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Accuracy of Different Scoring Systems for Predicting Successful Induction of Labor: A Cross-Sectional Study

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ABSTRACT

Background: Nowadays, inducing of labor (IOL) is a routine treatment in obstetric practice. For different maternal and fetal reasons, IOL is currently performed for 20 percent of pregnancies. Limited to non-pregnant women, prediction score methods for IOL success have indicated that a good preoperative cervical exam is the most important factor.

AIM: To evaluate the accuracy of Different Scoring Systems for Predicting Successful Induction of Labor.

Patients and methods: the study was conducted on department obstructs and gynecology faculty of medicine Assiut University on 410 patients and they divided into CS (n= 104) and Vaginal delivery (n= 306) .

Results: there was a statistical significant difference between groups regarding Kaplan Meier analysis of time to delivery based Bishop score and Manipal U/S scoring system, Protocol of induction and Pregestational DM. There was no statistical significant difference between groups regarding to Accuracy of different scoring system in prediction of successful induction. **Conclusion:** Predicting whether or not a woman will have a successful vaginal birth following induction of labor is becoming increasingly important as a result of the possible impact on healthcare spending, as evidenced by the rapid increase in the development of prediction models. But because most published models lack external validation and there are limitations in scope, methodology, and/or measurement of effectiveness in clinical settings, it is difficult to endorse any one model for widespread clinical usage.

Keywords: Scoring Systems, Induction of Labor.

INTRODUCTION

Nowadays, inducing labor (IOL) is a routine treatment in obstetric practice. For different maternal and fetal reasons, IOL is currently performed for 20 percent of pregnancies [(1)], and approximately 20 percent of labor inductions result in caesarean delivery [(2)].

The cervix's favorability, which is often determined by the physical inspection and Bishop Score, is the primary determinant of IOL success [(3)]. Despite being used on all patients prior to IOL, this approach is constrained by subjectivity and consistency, and numerous readings have shown a weak relationship between Bishop Score and IOL result [(4)].

Tolcher et al. (2015) developed a nomogram for discovering independent risk variables that can be utilized to predict CS among term-delivering nulliparous females having IOL. A score was assigned based only on these factors: maternal age, height, BMI, weight change, gestational age, hypertension/diabetes status, and early cervical dilatation. The anticipated likelihood of CS following IOL at term is equal to the sum of the individual scores [(5)].

When counselling women on the possibility of a caesarean section (CS) following intraocular lens (IOL) surgery with an unfavorable cervix, Levine et al. (2018) suggested using a new online calculator. Probability of CS was determined using the Levine scoring method, which took into account maternal height, parity, BMI at delivery, and the outcomes of the modified Bishop's score [(6)]. In 2019, Jochum et al. reported a second scoring method to predict CS following IOL that was simple, effective, and had external validation. Maternal factors such as height, parity, body BMI, gestational age, cervical dilation, fetal head presentation, cervical effacement, and the primary rationale for IOL were all factored into the final score [(7)].

PATIENTS AND METHODS

Woman's Health Hospital-Assiut University was the site of the current cross-sectional investigation. Between December 2020 and May 2022, the research was conducted. The Assiut University Medical School's IRB (IRB No. 17101126/2020) gave its stamp of approval to the study's methodology. All subjects provided written informed permission in accordance with the principles of the Declaration of Helsinki. The study protocol is registered at Clinicaltrails.gov ID: NCT04325256.

Eligible participants

It was hoped that all pregnant women who came to the labor unit for IOL for any reason throughout the research period would participate. Women who were willing to take part in the research were required to be carrying a single baby, have a gestational age o $\geq$ 37 weeks, and show no signs of vaginal bleeding. Both breech and vertex presented fetuses are included. Women who had a prior caesarean, uterine surgery, or antepartum hemorrhage, or who presented with cephalo-pelvic disproportion, were not eligible to participate. Fetuses with significant congenital abnormalities, intrauterine fetal death (IUFD), fetal growth restriction (FGR), and a presentation other than cephalic are not included.

