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Could Admission Non-stress Test Predict Neonatal Outcomes in Cesarean Deliveries? An Observational Study

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Abstract

Objectives: Despite the certainty of evidence regarding the predicting value of admission non-stress test (NST) in high-risk pregnancies at labor onset, data regarding low-risk pregnancies is conflicting. Additionally, most studies have mainly reported fetal heart rate (FHR) interpretation and categorization in laboring mothers and not in mothers experiencing false labor or even no uterine contractions. So, we aimed to assess the association between admission cardiotocography (aCTG) findings and neonatal outcomes in scheduled cesarean deliveries, who are a main subgroup of these patients.

Materials and Methods: In this prospective observational study, 376 subjects were investigated in a tertiary center in Tehran, Iran from May 2020 to October 2021. All participants underwent a 20-minute aCTG and two blinded independent perinatologists interpreted each trace. Neonatal outcomes, including birth weight, Apgar scores, cord blood gas status, and neonatal admission were also recorded.

Results: The mean number of late deceleration was 0.5 in neonates not admitted to the neonatal ward and 1 in neonates admitted to the neonatal ward, and the difference was statistically significant ($P=0.001$). Numbers of Lambda decelerations were statistically correlated with cord blood pH (correlation coefficient=-0.119; $P=0.022$). No other significant association was found between CTG characteristics and cord blood gas status, low birth weight, and/or Apgar scores. Although adverse outcomes were uncommon, associations between these outcomes and CTG findings were not significant.

Conclusions: Performing an aCTG does not seem cost-beneficial in predicting perinatal outcomes in scheduled term cesarean deliveries.

Keywords: Cardiotocography, Pregnancy, Newborn, Cesarean section, Predictive Value of Tests, Neonatal Intensive Care Units, Obstetrical delivery

Introduction

Non-stress test (NST) has been a well-known method for antenatal fetal surveillance since the 1970s (1). The NST hypothesis is based on the fact that in non-hypoxic conditions, fetal movements lead to fetal heart rate (FHR) accelerations, but under hypoxic circumstances, accelerations will disappear. Furthermore, as hypoxia prolongs, more significant ominous changes will occur (2,3).

Obstetricians apply a fetal admission test for early detection of fetal distress during labor to prevent adverse outcomes. An admission cardiotocography (aCTG) is a recording of FHR and uterine contractions for at least 20 minutes, immediately after labor admission (4). Based on the evidence, aCTG could improve fetal and neonatal outcomes in high-risk pregnancies. However, evidence regarding low-risk pregnancies is insufficient and equivocal (5-10). Moreover, there is not sufficient research focusing on predictive value of admission NST in scheduled cesarean sections (CSs). Although adverse neonatal outcomes are rare events in these deliveries, newborns delivered by CS are more prone to neonatal intensive care unit (NICU) admission, supplementary oxygen requirement, and ventilation support (11,12). Moreover, in comparison with newborns delivered vaginally, respiratory morbidities, especially respiratory distress syndrome, transient tachypnea of newborns , and persistent pulmonary hypertension are also higher among newborns delivered by CS (13,14).

Accordingly, as a novel work, we decided to assess the association between detailed admission NST findings and neonatal outcomes among planned term CS deliveries.

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Key Messages

- Number of lambda decelerations were statistically correlated with umbilical cord blood PH in scheduled cesarean deliveries.
- Minimal beat to beat variability was significantly associated with neonatal hospitalization in neonatal ward.
- Performing an aCTG and its detailed interpretation as well as fetal heart rate categorization do not seem cost-beneficial in scheduled cesarean deliveries.

In fact, NST reactiveness, presence or absence of decelerations and deceleration type, baseline FHR, beat-to-beat variability (BBV), and numbers of accelerations and decelerations and their correlation with short-term perinatal outcomes were investigated.

