Exercise stress test through brisk walking: A complementary way to assess fetal well-being in term pregnancy*

By Princess May P. Aquino, MD; Eileen Co- Sy, MD, FPOGS and Maria Dolores A. Mercado, MD, FPOGS

Department of Obstetrics and Gynecology, Angeles University Foundation Medical Center

ABSTRACT

Objective: To determine the effect of exercise stress test (EST) through brisk walking on the cardiotocogram tracings (CTGs) and the association of the tracings to neonatal outcomes.

Methodology: This one-group pretest-post test experimental study involved 65 term pregnant women (mean age = 25.94 + 4.66 years) who underwent brisk walking exercise using a motorized treadmill for 30 minutes, following American College of Obstetricians and Gynecologists (ACOG) guidelines for exercise among pregnant women. Pre- and post- walk CTGs were assessed, with presence of post-walk decelerations taken to mean a positive EST. Sensitivity (positive EST in sick / meconium-stained / cord coil babies), specificity (negative EST in well babies), positive predictive value (PPV) (probability of sick / meconium-stained / cord coil babies given positive EST) and negative predictive value (NPV) (probability of well babies given negative EST) were computed.

Results: A significant difference in the proportion of subjects with pre- and post- walk decelerations was noted (p-value = 0.000) wherein 18 subjects (28.13%) without decelerations in the baseline CTG had decelerations in the post-walk CTG. These decelerations were significantly associated to having sick, meconium-stained, or cord coil babies (p-values < 0.05). EST had 80% sensitivity, 75% specificity, 21.1% PPV and 97.8% NPV for detecting sick babies; 75% sensitivity, 77.2% specificity, 31.6% PPV and 95.7% NPV for detecting meconium-stained babies; and 75% sensitivity, 85.7% specificity, 63.2% PPV and 91.3% NPV for detecting nuchal cord.

Conclusion: Exercise stress testing is a complementary way of assessing fetal well-being due to manifestation of decelerations in the post-walk CTG which could have gone undetected if only the resting CTG was done. The EST had high sensitivity for detecting sick / meconium-stained / cord coil babies and has the advantage of reinforcing a reassuring fetal condition due to its high NPV for detecting well babies.

Keywords: cardiotocogram, exercise test, fetal heart rate

INTRODUCTION

Cardiotocography (CTG) is widely used in maternity care, both in the antepartum and intrapartum periods. Antepartum CTG is commonly referred to as the 'non-stress test.'[1] However, many pregnant women still engage in moderate intensity physical activity such as daily household chores, and some occupational tasks.[2] Even the Centers for Disease Control and American College of Sports Medicine (CDC-ACSM) and American College of Obstetricians and Gynecologists (ACOG) recommend 30 minutes or more of moderate exercise a day on most, if not all days of the week.[3,4] If such moderate physical activity is maintained during pregnancy then it is prudent to note if such activities would show any changes in the CTGs.

It is in this light that this study was conceptualized. Exercise stress test (EST) is widely available in cardiovascular centers at relatively low cost[5] to provide information if the heart has sufficient blood and oxygen circulation during physical stress which may not show in resting electrocardiogram. If pregnant women would be placed in a similar EST through brisk walking, normal resting CTGs could turn out differently in the post-exercise test. If this type of test will show any changes, it may be an effective intervention to improve fetal outcomes.

To date, there is no published study correlating post-exercise CTGs to neonatal outcomes with the end goal of using the post-exercise CTGs as a way of assessing antepartum fetal condition. This research was done to determine if EST in pregnancy through brisk walking can be a complementary way to assess antepartum fetal wellbeing in term pregnancy.

OBJECTIVES

General:

To determine the effect of EST through brisk walking on the CTGs and the association of the tracings to neonatal outcomes

Specific:

1. To evaluatethe effect of EST on fetal heart rate (FHR) patterns and category tracings

* Philippine Obstetrical and Gynecological Society (POGS) Research Paper 2015

2. To determine association between EST result (indicated by presence of decelerations on post-walk CTGs) and selected neonatal outcomes (characteristic of amniotic fluid, presence or absence of nuchal cord, Apgar score, and fetal condition either well or sick baby)
3. To determine sensitivity, specificity, positive predictive value and negative predictive value of the EST in determining fetal condition, presence of meconium staining and presence of nuchal cord.

