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Cervical length as a predictor of success in labor induction.

Longitud cervical como predictor de éxito en la inducción del trabajo de parto

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Abstract

OBJECTIVE: To evaluate the role of cervical length as a predictor of success in labor induction and its relationship with Bishop's scale, and to determine a cut-off value to estimate the success rate.

MATERIALS AND METHODS: Prospective, observational, and analytical study carried out at the University Hospital of Saltillo, conducted with patients with term pregnancy and induction of labor. *Inclusion criteria*: nulliparity, between 37 and 41 weeks 6-7 days of gestation, singleton pregnancies with live fetus in cephalic presentation and intact amniotic membranes. *Exclusion criteria*: severe acute maternal morbidity, death, or newborns weighing more than 4,000 g. Induction was performed within 4 hours of cervical measurement by different methods.

RESULTS: One hundred and thirty-one patients with a mean gestational age of 39.2 weeks were included. The main indication for labor induction was post-term in 31% of cases (n = 41). Bishop's score was less predictive of success. Patients with a cervical length of less than 23.4 mm were more likely to deliver. The 23.4 mm measurement was used as a cut-off point with a sensitivity of 77%, and specificity of 38.3%. The association between cervical length and Bishop was statistically significant. In the multivariate analysis, cervical length showed statistical significance (p = 0.006).

CONCLUSIONS: The results suggest that cervical length is a more reliable indicator than the Bishop's score to predict the success of labor induction. Different cut-off points were explored, and 23.4 mm was considered an adequate threshold to improve the test's precision.

KEYWORDS: Cervical length measurement; Bishop's score; Labor induction; Nulliparity; Gestation; Fetus; Amniotic membranes; Maternal morbidity; Gestational age.

Resumen

OBJETIVO: Evaluar el papel de la medición de la longitud cervical como predictor de éxito en inducción del parto y su relación con la escala de Bishop, e identificar un valor de corte para estimar la tasa de éxito.

MATERIALES Y MÉTODOS: Estudio prospectivo, observacional y analítico llevado a cabo en el Hospital Universitario de Saltillo en pacientes con embarazo a término e inducción del parto. *Criterios de inclusión*: nuliparidad, entre 37 y 41 semanas 6-7 días de gestación, embarazos únicos con feto vivo en presentación cefálica y membranas amnióticas intactas. *Criterios de exclusión:* morbilidad materna aguda severa, óbitos o recién nacidos con peso mayor a 4,000 g. La inducción se practicó en el trascurso de las 4 horas posteriores a la medición cervical mediante distintos métodos.

RESULTADOS: Se incluyeron 131 pacientes con media de 39.2 semanas de gestación. La principal indicación de inducción del parto fue el postérmino en el 31% de los casos (n = 41). El puntaje de Bishop mostró menor rendimiento en la predicción del éxito. Las pacientes con longitud cervical menor a 23.4 mm tuvieron mayor probabilidad de parto. Se utilizó la medida de 23.4 mm como valor de corte, con sensibilidad del 77% y especificidad del 38.3%. La asociación entre longitud cervical y Bishop fue

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estadísticamente significativa. En el análisis multivariado, la longitud cervical demostró significación estadística (p = 0.006).

CONCLUSIONES: Los resultados sugieren que la longitud cervical es un indicador más confiable que el puntaje de Bishop para predecir el éxito de la inducción del parto. Se exploraron diferentes puntos de corte y destacó el de 23.4 mm como posible umbral para mejorar la precisión de la prueba.

PALABRAS CLAVE: Medición de la longitud cervical; puntuación de Bishop; inducción del parto; nuliparidad; embarazo; feto; membranas amnióticas; morbilidad materna; semanas de gestación.

BACKGROUND

The Bishop's score is widely used because of its simplicity and its reasonable correlation with labor induction success.[1] This method evaluates cervical maturity in pregnant women, which can indicate the probability of success in labor induction.[2] It is based on a subjective tactile examination of the cervix which depends on the doctor's interpretation.[3] While different techniques have been suggested to replace it, the Bishop's score is still favored, even though it is not without criticism. Its precision has been questioned due to its inability to evaluate certain areas of the cervix, especially the upper part, which is decisive at the start of the process of dilation. Also, the subjectivity, the discomfort for the patient, and the potential risks, such as infections or membrane rupture, are outstanding limitations of this method.[4] The tactile examination is also limited for the evaluation of changes in the internal cervical orifice, when the external one is closed.[5]

Some reports show that the Bishop's score and the cervical length, measured with transvaginal ultrasound, are good predictors of a successful labor induction, only in nulliparous women.[6] The transvaginal ultrasound as a replacement, or modification of the traditional Bishop's score, is an interesting research field.

