

# The Correlation between Intra-Partum Cardiotocography (CTG) and Umbilical Cord Arterial pH in Predicting Perinatal Outcome

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**Abstract:** *Introduction:* Monitoring of fetus intrapartum is an important step for prediction of fetal distress and impending worst situations. Aim of this study is to find the correlation between the most common used techniques i.e. CTG and the less common used technique i.e. umbilical cord pH to predict fetal distress and further improve its accuracy. *Methods:* 250 women were enrolled with singleton pregnancies. CTG were classified according to NICHD 2008 guidelines. Immediate umbilical cord artery blood was sent to laboratory for testing of pH. Various analyzing factors were used to find correlation among above two. *Result:* Enrolled cases were from age group 21-30 years (82.80%), having gestational age of 37-40 weeks (79.2%). CTG category I were in 51.6% of subjects, followed by category II in 34.8% of subjects, lastly category III in 13.6% of subjects. CTG Category I only 11 (8.53%) were having acidosis; category II were 21 (24.14%) patients lastly with category III 18 (52.94%). *Conclusion:* from this study, a very important conclusion is that, intrapartum cardiotocography has good correlation with umbilical cord arterial pH for predicting neonatal outcome and can be used for screening fetuses in distress and to save the most venerable fetal hypoxia by early warning signs given by this technique.

**Keywords:** CTG, umbilical cord blood, pH, fetal monitoring.

## 1. Introduction

Monitoring of fetal wellbeing, intra-partum is witnessed a great importance in recent times. Also many of the new systems were introduced these days to monitor it most accurately, as in view of increase in litigations<sup>1</sup> for doctors and also prenatal deaths, which points towards the intra-partum stress as a cause.<sup>2</sup> Various techniques commonly used are auscultation, cardiotocography, fetal scalp stimulation test, blood analysis of fetal scalp, oxymetry of fetal pulse and fetal ST analysis. History dates back to 1958,<sup>3</sup> where it was recognized that blood gas analysis of umbilical cord can give an indication for preceding fetal hypoxic stress. Both British and American Colleges now included in guidelines that, every high risk deliveries it must be done.<sup>4,5</sup> These days CTG is routinely done in advanced care hospitals in India, usually done intermittently or continuously depending on facilities available. But in low resource settings, umbilical cord, intra-partum fetal blood and very early neonatal blood sampling can be done.<sup>6</sup> It may indicated the early hypoxic event or intra-partum acidosis, indicating infants with high risk of hypoxic sequel.<sup>7</sup>

Aim of the current study is to find out the correlation between the first technique, i.e. umbilical cord blood gas monitoring and most common used technique i.e. CTG in predicting fetal blood acidotic event and effect of it on fetus during very early neonatal period.

## 2. Materials and Methods

This study includes 250 women admitted to hospital fulfilling both exclusion and inclusion criteria's and with full consent of this study. This study was conducted in

Department of Obstetrics and Gynecology, SMGS Hospital, GMC Jammu during Nov. 2019 to Oct 2020, with institutional ethical approval.

Intra-partum CTG tracing was done and classified into 3 categories as of NICHD 2008 classification. This was in accordance to guidelines followed in India as per ACOG 2013.<sup>8,9</sup> In this study we classify enrolled cases in three categories- a. Normal (category-I), b. Indeterminate (category-II) and Abnormal (category-III).

Pre heparinized syringe was used to collect umbilical cord blood, immediately after birth and sent for analysis to detect acidosis. Ph > or equal to 7.2 was considered as normal but < 7.2 was considered as acidosis.

$n = Z^2 \times (p) \times (1-p) / \Delta^2$  this formula used for calculation of sample size. For  $Z = 1.96$  at 95% and  $\Delta$  is 0.05 for  $\pm 5\%$  and incidence from previous studies were 19.4% the sample size came to be 240. But we have included 250 women with single fetus in this study.

Inclusion criteria was-women age 18-45 years, with single fetus, at gestational age >34 weeks, in labor and cephalic presentation. Only cases with full consent in patient's own language were included.