Materials and Methods

A prospective observational study was conducted in Erfan Hospital, a private tertiary center in Tehran, Iran from May 2020 to October 2021. We chose a private center to omit the confounding effect of the surgeon's experience and expertise on perinatal outcomes. The study population consisted of singleton term (gestational age ≥37 weeks) pregnant women aged over 18 years, who were scheduled for CS by a single surgeon. All eligible women signed an informed consent before inclusion in the study. The participants' demographic characteristics and obstetrical history were recorded in a checklist. The exclusion criteria were uncontrolled or poorly controlled co-morbidities, pregnancies affected by fetal growth restriction with concomitant oligohydramnios and/or abnormal Doppler study, anterior Previa placentation, placenta accrete spectrum, fetal major congenital malformations, and anterior lower segment uterine myoma.

NST Taking and Pre-operative Preparation

Oral intake was forbidden from last midnight, but pulp-free liquids were allowed till 2 hours before the surgery time (7-10 AM). On admission, all participants received a bolus of 500 cc Ringer solution. Then, a 20-minute admission NST was performed in the left lateral decubitus position. Subsequently, women were transferred to the operation room. CSs inadvertently done through a vertical skin or uterine incisions and those performed under general anesthesia were also excluded.

Neonatal outcomes including birth weight, 1-minute Apgar score, 5-minute Apgar score, umbilical cord blood gas status, and admission rate at neonatal ward or NICU within the first 48 hours of the postnatal period were recorded.

NST Interpretation

Two perinatologists interpreted each CTG while they were blinded to the neonatal outcomes and a colleague's report on that CTG. In case of two different interpretations on a single CTG, a third experienced perinatologist interpreted that CTG, and her findings were recorded and used in the data analysis. Each NST reactiveness, baseline FHR, BBV, number of accelerations, number and type of decelerations based on National Institute of Child Health and Human Development (NICHD) guidelines were investigated (15). Moreover, BBV was initially categorized into three main groups: minimal, moderate, and marked variability. Then, the moderate group was classified into four sub-groups with variability of 6-10, 11-15, 16-20, and 21-25 beats/minute (bpm), respectively.

Data Analysis

SPSS software version 23 (EBM, USA) was used for data analysis. Quantitative and qualitative variables were reported as mean ± standard deviation and number/percent, respectively. For non-normally distributed quantitative variables, the Mann-Whitney test was used to compare two quantitative variables. Correlation coefficients were also obtained using Spearman's test. Qualitative variables were compared by Chi-Square test, and *P* values less than 0.05 was considered statistically significant.

Sample Size

According to Agarwal's study (16), which reached 85% accuracy for NST in predicting neonatal outcomes in low-risk pregnancies, considering a 95% confidence interval, and power of 80%, a minimum sample size of 205 was required. However, no similar study was found on the objectives of the present study.

Results

Of 399 scheduled CSs done during the study period, 23 cases were excluded (15 cases due to poorly or uncontrolled pregnancy co-morbidities; 4 cases due to general anesthesia; 2 cases due to small for gestational age fetuses with abnormal umbilical cord Doppler study; 1 case due to presumed placenta accreta spectrum; and 1 case due to severe oligohydramnios). Finally, 376 cases were included in the data analysis. Mean ± standard deviations (SD) of maternal age, gestational age, gravidity, live birth, abortion, and body mass index were 33.32 ± 4.9 years, 38.47 ± 0.6 weeks, 1.95 ± 1.0, 0.60 ± 0.68, 0.34 ± 0.67, and 30.82 ± 4.20 kg/m^2, respectively. All patients were hemodynamically stable and the means of maternal respiratory rate, peripheral O2 saturation in room air, central body temperature, pulse rate, and systolic/diastolic blood pressures were 15.89 ± 1.48 breaths/min, 98.40% ± 0.57%, 36.59 ± 0.37 °C, 88.14 ± 7.92 bpm, and 114.07 ± 9.34 /71.12 ± 7.43 mm Hg, respectively.

The two most common CS indications were previous CS history (46.5%) and maternal request (43.1%). Hypothyroidism and diabetes were also the two most prevalent pregnancy complications. More details on CS indications and pregnancy comorbidities are provided in

Table 1.

Concerning neonatal outcomes, 1.1% of neonates had umbilical cord acidosis (pH less than 7.15), 3.4% were low birth weight, and 0.8% were hospitalized in NICU or neonatal ward within the first 48-hour, but none had Apgar scores <7 at 1st or 5th minutes.

