ORIGINAL ARTICLE

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Statement of ethical issues

Acknowledgment of authorship: All authors declare that they have contributed to the idea, study design, data collection, data analysis and interpretation, critical review of the intellectual content, and final approval of the manuscript we are submitting.

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Confidentiality of data: The authors declare that they have followed the protocols of the Central Hospital "Dr. Urquinaona" and the University of Zulia on the publication of patient data.

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Cervical tunneling as a predictor of successful induction of labor in term pregnancies

Tunelización cervical como predictor del éxito de la inducción del parto en embarazos a término

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ABSTRACT

Objective: To evaluate the usefulness of cervical funneling as a predictor of successful labor induction in term pregnancies. Design: Case-control study. Institution: Hospital Central de Maracaibo, Venezuela. Participants: Pregnant women who underwent labor induction. Methods: Pregnant women were evaluated by ultrasound to establish the presence or absence of cervical tunneling before the start of labor induction. Main outcome measures: Maternal characteristics, induction-delivery interval and type of delivery. Results: A total of 443 pregnant women who underwent induction or labor were selected. Cervical ultrasound evaluation revealed that 192 patients (44.3%) displayed cervical funneling. No statistically significant differences were observed between the two groups in general characteristics (p = ns). In patients with cervical tunneling, the induction and delivery onset interval was 14.2 ± 5.5 hours, while in those without it was 16.0 ± 5.0 hours (p = 0.0004). As for mode of delivery, patients with tunneling had 168 deliveries (87.5%) compared to 181 deliveries (72.1%) in group B (p < 0.0001). On the other hand, 67 deliveries (34.8%) in the cervical tunneling group occurred within 12 hours after induction, while patients without cervical tunneling recorded 66 deliveries (26.2%) in the same period (p = 0.0497). Conclusion: The findings of this investigation suggest that cervical tunneling is a useful predictor for successful induction of labor in term pregnancies.
Key words: Cervix uteri, Labor, induced, Prediction

RESUMEN

Objetivo. Evaluar la utilidad de la tunelización cervical como predictor del éxito de la inducción del parto en embarazos a término. Diseño. Estudio de casos-controles. Institución. Hospital Central de Maracaibo, Venezuela. Participantes. Embarazadas que fueron sometidas a inducción del parto. Métodos. Las embarazadas fueron evaluadas por ecografía para establecer la presencia o ausencia de tunelización cervical antes del inicio de la inducción del parto. Principales medidas de resultado. Características maternas, intervalo inicio de la inducción - parto y tipo de parto. Resultados. Se seleccionaron 443 embarazadas que fueron sometidas a inducción del parto. La evaluación ecográfica cervical reveló que 192 pacientes (44,3%) presentaban tunelización cervical. No se observaron diferencias estadísticamente significativas entre ambos grupos a las características generales (p = ns). En las pacientes con tunelización cervical, el intervalo inicio de la inducción y parto fue de 14,2 ± 5,5 horas, mientras que en aquellas que estaba ausente fue de 16,0 ± 5,0 horas (p = 0,0004). En cuanto al modo de parto, las pacientes con tunelización presentaron 168 partos (87,5%) comparado con 181 partos (72,1%) en el grupo B (p < 0,0001) Por otra parte, 67 partos (34,8%) en el grupo con tunelización cervical ocurrieron dentro de las 12 horas posteriores a la inducción, mientras que las pacientes sin tunelización cervical registraron 66 partos (26,2%) en el mismo periodo (p = 0,0497). Conclusión. Los hallazgos de esta investigación sugieren que la tunelización cervical constituye un predictor útil del éxito de la inducción del parto en embarazos a término.
Palabras clave. Cuello del útero, trabajo de parto inducido

Introduction

Induction of labor is the artificial stimulation of uterine contractions prior to the spontaneous onset of labor. This procedure is performed in up to 35% of all pregnant women worldwide[1,2]. One of the factors contributing to the increase in labor induction is the increased need for preventive measures to reduce fetal risks[3,4]. This procedure may decrease the effects of shoulder dystocia or the need for instrumental delivery, which cause maternal-fetal complications. In addition, it may

reduce the risk of adverse neonatal complications, such as meconium aspiration syndrome and neonatal death[5]. However, pregnant women with unfavorable cervixes frequently experience pain, which can make induction challenging and require a cesarean section[6,7].

Bishop's score and cervical length have proven to be useful tools for assessing cervical maturity in term pregnancies and are used as indicators of successful induction of labor[8-10]. Bishop's score, as the first clinical index created to predict induction outcomes and determine cervical maturity, has gained wide acceptance because of its simplicity and ease of implementation. However, despite these advantages, doubts remain about its accuracy due to its subjective nature[11]. Cervical length measured by transvaginal ultrasound offers an alternative predictor of induction success. Nevertheless, some studies suggest that interobserver variability may affect its reliability and limit its clinical usefulness[12].

