

The role of intrapartum doppler of uterine and middle cerebral artery evaluation on prediction and prevention of adverse perinatal outcome in normal size fetuses at term

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Abstract

Objective: To assess the value of uterine and middle cerebral artery Doppler of the fetus in predicting and prevention of the outcome of normal size fetuses at term in the latent phase of labor and to answer the question of whether the fetus can tolerate vaginal delivery conditions.

Method: This was a prospective cohort study performed in single tertiary referral centers including 148 singleton term fetuses and conducted from March 2018 to February 2019. Patients were subjected to Doppler ultrasound in the latent phase of labor and were evaluated based on the rate of CPR and uterine artery resistance and its effect on pregnancy outcomes such as cord PH, Apgar scores 5 minutes after birth, NICU admission and the rate of cesarean section due to fetal distress.

Result: 53 patients had to mean uterine artery PI > 95th centile and low PH level in this group was (32.6% vs. 49.1%), NICU admission rate was (26.3% vs. 32.1%), the low Apgar score was (49.1% vs. 35.8%), and the rate of cesarean section was (22.6% vs. 18.94). Out of a total of 148 patients, 36 patients had CPR less than 5th centile, low PH level in this group was 31 patients (86.1% vs. 23.2%, PV=0.001), low Apgar score (83.3% vs. 26.8%), and NICU admission rate (69.4% vs. 15.2%), and cesarean section due to fetal distress was (77.8% vs. 7.1%, PV=0.001) in them.

Conclusion: AGA fetuses with CPR < 5th centile and abnormal uterine arteries (> 95th centile) have an increased risk of developing distress, low Apgar score, low level of PH, NICU admission and being delivered by emergency Cesarean section. On the other hand, when both vessels have normal waveforms, the chances of fetal distress are small (7.1%) and expectant management is the most reasonable choice.

Introduction

The important challenge of obstetricians and care providers is whether the patient and their fetus can tolerate labor and conditions of delivery? How to predict and prevent intrapartum complications? As regards, 10-15% of cerebral palsy cases are due to intrapartum hypoxia, but the antenatal identification of the fetus at risk of cerebral palsy and other hypoxia-related outcomes remain challenging [1].

Therefore, obstetricians intend to assess the conditions of the embryo and placenta sufficient blood flow using ultrasound and as a result the physician will make a correct decision if there is a disorder.

Admission cardiotocography (CTG) is a commonly used screening test consists of a short (usually 20 minutes) recording of the fetal heart rate (FHR) and uterine activity performed on the mother's admission to the labor ward [2]. Furthermore, the widespread use of CTG and continues intrapartum FHR monitoring led to an increasing risk of cesarean section in low-risk women without any reduction in the incidence of cerebral palsy or detecting fetuses with metabolic acidosis and hypoxic-ischemic encephalopathy [3-5]. Today, Doppler ultrasound is examined to determine whether it can identify these fetuses more accurately.

Adverse events related to fetal hypoxia are known to be more frequent in fetal growth restriction (FGR) secondary to placental insufficiency. Recent studies have reported that fetal Doppler assessment

might also be of value in detecting AGA pregnancies, yet complicated by placental insufficiency [6]. Hence, the role of the Doppler evaluation of the uterine and fetal artery in term and normal size fetuses (AGA) is an interesting and growing topic in Perinatology to help physicians to properly analyze the FHR monitoring during labor or induction [7].

Previous studies have shown that the diagnostic value of uterine artery Doppler ultrasonography may be increased by adding other Doppler characteristics [8-10]. It has been suggested recently that the use of Doppler ultrasound among normal sized fetuses at term is able to identify those with subclinical placental impairment. Previous studies reported a significantly higher incidence of obstetric intervention due to intrapartum distress in low risk fetuses showing reduced CPR before delivery [11-13].

The use of electronic fetal heart rate monitoring lead to a 5-fold increase in the cesarean delivery rate despite it has not decreased the rate of cerebral palsy over the past 30 years [14].

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There are different comments about efficacy and potency of Doppler assessment and early detection of a hypoxic baby, but no data is yet available on the clinical implications of such Doppler findings obtained during labor because labor represents the most challenging time span for the fetoplacental unit being uterine contractions associated with an up to 60% reduction in placental perfusion [15,16].

The present study aims to answer whether the fetal cerebroplacental ratio or the uterine artery PI can be useful as a predictor of intrapartum fetal compromise, neonatal acidosis and NICU admission? And finally, may it be recommended as a screening tool for identifying pregnancies that will subsequently be complicated by fetal distress?

