ORIGINAL ARTICLE

Predictive value of the non-stress test for cesarean section and neonatal depression

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ABSTRACT

Objective: To evaluate the predictive capacity of the non-stress test (NST) to determine the mode of delivery by cesarean section and Apgar scores at 1 and 5 minutes.
Methods: Quantitative, analytical diagnostic validity, non-experimental, and cross-sectional study conducted using NST results from 944 pregnant women attended at the electronic fetal monitoring service of a public hospital in Lima, Peru, during 2023. Live-born neonates whose mothers had a conclusive NST were included, excluding cases with congenital malformations or interrupted tests. Mathematical formulas were applied to calculate diagnostic validity measures and predictive values.
Results: The median maternal age was 29.0 years (IQR: 24.0–34.0). A total of 71.0% of NST results were reactive and 29.0% were non-reactive. Cesarean delivery predominated (52.2%). The NST showed a sensitivity of 27.4%, specificity of 69.2%, positive predictive value (PPV) of 49.3%, and negative predictive value (NPV) of 46.6% for predicting cesarean delivery. For an Apgar score <7 at 1 minute, the sensitivity of the NST was 36.1%, specificity 71.3%, PPV 4.7%, and NPV 96.6%. At 5 minutes, the sensitivity of the NST decreased to 16.7%, specificity to 70.9%, PPV to 0.4%, and NPV to 99.3%.
Conclusions: The NST shows limited sensitivity and PPV for determining the mode of delivery and initial neonatal depression based on the Apgar score. However, its high NPV supports its usefulness as a screening tool to rule out acute fetal compromise, always in combination with clinical and obstetric criteria within a comprehensive fetal assessment approach.

Keywords: Apgar Score; Cesarean Section; Fetal Monitoring; Childbirth; Forecasting (Source: MeSH)

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Valor predictivo del test no estresante para cesárea y depresión neonatal

RESUMEN

Objetivo: Evaluar la capacidad predictiva del test no estresante (NST) para determinar la vía de parto por cesárea y los resultados del puntaje de Apgar al primer y quinto minuto del neonato.
Métodos: Estudio cuantitativo, analítico de validez diagnóstica, no experimental y transversal realizado con los NST de 944 gestantes atendidas en el servicio de monitoreo electrónico fetal de un hospital público de Lima, Perú durante el año 2023. Se incluyeron neonatos vivos cuyas madres contaron con un NST concluyente, excluyendo casos con malformaciones congénitas o test interrumpidos. Se aplicaron las fórmulas matemáticas para calcular las medidas de validez diagnóstica, así como los valores predictivos.
Resultados: La mediana de edad materna fue 29,0 años (RIC: 24,0–34,0). El 71,0 % de los NST fueron reactivos y el 29,0 % no reactivos. Predominó la cesárea (52,2 %). El NST mostró una sensibilidad de 27,4 %, especificidad de 69,2 %, valor predictivo positivo (VPP) de 49,3 % y negativo (VPN) de 46,6 % para predecir la cesárea. Para el puntaje de Apgar < 7 al primer minuto, la sensibilidad del NST fue de 36,1 %, la especificidad de 71,3 %, el VPP de 4,7 % y el VPN de 96,6 %, mientras que al quinto minuto la sensibilidad del NST disminuyó a 16,7 %, la especificidad a 70,9 % y el VPP a 0,4 % y el VPN alcanzó 99,3 %.
Conclusiones: El NST presenta una sensibilidad y VPP limitados para determinar la vía de parto y la depresión neonatal inicial mediante el Apgar. Sin embargo, su alto VPN respalda su utilidad como herramienta de tamizaje para descartar compromiso fetal agudo, siempre en combinación con criterios clínicos y obstétricos dentro de un enfoque integral de evaluación fetal.