Cervical tunneling is defined as painless dilatation of the internal cervical os caused by bulging of the amnion while the external cervical os remains closed[13]. Although its presence is associated with an increased risk of impending preterm delivery[14,15], a clear relationship with the success of labor induction in term pregnancies has not yet been established. The aim of the investigation was to evaluate the usefulness of cervical tunneling as a predictor of successful induction of labor in term pregnancies.

Methods

This prospective, comparative, case-control study was conducted at the Maracaibo Central Hospital between November 2020 and May 2024. Participants were pregnant women who regularly attended prenatal visits and were selected for labor induction. All participants provided written informed consent prior to inclusion in the trial. The study was approved by the hospital ethics committee.

The trial included women aged 18-40 years with singleton pregnancies, cephalic vertex presentation, intact membranes, and gestational age 37-40 weeks. Indications for labor induction were maternal illness, oligohydramnios, hypertensive disorders of pregnancy, controlled pregestational/gestational diabetes, and fetal anomalies.

Patients with multiple pregnancies, ongoing labor, premature rupture of membranes, uncontrolled diabetes or arterial hypertension, hemorrhage in the second half of pregnancy, intrauterine fetal death, suspected fetal growth restriction, uterine tumors (myomas) and previous uterine, cervical or cesarean surgeries were excluded. Patients who did not want to participate in the study were also excluded.

Prior to labor induction, all participants underwent a comprehensive obstetric and clinical evaluation in a special unit, not the emergency department. This evaluation included fetal heart rate monitoring for 30 minutes to assess fetal well-being. Fetal head engagement (fit) was assessed by the on-call medical staff and confirmed by a specialist independent of the study to ensure safe delivery through the birth canal.

Cervical evaluation was subsequently performed by transvaginal ultrasound by two experienced specialists. Each patient was placed in the dorsal lithotomy position, with an empty bladder. A Voluson® V730 Expert ultrasound machine was used with a 7 MHz vaginal transducer coated both internally and externally with a lubricated condom. The transducer was introduced into the vagina 3 centimeters from the cervix to measure the distance between the internal and external cervical os. The presence of cervical tunneling was confirmed by dilatation of at least 5 millimeters of the internal cervical os with bulging of the membranes, protrusion of at least 15% of the cervical length and the external cervical os closed. Subsequently, transabdominal ultrasound was performed to evaluate fetal presentation, placental insertion site, head and abdominal circumference and femur length.

The on-call medical staff, unaware of the results of the cervical assessment, performed labor induction following standard institutional protocol. Oxytocin diluted at 5 IU per 500 mL of glucose solution was administered intravenously continuously. It was started at a dose of 2 IU/min (4 drops/min) and increased by 2 IU every 30 min until effective contractions were achieved. The maximum dose was 32 mIU/min (64 drops/min). Once cervical dilatation of 5 centimeters was achieved, amniotomy was performed. The fetal heart rate was continuously monitored by cardiotocography between 30 and 60 minutes after the beginning of the induction.

Labor induction was discontinued if there were signs of potential fetal distress, such as changes in the fetal heart rate or the presence of meconium-stained fluid. Failure of induction was attributed to failure to reach the active stage of labor (cervical dilatation less than 4 centimeters after 12 hours of oxytocin infusion), delay in the second stage (no change in descent or rotation of the fetal head for 2 hours in nulliparous and 1 hour in multiparous) or unsatisfactory evolution (progression of cervical dilatation less than 2 centimeters after 4 hours of oxytocin infusion).

A database was created that included maternal variables such as maternal age, gestational age and body mass index, as well as variables such as newborn weight and the presence or absence of cervical tunneling. The interval between the start of induction and delivery and type of delivery were the main study variables. During the study, all data were recorded and securely stored for later analysis, with access restricted to the personnel responsible for the research only.

For the final analysis, measures of central tendency (mean and standard deviation) and frequency measures (percentages) were used. The normality of the data distribution was assessed using the Shapiro-Wilk test. To compare continuous variables, the Student t-test was used for independent samples when the assumptions of normality and homoscedasticity were met, and the Mann-Whitney U test was used otherwise. To compare categorical variables, the chi-square test was used. A Cox regression model was used for survival analysis, estimating the period between induction and delivery as a function of prognostic variables. To evaluate the predictive capacity of the model, sensitivity, specificity, positive and negative predictive values, positive and negative likelihood ratio, with their respective 95% confidence intervals (95%CI) were calculated. A statistical significance level of $p < 0.05$ was considered.