MATERIALS AND METHODS

Study Design

This study employed a one-group pretest-posttest experimental design. It is not a true experiment because it has only one group and there was no random assignment of treatments. It involved only one group of subjects who were exposed to the intervention - the brisk walking. It has pretest or baseline observation, which allows the researcher to measure the effect of the intervention by comparing pretest and posttest results.[6]

Patient Population

Sixty-five (65) term pregnant women who were qualified based on the inclusion/exclusion criteria were enrolled in this study from January 2013 to May 2014. These women were both charity and private obstetric patients from a private tertiary hospital in Angeles City.

Methodology

An Entry Form was used to assess eligibility and collect baseline information. Subjects were included if they were women aged 18 to 35 years-old, medically stable, singleton term pregnancies (37-42 weeks age of gestation), not in active labor and with intact membranes. Excluded were high risk pregnant woman with contraindications to exercise - hemodynamically significant heart and lung disease, poorly controlled hypertension or diabetes mellitus type I, poorly controlled seizure disorder orthyroid disease, severe anemia, incompetent cervix or with cerclage, multiple gestation, malpresentation, second or third trimester bleeding, premature labor, ruptured membranes, previous cesarean section (CS) and with orthopedic limitations.[3,7]

A written informed consent was obtained from each participant and a general data form filled-up including Physical Activity Readiness Medical Examination form (PARmed-X for Pregnancy) to ensure ability to engage in physical activity while pregnant.[8]

Pre-walk CTGs were recorded for a minimum of thirty minutes to ensure fetal well being prior to EST. If the initial assessment showed abnormal tracings, brisk walking was no longer advised and prompt evaluation and resuscitative measures were done.

Figure 1: Participants were exposed to recommended brisk walking exercise regimen using Treadmill

If pre-walk CTGs were normal, the subjects were exposed to the recommended brisk walking exercise regimen using a motorized treadmill for 30 minutes of moderate intensity physical activity (Figure 1) with an energy requirement of 3 to 5 metabolic equivalents (METs) until maternal heart rate reached 60 to 70% of age-predicted maximal heart rate, appropriate for most pregnant women.[3] A modified version of the conventional age-corrected heart rate target zone to account for reduction in maximal heart rate reserve was used for objective measure of exercise intensity[7] combined with a visual rating of perceived exertion with Borg's scale. A target rating of 12 to 14 of perceived exertion was suggested during pregnancy.[7,9] This was then followed by post-walk CTG immediately after the EST.

All ESTs and CTG monitoring were facilitated by Obstetrics and Gynecology residents. Only one resident blinded to either pre- and post- walk CTGs interpreted the

results. Participants were given instructions and closely observed by another resident for the entire duration of the exercise. Careful measures were taken to ensure the safety of pregnant women. No participant experienced any untoward effects[7] during the EST. Likewise, no patient requested to stop the exercise due to physical exhaustion. All the 65 subjects completed the 30-minute brisk walking exercise.

Outcomes

Outcomes measured were changes in the FHR and variability, presence or absence of accelerations or decelerations, and category type of tracing as evident by either the pre- versus post- walk CTGs. Interpretation of CTGs was performed using the 2008 *Eunice Kennedy Shriver* National Institute of Child Health and Human Development (NICHD) criteria for electronic fetal monitoring patterns, a three-tier system.[10,11]

Associations between EST results and selected neonatal outcomes such as characteristic of amniotic fluid, presence or absence of cord coil, Apgar score, and fetal condition (either well or sick baby) were considered.

Pre- and post- walk CTGs assessed, with the presence of post-walk decelerations taken to mean a positive EST. Sensitivity (positive EST in sick / meconium-stained / cord coil babies), specificity (negative EST in well babies), PPV (probability of sick / meconium-stained / cord coil babies given positive EST) and NPV (probability of well babies given negative EST) were computed.