Palabras clave: Puntaje de Apgar; Cesárea; Monitoreo Fetal; Parto; Predicción (Fuente: DeCS)

INTRODUCTION

Cesarean section constitutes one of the most frequent and relevant surgical interventions in obstetrics, whose main purpose is to reduce maternal and perinatal morbidity and mortality associated with complicated vaginal delivery (1). However, in recent decades, a sustained increase in its frequency has been observed globally, becoming a significant public health challenge (2). The World Health Organization has indicated that ideal cesarean section rates should range between 10 and 15% (3); nevertheless, several reports show considerably higher figures, reaching 42.8% in South and Central America, 31.6% in North America, and 25.7% in Europe. In Peru, 37.8% of registered births were cesarean deliveries in 2023, with a higher concentration in Metropolitan Lima, according to the Instituto Nacional de Estadística e Informática (4).

Although cesarean section is vital when medically indicated, performing it without clear clinical criteria may increase the risk of maternal and neonatal complications, in addition to raising hospital costs and prolonging hospital stay (5). In this context, antepartum fetal surveillance plays a fundamental role in the timely identification of signs of fetal compromise that justify obstetric intervention (6).

Among the most widely used fetal monitoring techniques is the non-stress test (NST), a non-invasive tool based on recording fetal heart rate in relation to fetal movements, to evaluate the integrity of the fetal autonomic nervous system and placental oxygenation (7). Its use is widely extended in both high-risk pregnancies and term pregnancies due to its simplicity, relatively low cost, and availability in most healthcare facilities (8).

Several studies have documented the association between NST results and perinatal outcomes. A non-reactive result has been correlated with a higher risk of cesarean section due to suspected fetal distress, low Apgar score, and subsequent need for admission to a neonatal intensive care unit (9,10–12). In a study conducted in Bangladesh, 98% of pregnant women with a non-reactive NST ended in cesarean delivery compared with 49% with a reactive NST (11). Similarly, studies in Nepal report a higher frequency of cesarean sections and adverse neonatal outcomes (such as the need for resuscitation or admission to the neonatal intensive care unit) in cases with non-reactive or non-reassuring NST, although without showing a statistically significant association (10).

Recent studies have also explored the predictive capacity of the NST for the mode of delivery, showing that non-reactivity is associated with a greater probability of cesarean section (13). However, the presence of false positives limits its diagnostic value as a single criterion (14). Even so, its systematic application in resource-limited settings continues to be highly useful due to its simplicity and ability to guide timely clinical decisions (15).

In Latin America, the literature evaluating the effectiveness of the NST in predicting the mode of delivery remains limited, especially in public hospitals where technological and human resources are scarce and where high service demand generates hospital overcrowding that complicates the application of complementary diagnostic methods (15). In Peru, most available studies come from higher-complexity institutions where complementary tests such as the biophysical profile or Doppler are available. Although the level of complexity does not modify the diagnostic properties of the NST, its evaluation in second-level hospitals is relevant because in these settings the NST is often the main tool for antepartum fetal surveillance and clinical decision-making in the absence of other complementary methods (16). Likewise, the evaluation of the Apgar score at 1 and 5 minutes allows correlation of NST findings with the immediate condition of the newborn, providing an objective measure of neonatal well-being at birth and of the effectiveness of intrapartum management (9). Therefore, including the Apgar score as a complementary outcome contributes to a more comprehensive understanding of the predictive value of the NST in settings where diagnostic resources are limited.

Therefore, this study aimed to assess the usefulness of the NST as a predictor of mode of delivery and early neonatal depression, measured using the Apgar score, in a second-level public health facility in Peru, to provide evidence applicable to similar settings within the national health system.

METHODS

Study design

Quantitative, non-experimental, diagnostic validity, analytical, cross-sectional, and retrospective study.

Population and sample

The population consisted of neonates whose mothers underwent electronic fetal monitoring at Hospital San Juan de Lurigancho, a level II public health facility belonging to the Ministry of Health network in Lima, Peru. This hospital provides care in San Juan de Lurigancho, the most populated district at both the regional and national levels (17). The data correspond to care records closest to delivery during 2023.

