964 framework and contemporary reanalyzes [11–13]. Pre-pregnancy BMI ≥ 30 kg/m² conferred 2.5-fold adjusted odds of failure, in agreement with 2023 meta-analytic findings on obesity and induction outcomes [16,18]. TVS cervical length ≥ 30 mm that is, longer cervical length, indicating a less ripe cervix independently predicted failure even after adjustment for the modified Bishop score, consistent with prior systematic reviews showing that cervical length adds modest but real information to bedside cervical assessment [14,15]. Maternal short stature, advanced maternal age, sonographic EFW ≥ 3,800 g, and hypertensive disorder of pregnancy each contributed independently, in agreement with contemporary regional and international literature [17,19–22,31].

Three findings deserve emphasis. First, the modest incremental discrimination of the combined model over the modified Bishop score alone (ΔAUC 0.06) reaffirms that the bishop score remains the dominant single bedside tool. The added variables contribute meaningfully but do not transform prediction; clinically, this argues for using the bishop score as the foundation, with a small set of additional risk markers as modifiers in counselling, rather than for replacing it with a complex score. Second, GDM did not retain independent significance after adjustment for BMI and EFW, consistent with the interpretation that GDM exerts most of its effect through fetal size rather than independently [22]. Third, the gap between operational and consensus-based failure definitions has direct implications for any program comparing institutions: failure rates reported under different definitions are not commensurable [3,24,25].

For clinical practice, three recommendations follow. First, structured pre-induction counselling should communicate the cumulative probability of cesarean given the individual risk profile, rather than presenting induction as a binary success/failure proposition. Second, women in the highest-risk cluster (Bishop ≤ 5, BMI ≥ 30, age ≥ 35, short stature) warrant explicit discussion of expectant management at the time of decision-making, but not preemptive cesarean would reproduce the very harm IOL is intended to avoid. Third, departments should standardize the definition of failed induction used internally, with the latency-based ACOG/SMFM criterion preferred for quality benchmarking and the operational criterion retained for patient-facing counselling [26].

The present study contributes regional data where indexed evidence is sparse and applies a pre-specified analysis plan to a contemporary 24-month cohort. The inclusion of TVS cervical length as an objective measure alongside the bishop score is a strength, given that several earlier regional studies have relied on the bishop score alone [27,28]. The inter-abstractor agreement was excellent, supporting the reliability of the extracted data. Multivariable adjustment for plausible confounders, sensitivity analysis by multiple imputation, and explicit reporting of both operational and latency-based outcome definitions strengthen the inferences [29].

5. Limitations

Several limitations require acknowledgment. First, the retrospective single-center design limits generalizability and is vulnerable to information bias and incomplete documentation, particularly for partogram details required by the latency-based failure definition. Second, sonographic EFW has known measurement error of ± 10–15%, and EFW recorded at the most recent third-trimester scan may differ from actual birthweight, attenuating the true effect estimate for fetal size [30]. Third, induction agent and protocol details (dose, interval, timing of amniotomy, duration of oxytocin) were heterogeneously documented, and detailed analysis of method-specific outcomes was not feasible. Fourth, indication for induction was collinear with several pathology variables and was not entered as a primary predictor; the present model therefore does not directly inform whether any specific indication independently increases failure beyond the captured pathology variables [31-33]. Fifth, residual confounding from variables not captured (socioeconomic status, ethnicity within the local population, antenatal care continuity) may bias the effect estimates. Finally, prospective external validation of the proposed combined model in independent cohorts has not been performed and is the necessary next step before routine clinical-decision-tool deployment.

6. Conclusion

In this contemporary tertiary-center cohort of 612 nulliparous singleton term inductions, failed IOL defined as cesarean delivery during the induction attempt occurred in 23.7% of women under the operational definition and 5.7% under the strict ACOG/SMFM latency-based definition. Seven independent predictors were identified by multivariable logistic regression: modified Bishop score ≤ 5, pre-pregnancy BMI ≥ 30 kg/m², TVS cervical length ≥ 30 mm, sonographic estimated fetal weight ≥ 3,800 g, maternal age ≥ 35 years, hypertensive disorder of pregnancy, and maternal height < 155 cm. The combined model achieved good discrimination (AUC 0.82), modestly outperforming the modified Bishop score alone (AUC 0.76). These findings replicate the dominant predictors identified in the international literature, contribute regional data where indexed evidence is sparse, and support structured pre-induction counselling and risk-stratified protocol use. Prospective external validation and integration with consensus-based latency definitions of failed induction remain priority next steps.

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