Regarding NST findings, in four out of 376 cases (1.1%), NST had salutatory pattern, which limited the NST interpretation. In remaining NSTs, the mean baseline FHR was 140.9 ± 7.6 beats/min. In 181 cases (48.1%), NST was assumed reactive and in 191 (50.8%) it was non-reactive. Regarding BBV, 4 (1.06%), 40 (10.64%), and 332 cases (88.30%) had marked, minimal, and moderate variability, respectively. Furthermore, in moderate BBV group, 125 (37.65%), 162 (48.80%), 42 (12.65%), and 3 cases (0.90%) were in subgroups 1 to 4, respectively.

Additionally, decelerations were evident in 36 NSTs (9.6%). To be more specific, early, late, variable, and Lambda decelerations were seen in 1 (0.30%), 10 (2.66%), 19 (5.05%), and 6 (1.6%) NSTs, respectively.

Regarding the 1- and 5-minute Apgar scores, the mean ± SD were 8.98 ± 0.125 and 9.95 ± 0.052, respectively. Additionally, with respect to cord blood gas status, mean ± SD values for blood PH, HCO3, PCO2, PO2, and Base Excess were 7.31 ± 0.06, 23.66 ± 3.02 mmol/L, 46.28 ± 8.78 mm Hg, 22.5 ± 16.95 mm Hg, and -2.73 ± 2.67 mmol/L, respectively. Considering 7.15–7.38 as the normal cord blood pH range (18), 4 (1.1%) neonates had acidosis; however, none were admitted. More details on these neonates' characteristics are shown in Table 2.

Table 1. Distribution of Different Reasons for Cesarean Section and Pregnancy Comorbidities

	Numbers (n=376)	Percent
Causes of cesarean section		
Previous cesarean section	175	46.5
Maternal request	162	43.1
Breech presentation	15	4
Macrosomia	7	1.9
Transverse presentation	4	1.1
Previous myomectomy	3	0.8
Ophthalmologic problems	2	0.5
Disc herniation	2	0.5
Others[a]	6	1.6
Pregnancy comorbidities		
Hypothyroidism	141	37.5
Pre-gestational or gestational diabetes	88	33.4
Non-sever gestational hypertension	12	3.2
Rheumatologic disorders	5	1.3
Epilepsy	2	0.5
Hematologic disorders	4	1.1
Others[b]	4	1.1

[a] Presence of the bilateral pelvic prosthesis; clinically apparent contracted pelvic; Maternal prodromal signs of genital herpes; Large lower posterior intramural myoma; Posterior placenta previa; Severe vaginismus. [b] Treated congenital atrial septal defect, cholestasis of pregnancy with normal maternal liver function test, major depression, mild to moderate mitral stenosis.

Additionally, the mean birth weight of newborns was 3201.8 ± 400.8 g, and 13 (3.4%) neonates had birth weights <2500 g. Of all neonates, 3 (0.8%) were hospitalized; one in the neonatal ward and two at NICU. The neonate with birth weight of 3960 g admitted to the neonatal ward discharged 24 hours after birth, but was re-hospitalized due to nausea, vomiting, and tachypnea several hours later. She received empiric broad-spectrum antibiotic therapy due to suspected sepsis, but her blood and urine cultures turned negative. The baby was discharged home seven days later. Her mother had hypothyroidism, and CS had been done due to suspected macrosomia. The two NICU-admitted neonates were both initially well babies with normal 1- and 5-minute Apgar scores, but both felt granting and respiratory distress in the nursery ward. Also, one neonate became cyanotic, and the O_2 saturation dropped to 60%. The birth weights of these two newborns were 3275 and 2340 g. Broad-spectrum antibiotics were administered for seven days, and both received N-CPAP (nasal continuous positive airway pressure) without endotracheal intubation. The only maternal pregnancy complication in these neonates was hypothyroidism and CS had been done due to previous CS and maternal request. More details on their cord blood gas status and NST findings are illustrated in Table 3.