Results

A total of 443 pregnant women who underwent induction of labor were selected for the study. The general characteristics of the participants are summarized in Table 1. The mean maternal age was 27.6 ± 5.6 years and the mean gestational age was 38.4 ± 0.9 weeks. Ultrasonographic evaluation of the cervix revealed that 192 patients (44.3%) had cervical tunneling.

Table 1. Characteristics of the selected pregnant women.

Characteristics +/- Standard deviation	(n = 443)
Maternal age, years	27.6 +/- 5.6
Gestational age, weeks	38.4 +/- 0.9
Body mass index, kg/m2	29.8 +/- 1.7
Nulliparous, n (%)	284 (64.1)
Cervical tunneling, n (%)	192 (44.3)
Induction-to-delivery interval, hours	15.2 +/- 5.3
Vaginal delivery, n (%)	349 (78.7)
Delivery before 12 hours, n (%)	133 (30.0)
Newborn birth weight, grams	3127 +/- 592

Indications for induction of labor are shown in Table 2. The most common causes were elective induction (142 patients, 23.0%), maternal disease (88 patients, 19.8%) and hypertensive disorders of pregnancy (83 patients, 18.7%).

Table 3 presents the characteristics of pregnant women with cervical tunneling (group A, n = 192) and those without cervical tunneling (group B, n = 251). No statistically significant differences were observed between the two groups in terms of maternal age, gestational age at delivery, body mass index, percentage of nulliparous women and newborn weight (p = ns). In group A, the interval between the start of induction - average delivery was 14.2 ± 5.5 hours, while in group B it was 16.0 ± 5.0 hours. This difference proved to be statistically significant (p = 0.0004). The Log-

Table 2. Causes of labor induction.

Causes	(n = 443)
Elective	142 (32.0)
Maternal illness	88 (19.8)
Hypertensive disorders of pregnancy	83 (18.7)
Oligohydramnios	75 (16.9)
Controlled pre-gestational / gestational	30 (6.7)
Fetal anomalies	25 (5.6)

Table 3. General characteristics of cases and controls.

	Group A Cases (n = 192)	Group B Controls (n = 251)	p
Maternal age, years	27.4 +/- 5,6	27.8 +/- 5.8	0.4657
Gestational age, weeks	38.4 +/- 0,8	38.5 +/- 0.9	0.2248
Body mass index, kg/m2	29.9 +/- 1,7	29.8 +/- 1.8	0.5532
Nulliparous, n (%)	115 (58.8)	169 (67.3)	0.1199
Induction-to-delivery interval, hours	14.2 +/- 5.5	16.0 +/- 5.0	0.0004
Vaginal delivery, n (%)	168 (87.5)	181 (72.1)	< 0.0001
Delivery before 12 hours, n (%)	67 (34.8)	66 (26.2)	0.0497
Newborn birth weight, grams	3,130 +/- 584	3,100 +/- 599	0.5977

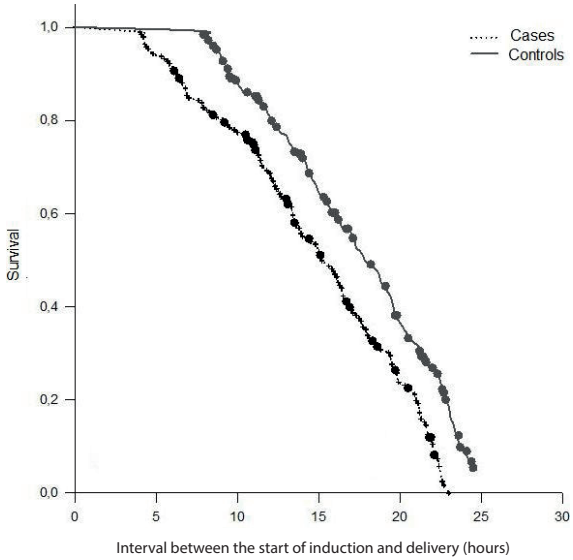
Rank comparison test (Figure 1) to evaluate the interval between the start of induction - delivery showed significant differences between the two groups (p = 0.0001). Regarding mode of delivery, patients in group A had 168 deliveries (87.5%), compared to 181 deliveries (72.1%) in group B (p < 0.0001). Notably, 67 deliveries (34.8%) in group A occurred within 12 hours after induction, whereas group B had 66 deliveries (26.2%) in this same period. This difference was also considered statistically significant (p = 0.0497).

