Validity Of Cardiotocography In The Diagnosis Of Acute Fetal Hypoxia In Low Resources Settings

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Citation

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Abstract

Objective: To evaluate the validity and reliability of CTG in diagnosis of acute fetal hypoxia and to determine the influence on the rate of performing cesarean section in low resources settings.
Background: Acute foetal hypoxia is one of the most serious pathological conditions in the prenatal and perinatal periods, It is routinely diagnosed by cardiotocography (CTG). However, it often gives false positive results which may be an indication for caesarean section
Patients and Methods: This prospective study on 100 pregnant females, at Ain Shams University Maternity Hospital who delivered by caesarean section because of pathological or suspected pathological CTG findings suggestive of fetal hypoxia, Cord blood sample was immediately taken after birth to determine its pH , 1-min and 5-min Apgar score had been assessed by the neonatologist and need for NICU admission was recorded, the neonates were then divided into acidosis group with pH value lower than 7.2 and normal group with pH value equivalent to or more than 7.2.Results: Of the included women in this study 52% had suspicious CTG, while 48% had pathological CTG. The acidosis group comprised only 34% of their neonates, while 66% had normal cord blood pH, there was a significant positive correlation between cord blood pH and Apgar scores at 1 and 5 minutes., neonatal outcomes of Pathological and suspected pathological cardiotocographs were statistically significant regarding 1-min Apgar scores ≤ 4 and cord blood pH < 7.2, but insignificant regarding 5-min Apgar score and need for NICU admission, Also according to the results of the study; Baseline bradycardia, abnormal beat to beat variability, atypical variable decelerations, late decelerations and pathological (rather than suspicious) traces significantly increased the risk of fetal hypoxia and subsequent fetal acidosis. Conclusion: The study concluded that fetal monitoring using cardiotocography is associated with a high number of false positive results and subsequent surgical intervention was probably not necessary. Thus, using of fetal heart rate abnormalities alone as a measure of diagnosis of fetal distress during labour is a contributing factor of rising rate of cesarean sections.

INTRODUCTION

Acute fetal hypoxia is one of the most serious pathological conditions in the intrapartum period and is a major risk factor for significant neonatal mortality and morbidity 1.It can present as lack of oxygen, metabolic acidosis or impaired organ function as a result of cascade of events over time. 2

The fetus depends on the mother for placental exchange of oxygen and carbon dioxide. This in turn relies on adequate maternal blood gas concentrations, uterine blood supply, placental exchange and fetal gas transport. Disruption of one of these factors may lead to fetal hypoxia , and so the causes of acute fetal hypoxia and subsequent acidosis include reduced utero-placental blood flow, placental abruption or continous fetal cord compression. The consequences of acidosis depend on its severity and duration and also the state of the fetus before the insult 3

On current evidence, it is estimated that in about 10% of brain damaged infants, the cause is hypoxia during labour 4, the Pathophysiology of this hypoxic brain damage include potassium channel activation, enhanced release of excitoxic amino acids, activation of NMDA (N-Methyl-D-aspartate) receptors, formation of free oxygen radicals and gene induction 5

In the 1970s, CEFM (Continous electoronic fetal monitoring) was introduced in the belief that it would improve the detection of fetal hypoxemia and reduce cerebral palsy and perinatal mortality, particularly in high risk pregnancies6. By the early 1990s, more than 75 percent of birth attendants had switched from intermittent auscultation to CEFM and by 2003 it was used in up to 85% of deliveries7. However, this widespread use wasn't supported by scientific evidence of efficacy in preventing

most of perinatal morbidities 8.