Data Analysis

Mean + standard deviation (SD) and count (percentage, %) were computed for normally distributed and categorical data, respectively. Shapiro-Wilk's test was employed to test the normality of the data.

Paired t-test was carried out to test differences in the means of normally distributed pre- and post- walk outcomes while McNemar's test was used to compare pre- and post- walk outcomes which were expressed as categorical variables. Chi-square test or Fisher's exact test, whenever was appropriate, was employed to test the association between EST results and neonatal outcomes. P-values less than 0.05 were considered significant. Data were encoded and analyzed using Stata IC 13.

RESULTS

A total of 65 women (mean age = 25.94 $\pm$ 4.66 years) with term, singleton gestations ranging from 37 to 42 weeks (mean = 38.92 $\pm$ 4.66 weeks) were the subjects of this study [Table 1].

Post-brisk walking FHRs were found to be significantly higher statistically (p-value = 0.000) but the difference is not clinically significant. No significant difference was noted in pre- and post- brisk walking variability (p-value = 0.317). Significant differences in pre- and post- walk CTG were noted with 20 out of 65 subjects (30.77%) from category I re-classified to category II after the brisk walking (p-value = 0.000) [Table 2]

A significant difference in the proportion of the subjects with pre- and post- walk decelerations was noted (p-value = 0.000) wherein 18 subjects (28.13%) without decelerations in the baseline CTG had decelerations in the post-walk CTG [Table 3].

EST results were found to be significantly associated to selected neonatal outcomes. Specifically, 4 out of 19 subjects with post-walk decelerations (21.05%) were sick babies (p-value = 0.009), 6 (31.58%) were meconium-stained (p-value = 0.002)and 12 (63.16%)had nuchal cord(p-value = 0.000). [Table 4]

Majority of the babies of the women who underwent brisk walking had normal APGAR scores of 8 or 9 at 1 minute (86.15%). At 5 minutes, all of the babies had APGAR scores of 9 except for one baby who had an APGAR score of 6 which eventually became a score of 9 at 10 minutes. The 19 women with post-walk decelerations had babies with APGAR scores of 7 or 8 at 1 minute (n = 2 and 17, respectively). All of the 19 babies had a score of 9 at 5 minutes.

The EST showed 80% sensitivity, 75% specificity, 21.1% PPV and 97.8% NPV for detecting sick babies; 75% sensitivity, 77.2% specificity, 31.6% PPV and 95.7% NPV for detecting meconium-stained babies; and 75% sensitivity, 85.7% specificity, 63.2% PPV and 91.3% NPV for detecting nuchal cord. [Table 5].

DISCUSSION

The results of this study confirmed that after EST, the most common FHR response is an increase in FHR immediately after brisk walking and no difference in accelerations. Baseline FHR was significantly higher approximately 5.5 beats per minute. The difference is not likely to be clinically significant. Most of the studies showed a minimum or moderate increase in FHR by 10-30 beats per minute over baseline during or after maternal exercise.[3] Integrated fetal chemoreceptor, baroreceptor, and adrenal responses appear to influence transient increases in FHR, resulting in increased fetal cardiac output and hence increased oxygen availability. This is a protective mechanism to facilitate transfer of oxygen and decrease carbon dioxide tension across the placenta or reflex response to compensate for relative hypoxia resulting from reduced uterine blood flow during maternal exercise. Any acute alterations can result in FHR changes, whereas chronic effects may result in intrauterine growth

Table 1. Characteristics of Study Participants

Characteristics	(n = 65)
Age (years)	
Mean (Standard Deviation)	25.94 (4.66)
Median (Interquartile Range)	25 (7)
[Minimum, Maximum]	(18, 37)
AOG (weeks)	
Mean (Standard Deviation)	38.92 (1.00)
Median (Interquartile Range)	39 (1.42)
[Minimum, Maximum]	(37, 41.86)
OB Score	
G1P0 (n, %)	37 (56.9)
G2P1 (1001) (n, %)	16 (24.6)
G2P1 (1000) (n, %)	1 (1.5)
G2P0 (0010) (n, %)	2 (3.1)
G3P1 (1011) (n, %)	2 (3.1)
G3P0 (0020) (n, %)	1 (1.5)
G3P2 (2002) (n, %)	2 (3.1)
G4P2 (2011) (n, %)	1 (1.5)
G4P2 (2012) (n, %)	1 (1.5)
G4P3 (2002) (n, %)	2 (3.1)
Medical Conditions	
Bronchial Asthma (n, %)	1 (1.5)
GDM, diet controlled (n, %)	11 (16.9)
Hepa B reactive (n, %)	1 (1.5)
History of IUFD (n, %)	1 (1.5)
Poor OB History (n, %)	1 (1.5)