Neonates whose mothers had an NST result recorded at Hospital San Juan de Lurigancho, who were born alive, and whose birth was attended in a public or private institution, were included. Neonates whose mothers had a non-conclusive NST result or whose test was interrupted during the procedure, as well as neonates with congenital malformations, were excluded.

The minimum sample size was established based on the study by Solórzano (18). The sample size was calculated using Epidat 4.2 (Dirección Xeral de Saúde Pública, Xunta de Galicia, Spain), considering an expected sensitivity of 13%, specificity of 98%, confidence level of 95%, and precision of 5%. The estimated minimum sample size was 205 pregnant women (174 with cesarean delivery and 31 with vaginal delivery). However, during the study period, 451 vaginal deliveries and 493 cesarean deliveries were identified through convenience sampling, resulting in a total of 944 units of analysis.

Variables

The main variables were the NST result and the mode of delivery. The NST result depends on parameters assessed in cardiotocography, such as baseline fetal heart rate, baseline variability, accelerations, decelerations, and fetal movements. These parameters allow classification of the NST result as reactive, non-reactive, or pathological according to the score obtained using the Fisher test (19), a method widely used in the field of obstetrics and gynecology. Scores can range from 0 to 10, with a minimum score of 8 required to consider the NST reactive, which suggests preserved neurological function and fetal motor activity. When fewer points are obtained, it indicates the absence of motor activity and possible neurological impairment; it is therefore considered a non-reactive or pathological result. These criteria are applied by professionals in the electronic fetal monitoring service for decision-making in the institution (19).

The outcome variable of interest was the mode of delivery, specifically cesarean section. The mode of delivery was identified through review of the REUNIS platform, in the Live Birth Certificate section, where information is also recorded regarding the professional who attended the delivery, the institution where it occurred, and its level of complexity.

As a secondary outcome, in an exploratory manner, the Apgar score at 1 minute and its evolution at 5 minutes were considered as early indicators of initial neonatal depression (20). This classification is established when the Apgar score is less than 7. A score of 7 to 10 is interpreted as adequate neonatal adaptation, 4 to 6 as moderate neonatal depression, and 0 to 3 as severe depression (9). In this study, an Apgar value lower than 7 was considered neonatal depression according to previous literature (15).

Other variables included maternal characteristics such as age, marital status, educational level, and number of living children. Neonatal variables such as sex, birth weight, length, gestational age, head circumference, and chest circumference were also analyzed. Finally, characteristics related to delivery were considered, such as the institution and facility where the delivery occurred, as well as the category and type of personnel who provided care (obstetrician or other healthcare professional).

Data collection procedures

A data collection form based on medical records was developed to identify and record the variables proposed for the research. It consisted of three sections. The first recorded information about the sample, such as maternal and neonatal characteristics, the institution where the delivery occurred, and the attending professional. The second described the NST results, and the third the mode of delivery.

Once the necessary permissions were obtained from the hospital and the electronic fetal monitoring service, data from this service were linked with live birth records stored in the Repositorio Único Nacional de Información en Salud, an open-access web platform that records data on all live births nationwide, among other information. Linking these data enabled the identification of the mode of delivery and Apgar scores, as well as information on malformations, multiple gestations, and other variables.

Data analysis

The databases were cleaned and analyzed using the statistical package STATA version 17 (StataCorp LLC, College Station, TX, USA). A descriptive analysis of the main and secondary variables was performed using frequencies and percentages, as well as means and standard deviations for normally distributed variables, or medians and interquartile ranges (IQR) when they showed non-normal distribution. The Shapiro–Wilk test was used to evaluate the distribution of numerical variables and determine whether they were normal. To evaluate the diagnostic usefulness of the NST in predicting the mode of delivery (cesarean section) or Apgar score < 7, the "diagt" command was used to estimate sensitivity, specificity, and predictive values.

Ethical considerations

The project was approved by the Research Committee of the School of Obstetrics of the Universidad Nacional Mayor de San Marcos and by the Institutional Research Ethics Committee of Hospital San Juan de Lurigancho (Certificate No. 065-2025).