The Pearson's correlation test was used to evaluate the associations between NST characteristics and Apgar score and cord blood gas status. Among all NST features, only the number of Lambda decelerations was inversely correlated with cord blood pH (correlation coefficient = -0.119 and $P = 0.022$); however, all these blood pHs were in normal range. No significant correlation was found between NST findings and 1- and 5-minutes Apgar Scores (all $P > 0.05$). Detailed information on these six NSTs and pregnancy outcomes are shown in Table 4.

Other NST features (baseline FHR, number of accelerations, or decelerations other than lambda type) were not correlated with Apgar scores or cord blood gas parameters ($P > 0.05$) (Table 5).

As previously mentioned, although in four cases NST had salutatory patterns, no case of neonatal hospitalization was seen among them. Excluding these cases, the mean number of late deceleration was 0.5 and 1 in non-hospitalized and hospitalized neonates in neonatal ward, respectively, which was statistically significant (Man-Whitney test, $P = 0.001$). Minimal BBV was significantly associated with neonatal hospitalization in neonatal ward (Chi-square test, $P = 0.015$). In fact, the neonates hospitalized in the neonatal ward had minimal variability, while only 10.4% of non-hospitalized neonates

Table 2. Cord Blood Gas, Neonatal Outcomes, Pregnancy Comorbidities, and Admission NST Characteristics of Neonates Born With Cord Blood Acidosis

	pH	PCO2 (mm Hg)	Base Excess (mmol/L)	1st min Apgar Score	5th min Apgar Score	Birth weight (g)	Gestational age (wk)	Pregnancy Comorbidities
Case 1	7.08	74	-9.5	9	10	2975	38^{+5}	No
Case 2	7.11	65	-9.6	9	10	3010	38^{+1}	Hypothyroidism
Case 3	7.11	69	-8.6	8	10	3585	39^{+1}	No
Case 4	7.03	87	-10	8	10	2875	38^{+5}	GDM and hypothyroidism
Admission NST Characteristics								
	Baseline FHR	**Reactiveness**	**No. of Acceleration**	**Beat-to-Beat Variability**	**No. of Early Deceleration**	**No. of Variable Deceleration**	**No. of Late Deceleration**	**No. of Lambda Deceleration**
Case 1	135	Non-reactive	0	Moderate	0	0	0	0
Case 2	135	Non- reactive	1	Moderate	0	0	0	0
Case 3	145	Reactive	8	Moderate	0	0	0	0
Case 4	130	Reactive	6	Moderate	0	0	0	0

GDM: Gestational diabetes mellitus on Insulin; FHR: fetal heart rate.

Table 3. NST Findings and Values of Cord Blood Gas Status in Three Admitted Neonates

Cases and Gestational Age	Baseline FHR (beats/min)	Beat to Beat Variability (beats/min)	NST Reactiveness	No. of Deceleration	pH	HCO3	PCO2 (mm Hg)	PO2 (mm Hg)	Base Excess	Birth Weight (g)
Case 1: 38 weeks	150	<5	Non-reactive	1 (late deceleration)	7.30	29.0	59	10	-0.8	3960
Case 2: 38^{+3} weeks	125	16-20	Reactive (with 6 accelerations)	0	7.34	23.7	44	26	-2.2	3275
Case 3: 38^{+3} weeks	140	11-15	Reactive (with 8 accelerations)	0	7.26	25.1	56	11	-2.8	2340

Note: Neonate 1: Admitted to the neonatal ward; Neonates 2 and 3 were admitted to NICU.

Table 4. NST Characteristics of Those With Lambda Deceleration and Associated Pregnancy and Neonatal Outcomes

NSTs	Baseline FHR (beats/min)	BBV	NST Reactiveness	No. of Lambda-Other Deceleration	pH	Birth Weight (g)	Neonatal Admission	Co-morbidities	Cause of Cesarean
NST1	145	M	Non-reactive	1-0	7.22	2950	No	No	Maternal request
NST2	150	M	Reactive	1-1 (late)	7.30	3505	No	Hypothyroidism	Maternal request
NST3	140	M	Reactive	1-0	7.28	4185	No	No	Previous cesarean
NST4	145	M	Reactive	2-0	7.27	2620	No	No	Maternal request
NST5	145	M	Reactive	4-0	7.21	3200	No	Hypothyroidism	Maternal request
NST6	135	M	Non-reactive	4-0	7.21	2815	No	No	Maternal request

M: Moderate.

had minimal BBV. Furthermore, considering BBV in six groups (minimal, moderate subgroups of 1 to 4, and marked), the correlation was not significant ($P=0.13$). Also, neonatal ward hospitalization was not correlated with NST reactiveness ($P=0.513$) or the presence of decelerations ($P=0.097$).