Exclusion criteria was-preterm premature rupture of membranes, multi-fetal gestation, mal-presentation, congenital anomalies, diagnosed fetal growth restriction, documented abnormal umbilical doppler study, ante-partum hemorrhage, elective caesarean sections and women refusing to participate in the study.

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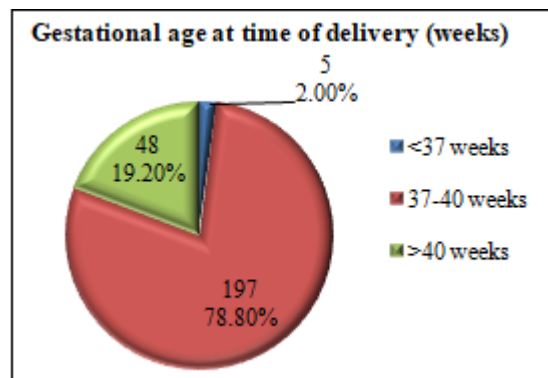
Process-demographic details, Obstetrical history and examination was done for patient of admission. Labor monitoring was done closely. Apgar score at t = 1 min and t = 5 min were record. CTG was done with Philips EF monitor machine (as per hospital facility). Records were taken at speed of 3 cm/min for 20 min on admission, membrane rupture and during active labor (>4cm dilatation) every two hours till successful outcome. If stress was seen then interval was reduced to 1 hour for every repetition. For blood analysis, sample of 2 to 3 ml was taken before baby's first breath and before placental delivery but after Kocher's clamping as per the guidelines<sup>10</sup>. Sample collected was sent to laboratory for analysis within 5 minutes of retrieving it.

Statistical analysis-Categorical variables were presented in number and percentage (%) and continuous variables were presented as mean ± SD and median. Qualitative variables were associated using Chi-Square test/Fisher's Exact test. Sensitivity, specificity, PPV and NPV were calculated for category 3 for predicting acidosis. A p value of <0.05 was considered statistically significant. The data was entered in MS EXCEL® spreadsheet and analysis was done using Statistical Package for Social Sciences (SPSS) version 21.0.

### 3. Results

This is an observational prospective study conducted on 250 pregnant female patients admitted to the labour room and delivered here on the same hospital. Following are the observations made from the excel sheet prepared from the observations of the current study population. Most of the enrollments were from age group 21-30 years, 207(82.80%), followed by >30 years (10%) and least <20 years (7.20%). Mean ± SD 25.73 ± 3.8 i.e., mean age was 25 years and 8 months, with median (IQR) is 25 (23-28), ranging 19 to 38 years.

The on analysis of obstetrics parameters we found, maximum females were primigravida (130; 52%) and rest were multigravida (120; 48%). Maximum number of patients were 37-40 weeks gestational age (198; 79.2%) followed by > 40 weeks (48; 19.2%) and < 37 weeks ( 5; 2%). Mean ± Standard Deviation was 39.04 ± 1.1 weeks and range was 35.57 ± 41.57 weeks.



82.4% (206) were delivered vaginally and 17.6% (44) required caesarean section. Electronic fetal heart monitoring was done according to standard definitions available in various guidelines for it<sup>11</sup> and the following results were observed-Table-1

**Table 1:** Distribution of CTG of study subjects

CTG	Frequency	Percentage
<b>Intrapartum FHR</b>		
Normal	227	90.80%
Bradycardia	20	8.00%
Tachycardia	3	1.20%
<b>Beat to beat variability</b>		
Absent	34	13.60%
Marked	4	1.60%
Minimal	80	32.00%
Moderate	132	52.80%
<b>Acceleration</b>		
Absent	132	52.80%
Present	118	47.20%
<b>Decelerations</b>		
Absent	206	82.40%
Early	5	2.00%
Late	10	4.00%
Prolonged	4	1.60%
Variable	25	10.00%
<b>Category</b>		
I	129	51.60%
II	87	34.80%
III	34	13.60%