RESULTS

The maternal age in the final sample had a median of 29.0 years (IQR: 24.0–34.0). Most pregnant women were in the age group of 20 to 34 years (69.5%), while 23.2% were 35 years or older, and only 7.3% were younger than 20 years. Single marital status predominated (92.4%) compared with cohabiting or married (7.6%). Regarding educational level, most reached secondary education (67.2%), followed by primary education or none (22.4%) and higher education (10.4%). Regarding the number of living children, 36.9% had one child, 33.2% had two, and 30.0% had three or more, totaling 944 pregnant women evaluated (Table 1).

Most neonates were born at term (98.1%) and were male (50.9%). The median birth weight was 3,405.0 g (IQR: 3,125.0–3,705.0), with 88.2% between 2500 and 3999 g and only 0.1% weighing less than 1,500 g. The median head circumference was 34.5 cm (IQR: 33.5–35.5), chest circumference was 34.0 cm (IQR: 33.0–35.0), and the median length was 50.0 cm (IQR: 49.0–51.0). Regarding the NST, 71.0% of results were reactive and 29.0% were non-reactive. The Apgar score was ≥7 at 1 minute in 96.2% of cases and at 5 minutes in 99.4%, indicating adequate neonatal vitality in most neonates (Table 2).

A total of 98.2% of deliveries were attended in other Ministry of Health institutions, and 75.3% occurred in the study hospital. Regarding the mode of delivery, a slightly higher frequency of cesarean sections was observed (52.2%) compared with vaginal deliveries (47.8%). Most deliveries were recorded in level II facilities (76.7%), and in 59.9% of cases the care was provided by professionals other than obstetricians, while obstetricians attended the remaining 40.2% (Table 3).

Table 1. Maternal characteristics of women attended at the electronic fetal monitoring service

Characteristics	n	%
Maternal age (years)		
Median (IQR)	29.0 (24.0–34.0)	
< 20	69	7.3
20–34	656	69.5
≥ 35	219	23.2
Marital status		
Cohabiting / married	72	7.6
Single	872	92.4
Maternal educational level		
Primary or none	211	22.4
Secondary	635	67.2
Higher education	98	10.4
Number of living children		
1 child	348	36.9
2 children	313	33.2
≥ 3 children	283	30.0
Total	944	100.0

IQR: interquartile range.

On the other hand, in this sample, the NST showed a sensitivity of 27.4% and specificity of 69.2% for predicting cesarean delivery, with a positive predictive value (PPV) of 49.3% and a negative predictive value (NPV) of 46.6% (Table 4). Among pregnant women with a non-reactive NST, 49.3% ended in cesarean delivery and 50.7% in vaginal delivery, suggesting that the ability of the NST to predict the mode of delivery was limited in this sample.

Regarding the Apgar score at 1 minute, 4.7% of neonates with a non-reactive NST presented neonatal depression (Apgar < 7), compared with 3.4% of those with a reactive NST. The NST showed a sensitivity of 36.1% and specificity of 71.3% for predicting low Apgar at 1 minute, with a PPV of 4.7% and an NPV of 96.6% (Table 4).

At 5 minutes, the proportion of neonates with Apgar < 7 decreased in both groups (0.4% with non-reactive NST and 0.8% with reactive NST), maintaining high recovery of neonatal vitality. In this case, sensitivity was 16.7% and specificity was 70.9%, with a PPV of 0.4% and an NPV of 99.3%, indicating a good ability of the NST to rule out significant initial neonatal depression when the result is reactive (Table 4).