Moreover, the same analytic tests were applied to evaluate the correlation between neonatal hospitalization in NICU and NST characteristics. The mean number of accelerations in NICU-admitted neonates was significantly higher than non–NICU-admitted ones (7 vs. 2.39 and $P=0.042$). No statistically significant correlation was found between NICU admission and other NST characteristics (baseline FHR: $P=0.229$, BBV: $P=0.104$, and numbers of different deceleration types or reactiveness: $P>0.05$).

Additionally, putting all these three hospitalized neonates in a group, a statistically significant correlation was found between the number of late decelerations and hospitalization. In other words, the mean number of late decelerations was 0.33 in hospitalized and 0.05 in non-hospitalized neonates (Man Whitney test, $P=0.001$). NST reactiveness and BBV category had no correlation with neonatal hospitalization ($P=0.614$, Fisher exact test, and $P=0.436$, chi-square test, respectively).

Finally, newborns were divided into two main groups

Table 5. Correlations Between Neonatal Outcomes and NST Characteristics

P Value of Variables	Baseline FHR	Beat to Beat Variability	No. of Acceleration	No. of Variable Deceleration	No. of Late Deceleration	No. of Early Deceleration
1st minute Apgar score (Correlation coefficient; *P* value)	-0.052; 0.319	0.050; 0.335	0.015,0.773	0.030,0.568	0.021; 0.682	0.007; 0.898
5th minute Apgar score (Correlation coefficient; *P* value)	0.000; 0.992	-0.008; 0.875	-0.016; 0.756	0.012; 0.817	0.009; 0.868	0.003; 0.959
Cord blood HCO3 (Correlation coefficient; *P* value)	0.020; 0.697	-0.090; 0.080	-0.003; 0.948	-0.031; 0.548	0.040; 0.441	0.025; 0.632
Cord blood PO2 (Correlation coefficient; *P* value)	-0.037; 0.476	-0.013; 0.806	0.056; 0.279	-0.006; 0.909	0.013; 0.805	-0.033; 0.521
Cord blood PCO2 (Correlation coefficient; *P* value)	-0.024; 0.642	-0.061; 0.237	-0.009; 0.867	-0.021; 0.686	0.019; 0.721	0.001; 0.981
Cord blood Base Excess (Correlation coefficient; *P* value)	0.061; 0.239	-0.043; 0.409	-0.005; 0.918	-0.039; 0.452	0.033; 0.523	0.032; 0.536
Cord blood pH (Correlation coefficient; P-Value)	0.039; 0.449	0.008; 0.872	0.012; 0.815	0.025; 0.636	0.018; 0.724	0.029; 0.583

according to their birth weight (below or above 2500 g). Chi-square test found no association between low birth weight and NST baseline FHR ($P=0.78$, Fisher exact test), BBV ($P=0.44$, chi-square test), NST reactiveness ($P=0.162$, Fisher exact test), and presence of decelerations ($P=0.624$, Fisher's exact test).

Discussion

In the current study, previous CS and maternal request were the two most common indications for CS. These findings are in line with previous local studies reporting that CS is the most common reason for subsequent surgical delivery among Iranian population (17-19). Additionally, fear of normal vaginal delivery, fear of injury to the pelvic floor, urine incontinency and or sexual dysfunction, besides obstetricians' tendency were all introduced as potential causes that may increase requests for CS among Iranian primiparous women (20).

In the current study, the mean gestational age at CS delivery was 38.47 ± 0.6 weeks, which may be justified by high prevalence of pregnancy co-morbidities such as hypothyroidism, pre-gestational or gestational diabetes among the study population (21,22).