Most of the patients in this study were under CTG category 1 (129; 51.6%) followed by category 2 (87; 34.8%) and only 34 (13.6%) were under category 3. 8% had bradycardia, 1.2% had tachycardia, 47.2% had abnormal beat to beat variability. Of these, 13.6% had absent beat to beat variability, 32% had minimal (<5bpm), 1.6% had marked (>25bpm) beat to beat variability and 52.8% had normal variability. 52.8% had no accelerations and 17.6% had decelerations. Of them, 2% had early decelerations, 4% late decelerations, 10% variable decelerations and 4% had prolonged decelerations.

As we further explored the data we found the association of delivery with CTG categories as follows-Table 2

**Table 2**

Mode of delivery	Cat-I (n=129)	Cat -II (n=87)	Cat -III (n=34)	Total	P value	Test Performed
LSCS	2 (1.55%)	8 (9.20%)	34 (100%)	44 (17.60%)	<.0001	Fisher Exact test
Vaginal	127 (98.45%)	79 (90.80%)	0 (0%)	206 (82.40%)		
Total	129 (100%)	87 (100%)	34 (100%)	250 (100%)		

In category I women, 98.45% were delivered vaginally and 1.55% by LSCS. In category II, 90.8% delivered vaginally and 9.2% by LSCS. In category III, all were delivered by LSCS. Results were highly significant with P value < 0.001. Caesarean sections were due to fetal distress (category 2&3). Rest caesarean sections were for maternal indications.

Maximum newborns were between 2.5 to 3.5 kg (90.80%) followed by 8% <2.5 kg and 1.2% >3.5 kg. Apgar score <7 at 1 min was observed in 38(15.2%) and >= 7 at 1 min was seen in 212(84.8%) newborns while Apgar score < 7 at 5

min was observed in 3(1.2%) and >=7 at 5 min was seen in 247(98.8%) newborns.

The most important parameter of the study was measurement of pH of cord arterial blood in new born. We found that 80% of the subjects were in category >=7.2 but 20 % were below 2.3 with Mean ± SD 7.25 ± 0.1, and range of 7.13-7.6. As we compare the two most important parameters i. e CTG outcomes in relation to acidosis, results observed were highly significant in each category, table-3

Table 3

CTG	pH <7.2 (n=50)	pH >=7.2 (n=200)	Total	P value	Test Performed
<b>Intrapartum FHR</b>					
Normal	38 (16.74%)	189 (83.26%)	227 (100%)	0.0002	Fisher Exact test
Bradycardia	11 (55%)	9 (45%)	20 (100%)		
Tachycardia	1 (33.33%)	2 (66.67%)	3 (100%)		
<b>Beat to beat variability</b>					
Absent	18 (52.94%)	16 (47.05%)	34 (100%)	<.0001	Fisher Exact test
Moderate	12 (9.10%)	120 (90.90%)	132 (100%)		
Minimal	18 (22.50%)	62 (77.50%)	80 (100%)		
Marked	2 (50%)	2 (50%)	4 (100%)		
<b>Acceleration</b>					
Absent	39 (29.55%)	93 (70.45%)	132 (100%)	<.0001	Chi square test,15.926
Present	11 (9.32%)	107 (90.68%)	118 (100%)		
<b>Decelerations</b>					
Absent	34 (16.50%)	172 (83.50%)	206 (100%)	0.004	Fisher Exact test
Early	0 (0%)	5 (100%)	5 (100%)		
Late	3 (30%)	7 (70%)	10 (100%)		
Prolonged	1 (25%)	3 (75%)	4 (100%)		
Variable	12 (48%)	13 (52%)	25 (100%)		
<b>Category</b>					
I	11 (8.53%)	118 (91.47%)	129 (100%)	<.0001	Chi square test,34.602
II	21 (24.14%)	66 (75.86%)	87 (100%)		
III	18 (52.94%)	16 (47.06%)	34 (100%)		

CTG category I only 11 (8.53%) were having acidosis, followed by category II with acidosis were in 21 (24.14%) patients lastly with category III 18 (52.94%) were having acidosis.