Table 2. Neonatal characteristics

Characteristics	n	%
Gestational age (weeks)		
32–36	18	1.9
≥ 37	926	98.1
Sex		
Female	464	49.2
Male	480	50.9
Weight (g)		
Median (IQR)	3,405.0 (3,125.0–3,705.0)	
1000–1499	1	0.1
1500–2499	22	2.3
2500–3999	833	88.2
4000–4499	84	8.9
≥ 4500	4	0.4
NST result		
Non-reactive	274	29.0
Reactive	670	71.0
Apgar at 1 minute		
Normal (≥ 7 points)	908	96.2
Depression (< 7 points)	36	3.8
Apgar at 5 minutes		
Normal (≥ 7 points)	938	99.4
Depression (< 7 points)	6	0.6
Head circumference (cm)		
Median (IQR)	34.5 (33.5–35.5)	
Chest circumference (cm)		
Median (IQR)	34.0 (33.0–35.0)	
Neonatal length (cm)		
Median (IQR)	50.0 (49.0–51.0)	
Total	944	100.0

NST: non-stress test; IQR: interquartile range.

Table 3. Institutional characteristics of delivery

Characteristics	n	%
Institution where delivery was attended		
Ministry of Health	927	98.2
Other*	17	1.8
Delivery at HSJL		
Yes	711	75.3
No†	233	24.7
Mode of delivery		
Cesarean section	493	52.2
Vaginal	451	47.8
Category		
Level I	3	0.3
Level II	724	76.7
Level III	217	23.0
Attending professional		
Obstetrician	379	40.2
Other**	565	59.9
Total	944	100.0

* Includes EsSalud, Policía Nacional del Perú, and private clinics.
** Includes obstetrician–gynecologist, resident physician, and nurse.
HSJL: Hospital San Juan de Lurigancho (Ministry of Health hospital).
† Women who underwent electronic fetal monitoring at HSJL but delivered elsewhere.

DISCUSSION

The present study aimed to assess the predictive capacity of the NST to anticipate cesarean delivery in pregnant women attended in a public hospital in Lima, as well as the Apgar score as an early indicator of initial neonatal depression. The findings showed a low capacity of the NST to predict cesarean delivery, suggesting that its isolated diagnostic value is limited and that the obstetric decision continues to depend on multiple clinical and contextual factors.

Similar results were reported by Martínez and Maldonado (21) in term pregnancies, where most NSTs were reactive and did not show a significant correlation with the mode of delivery, confirming that a reactive NST is associated with good fetal well-being but not necessarily with lower cesarean rates. In the same line, Weinberger et al. (22) concluded that the presence of sporadic variable decelerations in a reactive NST was not related to a higher risk of cesarean section due to fetal distress, highlighting that isolated interpretation of the NST could overestimate risk and lead to unnecessary interventions. On the other hand, Priya and Anushree (13) found a PPV of 85% for non-reactive NST in cesarean deliveries due to fetal distress, although with a high rate of false positives when attempting to predict neonatal outcomes, possibly due to early cesarean intervention, which coincides with the tendency of this study to overestimate non-reactive results compared with the actual surgical indication.

Table 4. Predictive values and diagnostic usefulness of the NST to predict cesarean delivery and Apgar score at 1 and 5 minutes

Outcomes of interest	Non-reactive		Reactive		PPV (%)	NPV (%)	Sensitivity (%)	Specificity (%)
	n	%	n	%				
Mode of delivery								
Cesarean section	135	49.3	358	53.4	49.3	46.6	27.4	69.2
Vaginal	139	50.7	312	46.6				
Apgar at 1 minute								
Depression (< 7 points)	13	4.7	23	3.4	4.7	96.6	36.1	71.3
Normal (≥ 7 points)	261	95.3	647	96.6				
Apgar at 5 minutes								
Depression (< 7 points)	1	0.4	5	0.8	0.4	99.3	16.7	70.9
Normal (≥ 7 points)	273	99.6	665	99.3				

PPV: positive predictive value; NPV: negative predictive value.