Ultrasound measurements with calibrator are objective and seem to be more precise than the tactile examination.[7] This is due to the capability of the transvaginal ultrasound to measure the whole length of the cervix in patients admitted for labor induction, to predict the termination of the pregnancy, and to visualize the cervix beyond the closed external orifice.[8-10] The supravaginal portion of the cervix constitutes approximately 50% of the cervical length, and this is variable in different women, hence the complexity of being able to estimate the success of labor induction by tactile examination.[11-12] The cervical length has showed to be an independent predictor of a successful labor induction, mainly in nulliparous women.[13] The shorter the length of the cervix, the higher the probabilities for a vaginal delivery.[13]

The objectivity of the transvaginal ultrasound to evaluate cervical length makes it a good option. The comparison between induction and wait in prolonged pregnancies highlights the benefit on a reduction of perinatal mortality, even though a significant percentage of women require C-section. A prolonged labor implies additional and costly risks, while the ultrasound measurement offers valuable predictions about the delivery and the time between induction and birth.

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The objective of the study was to determine a cut-off point for the ultrasound measurement of cervical length, to be able to estimate with better precision the success rate of labor induction, in comparison with Bishop's score.

MATERIALS AND METHODS

Prospective, observational, analytical study, carried out in the area of labor and delivery of the University Hospital of Saltillo, Coahuila, from March 2021 to June 2023. The viability for labor induction was evaluated in patients with full-term pregnancy. *Inclusion criteria*: nulliparity, between 37 and 41 weeks 6-7 days of gestation, singleton pregnancies with live fetus in cephalic position, with cardiotocography of fetal well-being, negative oxytocin tolerance test, and intact amniotic membranes. *Exclusion criteria*: premature membrane rupture, acute severe maternal morbidity, fetal death, or estimated weight over 4,000g.

To ensure the statistical validity of the results, we calculated the necessary sample size with the formula for an estimation of a proportion in a finite population. The parameters for the calculation were: population at the University Hospital in 2022: 155 patients; estimated success probability: 68%; maximum acceptable error estimation: 5%.

It was determined with these parameters that the sample size was at least of 106 patients. This calculation was adjusted, and the result was the inclusion of 131 patients for the study.

For the statistical analysis we considered a probability of detecting a real effect of 80% (statistical power), and a beta error of 0.2. This approach balanced the feasibility of the study and the reliability of the results. It also allowed for a more robust interpretation of the data, and it ensured that the study conclusions were valid and reproducible.

Weeks of gestation were determined considering the last date of menstruation, confirmed by ultrasound measurements made during prenatal control. For the evaluation of the cervical characteristics all the patients underwent a tactile vaginal examination to determine the Bishop's score. For the ultrasound cervical length measurement, a Siemens Acuson X3000 ultrasound with EV-9 Transducer of 4-9 MHz was used, and Ultragel Plus high viscosity ultrasound gel (Bordson) was applied as a conductive agent. The procedure was performed according to the recommendations of the Fetal Medicine Foundation.[14]

The ultrasound measurement was made before the induction, applying the inclusion criteria. The induction was initiated within 4 hours of the measurement of the cervical length using diverse techniques, including the oxytocin tolerance test. The administration was intravenous with 500 mL of Hartmann solution and 5 UI of oxytocin in infusion pump. The procedure started with 1 mUI/min and it increased every 20 minutes, doubling this time until reaching 60 minutes. When regular uterine activity was reached, labor conduction was continued, with 2 mUI/min every 20 minutes, evaluating response to dosage, until regular uterine activity. Another method was the administration, by oral or vaginal route, of 50 mcg of misoprostol every 4 hours until completing 3 doses. As a last option, the Krause method was used: placing a cervical 18 Fr Foley catheter insufflated with 60 mL of injectable water. This method was combined with oxytocin or misoprostol.

Ambulation was encouraged as tolerated. When favorable cervical conditions were reached, without regular uterine activity, amniotomy was performed or 2 mUI/min of oxytocin was increased every 30 minutes, as necessary, with a maximum of 40 mUI/min. At least 12 hours of labor in latent phase were allowed, before diagnosing a failed induction, with the aim of

reducing the risk of finalizing pregnancy with C-section. It was considered failed induction when there was no delivery, despite having allowed a trial of labor following the induction method used; that is, allowing 4 hours without favorable cervical modifications, or regular and effective uterine dynamics.[15]

The main result to be evaluated was birth route in comparison with the cervical length. The data was obtained form the medical records. The statistical analysis consisted of Fisher's test for continuous variables, and squared chi for categorical variables. Frequencies and percentages were used for categorical variables in the descriptive statistics. To analyze the performance and effectiveness of the classification models, in terms of sensitivity and specificity, the ROC curve was used. A value of $p < 0.05$ with 95%CI was considered statistically significant. The SPSS v.25 software was used.