When compared with intermittent auscultation of FHR, continuous electronic FHR monitoring is associated with a reduction in the risk of neonatal seizures at the expense of an increased risk of cesarean delivery9, Irrespective of the method used to analyze fetal heart rate when anomalies are detected, metabolic acidosis induced by anoxia is an indispensable element for assessing severity. 10

After birth, the degree of hypoxia can be assessed indirectly utilising two approaches: subjectively, neonatolgist examination (Apgar score determination) and objectively by analysis of umbilical artery blood sample. 1

Apgar score at 1 and 5 minutes is a poor predictor of long term neurological outcome.4 Evidence of a metabolic acidosis at birth with pH<7.00 is one of the essential criteria tsufficient to cause cerebral palsy, while Apgar score of 0-3 beyond 5 minutes is non specific to asphyxial insult but only suggests intrapartum timing 4,11

Careful interpretation of FHR patterns could be a useful screening test for fetal asphyxia; however, supplementary tests are required to confirm the diagnosis and to identify the large number of false positive patterns to avoid unnecessary intervention.12,13

PATIENTS AND METHODS

This was an observational prospective study included 100 pregnant women, recruited from observation and labour wards at Ain Shams University Maternity Hospital in the period from June 2009 to March 2011. The study was approved by the Ethics Committee of Ain Shams University Maternity Hospital, Cairo, Egypt in accordance with local research governance protocols. Informed and written consent was obtained from each participant.

Women were selected from those who underwent electronic fetal monitoring because of medical or obstetric causes categorizing them as a high risk pregnancy e.g. Antepartum hemorrhage, pre-labour rupture of membrane, pregnancy associated with medical disorders...etc , women who delivered by CS based upon the presence of pathological or suspected pathological CTG findings suggestive of fetal hypoxia were included in the study while normal CTG findings and delivery by vaginal route are considered as exclusion criteria for this study.

After admission of patients full history was taken followed by General, Abdominal and Vaginal examination, Ultrasonography was done to detect placental position, assessment of amount of liquor and fetal weight and confirmation of post maturity.

Then every selected patient had fetal assessment using electronic fetal monitoring by CTG

According to NICE (National Institute of Clinical Excellence) guidelines based on baseline rate, variability, decelerations and accelerations, the trace may be:

 Normal; all four features are reassuring.

 Suspicious; one of the features is non-reassuring.

 Pathological; two or more non-reassuring features or one or more abnormal feature.14

Cord blood sample was taken after birth and before placenta was delivered then it was sent to the labouratory to determine its pH , 1-min and 5-min Apgar score was assessed by the neonatologist. The newborn weight was recorded together with the number of cases admitted to NICU (neonatal intensive care unit) along with the reason for admission.

Neonates were classified according to values of their blood pH into two groups:

- Acidosis group; with pH lower than 7.2
- Normal group; with pH more than 7.2

Statistical analysis was performed using Microsoft® Excel® version 2010 and Statistical Package for Social Sciences (SPSS®) for Windows® version 15.0. Measured variables were expressed in descriptive statistics in terms of range, mean and standard deviation (for parametric variables), range, median and interquartile range (for non-parametric variables), number and percentage (for categorical variables). Difference between two independent groups was estimated using continuity-corrected chi-squared test. Correlation between two metric variables was estimated using Pearson's correlation coefficient. Association between two dichotomous variables was estimated using binary logistic regression analysis; the outcome was in terms of relative risk (RR) and its 95% confidence interval (95% CI). Validity of variable(s) as predictor of certain outcome was expressed in terms of sensitivity, specificity, predictive values and overall accuracy. Significance level was set at 0.05.

Sample Size:

Sample size was calculated using EpiInfo® version 6.0, setting the type-1 error ( ) at 0.05 and the power (1-) at 0.8. Data from previous study 15 showed that the positive predictive value of suspicious and pathological traces of CTG for fetal acidemia were 17% and 100%, respectively. Calculation according to these values produced a minimal sample size of 47 cases in each group in order to find such a difference. Therefore, 100 women were recruited in the current study.

RESULTS

The mean age of included women was 26.94±6.23 years (range: 17-42 years). The median parity was 1 (range: 0-5). The median number of previous miscarriages was 0 (range: 0-5). The mean gestational age was 38.41±2.65 weeks (range: 29-42.14 weeks).