The present study was designed to assess the possible correlation between admission NST findings and neonatal outcomes in scheduled term CS deliveries. We found that NSTs were non-reactive in approximately half of the participants (50.8%). This high prevalence of non-reactiveness could not be due to maternal dehydration, because all NSTs were taken after adequate maternal hydration in the left lateral decubitus position. Also, since pulp-free liquid intake was allowed until to 2 hours before surgery and all CSs were done at 7–10 AM, fetal hypoglycemia could not be considered a main reason. Instead, it seems that the high frequency of non-reactiveness may be as a result of the short test duration (20 minutes); if the time was extended to 40 minutes, more proportion of NSTs would have turned into reactive ones (23,24).

Regarding BBV, a notable rate of minimal variability by 10.64% was observed. As study participants had no uncontrolled or poorly controlled pregnancy co-morbidities and they were well hydrated and liquid intake was allowed, other factors except maternal dehydration or fetal hypoglycemia such as fetal sleep cycle may be responsible for this amount of observed minimal BBV. It has been shown that fetal sleep cycle, maternal BMI or metabolism, environmental noise, temperature, and humidity, as well as interfering factors caused by the inappropriate procedure, equipment, and vicinity of other electronic devices may affect FHR BBV (25).

It should also be emphasized that minimal variability was not a frequent pattern among admitted neonates. So, it could be drawn that minimal BBV as a single variable could not be a significant risk factor for NICU admission or neonatal acidosis. In fact, minimal BBV accompanied by tachycardia, non-reactiveness, and late decelerations should be considered an alarming sign for perinatal adverse events (26,27). To the best of our knowledge, no similar study has been conducted so far, though a study by Sethia et al assessed the association between CTG findings with cord blood pH among 90 pregnant women with uncomplicated term pregnancy experiencing spontaneous labor. Cord blood pH <7 was seen in 40% of their participants, and a significant correlation was found between cord blood acidosis and abnormal BBV (28). Limited number of hospitalized or acidotic cases in our study and different study population may justify this difference and future larger sample-size studies may provide more evidence.

A significant correlation between hospital admission and the number of late decelerations was also found in this study, but surprisingly, the mean number of accelerations was significantly higher in NICU-admitted neonates. Hence, it could be drawn that despite more accelerations in NICU-admitted neonates, the importance of late deceleration and its effect on neonatal outcome seems higher.

In this study, as the number of lambda decelerations increased, cord blood PH significantly decreased; however, the pH remained in the normal limits. This finding may indicate the potential risk of cord blood acidosis as the number of lambda decelerations reaches a specific threshold. So, cord blood acidosis could be suspected in the cases with frequent lambda decelerations; however, further investigations are essential for clinical implication.

Finally, although adverse neonatal outcomes were uncommon in the current study, no main significant correlations between admission NST characteristics and short-term neonatal outcomes were found. Despite some statistically significant correlations between late or lambda decelerations and neonatal outcomes, their clinical implications and generalizing the result require further investigations. However, it seems that performing admission test in term planned CS deliveries would not be beneficial.

Research Implications

To generalize our findings, studies with larger sample sizes are required. Additionally, we recommend future researchers to design a study to compare the prognostic role of admission NST in pregnancies complicated by co-morbidities, which are uncontrolled or poorly controlled, with those who have well-controlled or lacking any associated fetal and/or maternal complications.

Strengths and Limitations

The main strength of our study was its novel objectives. To the best of our knowledge, no similar study has been conducted so far. However, the study had several main limitations. Firstly, as NSTs were taken during a 20-minute period, a high frequency of non-reactiveness was observed; If the test duration were prolonged, more NSTs would turn reactive. Secondly, adverse neonatal outcomes were rare; hence, assessing any potential association between NST and neonatal outcomes was limited, and clinical implications of our results seem unreasonable. Thirdly, CS was done shortly after NST, which per se could confound any significant effect of more prolonged NST abnormalities on neonatal outcomes; however, as generally scheduled CS deliveries are often done shortly after admission, our findings may enhance the hypothesis that in elective low-risk pregnancies in which surgery is done soon after admission, taking an admission NST seems unreasonable. Fourthly, this study assessed low-risk pregnancies or those with well-controlled co-morbidities, which hinders generalization of the findings to all scheduled term CS deliveries; Although a significant portion of our population had pregnancy controlled co-morbidities, due to the rarity of adverse perinatal outcomes in the study, the confounding effect of these comorbidities on perinatal outcomes was not investigated. Also, besides the low frequency of adverse short-term neonatal outcomes, the study design also limits the precise implication of the findings. So, more analytical studies should be designed.