Table 2. Comparison of Pre- and Post-Brisk Walking Cardiotocogram

FHR tracings	Pre-walk CTG	Post-walk CTG	p-value
Fetal Heart Rate			
Mean (Standard Deviation)	136 (7.82)	141.46 (8.18)	0.000*
Variability			
Minimal	0 (0.0)	1 (1.54)	0.317
Moderate	65 (100.0)	64 (98.46)	
Category			
I (n, %)	65 (100.0)	45 (69.23)	0.000*
II (n, %)		20 (30.77)	

**Significant up to 0.001 level*

Table 3. Comparison of Pre- and Post-Brisk walking cardiotocogram

Pre-walkCTG	Pre-walk CTG		p-value
	Without decelerations (n, %)	With decelerations (n, %)	
Without decelerations (n, %)	46 (71.88)	18 (28.13)	0.000*
With decelerations (n, %)	0 (0.00)	1 (100.0)	

**Significant up to 0.001 level*

restriction.[3,12]

Moderate FHR variability reliably predicts the absence of fetal metabolic acidemia at the time it was observed. It is thought to indicate central nervous system integrity, adequate oxygenation and fetal well being. However, a reduction in variability in the absence of other ominous findings such as decelerations might not imply asphyxia result.[10,12] In our study, there was no significant difference from baseline moderate variability and after EST except for one subject who had minimal variability after brisk walking and eventually delivered vaginally.

Based on the interpretation on the 2008 NICHD Workshop Report on Electronic Fetal Monitoring[10,11], in this study, all the subjects included had interpretation of category I FHR tracings pre-brisk walking. These patterns are assumed to be reflective of normal oxygenation status, and bad outcomes are uncommon.[13] Out of 65, 20 of the subjects (30.77%) were then re-classified as having category II post-brisk walking (indeterminate result). Nineteen (19) subjects were due to presence of either variable or late decelerations (28.13%) and one subject due to presence of minimal variability without decelerations. Fortunately, no category III FHR pattern was noted. Majority of newborns who had predominantly category II tracings experienced no short term morbidity. However, increasing time in category II was associated with adverse short-term outcomes with increased likelihood of neonatal intensive care unit (NICU) admission or Apgar score of less than 7.[13] In general, category II tracing is still not absolutely predictive of abnormal fetal acid-base status, since it has broad range of outcomes. This is based on recommendations for management of category II tracing, which requires further evaluation and continued surveillance, initiation of appropriate corrective measures when indicated.[10,13] Same findings in our study were observed. After category II tracing noted for the 20 subjects and continued antenatal fetal surveillance done, only four subjects showed significant finding in neonatal outcome after delivery and were found to be sick babies (21.05%). These findings were attributed to the decrease in vascular resistance resulting to a transiently increased blood flow to the fetus with net effect of increasing fetal cardiac output and increased oxygen availability to compensate for a relative hypoxia resulting from a transient decrease

Table 4. Association between Presence of Decelerations based on Post-brisk walking cardiotocogram and Neonatal Outcomes