Of the included women in this study 52% had suspicious CTG, while 48% had pathological CTG (table 1). The mean cord blood pH was 7.24 ± 0.07 (range: 7.05 – 7.39). The acidosis group comprised only 34% of their neonates, while the resting 66% had normal cord blood pH.(table 2)

Table 1

Features and Category of CTG in Included Women

Baseline fetal heart rate	
Normal:	82 (82%)
Baseline bradycardia:	1 (1%)
Baseline tachycardia:	17 (17%)
Variability	
Reassuring:	31 (31%)
Non-reassuring:	14 (14%)
Abnormal:	55 (55%)
Accelerations	
Present:	6 (6%)
Absent:	94 (94%)
Decelerations	
Absent:	47 (47%)
Present:	53 (53%)
Early:	1 (1%)
Late:	15 (15%)
Variable:	37 (37%)
Typical:	22 (22%)
Atypical:	15 (15%)
Special pattern	
Sinusoidal pattern:	2 (2%)
NICE Category of CTG	
Suspicious:	52 (52%)
Pathological:	48 (48%)

Data presented as number (percentage)

Table 2

Neonatal Cord Blood pH in Included Women

Cord Blood pH	
Range:	7.05 – 7.39
Mean ± SD:	7.24 ± 0.07
Cord Blood pH	
≥ 7.2:	66 (66%)
< 7.2:	34 (34%)

Data presented as range, mean ± SD or number (percentage)

Table 3 shows that Neonatal Outcome in women with Pathological and suspected pathologiacal cardiotocographs were statistically significant regarding 1-min Apgar ≤ 4 and cord blood pH < 7.2 [p=0.02, 0.002, respectively], but insignificant regarding 5-min Apgar score and need for NICU admission [p=0.423, 0.274, respectively]

Table 3

Neonatal Outcome in Included Women Categorized according to CTG NICE Category

	Women who Had Pathological CTG [n=48]	Women who Had Suspicious CTG [n=52]	P*
1-min Apgar Score			
≤ 4	14 (29.2%)	5 (9.6%)	0.02
> 4	34 (70.8%)	47 (90.4%)	S
5-min Apgar Score			
≤ 6	4 (8.3%)	2 (3.8%)	0.423
> 6	44 (91.7%)	50 (96.2%)	NS
Cord Blood pH			
Abnormal(< 7.2)	24 (50%)	10 (19.2%)	0.002
Normal (≥ 7.2)	24 (50%)	42 (80%)	S
Need for NICU Admission			
Yes	16 (33.3%)	12 (23.1%)	0.274
No	32 (66.7%)	40 (76.9%)	NS

Data presented as number (percentage)
* Analysis using Continuity-Corrected Chi-Squared Test
S significant – NS non-significant

There was a significant positive correlation between cord blood pH and Apgar scores at 1 and 5 minutes (r=0.638, p<0.001; r=0.452, p<0.001; respectively) figures (1, 2). There were no significant correlation between cord blood pH and each of gestational age, baseline fetal heart rate and birth weight.

Figure 1

Scatter-Plot showing Correlation between Cord Blood pH and 1-min Apgar Score.