Conclusions

As correlations between perinatal adverse outcomes and admission NST findings were not statistically significant, performing admission NST might not be beneficial in scheduled CS deliveries with well-controlled comorbidities or pregnancies without complications. Future well-designed investigations with larger sample sizes would be more informative.

Authors' Contribution

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Conflict of Interests

Authors declare that they have no conflict of interests.

Ethical Issues

The study was conducted in accordance with the Helsinki declaration and the protocols of the Ethical Committee of Tehran University of Medical Sciences, Tehran, Iran (ethics code: IR.TUMS.IKHC.REC.1400.278).

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References

1. Rochard F, Schifrin BS, Goupil F, Legrand H, Blottiere J, Sureau C. Nonstressed fetal heart rate monitoring in the antepartum period. Am J Obstet Gynecol. 1976;126(6):699-706. doi:10.1016/0002-9378(76)90523-8
2. Umana OD, Siccardi MA. Prenatal nonstress test. In: StatPearls (Internet). Treasure Island, FL: StatPearls Publishing; 2023.
3. Jamatia A, Malhotra V, Nanda S, Gupta S, Sangwan N, Bhuria V. Role of nonstress test in improving the perinatal outcome in pregnancies complicated by preeclampsia. Int J Clin Obstet Gynaecol. 2019;3(2):30-35. doi:10.33545/gynae.2019.v3.i2a.09
4. Archana T, Kavita NS, Sonal S. Study of admission cardiotocography screening of high-risk obstetric cases and its correlation with perinatal outcome. Indian J Obstet Gynecol Res. 2018;5(2):209-214.
5. Farzipour S, Jalilvand F, Zandian H, Ghazi A. Evaluation of PH