Presence of Decelerations based on Post- walk CTG	Neonatal Outcome		p-value
	Well Baby (n, %)	Sick Baby (n, %)	
Without decelerations (n, %)	45 (97.83)	1 (2.17)	0.009*
With decelerations (n, %)	15 (78.95)	4 (21.05)	
Presence of Decelerations based on Post- walk CTG	**Amniotic Fluid**		**p-value**
	Clear (n, %)	Meconiun Stained (n, %)	
Without decelerations (n, %)	44 (95.65)	2 (4.35)	0.002*
With decelerations (n, %)	13 (68.42)	6 (31.58)	
Presence of Decelerations based on Post- walk CTG	**Cord Coil**		**p-value**
	Without (n, %)	With (n, %)	
Without decelerations (n, %)	42 (91.30)	4 (8.70)	0.000*
With decelerations (n, %)	7 (36.84)	12 (63.16)	

**Significant up to 0.01 level*
***Significant up to 0.001 level*

Table 5. Sensitivity, Specificity, Positive Predictive Value and Negative Predictive Value of Post-walk CTG for Determining Fetal Condition, Presence of Meconium Staining and Presence of Nuchal Cord

Presence of Decelerations based on Post-walk CTG	Neonatal Outcome		Sensitivity	Specificity	PPV*	NPV**
	Well Baby (n, %)	Sick Baby (n, %)				
Without decelerations (n, %)	45 (97.83)	1 (2.17)	80%	75%	21.1%	97.8%
With decelerations (n, %)	15 (78.95)	4 (21.05)				
Presence of Decelerations based on Post-walk CTG	**Amniotic Fluid**		**Sensitivity**	**Specificity**	**PPV***	**NPV****
	Clear (n, %)	Meconiun Stained (n, %)				
Without decelerations (n, %)	44 (95.65)	2 (4.35)	75%	77.2%	31.6%	95.7%
With decelerations (n, %)	13 (68.42)	6 (31.58)				
Presence of Decelerations based on Post-walk CTG	**Nuchal cord**		**Sensitivity**	**Specificity**	**PPV**	**NPV**
	Without (n, %)	With (n, %)				
Without decelerations (n, %)	42 (91.30)	4 (8.70)	75%	85.7%	63.2%	91.3%
With decelerations (n, %)	7 (36.84)	12 (63.16)				

in uterine blood flow during brisk walking. But for a fetus that is starting to become hypoxic or is hypoxic, one would expect vasoconstriction in placental circulation after a while, resulting in an increased vascular resistance, that would be reflected by the presence of decelerations as FHR monitoring continued and therefore lead into potential perinatal morbidity such as meconium aspiration, NICU admission or Apgar score of less than 7, which are usually used as functional markers for neonatal hypoxia.

Six out of the 19 subjects (31.58%) in the study with positive EST were found to be meconium-stained and 4 of these babies were sick babies. The incidence of meconium stained amniotic fluid and CS for fetal distress and small for gestational age infants were highest for patients with abnormal results such as presence of late deceleration.[14] Between 15 to 20% of term pregnancies are associated with meconium stained amniotic fluid in vast majority is not a cause of concern. However, in some circumstances, the passage of meconium in utero is associated with significant increases in perinatal morbidity and mortality which can result in life threatening situation known as meconium aspiration syndrome (MAS) and accounts for 2% perinatal deaths. A cross sectional study showed that two variables were found associated with presence of meconium: repeated or recurrent variable decelerations and early decelerations.[15] The incidence of FHR abnormality was significantly higher in babies who developed MAS than those who did not[16] especially those associated with moderate or thick meconium.[17] There is strong evidence that babies with meconium staining were more likely to experience fetal distress compared with clear amniotic fluid after 38 weeks of gestation.[18] A cohort study done evaluated role of meconium staining in low risk obstetric population in terms of fetal distress and perinatal morbidity and mortality showed that it was associated with poor outcome in all the outcome measures assessed.[19,20] As such, continuous EFM should be considered for these women.

In this study, 12 out of the 19 subjects (63.16%) with positive EST, most of which are recurrent variable decelerations, were found to have nuchal cord. In the first stage of labor, frequencies of variable decelerations are noted on various cord abnormalities such as nuchal cord, marginal cord insertion, vilamentous insertion and hypercoiled coil particularly of the latter two.[36] In this study, the appearance of such findings may be due to variability of umbilical cord length and gravitation force. As the number of loops in a nuchal cord increases to more than two loops, the operative interference increases.[37] In this study, only 2 cases underwent CS due to other reasons and 10 subjects underwent normal delivery. It would reflect that such occurrence after brisk walking would still be safe for the babies in utero. Although recorded by FHR tracing, no perinatal morbidity was noted with the presence of such nuchal cords. But such presence would be very informative to prevent occurrence of cord accidents.