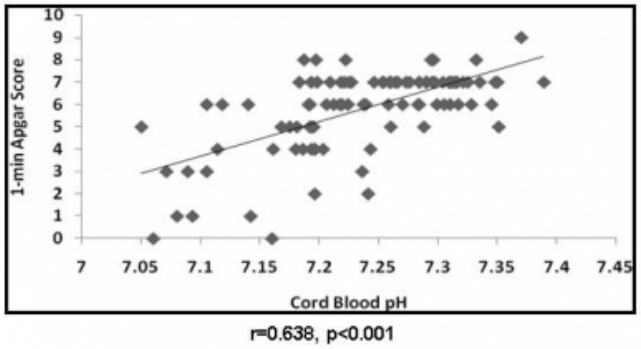

Figure 2

Scatter-Plot showing Correlation between Cord Blood pH and 5-min Apgar Score

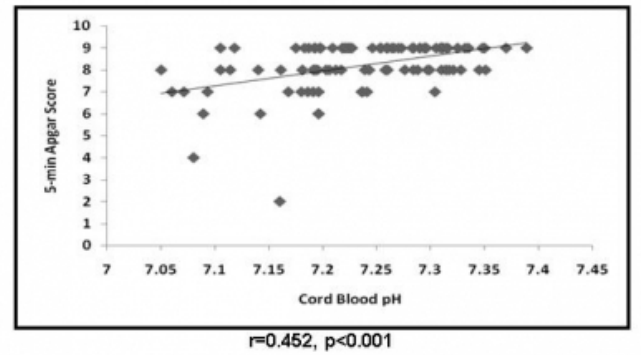

Table 4 shows Binary logistic regression analysis of different features of CTG as predictor of abnormal cord blood pH

(< 7.2) Baseline bradycardia significantly increased the risk of abnormal cord blood pH almost 3-folds [RR 3.2, 95% CI (2.29 to 4.33)]., Abnormal beat-to-beat variability significantly increased the risk of abnormal cord blood pH almost 2-folds [RR 2.35, 95% CI (1.08 to 5.09)], Late decelerations significantly increased the risk of abnormal cord blood pH almost 7-folds [RR 7.1, 95% CI (3.86 to 12.3)], Presence of atypical variable decelerations significantly increased the risk of abnormal cord blood pH almost 2-folds[RR 1.9, 95% CI (1.1 to 3.27)], Pathological (rather than suspicious) CTG significantly increased the risk of abnormal cord blood pH almost 2.5-folds[RR 2.6, 95% CI (1.39 to 4.85)]., Neither of other features was significantly associated with abnormal cord blood pH.

Table 4

Association between Different Features of CTG and Abnormal Cord Blood pH

	Abnormal Cord Blood pH	RR	95% CI
Baseline FHR **Abnormal** **Normal**	8/10 26/56	1.4	0.76 to 2.57 NS
Baseline FHR **Tachycardia** **Normal**	7/10 26/56	1.3	0.68 to 2.49 NS
Baseline FHR Bradycardia Normal	1/0 26/56	3.2	2.29 to 4.33 S
Variability **Non-Reassuring** **Normal**	3/11 6/25	1.11	0.32 to 3.8 NS
Variability **Abnormal** **Normal**	25/30 6/25	2.35	1.08 to 5.09 S
Accelerations **Absent** **Present**	33/61 1/5	2.1	0.35 to 12.87 NS
Early Decelerations **Present** **Absent**	0/1 34/65	NE	NE
Late Decelerations **Present** **Absent**	10/5 24/61	7.1	3.86 to 12.3 S
Typical Variable Decelerations **Present** **Absent**	5/17 20/43	0.7	0.31 to 1.68 NS
Atypical Variable Decelerations **Present** **Absent**	9/6 20/43	1.9	1.1 to 3.27 S
Sinusoidal Pattern of CTG **Present** **Absent**	2/1 32/65	2.03	0.25 to 12.23 NS
NICE Category of CTG **Pathological** **Suspicious**	24/24 10/42	2.6	1.39 to 4.85 S

RR relative risk
95% CI: 95% Confidence Interval for the RR
NS non-significant association – S significant association – NE not estimable

Table 5 shows different features of CTG as a predictor of 1-min Apgar score ≤ 4 and and 5- min Apgar Score ≤ 6, Abnormal beat-to-beat variability significantly increased the risk of having 1-min Apgar score ≤ 4 almost 1.5-folds [RR 1.55; 95% CI (1.31to 2.59)]., Presence of late decelerations significantly increased the risk of 1-min Apgar score ≤ 4 almost 3-folds [RR 3.31; 95% CI (1.56 to 7.04)]., Pathological (versus suspicious) CTG significantly increased the risk of 1-min Apgar score ≤ 4 almost 3-folds [RR 3.03; 95% CI (1.18 to 7.81] None of other features of the CTG had significant association with 1-min Apgar score ≤ 4. While none of the features of the CTG had significant association with 5-min Apgar score ≤ 6, among the included women .