RESULTS

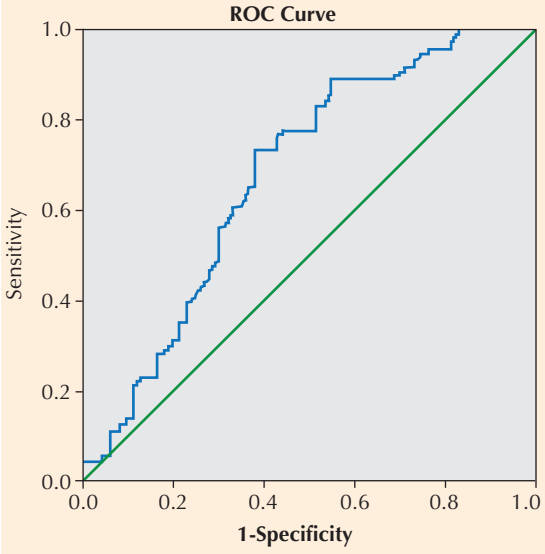
One hundred and thirty-one patients were included out of 515 initially identified records. The mean gestation week at the time of induction was 39.2 (range 37 – 41.6). The main indication for labor induction was post-term in 31% of the cases (n = 41). The other indications were hypertensive disorders (22%, n = 29), diabetes mellitus (16%, n = 21), oligohydramnios (4%, n = 5), small fetus for gestational age (7%, n = 9), elective by maternal choice (17%, n = 22), maternal cholestasis (1%, n = 1), gestational thrombocytopenia (1%, n = 1), and previous C-section (1%, n = 1). The study analyzed diverse induction techniques, and the most widely used was the combination of oxytocin with Krause method (61.83% of the cases). Nineteen (14.50%) patients had induction with misoprostol, in other patients it was combined with transcervical catheter (14.50%, n = 19), in 8.39% (n = 11) tolerance to oxytocin was used, and in only 0.76% (n = 1) the induction was made with an intracervical catheter. In the group of patients with failed induction the outcome was finalization by C-section.

The calculation of the area under the curve for cervical length was 0.675 (**Figure 1**), and there was a 67.5% probability that this model could distinguish between the positive class (successful induction) and the negative class (failed induction). The median cervical length in patients with successful induction was 20.3 mm. If this value were used as a cut-off point in this test, 53.5% of the cases would be considered positive (without induction failure), with a false positive rate of (1-specificity) 30%. **Figure 1**

Seeking the best value, based on the test's results, we considered 23.4 mm as cut-off point, which would classify 73.2% of the cases as positive (correctly), with a false positive rate of 38.3%. The area under the curve for the Bishop's score was 0.633 (**Figure 2**), which shows that there is a 63.3% chance that this model can distinguish between positive class (successful induction) and negative class (failed induction). Being close to 0.6, this meant that the Bishop's score was not adequate to analyze the determination of labor induction success (**Figure 2**). The study was not adequate to determine if the Bishop's score can predict a successful induction. The median for Bishop in patients with a successful induction was 3.

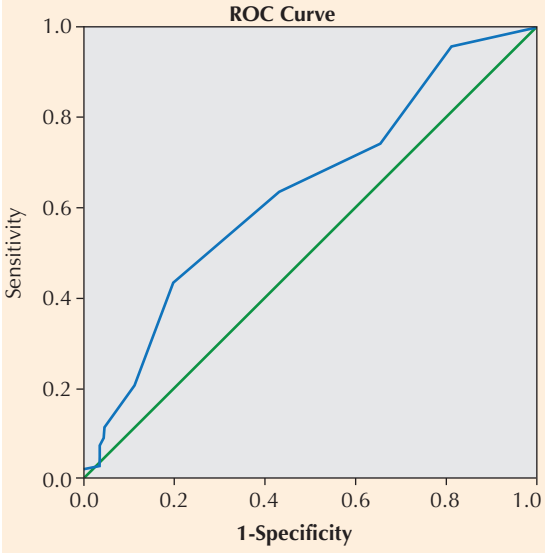
Figures 3 and **4** show the association between the duration of labor with cervical length and Bishop, respectively. As it can be seen, both r2 values are far from 1 (0.039 and 0.028, respectively), so they are interpreted as dispersion points not explained by the regression. A linear regression was made, and we observed that there is an association between cervical length and duration of labor ($p = 0.024$) (**Tables 1 and 2**). Labor duration and Bishop were not associated, significantly, with the outcome variable. This is to say that if the cervical length were increased by 1 mm, in average, the duration of labor would increase 0.153 hours.