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Recruitment

All participants were subjected to thorough history taking and clinical evaluation. Also, obstetric history was recorded in all women. Maternal age, parity, gestational age, history of miscarriage, place of residence, level of education, reason for induction, height, weight, and (BMI) before & after delivery were all collected as part of the baseline data.

Induction failure: which means failure to progress of the active phase of labor, as shown by a cervical dilation of ≥ four cm following a minimum of 24 hours of oxytocin treatment in the presence of ruptured membranes, is described as the inability to progress to the active phase of labor [98].

Follow up

The presence or absence of meconium aspiration syndrome (MAS), and hospitalization to the neonatal intensive care unit (NICU) were recorded as postpartum birth outcomes.

Adverse neonatal outcomes included the need for an emergency C-section due to fetal distress, an Apgar score of less than 7 at 1 and 5 minutes, meconium aspiration syndrome (MAS), or admission to the neonatal intensive care unit (NICU). Diagnostic of MAS included a greenish discoloration of fluid, respiratory discomfort, and chest X-ray findings of lung hyperinflation and diffuse coarse infiltration [9].

Indicative changes in heart rate (FHR) necessitating a caesarean section (CS) or forceps/ventouse delivery, the presence of moderate-thick meconium stained liquor (MSL), an Apgar score of less than five minutes than 7, and/or admission to the neonatal intensive care unit (NICU) for birth asphyxia and neonatal seizures within the first four weeks of life were all used to define fetal and neonatal distress.

Ethical Approval:

The study was approved by the Ethics Board of Assuit University and the patients were given all the information they need about the trial. Informed written consent was taken from each participant in the study. This work has been carried out following The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

Statistical analysis was performed on the data using SPSS Version 23. Statistics were shown as in the form of means ± standard deviation and median (interquartile range). Quantitative measures of the qualitative variables were provided as frequencies and percentages.

Construction of ROC curves, which measure the efficiency of a system, was performed. To compare the efficacy of different scoring systems for predicting IOL outcomes, we computed the area under each ROC curve. Sensitivity, specificity, and accuracy area under the curve (AUC) were used to evaluate the diagnostic qualities of these cut off points, and their results accurately represented the capabilities of the various scoring systems.

RESULTS

A total of 410 ladies who were receiving care at the Woman's Health University Hospital's maternity ward were enrolled. individuals at Assiut University, Egypt, who were candidates for IOL for a variety of reasons, with the goal of evaluating the predictive accuracy of several models for IOL.

Mean age of enrolled women was 24.90 years with a range between 16 and 41 years old. Majority (73.9%) of women came from rural areas. Based on social class; 144 (35.1%), 264 (64.4%) and 2 (0.50%) women had low, medium and high social class, respectively. Up to 37% women were illiterate while 182 (44.4%), 67 (16.3%) and 8 (2%) women had primary, secondary and high education level, respectively. Other data are summarized at table 1.

Table (1) Baseline data of enrolled women:

	N= 410
Age (years)	24.90 ± 5.45
Range	16-41
Parity	1 (0-6)
Abortion	0 (0-7)
Body mass index (kg/m^2)	29.84 ± 2.62
Range	23-42.90
Gestational age (weeks)	39.39 ± 1.45
Range	37-42.30
Residence	
Urban	107 (26.1%)
Rural	303 (73.9%)
Social class	
Low	144 (35.1%)
Medium	264 (64.4%)
High	2 (0.50%)
Education level	
Illiterate	153(37.3%)
Primary level	182(44.4%)
Secondary level	67(16.3%)
High level	8 (2%)

Data expressed average (Standard Deviation), Median (Range), and Percentage (Frequency)

Mean duration of induction was 8.62 hours. Mode of delivery was vaginal delivery in 306 (74.6%) women while cesarean section was performed in 104 (25.4%) women. Indications of CS were failed induction (30 cases; 7.3%), fetal distress (60 cases; 14.6%) and failed progression (14 cases; 3.5%). Indications of CS in the current study were fetal distress, failed progress and failed induction in 57 (54.8%), 34 (32.7%) and 13 (12.5%) women, respectively. Table (2)