Table 5

Association between Different Features of CTG and 1-min Apgar Score ≤ 4 and 5- min Apgar Score ≤ 6

	1-min Apgar Score ≤ 4	RR	95% CI	5-min Apgar Score ≤ 6	RR	95% CI
Baseline FHR **Abnormal** **Normal**	5/13 14/68	1.62	067 to 3.94 NS	0/18 6/76	NE	NE
Baseline FHR **Tachycardia** **Normal**	5/12 14/68	1.72	0.72 to 4.15 NS	0/17 6/76	NE	NE
Baseline FHR **Bradycardia** **Normal**	0/1 14/68	NE	NE	0/1 6/76	NE	NE
Variability **Non-Reassuring** **Normal**	1/13 8/23	0.28	0.04 to 2.01 NS	0/14 2/29	NE	NE
Variability **Abnormal** **Normal**	22/33 8/23	1.55	1.31 to 2.59 S	4/51 2/29	1.13	0.219 to 5.81 NS
Accelerations **Absent** **Present**	18/76 1/5	1.15	0.18 to 7.21 NS	6/88 0/6	NE	NE
Early Decelerations **Present** **Absent**	0/1 19/80	NE	NE	0/1 6/93	NE	NE
Late Decelerations **Present** **Absent**	7/18 12/73	3.31	1.56 to 7.04 S	2/13 4/81	2.83	0.57 to 14.08 NS
Typical Variable Decelerations **Present** **Absent**	3/19 11/52	0.78	0.24 to 2.54 NS	0/22 4/59	NE	NE
Atypical Variable Decelerations **Present** **Absent**	5/10 11/52	1.91	0.78 to 4.67 NS	5/10 11/52	1.19	0.78 to 4.67 NS
Sinusoidal Pattern of CTG **Present** **Absent**	0/2 19/79	NE	NE	0/2 19/79	NE	NE
NICE Category of CTG **Pathological** **Suspicious**	14/34 5/47	3.03	1.18 to 7.81 S	4/44 2/50	2.17	0.42 to 11.24 NS

RR relative risk
95% CI: 95% Confidence Interval for the RR
NS non-significant association – S significant association – NE not estimable

Table-6. Shows that none of the features of the CTG had significant association with NICU admission, among the included women.

Table 6

Association between Different Features of CTG and NICU Admission

	NICU Admission	RR	95% CI
Baseline FHR **Abnormal** **Normal**	6/12 22/60	1.24	0.38 to 1.69 NS
Baseline FHR **Tachycardia** **Normal**	5/12 22/60	1.09	0.69 to 2.49 NS
Baseline FHR **Bradycardia** **Normal**	1/0 22/60	NE	NE
Variability **Non-Reassuring** **Normal**	6/8 7/24	1.89	0.78 to 4.62 NS
Variability **Abnormal** **Normal**	15/40 7/24	1.21	0.55 to 2.64 NS
Accelerations **Absent** **Present**	27/67 1/5	1.72	0.28 to 10.61 NS
Early Decelerations **Present** **Absent**	0/1 28/71	NE	NE
Late Decelerations **Present** **Absent**	7/8 21/64	1.89	0.98 to 3.64 NS
Typical Variable Decelerations **Present** **Absent**	6/16 17/46	1.01	0.46 to 2.24 NS
Atypical Variable Decelerations **Present** **Absent**	5/10 17/46	1.24	0.54 to 2.81 NS
Sinusoidal Pattern of CTG **Present** **Absent**	0/2 28/70	NE	NE
NICE Category of CTG Pathological Suspicious	16/32 12/40	1.44	0.76 to 2.73 NS

RR relative risk
95% CI: 95% Confidence Interval for the RR
NS non-significant association – NE not estimable

DISCUSSION

In the present study we analysed 100 pregnant females, recruited from observation and labour ward of Ain Shams University Maternity Hospital. Theu have given birth by caesarean section due to interpretation of a pathological or suspected pathological CTG findings suggestive of fetal hypoxia. The evaluation had been based on blotting a correlation between measurement of cord blood pH after delivery and the pathological or suspected pathological findings of CTG trace before delivery.