On further analyze of the data, the results were astonishing. With increase in CTG category there was increase in the diagnostic accuracy of cord arterial blood pH (table-4).

Table 4

Cord Arterial blood pH>=7.2	Category 1	Category 2	Category 3	Category 3(2+3)
Sensitivity(95% CI)	59% (51.84% to 65.89%)	65.62% (46.81% to 81.43%)	36% (22.92% to 50.81%)	78% (64.04% to 88.47%)
Specificity(95% CI)	78% (64.04% to 88.47%)	64.13% (56.74% to 71.05%)	92% (87.33% to 95.36%)	59% (51.84% to 65.89%)
AUC(95% CI)	0.69(0.62 to 0.74)	0.65(0.58 to 0.71)	0.64(0.58 to 0.70)	0.69(0.62 to 0.74)
Positive Predictive Value (95% CI)	91.47% (85.25% to 95.67%)	24.14% (15.60% to 34.50%)	52.94% (35.13% to 70.22%)	32.23% (24.02% to 41.33%)
Negative Predictive Value (95% CI)	32.23% (24.02% to 41.33%)	91.47% (85.25% to 95.67%)	85.19% (79.73% to 89.64%)	91.47% (85.25% to 95.67%)
Diagnostic accuracy	62.80%	64.35%	80.80%	62.80%

4. Discussion

Aim of this paper is to evaluate the relation between CTG and umbilical cord arterial blood pH for early detection of fetal distress. As we know the world is advancing fast in the manufacturing of electric device<sup>12</sup>, but it is also increasing the cost of patient treatment.<sup>13</sup> So the countries where the resources are scarce we need to find and evaluate other cheap, easy and instant methods to evaluate the fetus which are under distress, so that it can give a warning to

gynecologist and pediatrician for impending doom. Hence we are presenting this paper for awareness and importance of umbilical artery pH as indicator for fetal distress, especially the places where continuous CTG monitoring is not available or where intermittent manual auscultation<sup>14</sup> is done these days for intra-partum fetal monitoring.

This present study was conducted carefully in a tertiary care hospital also points towards use of arterial blood pH of umbilical cord in all settings. It was conducted on 250

patients presented to the hospital since October 2020. In this study, 51.6% of subjects had Category I (normal) CTG tracings, 34.8% had Category II (indeterminate) CTG tracings, 13.6% had Category III (abnormal) intrapartum CTG tracings, nearly similar to the a study conducted by Ray C et al.<sup>15</sup> having results of 50.2% had category I, 36.5% category II & 13.3% had category III CTG tracings. But different from Nikita V et al<sup>16</sup>, and Nainani R et al<sup>17</sup> having higher percentage of category I (77% and 67%), category II (20% and 27%) and category III (3% and 6%). This can be explained on the basis as we were conducting this study in tertiary care hospital have more of referred and complicated cases. Secondly, CTG vary in sensitivity and specificity with the operator experience hence can make difference in the values of detection.

In this paper, the fetal heart rate (FHR) was recorded 90.8% in normal category, 8% of the patients were having bradycardia and 1.2% tachycardia. The results of this paper were nearly similar to the studies conducted by Aboulghar W et al<sup>18</sup> and Ray C et al<sup>15</sup>. But little different in study conducted in 2019 by Shuffrey et al.<sup>19</sup> The reason behind the nearly similar results was, the dedicated range of variability in each category is so wide that only few outlines were left over. There are well known factors already studied<sup>20</sup> which indicate variability in this study most dominant was fetal distress.