Table (2): Mode of delivery, duration of induction and indications of cesarean section among studied women:

Indication of induction	**N= 410**
PROM	199 (48.5%)
Postdate	113 (27.6%)
Oligohydramnios	98 (23.9%)
Protocol of induction	
Misoprostol	222 (54.1%)
Oxytocin	188 (45.9%)
Indications of cesarean section	
Risk of CS	N= 104
Fetal distress	57 (54.8%)
Failed progress	34 (32.7%)
Failed induction	13 (12.5%)

Both groups of studied women had insignificant differences as regard different characteristics with the except of the protocol of induction where misoprostol was frequently used in vaginal delivery group (56.9%) while oxytocin was frequently used in case of CS group (53.8%). Also, pregestational DM was present in only four women and all of them had CS as shown in table (3).

Table (3): Characteristics of studied women based on mode of delivery

	Mode of delivery		*P* value
	CS (n= 104)	**Vaginal delivery (n= 306)**	
Age (years)	24.41 ± 5.23	25.06 ± 5.53	0.29
Parity	2 (0-7)	2 (0-7)	0.20
Abortion	1 (0-5)	1 (0-6)	0.06
BMI (kg/m^2)	29.93 ± 2.94	29.80 ± 2.53	0.66
Gestational age (wks)	39.25 ± 1.47	39.44 ± 1.44	0.24
Residence			
Urban	31 (29.8%)	76 (24.8%)	0.19
Rural	73 (70.2%)	230 (75.3%)	
Social class			
Low	34 (32.7%)	110 (35.9%)	0.57
Medium	70 (67.3%)	194 (63.45)	
High	0	2 (0.70%)	
Education level			
Illiterate	33 (31.7%)	120 (39.2%)	
Primary level	48 (46.25)	134 (43.8%)	0.26
Secondary level	22 (21.2%)	45 (14.7%)	
High level	1 (1%)	7 (2.3%)	
Indication ofinduction			
PROM	54 (51.9%)	145 (47.4%)	
Postdate	26 (25%)	87 (28.4%)	0.70
Oligohydramnios	24 (23.1%)	74 (24.2%)	
Protocol of induction			
Misoprostol	48 (46.2%)	174 (56.9%)	**0.03**
Oxytocin	56 (53.8%)	132 (43.1%)	
Pre-eclampsia	6 (5.8%)	11 (3.6%)	0.24
Chronic HTN	1 (1%)	1 (0.30%)	0.44
Gestational HTN	1 (1%)	10 (3.3%)	0.14
Pregestational DM	4 (3.8%)	0	**< 0.001**
Pre-eclampsia/DM	1 (1%)	0	0.25

Data expressed as mean (SD), median (range), frequency (percentage). *P* value was significant if < 0.05. **CS**: cesarean section**; PROM**: premature rupture of membrane; **BMI:** body mass index; **DM**: diabetes mellitus; **HTN**: hypertension

Table (4) shows Accuracy of different scoring system in prediction of successful induction: For prediction of successful induction, it was found that bishop score at cutoff point 9 had 73.6% overall accuracy with area under the curve was 0.56 while the modified bishop score at cutoff point 8 had 75.9% overall accuracy with area under the curve was 0.54.
Manipal U/S scoring system, at cutoff point 5 had 50.9% overall accuracy with area under the curve was 0.0.59.
Levine scoring system, at cutoff point 6 had 77.2% overall accuracy with area under the curve was 0.57.
The 50-point scoring system, at cutoff point 28 had 76.4% overall accuracy with area under the curve was 0.65
Induction calculator score, at cutoff point 154 had 65% overall accuracy with area under the curve was 0.63.