In a Cochrane systematic review published study, the effectiveness of continuous cardiotocography during labour was evaluated compared to intermittent auscultation, women subject to continuous cardiotocography were more likely to undergo caesarean section for abnormal fetal heart rate or acidosis (RR 2.37, 95% CI 1.88 to 3.00, n = 33,379, 11 trials).16

The present study showed a high number of false positive results. Out of 100% of pathological or suspected

pathological cardiotocograms, only 34 % were valid (i.e., the infants were hypoxic after birth). The remaining 66% of infants, although their CTG findings were suggestive of fetal hypoxia, were born healthy and CS was probably not necessary .

The average pH value of umbilical artery blood was 7.24 ± 0.07 (range 7.05 - 7.39). There was a significant positive correlation between cord blood pH and Apgar scores at 1 and 5 minutes ($r = 0.638$, $p<0.001$; $r = 0.452$, $p<0.001$; respectively), There were no significant correlation between cord blood pH and each of gestational age, baseline fetal heart rate and birth weight, These results are also supported by that obtained by Hogan et al who performed a case-control study to evaluate how often low five-minute Apgar scores are associated with asphyxia. Cases were 183 term newborns with five-minute Apgar scores below seven, Controls were 183 randomly selected term newborns with five-minute Apgar scores of nine to ten. They found a strong positive correlation between low five-minute Apgar scores, abnormal cardiotocography and cord blood acidosis. They concluded that a five-minute Apgar score below four is a good proxy for asphyxia.17

In the present study, Binary logistic regression analysis of different features of CTG as predictor of abnormal cord blood pH (< 7.2) was performed. Baseline bradycardia significantly increased the risk of abnormal cord blood pH almost 3-folds [RR 3.2, 95% CI (2.29 to 4.33)]. reduced beat-to-beat variability significantly increased the risk of abnormal cord blood pH almost 2-folds [RR 2.35, 95% CI (1.08 to 5.09)]. Late decelerations significantly increased the risk of abnormal cord blood pH almost 7-folds [RR 7.1, 95% CI (3.86 to 12.3)]. Presence of atypical variable decelerations significantly increased the risk of abnormal cord blood pH almost 2-folds [RR 1.9, 95% CI (1.1 to 3.27)]. Pathological (rather than suspicious) CTG significantly increased the risk of abnormal cord blood pH almost 2.5-folds [RR 2.6, 95% CI (1.39 to 4.85)]. Neither of other features was significantly associated with abnormal cord blood pH as well as, the present study showed that neonatal outcomes of pathological and suspected pathologiacal cardiotocographs were statistically significant regarding 1-min Apgar scores ≤4 and cord blood pH < 7.2 [p=0.02, 0.002, respectively], but insignificant regarding 5-min Apgar score and need for NICU admission [p=0.423, 0.274, respectively].

The statistically significant parameters obtained by binary logistic regression analysis of different features of CTG as predictor of 1-min Apgar score ≤ 4 were abnormal beat-to-beat variability [RR 1.55; 95% CI (1.31to 2.59)], presence of late decelerations [RR 3.31; 95% CI (1.56 to 7.04)] and Pathological (versus suspicious) CTG [RR 3.03; 95% CI (1.18 to 7.81] .

CONCLUSION

Fetal monitoring using cardiotocography is associated with a considerale false positive results and subsequent surgical intervention that might have not been necessary. Thus, using of fetal heart rate abnormalities alone as a measure of diagnosis of fetal distress during labour is a contributing factor of increasing rate of cesarean sections.

Other pathological features; Baseline bradycardia, reduced beat to beat variability, atypical variable decelerations, late decelerations and pathological, rather than suspicious, CTG traces increased the risk of fetal hypoxia and subsequent fetal acidosis significantly.

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