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Area under the curve				
Test result variable(a): Cervical length				
Area	Standard error	Asymptotic p value	95% asymptotic confidence interval	
			Lower range	Upper range
0.675	0.048	0.001	0.580	0.770

Figure 1. Area under the curve for cervical length (ROC curve).



Area under the curve				
Test result variable(a): Cervical length				
Area	Standard error	Asymptotic p value	95% asymptotic confidence interval	
			Lower range	Upper range
0.633	0.049	0.009	0.538	0.728

Figure 2. Area under the curve (ROC curve) for Bishop.

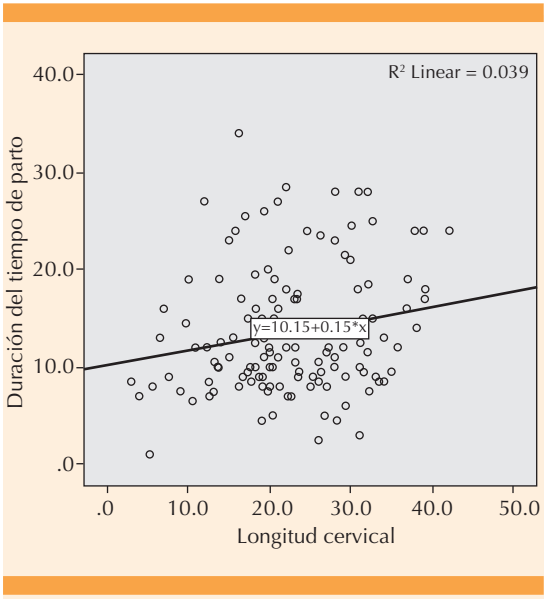


Figure 3. Association between labor length and cervical length.

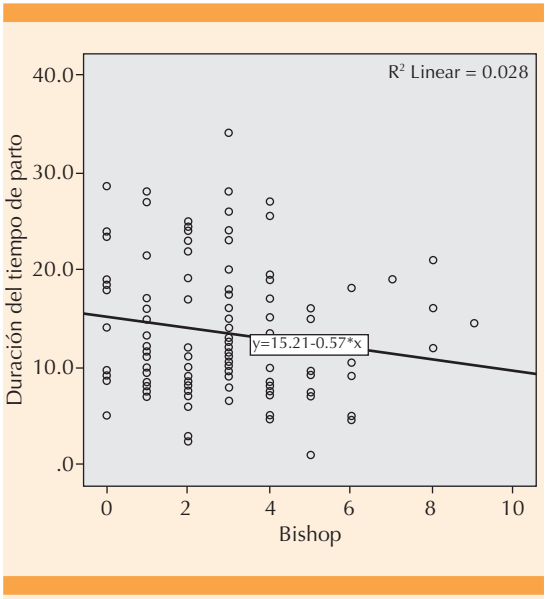


Figure 4. Association between labor length and Bishop.

Table 1. Simple linear regression between labor length and cervical length

Coefficients [a]								
Model		Non-standardized coefficients		Standardized coefficients	t	Sig.	95% confidence interval for B	
		B	Standard error	Beta			Lower range	Upper range
1	Constant	10.154	1.624		6.254	0.000	6.942	13.367
	Cervical length	0.153	0.067	0.197	2.280	**0.024**	0.020	0.285

[a] Dependent variable: Length of labor.

Table 2. Simple linear regression between the labor length and Bishop

Coefficients [a]								
Model		Non-standardized coefficients		Standardized coefficients	t	Sig.	95% confidence Interval for B	
		B	Std. Error	Beta			Lower range	Upper range
1	Constant	15.210	1.002		15.184	0.000	13.229	17.192
	Bishop	-0.566	0.295	-0.167	-1.919	0.057	-1.149	0.018

[a] Dependent variable: length of labor.