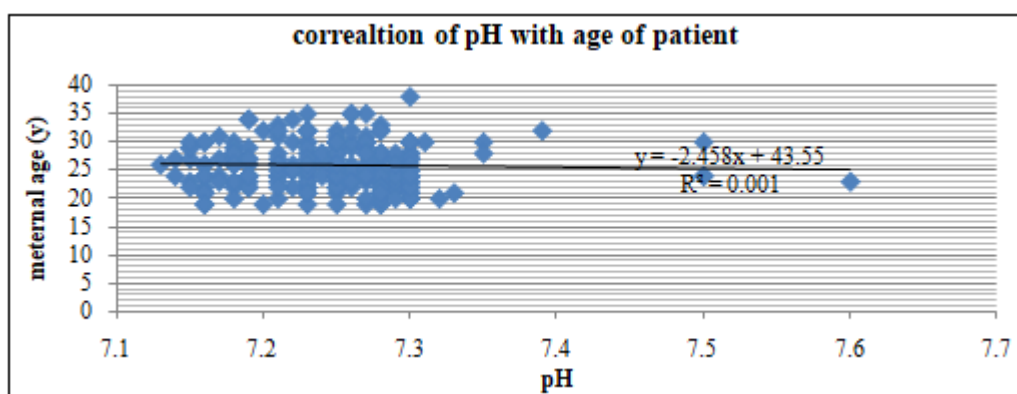
In this study as we explore the data, beat-to-beat variability was abnormal in 47.2% of cases. On further exploration, 32% were having minimal variability followed by 13.6% with absent variability and 1.6% with increased variability. Results were nearly similar to a study by Ray C et al<sup>15</sup> but little lower than the study by Aboulghar W et al<sup>18</sup>, which were 45.8% and 55% respectively. This difference can be explained by many reasons but one of the predominant was the detection sensitivity of the CTG module used by the machine and second can be the correct placement of the probe, lastly the training level of the doctors and nursing staff using the CTG machine.

In present study accelerations were recorded in 47.2% of cases and decelerations were recorded in 17.6% of cases. Results were nearly same to a study<sup>15</sup> conducted in hospital of Jharkhand, India (54.8% accelerations), but very opposite to study in Egypt indicated only 6% of accelerations but 53% of decelerations. CTG decelerations were in 14.25% a study conducted by Modarressnejad V et al.<sup>21</sup> The huge variability in bot accelerations and decelerations can be only explained by the reason, the presenting condition of patient, usually in such cases the deliveries were un-booked and were also presented late to emergency department, sometime the referred cases were also there from the peripheral regions.

In the present study, mean cord arterial blood pH was  $7.25 \pm 0.1$ . This is nearly comparable to several studies. Kaban A et al<sup>10</sup> was pH  $<7.2$ , Modarressnejad V et al<sup>21</sup> defined fetal acidosis as pH  $<7.1$ , Nainani R et al<sup>17</sup> mean pH was  $7.18 \pm 0.08$  ( $p=0.000$ ), Dellinger EH et al<sup>22</sup> observed lower mean pH in all  $7.06 \pm 0.14$  in pathological NST;  $p<0.05$ . As with the differences in the regions of studies the cut of values were defined by the physicians experience rather than any specific guidelines. There are no specific guidelines in such context hence the variability is there. In this present study the pH ( $<7.2$ ) was recorded in 20% cases nearly similar to study by Modarressnejad V et al<sup>21</sup> and meta-analysis<sup>23</sup> published in 2010 but different in Aboulghar W et al<sup>18</sup>, incidence of acidosis was higher, with 34% of babies having abnormal cord blood pH. This higher value of acidosis in the neonates could be explained by the fact that their study included only those women who had undergone caesarean section for pathological and suspicious CTG

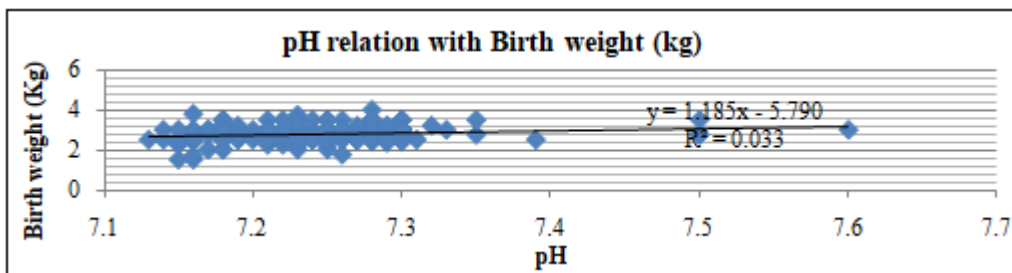
On statistical analysis, there was an interesting finding, the co-relation between-

- the correlation of arterial blood pH of the cord with maternal age and its variability so,  $R^2$  has a value of 0.001 or 0.1% indicating both the factors are independent, hence there is no effect of maternal age on arterial blood pH of the cord.