Low Apgar score is a surrogate marker for adverse outcomes. Nevertheless, because low Apgar scores are associated with neonatal encephalopathy and early neonatal death, we consider the link between increasing use of EFM and reduction in low 5-minute Apgar score to be important.[23] Even with the 19 women with positive EST in this study, they had babies with APGAR scores of 7 or 8 at 1 minute (n = 2 and 17, respectively). All of the 19 babies had a score of 9 at 5 minutes. Prompt re-evaluation and continued surveillance and initiation of appropriate corrective measures when indicated contributed to this result.

As a complementary screening test, consideration for the sensitivity, specificity, PPV and NPV of the EST was also computed for determining fetal condition, presence of meconium staining and nuchal cord. Sensitivity is a true positive rate that measures the probability that a screening test will be positive among those who are diseased. In contrast, specificity is a true negative rate that measures the probability that a screening test will be negative among those who in fact do not have the disease. PPV is the proportion of individuals who test positively and truly have the disease. NPV is the proportion of individuals who test negatively and truly do not have the disease.[24] If the screening test is to be useful, two conditions must be met. First, the test has to provide an advantage in distinguishing between those individuals with a disease. Second, one needs to demonstrate that early identification and treatment of the disease results in some improvement: a decreased probability of dying of the disease, or increased survival, or some measurable improvement in outcome.

As for this study, EST through brisk walking serves as a good complementary test for antenatal fetal wellbeing due to the manifestation of decelerations in sick babies (80% sensitivity) or with meconium staining (75% sensitivity) or nuchal cord (75% sensitivity), which could have gone undetected if only the resting CTG was done. It also has the advantage of reinforcing such a reassuring fetal condition due to its high NPV for detecting well baby (97.8%), without a meconium stained baby (95.7%) and without cord coil (91.3%).

CONCLUSION

EST is a complementary way of assessing fetal wellbeing due to manifestation of decelerations in the post-walk CTG which could have gone undetected if only the resting CTG was done. The EST had high sensitivity for detecting sick / meconium-stained / cord coil babies and has the advantage of reinforcing a reassuring fetal

condition due to its high NPV for detecting well babies.

LIMITATION

A limitation in this investigation is that fetal wellbeing measures were assessed immediately post exercise rather than during exercise because it is technologically difficult to evaluate the fetus during exercise. Our study evaluated the effect of FHR tracings but did not further assess other antenatal fetal surveillance such as biophysical profile, Doppler studies or umbilical pH since most of the subjects that entailed close antenatal monitoring were admitted and eventually delivered.

RECOMMENDATIONS

Cardiotocography after EST is not intended to replace the existing standard test (resting CTG) but serves as a complementary test to enable us clinicians to be confident on the fetal status of our patients. In the future, studies that involve different kinds of work, not just brisk walking, from housework to more strenuous exercise that can assess fetal wellbeing can be recommended.

REFERENCES

1. Grivell RM, Alfirevic Z, Gyte GM, Devane D. Antenatal cardiotocography for fetal assessment. *The Cochrane Collaboration* 2010; (1):1-47.

2. Ainsworth BE, Haskell WL, Whitt MC, et.al. Compendium of Physical Activities: an update of activity codes and MET intensities. *Medicine and Science in Sports and Exercise* 2002; 498-516.

3. Artal R, O'Toole M. Guidelines of the American College of Obsetricians and Gynecologists for exercise during pregnancy and the postpartum period. *British Journal of Sports Medicine* 2003; 37:6-12.

4. Haskell W, Lee IM, Pate RR, et.al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Medicine and Science in Sports and Exercise* 2007; 39(8):1423-34.

5. Gibbons RJ, Balady GJ, Bricker JT, et. al. ACC/AHA 2002 Guideline Update for Exercise Testing. A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Exercise Testing) 2002.