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The variables cervical length and Bishop were categorized by quartiles, to be able to associate them with the induction (**Table 3**). The association with the induction was statistically significant for both methods (0.001 and 0.031, respectively) (**Table 3**). Regarding cervical length and induction, we observed an inversely proportional relation, since the shorter the cervical length was, the higher the success for induction. This was not observed with the Bishop's score. **Figure 2**

A significant association was determined between gestation weeks and cervical length (p = 0.006) (**Table 4**) in a multivariate analysis.

DISCUSSION

The predictive usefulness of the Bishop's score was compared with the cervical ultrasound evaluation to determine their ability to predict success for labor induction, and the interval between the start of induction and delivery. We also sought to determine a useful cut-off point to help predict the success of labor induction at the University Hospital of Saltillo, Coahuila, Mexico.

Labor induction was considered successful when the outcome was vaginal birth and not C-section. Cervical length was confirmed as an objective method to predict the success of labor induction. The results showed that cervical length tends to be more reliable than Bishop's score to predict a successful labor induction. A cut-off point of 20.3 mm was identified (53.5% success of successful induction cases), with a 30% false positive rate. But when considering a cut-off value of 23.4 mm, the accuracy for identification was improved to 73.2%, with a false positive rate of 38.3%. The values found in the present study are contrasted with the previously reported 27 mm[13] and 28 mm,[14] which showed higher sensibility rates (80.3% and 85.9%, respectively), but with a corresponding increase in the false positive rate (51.7 and 55%). Similarly to what is previously reported,[16] the cervical length that allowed to predict birth within the first 24 hours of labor, was under 19 mm in the present study.

While the present study did not consider the distinction between the different induction methods, it did evaluate the global effect that their application has on the population. The study was centered on the need for C-section as an only indicator of failed induction, unlike other studies that have reported different results, such as the time until active phase of labor[5], or birth within 24 hours.[3,23]

Regarding the evaluation of the predictive ability of cervical length, the area under the curve of 0.675 indicated a moderate ability of the model to distinguish between successful and failed inductions. In the Bishop's score case, the area under the curve of 0.633 indicated a poorer performance to predict a successful induction. The evaluation with a range of 2.5 to 3.5 as cut-off point showed lower precision, with a false positive rate of 43.3 and 20%.

Table 3. Bivariate analysis between cervical length/Bishop and induction

Cervical length (mm)	Successful induction (%)	P value	Bishop	Successful induction (%)	P value
3-17.3	21 (29.6)	0.001*	0-2	26 (36.6)	0.031*
17.4-22	24 (33.8)		3	14 (19.7)	
22.1-29.3	18 (25.4)		4	16 (22.5)	
29.4-42	8 (11.3)		5-9	15 (21.1)	

Test: Fisher's exact test.
*Statistically significant.

With respect to the association between the variables and the duration of labor , the linear regressions showed a significant association only between cervical length and the duration of labor. An increase of 1 mm in cervical length is associated, in average, with an increase of 0.153 hours in labor length.

The quartile analysis confirmed significant associations between cervical length and Bishop with successful induction, with a higher relation between shorter cervical length and higher induction success. In the multivariate analysis which included cervical length, Bishop's score, and gestation weeks, we observed that only cervical length kept a statistical significance with regards to induction (p = 0.006). **Table 4**

The measurement of cervical length helped to decide which induction method to choose, to lower prostaglandin requirements, and to be able to choose mechanical methods, all of which yielded better results. This was in line with what's reported in the previous literature.[17] The present study represents a good starting point, so that in further studies the period of recruitment is extended, and the sample size increases, thus gaining in validity and precision. A bigger sample size will allow for the design of predictive methods to establish different groups, with better and worse delivery perspectives, after the medical induction of labor.

CONCLUSIONS

The results of the present study show that cervical length is a more reliable indicator than Bishop's score to predict a successful labor induction, with more consistent associations in the analysis. A cut-off point of 20.3 mm in suggested as predictor, with a lower false positive rate (30%), and of 23.4 mm with better precision (73.2%). The ability of the model to differentiate between successful and failed induction, evaluated with the area under the curve, showed an acceptable performance (67.5%), thus considering it a regular test. This study can be a watershed to undertake additional studies which analyze the predictive ability of cervical length in patients who are aiming for vaginal birth after a C-section, thus widening the future panorama for their medical care, and allowing for a more precise clinical orientation.

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Table 4. Multivariate analysis between birth variables and induction

Variable	OR	95% CI	P value
Bishop	0.909	0.709-1.164	0.449
Cervical length	1.083	1.023-1.147	0.006*
Gestational age	0.682	0.394-1.181	0.172

Test: Multivariate logistic regression.
*Statistically significant.

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