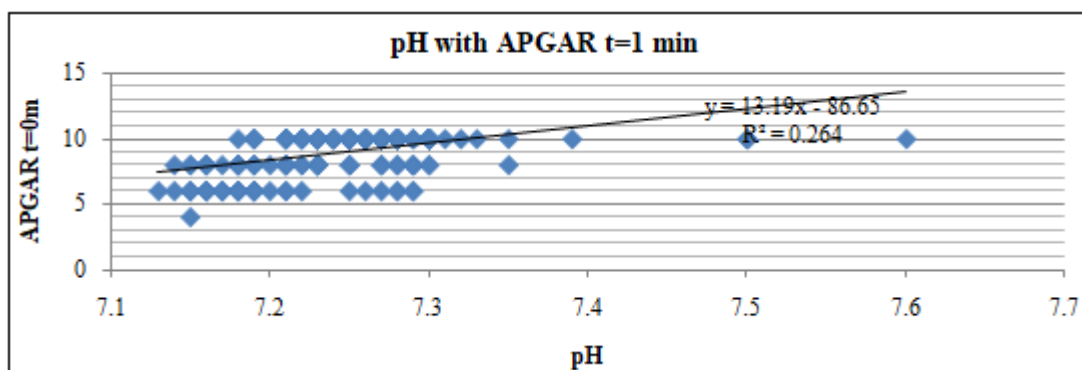
- The correlation of arterial blood pH of the cord with birth weight of new born and its variability so,  $R^2$  has a value of 0.033 of 3.3% indicating weak relation

between the two. Hence we need further studies to evaluate such with huge number of cases two.



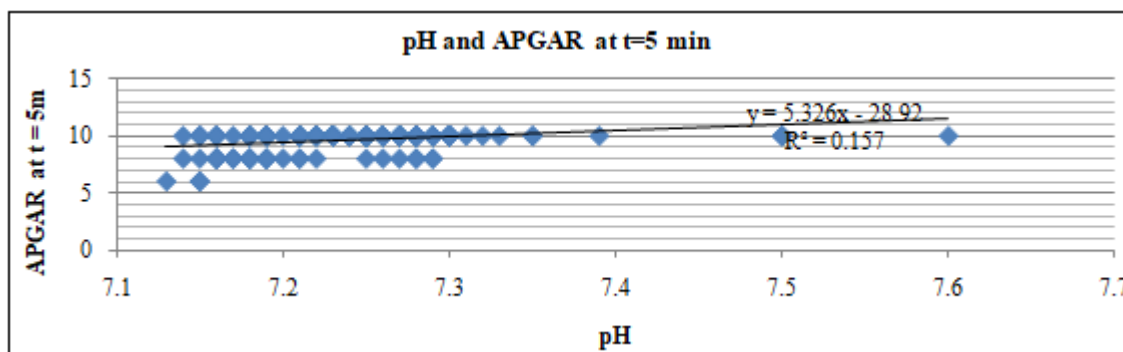
c) The correlation of arterial blood pH of the cord with APGAR score at t=1 min of new born and its variability so,  $R^2$  has a value of 0.260 or 26% indicating moderate

to weak relationship between the two. Hence APGAR score can affect the pH values.



d) The correlation of arterial blood pH of the cord with APGAR score at t=5 min of new born and its variability so  $R^2$  has a value of 0.157 or 15% indicating that with

improvement of APGAR score the relation between two variables disappear or become weak.