6. Ardales VB. Basic concepts and methods in research, 3rd edition. Manila:Educational Publishing House, 2008.

7. Davies GAL, Wolfe LA, Mottola MF, MacKinnon C. Joint SOGC/ CSEP Clincial Practice Guidelines: Exercise in Pregnancy and the Postpartum Period. *Canadian Journal of Applied Physiology* 2003; 28(3):329-341.

8. Wolfe LA, Mottola M. Physical Activity Readiness Medical Examination (PARmed-X) for Pregnancy. *Canadian Society for Exercise Physiology* 2013; 1-4.

9. Borg GA. Psychophysical bases of perceived exertion. *Medicine and science in sports and exercise* 1982; 14(5):377-81.

10. Macones GA, Hankins GDV, Spong CY, Hauth J, Moore T. The 2008 National Institute of Child Health and Human Development Workshop Report on Electronic Fetal Monitoring Update on Definitions, Intepretation, and Research Guidelines. *The American College of Obstetricians and Gynecologists* 2008; 112(3):661-666.

11. Parer JT, Ikeda T, King TL. The 2008 National Institute of Child Health and Human Development Report on Fetal Heart Monitoring. *American College of Obstetricians and Gynecologists* 2009; 114 (1):136-138.

12. Macphail A, Davies GAL, Victory R, Wolfe LA. Maximal Exercise Testing in Late Gestation: Fetal Responses. *The American College of Obstetricians and Gynecologists* 2000; 96(4):565-570.

13. Jackson M, Holmgren CM, Esplin MS, Henry E, Varner MW. Frequency of Fetal Heart Rate Categories and Short-Term Neonatal Outcome. *American College of Obstricians and Gynecologists* 2011; 118(4):803-808.

14. Eden RD, Seifert LS, Kodack LD, Trofatter KF, Killam AP, Gall SA. A Modified Biophysical Profile for Antenatal Fetal Surveillance. *American Collee of Obstetricians and Gynecologists*. 1988; 71(3):365-369.

15. Meis PJ, Hobel CJ, Ureda JR. Late meconium passage in labor - a sign of fetal distress?. *Obstetrics and Gynecology* 1982; 59(3):332-335.

16. Alchalabi H, Abu-Hejia AT, El-Sunna E, AS Meconium-stained amniotic fluid in term pregnancies - A clinical view. *Journal of Obstetrics and Gynecology* 1999; 19(3):262-264.

17. Ziadeh SM, Sunna E. Obstetric and perinatal outcome of pregnancies with term labour and meconium stained amniotic fluid. *Archives of Gynecology and Obstetrics*. 2000; 264(2):84-87.

18. Wong SF, Chow K, Ho LC. The relative risk of 'fetal distress' in pregnancy associated with meconium stained gestation. *Journal of Obstetrics and Gynecology* 2002; 22(6):594-599.

19. Mahomed K, Nyoni R, Masona D. Meconium staining of the liquor in a low risk population. *Pediatric and Perinatal Epidemiology* 1994; 8(3):292-300.

20. NICE guidelines. Intrapartum care of health women and their babies during childbirth. *Royal College of Obsetricians and Gynecologists* 2007; 208-215.

21. Hasegawa J, Matsuoka R, Ichizuka K, Nakamura M, Sekizawa A, Okai T. Do FHR deceleration patterns during labor differ between various umbilical cord abnormalities?. *Journal of Perinatal Medicine* 2009; 37(3):276-280.

22. Unmesh BN, Ashok SM. Study of length of umbilical cord and fetal outcome: A study of 1,000 deliveries. T*he Journal of Obsterics and Gynecology of India* 2012; 62(5):520-525.

23. Ananth CV, Chauhan SP, Chen HY, D'Alton ME, Vitnzileos AM. Electronic Fetal Monitoring in the United States: temporal trends and adverse perinatal outcomes. *American College of Obstetricians and Gynecologists* 2013; 121(5):927-933

24. Rothman KJ, Greenland S, Lash TL. Modern Epidemiology, 3rd ed. USA: Lippincott Williams & Wilkins, 2008.