When analyzing the ability of cervical tunneling in predicting the success of labor induction, these were: sensitivity 87.5% (95%CI, 82.1%-91.5%), specificity 27.9% (95%CI, 22.7%-33.7%), positive predictive value 48.1% (95%CI, 42.9%-53.4%), negative predictive value 74.5% (95%CI, 64.8%-82.2%) and prognostic accuracy 53.7% (95%CI, 49.1%-58.3%). The positive likelihood ratio was 1.21 (95% CI, 1.10-1.33) and the negative likelihood ratio 0.45 (95% CI, 0.30-0.68). The false-negative proportion was 12.5%. Cervical tunneling has a relative risk of 2.71 (95% CI, 1.63-4.50) for predicting successful delivery.

Discussion

An accurate assessment of the cervix is crucial for successful delivery, particularly in predicting the success of labor induction in term pregnancies. This research suggests that cervical funneling may be an effective predictor, and it's also associated with a shorter interval between induction and delivery. These results are consistent with previous research that found similar findings[16,17].

Figure 1. Kaplan-Meier survival curve comparing the interval between the start of induction and delivery in patients in both groups.



Induction of labor is a common obstetric practice, as approximately one quarter of all deliveries are induced to ensure maternal-fetal well-being[18]. Cervical length and Bishop's score have been considered useful tools to assess cervical conditions and the likelihood of successful delivery. However, recent research has cast doubt on the accuracy of both methods. Several studies have shown that cervical length is not a good predictor of induction success[19-22]. In addition, there is great variability in the predictive accuracy of different factors in the success of labor induction and it has been suggested that its accuracy is comparable to Bishop's score[12].

Cervical funneling is a hallmark change in the cervix as labor approaches. Various investigations, both with MRI and ultrasound, have shown that cervical effacement begins at the internal cervical os and progresses downward, allowing the fetal membrane to slide through the upper cervical canal. The softening of the cervix is caused by its changes in composition and microstructure, which facilitates the process of delivery[23].

The first study that evidenced the usefulness of cervical tunneling in predicting delivery was performed in preterm pregnancies[24]. However, another study reported that cervical tunneling could predict the onset of spontaneous labor in the following week[25]. It is important to note that the frequency of cervical tunneling in the present study was 44%, whereas two previous studies found values of 57% and 25%.

The ability of cervical tunneling to predict successful induction of labor in term pregnancies is uncertain. A study selecting 235 pregnant women found that pregnant women with cervical tunneling had a higher rate of successful delivery (90.5%) compared with pregnant women without cervical tunneling (76.2%; p = 0.004). This was an independent predictor of induction success, according to multivariate analysis (odds ratio 2.95, 95% confidence interval; 1.36-6.47; p = 0.007)[16].

Data from this investigation indicates that the presence of cervical tunneling is a positive predictor of successful induction, with an odds ra-

tio of 1.21 (95% CI 1.10-1.33). These findings are consistent with those of previous research that found a correlation between the presence of cervical tunneling and successful delivery (odds ratio 2.70, 95% CI 1.02-7.10, p = 0.04)[17]. Another study showed that the presence of cervical tunneling was as effective as Bishop's score and cervical length in independently predicting successful induction of labor[26].

However, some studies have suggested that cervical tunneling alone is not a significant predictor. For example, one study found no association between cervical tunneling and successful delivery (odds ratio 1.018, 95%CI 0.975-1.063, p = 0.415)[27]. On the other hand, another investigation showed that the presence of cervical tunneling was not useful in predicting the success of labor induction (p = 0.222)[28]. It is possible that these discrepancies are due to the lack of a single, universally accepted definition of cervical tunneling. Some authors suggest that amnion protrusion should reach at least 15% of the cervical length[16]. However, no consensus has yet been reached on the most appropriate definition.

One of the strengths of this study is the selection of patients under a uniform protocol, which included a standardized induction method and single definition of cervical tunneling, and obstetric care at a single center. Also, the performance of the cervical ultrasound determination by only two experts significantly reduced interobserver variations. Additionally, the clinical staff in charge of the induction and delivery process were not aware of the initial assessment performed by the investigators, which minimized information bias. Finally, confounding factors, such as the inclusion of pregnant women with premature rupture of membranes, were limited.

This study also has some limitations. First, since it is based on a sample from a single medical center, the results may not be extrapolable to other groups of pregnant women. Secondly, the definition of successful induction of labor used in this study (12 hours from the start of induction to delivery) differs from that used in other research, where periods of 48 or 72 hours are considered. This disparity could generate discrepancies when comparing the findings with those of other studies. Additionally, other ultrasound parameters of the cervix that could have predictive potential for the success of labor induction, such as posterior cervical angle, were not evaluated. The inclusion of these variables in future large-scale investigations could strengthen the evidence for the role of cervical tunneling as a predictor of successful labor induction.

Conclusión

The findings of this investigation suggest that cervical tunneling is a useful predictor of successful induction of labor in term pregnancies. Of note, pregnant women with funneling experienced a shorter interval between induction initiation and delivery.

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