As we evaluate APGAR score at birth and after 5 min, indicates correlation between the two. Various studies<sup>24, 25</sup> also evaluated such in past, indicating if cord pH is evaluated with APGAR score it will more correctly predict neonate suffered from birth asphyxia and also the short term prognosis with indication on high risk jeopardized baby.

In this study, 52.94% of the cases with category III (abnormal) CTG had acidosis, 24.14% cases with category II (indeterminate) CTG had acidosis and only 8.53% of the subjects with category I (normal) CTG had acidosis. There is a significant association between type of CTG and cord blood pH. This data clearly indicates that there is increase in risk of having abnormal pH if the CTG category was III>II>I. These values were comparable to studied by Aboulghar W et al<sup>18</sup> in 2013 and by Ray C et al<sup>15</sup> in 2017. Hence the findings clearly indicate that, if the cord blood pH is performed it will give better indication of fetal distress and impending fetal distress. So that proper steps can be taken as soon as possible for fetal wellbeing.

Category III of CTG had sensitivity of 36% and specificity of 92% in detecting acidosis, and because of its high specificity it had a good ability to identify those who did not have acidosis. Had a positive predictive value (PPV) of 52.94% but negative predictive value (NPV) of 85.19%. Diagnostic accuracy of an abnormal CTG in diagnosing fetal acidosis was 80.8%, but if combined with pH values may increase upto 88%<sup>26</sup>

This study also found that an indeterminate CTG had sensitivity of 65.62% and specificity of 64.13% in detecting acidosis, overall accuracy was 24.14% but when combined with pH values may increase upto 44%<sup>26</sup>

However, when we combine above two, they were shown to have a sensitivity of 78% and specificity as 59% in detecting acidosis. PPV and NPV were 32.23% and 91.47% respectively. It meant that in the absence of an abnormal or an indeterminate CTG, there was very less chance of having

a fetus with acidosis but on combination with pH values of fetal umbilical artery NPV can reach up to 94%<sup>26</sup>.

Hence, combining the CTG with pH values of fetal umbilical artery is always beneficial both for neonate, gynecologist and pediatrician for a successful outcome.

Lastly, in this study, normal CTG had a sensitivity, specificity, PPV and NPV of 59%, 78%, 91.47% and 32.23% respectively, for diagnosing normal cord blood pH and diagnostic accuracy of 62.8%. Meaning that a normal CTG can accurately detect babies without acidosis. There was minor possibility of fetus having acidosis with normal CTG values. These findings were nearly similar to study conducted<sup>27</sup> Parveen S et al.

Fewer studies like Nainani R et al<sup>17</sup> and Tasnim N et al<sup>28</sup> also concluded that suspicious CTG trace has low predictive value in terms of fetal acid base status at birth and needs to be complemented with other diagnostic modalities before undertaking any operative intervention

Thus, from the findings of the present study, although the sensitivity of CTG was found to be low, its high specificity, low cost and ease of carrying out the monitoring supported its use in intrapartum fetal monitoring and in alerting the obstetrician regarding an intra-uterine hypoxic event.

## 5. Conclusion

In this study, the combination of two techniques were studied and evaluated for specificity and sensitivity in detection of neonatal distress during intra- partum period. The first most common technique CTG was evaluated and found to be less sensitive in category I but highly specific, in category II it was only 64% accurate but in category III it was nearly 80% accurate. Hence on finding abnormal CTG, steps must be taken immediate for saving the fetal life. In intermediate category the labor must be watched closely. As we evaluate umbilical arterial blood pH for acidosis, it was found that its accuracy was high, hence combining both methods were eventually increase the accuracy of diagnosis in any CTG category. So, in end we want to conclude that umbilical arterial blood pH must be done for every case especially in CTG category I and II to increase its accuracy for detection of fetal distress. In low resource areas it must be done in every fetus to detect the impending complications earlier so to save the vulnerable fetus from demise.

**Conflicts of Interests-None**

**Financial support and sponsorship-None**

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