Table (4): Accuracy of different scoring system in prediction of successful induction

Scores	Indices							
	Sensitivity	**Specificity**	**Positive predictive value**	**Negative predictive value**	**Accuracy**	**Cutoff**	**Area under curve**	***P* value**
Bishop score	91%	22.33%	77.51%	46%	73.6%	9	0.56	0.07
Modified bishop score	98%	11%	76.38%	65.11%	75.90%	8	0.54	0.30
Manipal U/S scoringsystem	43%	72%	81.88%	30%	50.9%	5	0.59	0.002
Levine scoring system	98%	16%	77.43%	73.21%	77.2%	6	0.57	0.052
The 50-point scoringsystem	95.44%	20.39%	77.89%	60.46%	76.4%	28	0.65	0.001
Induction calculatorscore	85.3%	40.80%	80.81%	31.7%	65%	154	0.63	0.001

P value was significant if < 0.05

Table (5) Kaplan Meier analysis of time to delivery based Bishop Score and Manipal U/S scoring system: In case of Bishop score < 4; there was significantly longer time till vaginal delivery (14.72 vs. 9.51 (hour); p< 0.001) with hazard‘s ratio (HR) = 1.74. In case of Manipal U/S scoring system < 4; there was a significantly longer time till vaginal delivery (14 vs. 9.72 (hour); p<0.001) with hazard‘s ratio (HR) = 1.64.

Table (5): Kaplan Meier analysis of time to delivery based Bishop score and Manipal U/S scoring system

	Bishop score	**Manipal U/S scoring system**
Time till delivery (hr)		
Score < 4	14.72 (13-16.39)	14 (12-15.87)
Score ≥ 4Overall	9.51 (8.48- 10.54)	9.72 (8.71- 10.74)
	10.58 (9.94-11.76)	10.85 (9.94-11.76)
DF	1	1
Chi^2	20.86	16.18
Hazard ratio	1.74 (1.37-2.22)	1.64 (1.28-2.09)
***P* value**	**< 0.001**	**< 0.001**

Date expressed as mean (95 percent confidence interval). *P* value was significant if < 0.05.

DISCUSSION

Nearly a million women, or Up to 23 percent of all pregnant women, had labored artificially induced. Induction is a popular obstetric technique, although it is difficult for doctors to anticipate whether or not it will be successful. About a third of inductions result in a caesarean birth [(10)].

When compared with natural childbirth, caesarean sections have a higher risk of maternal morbidity. There is an increased risk of postnatal problems, such as respiratory distress, for the infant delivered via caesarean section without labor. Though induction is undertaken, cesarean delivery may be warranted [(11)]

Despite the fact that many potential causes of a botched induction have been pinpointed, it remains impossible to reliably predict how likely a woman is to need a caesarean section on the basis of risk factors alone. Thus far, induction success prediction models have only been developed for primiparous women, and these models have consistently indicated that a good cervical exam prior to induction is the most important factor in ensuring a successful induction [(5)].

But as this score was first developed for inducing oxytocin solely in multiparous women, its prognostic powers appear to be restricted [(12)]. While several alternatives to the Bishop score [(13)] for induction have been offered, none have gained widespread acceptance. Furthermore, none of these scores were specifically designed for induction of labor using cervical ripening, with the exception of the score published by Levine et al [(6)].

Prediction models that incorporate ultrasound and biochemical information show great potential, but in many countries, healthcare providers who care for pregnant women do not have access to these parameters. Consequently, there is a pressing need to create and verify prediction models that incorporate prenatal, demographic, and clinical information that are readily available to all healthcare providers [(14)].

In this work, we enrolled 410 women who were eligible for IOL for different indications aiming to assess accuracy of different models in prediction of successful IOL. These models included; Bishop score, modified bishop score, Manipal U/S scoring system, Levine scoring system, the 50-point scoring system and Induction calculator score. Out of those enrolled women; vaginal delivery with successful IOL was occurred in a total of 306 (74.6%) women while cesarean section wasperformed in 104 (25.4%) women. Similarly, in a previous study enrolled 1024 women underwent IOL, a total of 774 (75.6%) patients had vaginal delivery and CS was performed in the others women, 24.4% [(7)].