and APGAR score of neonates born by cesarean section due to the fetal distress. Caspian J Pediatr. 2021;7(2):552-559. doi:10.22088/cjp.bums.7.2.552
6. Rahman J, Begum HA. Prediction of foetal well-being with non-stress test. J Bangladesh Coll Phys Surg. 2015;33(2):65-69.
7. Kaur N, Jindal P. Study of 'nonstress test at admission' and its corelation with maternal and fetal outcome. J South Asian Fed Obstet Gynecol. 2015;10(3):161-166. doi:10.5005/jp-journals-10006-1581
8. Panda S, Das A, Nowroz HM, Singh AS. Role of admission tests in predicting perinatal outcome: a prospective study. J Preg Child Health. 2015;2(4):171. doi:10.4172/2376-127x.1000171
9. Garg S, Gupta A, Madhavan J. Non-stress test as an admission test to assess the outcome in high-risk pregnancy. Int J Reprod Contracept Obstet Gynecol. 2016;5(11):3993-400. doi:10.18203/2320-1770.ijrcog20163877
10. Astruc A, Verhaeghe C, Legendre G, Descamps P, Corroenne R. Is the admission cardiotocography test predictive of an emergent cesarean delivery during labor in prolonged pregnancies? J Clin Gynecol Obstet. 2022;11(1):9-13. doi:10.14740/jcgo791
11. Kamath BD, Todd JK, Glazner JE, Lezotte D, Lynch AM. Neonatal outcomes after elective cesarean delivery. Obstet Gynecol. 2009;113(6):1231-1238. doi:10.1097/AOG.0b013e3181a66d57
12. Mahmoodi F, Mobaraki A, Mahmoodi Z, Najar S, Haghighi MH, Borzoueisileh S, Ebrahimpour S. Comparison of Neonatal Arterial Blood Oxygen Saturation Rate Immediately After Birth in Normal and Elective Cesarean Delivery. Crescent Journal of Medical & Biological Sciences. 2016;3(1):19-22.
13. Ramachandrappa A, Jain L. Elective cesarean section: its impact on neonatal respiratory outcome. Clin Perinatol. 2008;35(2):373-393. doi:10.1016/j.clp.2008.03.006
14. Hansen AK, Wisborg K, Uldbjerg N, Henriksen TB. Risk of respiratory morbidity in term infants delivered by elective caesarean section: cohort study. BMJ. 2008;336(7635):85-87. doi:10.1136/bmj.39405.539282.BE
15. Villar J, Valladares E, Wojdyla D, et al. Caesarean delivery rates and pregnancy outcomes: the 2005 WHO global survey on maternal and perinatal health in Latin America. Lancet. 2006;367(9525):1819-1829. doi:10.1016/s0140-6736(06)68704-7
16. Agarwal S, Aggarwal A. Non-stress test-a prediction of neonatal outcome. J Evol Med Dent Sci. 2018;7(34):3796-3798.
17. Azami-Aghdash S, Ghojazadeh M, Dehdilani N, Mohammadi M, Asl Amin Abad R. Prevalence and causes of cesarean section in Iran: systematic review and meta-analysis. Iran J Public Health. 2014;43(5):545-555.
18. Rafiei M, Saei Ghare M, Akbari M, et al. Prevalence, causes, and complications of cesarean delivery in Iran: a systematic review and meta-analysis. Int J Reprod Biomed. 2018;16(4):221-234.
19. Ghanbari Z, Shokouhmand R, Asadi H, Naghizadeh S, Chupani F. Assessing the relative contribution of causes leading to cesarean section among women who had referred to Shahid Madani Clinic in Marand city. Int J Womens Health Reprod Sci. 2014;2(1):26-9.
20. Faisal I, Matinnia N, Hejar AR, Khodakarami Z. Why do primigravidae request caesarean section in a normal pregnancy? A qualitative study in Iran. Midwifery. 2014;30(2):227-233. doi:10.1016/j.midw.2013.08.011
21. Ehrenthal DB, Hoffman MK, Jiang X, Ostrum G. Neonatal outcomes after implementation of guidelines limiting elective delivery before 39 weeks of gestation. Obstet Gynecol. 2011;118(5):1047-1055. doi:10.1097/AOG.0b013e3182319c58
22. Tita AT, Landon MB, Spong CY, et al. Timing of elective repeat cesarean delivery at term and neonatal outcomes. N Engl J Med. 2009;360(2):111-120. doi:10.1056/NEJMoa0803267
23. Priya R. The diagnostic value of the non-reactive NST/non-reactive CTG in high-risk pregnancies. Int J Clin Obstet Gynaecol. 2018;2(5):142-146.
24. Joshi SK, Dangal G. Non stress test as a predictor of maternal and fetal outcome in patients presenting with reduced fetal movement at term. J Nepal Health Res Counc. 2022;20(1):21-25. doi:10.33314/jnhrc.v20i01.3628
25. Catai AM, Pastre CM, de Godoy MF, da Silva E, de Medeiros Takahashi AC, Vanderlei LC. Heart rate variability: are you using it properly? Standardisation checklist of procedures. Braz J Phys Ther. 2020;24(2):91-102. doi:10.1016/j.bjpt.2019.02.006
26. Dellinger EH, Boehm FH, Crane MM. Electronic fetal heart rate monitoring: early neonatal outcomes associated with normal rate, fetal stress, and fetal distress. Am J Obstet Gynecol. 2000;182(1 Pt 1):214-220. doi:10.1016/s0002-9378(00)70515-1
27. Mahjabeen N, Nasreen SZ. Analysis of normal and abnormal admission cardiotocography (CTG) and its association with perinatal outcomes. Sch Int J Obstet Gynecol. 2022;5(2):32-36. doi:10.36348/sijog.2022.v05i02.002
28. Sethia R, Naskar A, Tripathy S, Das R. Association between intrapartum cardiotocography and umbilical cord blood pH in term pregnancies: a cross-sectional study in a tertiary care centre, Kolkata, India. J Clin Diagn Res. 2022;16(2):QC19-QC22. doi:10.7860/jcdr/2022/51835.15965