Regarding immediate neonatal status, the present study found that non-reactive NST showed a sensitivity of 36.1% and specificity of 71.3% for predicting low Apgar at 1 minute, whereas at 5 minutes these values decreased to 16.7% and 70.9%, respectively, maintaining an NPV greater than 96%. This finding is consistent with that reported by Raghuwanshi and Sarda (23) and Amin et al. (14), who noted that reactive NST is usually associated with adequate neonatal vitality, although its capacity to anticipate depression at birth is limited. The low sensitivity observed in this work reinforces the idea that NST is more useful as a screening tool to rule out severe fetal compromise rather than as a confirmatory test. Nevertheless, the improvement in Apgar score at 5 minutes suggests that most neonates, even with non-reactive NST, achieve adequate postnatal adaptation, possibly as a result of timely interventions during delivery or immediate neonatal resuscitation.

Likewise, Raghuwanshi and Sarda (23) and Amin et al. (14) demonstrated that reactive NST is associated with better neonatal outcomes, such as higher Apgar scores and lower admission to neonatal intensive care units, but warned that its capacity to predict the mode of delivery is limited, as the decision for cesarean section depends not only on fetal reactivity but also on labor dynamics, the professional's experience, and institutional policies (24). In this study, the fact that more than 70% of NST results were reactive and yet cesarean delivery represented 52.2% of births reinforces this observation: a normal NST result does not guarantee vaginal delivery.

From an organizational perspective, Martins et al. (5) found that the type of hospital (public or private) was the main predictor of cesarean delivery in Rio de Janeiro, more than obstetric factors themselves. This finding is comparable to the Peruvian context, where care in level II hospitals and clinics could influence the high cesarean rates observed, more associated with the availability of resources and institutional protocols than with the immediate fetal condition. Similarly, Singh et al. (1) and Joshi and Dangal (10) pointed out that maternal education, insufficient prenatal care, and previous cesarean sections are more consistent determinants than NST results in the choice of delivery type.

At the local level, studies such as those by Zeta Zeta (25) and Miranda (26) also highlight the value of NST as a support tool in decision-making in the presence of possible signs of fetal distress rather than as a direct predictor of the mode of delivery. Although NST contributes to the timely identification of pregnancies with potential fetal compromise, allowing early interventions that may lead to cesarean delivery, its low sensitivity, as confirmed in this study, limits its use as an isolated diagnostic test for determining the mode of delivery. For this reason, authors such as Campbell et al. (16) and Rezaee et al. (27) suggest integrating NST with computerized cardiotocographic analysis tools and maternal risk factors to improve diagnostic accuracy and avoid unnecessary cesarean sections.

An important limitation of this study is that elective cesarean sections were not differentiated from emergency ones, which could have affected the true predictive value of the NST. In addition, other clinical and obstetric variables, such as fetal presentation or cervical dilation at admission, were not included, which could act as confounding factors. On the other hand, the large sample size and the integration of institutional data strengthen the internal validity of the results. However, it should be considered that the prevalence of Apgar < 7 is low, which may have affected the predictive values for this outcome.

Another aspect to consider is the possible selection bias derived from the fact that not all pregnant women evaluated completed delivery at Hospital San Juan de Lurigancho. In some cases, birth occurred in other public or private facilities with different clinical protocols and criteria for cesarean indication. This institutional heterogeneity could have influenced the final decision regarding the mode of delivery independently of the NST result, thus affecting a more precise estimation of the predictive value of the NST in this study.

In conclusion, the findings show that NST, although useful for evaluating fetal well-being, presents low performance for anticipating cesarean delivery and predicting neonatal depression due to its low sensitivity and PPV. However, its high NPV supports its use as a screening tool to rule out acute fetal compromise. It is recommended to consider NST within a multimodal fetal assessment approach rather than as a single criterion to define the mode of delivery, promoting its rational use and avoiding both unnecessary medicalization and delays in timely intervention.

Author contributions

PADQ, BALM, and BEGC conceptualized the study and developed the design; PADQ and BEGC performed data collection; BEGC conducted data analysis; BALM and BEGC supervised. All authors edited and approved both the draft and the final version of the manuscript.

Conflicts of interest

The authors declare no relevant financial or non-financial conflicts of interest.

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Data availability

The data supporting the findings of this study are available upon request from the corresponding author.

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