Generally, these percentages in our study, nearly similar to whatwas reported in the literature [(32-39)]. And yet some variations may be present in these studies, these could be attributed to timing, indications and methods of induction and characteristics of studied patients as body mass index, parity and presence of other comorbidities.

In the current study, the main indications for induction were PROM (48.5%), postdate (27.6%) and oligohydramnios (23.9%). Induction was done by misoprostol in 222 (54.1%) women while it was done by 188 (45.9%) women. In line with this study, Jochum et al. (2019)found that PROM was the main indication for IOL (27.1%) [(7)].

Also, another study enrolled 564 women had IOL. 472 ladies (or 84 percent of total) gave birth without any complications. Among the study's subjects, 131 (23.0 percent) had diabetes mellitus and 174 (31 percent) had reached their full-term pregnancy when they received IOLs [(15)].

In contrast, the study of Tolcher et al. (2016) found that up 96% of the studied women in their cohort (757/785) required IOL secondary medical indications [(5)].

This discrepancy may be explained that all patients in their study were nulliparous while we included all women irrespective their parity.

In general, there were wide variations in the indications of IOL in the reported studies and this mainly may be attributed to characteristics ofstudied women and their medical conditions [(16)]

Indications of CS in the current study were fetal distress, failed progress and failed induction in 57 (54.8%), 34 (32.7%) and 13 (12.5%) women, respectively. Consistent with these results, a prior research found that the most common reasons for a caesarean section were a failed induction or arrest of labor (51.4 percent), an arrest of descent (10.3 percent), and fetal indication (34.6 percent). [(6)].

In this study, we found that induction with oxytocin and pregestational diabetes were significantly higher among those groups with failed IOL (CS group). Also, we found that mean body mass index was higher among the CS group but of no significant value.

Consistent with these findings, Pevzner et al. (2009) determined that factors such as maternal health, body mass index (BMI), parity, age, and neonatal birth weight are crucial in determining whether or not an induction of labor would result in a healthy baby [(17)]. In addition, Al-Shaikh et al. (2012) discovered that higher maternal weight and having no previous children pose the greatest risk for CS [(15)].

The effectiveness of inducing labor was predicted using a Manipal cervical scoring system with transvaginal ultrasonography by BaJpai et al. (2015). Independent of one another, the authors showed that a longer cervical length and a greater distance of the presenting component from the external os significantly predicted the chance of induction failure and the need for a caesarean section [18].

Medical indication, suspicion of macrosomia, premature rupture of membranes, and concerning fetal status were also strongly associated with caesarean delivery; other factors included maternal height, body mass index, gestational age, parity, dilation, effacement, fetal head station, and medical indication (2019) [7].

In a study of induction of labor (IOL) in patients with hypertensive disorders of pregnancy, Beninati et al. found that maternal age, body mass index, gestational age, the need for cervical ripening, a history of caesarean section, and cervical dilation and effacement were associated with failed induction and the need for CS (2020). [19].

Therefore, from the perspective of shared decision-making, knowing how likely a vaginal delivery is following IOL is vital. In circumstances when there is a poor possibility of success and evidence of declining maternal and/or fetal health, it might help decide whether a less urgent reason for IOL should be securely postponed or whether a scheduled caesarean delivery should be favored over IOL [20].

Prediction models that incorporate ultrasound and biochemical information show great potential, but in many countries, healthcare providers who care for pregnant women do not have access to these parameters. As a result, there is a pressing need for the creation and validation of prediction models that incorporate prenatal, demographic, and clinical information that are readily available to all healthcare providers**.** [21].

Unfortunately , it is challenging to suggest any one model for broad clinical application due to constraints relating to scope, methodology, and/or assessment of performance. Shared decision making, parental satisfaction, caesarean birth rates, and resource usage might all benefit from the results of prospective clinical trials that verify current models in a variety of contexts. [20].

Bishop score, modified bishop score, Manipal U/S scoring system, Levine score, 50-point score, and Induction calculator score are all evaluated in this study.

The current investigation found that the Levine scoring system (77.2%) and the 50-point scoring system (76.4%) had the highest diagnostic accuracy, while the Manipal U/S scoring system (50.9%) had the lowest.

We discovered that the modified Bishop score, the Manipal US scoring system, and the Levin score were all equivalent to the Bishop score, whereas the 50-point scoring system and the induction calculator score were both superior.

Despite this, it is important to note that the models used in the current study were developed for specific populations and conditions, such as those with obesity, hypertensive disorders, other medical indications, prior caesarean births, nulliparity, unfavorable cervices, intact membranes, and preterm birth.

It is important to investigate building models that contain all these factors to allow the use of a single model for a more diversified population seen in clinical practice, as IOL is commonly conducted in pregnant persons with more than one of these problems. This is achievable with the help of AI and ML, as well as the availability of massive data sets [20].

The described models have been criticized mostly because their accuracy varies widely and because they all rely on a unique set of maternal and fetal variables. Many of the studies either failed to describe a method for handling missing data or, if participants' missing data were on predictor factors or the major outcome, they were left out of the final tally [21]

All of the more up-to-date models allow for maternal weight or body mass index at least once during pregnancy because of its significance in labor curves and IOL success. However, it is essential to think about weight-related variables in early pregnancy and at the time of IOL to represent gestational weight increase as these can change the success of IOL [22]

Birth weight estimates from ultrasounds performed in the third trimester (which have been shown to be inaccurate with a tendency to over-estimate the true weight), fetal sex, cervical lengths, and biochemical analyses of blood, urine, and cervical secretions should be excluded from the analysis because they are not routinely determined in all pregnancies [23].

However, only a small fraction of the published models have been tested in a wide range of scenarios to define their performance measures, in contrast to the preceding systematic review and models published in other medical domains. Due to the potential for harm posed by the dissemination of inaccurate information generated by poorly validated models, it is essential to analyze model performance in several contexts at once, rather than limiting the evaluation of performance to a single external cohort [24]

Time to vaginal birth was considerably longer in our study for women with a Bishop score of 4, at 14 hours versus 9 hours (p 0.001), HR= 1.74. Time to vaginal birth was substantially longer (14 vs. 9.72 (hour); p 0.001) in cases where the Manipal U/S rating system was 4. Cervix ultrasonography scoring was found to have a larger hazard function for Score 4 (6.96, p0.001) compared to Bishop Score 4 (1.32, p=0.23) [18].

To our surprise, we discovered that the real rate of caesarean sections rose along with the anticipated probability by induction calculator score. When the projected chance was greater than 60%, the actual incidence of CS reached 100%. The higher the anticipated chance of caesarean birth, the higher the actual rate of caesarean birth, as predicted by Levin ***et al. (2018).*** [(6)].

However, our study is not without limitations. The main limitation of the current study was that performing comparison between different models that were built on depend upon different maternal, fetal and radiological parameters. But still now, this is considered the first study that compares between such models. Also, we failed to obtain specific model based on the current findings secondary insufficient significant univariate variables.

Lastly, although it may be challenging to obtain and quantify, it is important to take into

account all variables that are likely to influence the success of IOL when customizing care for each patient. These variables include the attitudes of both pregnant patients and pregnancy care providers toward IOL, the threshold at which a provider elects to perform a caesarean birth, and the annual caesarean birth rates in each unit.

CONCLUSIONS

Predicting whether or not a woman will have a successful vaginal birth following induction of labor is becoming increasingly important as a result of the possible impact on healthcare spending, as evidenced by the rapid increase in the development of prediction models. But because most published models lack external validation and there are limitations in scope, methodology, and/or measurement of effectiveness in clinical settings, it is difficult to endorse any one model for widespread clinical usage. Prospective clinical trials that evaluate existing models in a range of settings could have a positive impact on shared decision making, parental satisfaction, caesarean birth rates, and resource utilization.

DECLARATIONS

- **Consent for publication:** I attest that all authors have agreed to submit the work.
- **Availability of data and material:** Available
- **Competing interests:** None
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