Material and method

This was a prospective cohort study performed in single tertiary referral centers (Dr. Shariati Hospital), including 148 singleton term fetuses, and conducted over a twelve-month period from March 2018 to February 2019. The current study was approved by Tehran University Medical Ethics Committee (IR.TUMS.MEDICINE.REC.1397.514) and it was in accordance with the Helsinki Declaration of 1975, revised in 1983. All participants provided written informed consent. All women with singleton term pregnancy were approached on admission for early spontaneous labor that performed a Doppler ultrasound scan in the latent phase and in time of uterine contraction. The main aim of this study was to evaluate the association in AGA at term pregnancies between fetal CPR and mean UtA PI both and intrapartum fetal compromise and adverse neonatal outcomes, this question was addressed in a subgroup analysis in this review. Cases were identified by Perinatologist in the Obstetrics Unit, Dr. Shariati Hospital, Tehran, Iran. The inclusion criteria were singletons, appropriate for gestational age (AGA) at term (≥ 37 weeks' gestation) that had an ultrasound scan within 7 days of delivery. Patients discussed about individual needs and wishes about monitoring the baby's Doppler. Pregnancies complicated by fetal abnormality, aneuploidy, growth restriction, multiple pregnancy, any chronic maternal medical disorders or complication diagnosed during pregnancy, including hypertensive disorders and gestational diabetes, morbid obesity as defined by body mass index (BMI) >40 kg/m², evidence of intrauterine infection, antepartum hemorrhage, premature rupture of the membranes for >18 hours, scarred uterus as per previous caesarean section and myomectomy or preterm labor were excluded from the study. Elective caesarean delivery patients were also excluded from the analysis of operative delivery for intrapartum fetal compromise. The gestational age was calculated from the crown-rump length measurement at 11-13 weeks or the head circumference for the pregnancies where the first ultrasound performed was in the second trimester, the fetal Biometry was performed according to a standard protocol and the estimated fetal weight (EFW) calculated using the formula of Hadlock *et al.* [17]. This threshold was used together with birth weight to classify fetuses into small for gestational age (SGA), AGA and large for gestational age (LGA), AGA was defined as birth weight between the 10th and 90th percentiles.

The fetal middle cerebral (MCA) artery and uterine artery (UtA) Doppler waveforms were examined using color Doppler ultrasound and the pulsatility index (PI) was measured according to a standard protocol, CPR values were also computed by dividing the MCA PI and the UtA PI and converted into multiples of the median (MoM) based on formerly reported reference ranges [18-21]. The uterine artery PI to both sides (right and left) was calculated and the mean was considered as mean UtA PI. All Doppler indices were converted into multiples of median (MoM), correcting for gestational age using reference ranges, and BW values were converted into centiles. Only

one (the last) doppler assessment per pregnancy was included in the analysis [6,22,23]. In each of the patients, Doppler recordings were undertaken by a single Perinatologist and performed in time of uterine contraction. Ultrasound examinations were performed by ultrasound machines (Philips, 70 affinities, Germany) using 2-8MHz convex probes during fetal quiescence in the absence of fetal tachycardia and keeping the insonation angle with respect to the examined vessels, as small as possible.

The study cohort was evaluated according to a CPR cutoff of the 5th centile and mean UtA PI cut off of the 95th centile, then intrapartum data recorded and evaluate to what extent was a pregnancy with a fetal CPR below the 5th centile and mean UtA PI over the 95th considered more likely to have placental insufficiency and fetal hypoxia? We use an umbilical arterial pH < 7.10 and Apgar less than seven at five minutes as an objective measure of the presence of intrapartum hypoxia and admission to neonatal special care and/or intensive care unit, cesarean section for abnormal fetal distress. The clinicians responsible for the intrapartum care and the patients themselves were unaware of the Doppler ultrasound findings, in order not to increase the possibility of subsequent clinical intervention and a "treatment effect". Information concerning maternal age, parity, gestation at the onset of labor was recorded and intrapartum and neonatal outcome data were collected from patient case notes.

The primary outcome of the study was to evaluate the relationship between CPR and mean UtA PI and the need to immediately deliver due to suspected intrapartum fetal compromise. Deliveries were categorized according to the mode of delivery in spontaneous vaginal delivery or operative delivery (instrumental or cesarean section) due to fetal distress. Finally, secondary outcomes were prescribed; perinatal events included low Apgar score at 5 minutes, low cord arterial PH, and Neonatal Intensive Care Unit (NICU) admission. Neonatal outcome was assessed by cord arterial PH and, Apgar score at 5 minutes, need for resuscitation at birth and admission to NICU. The diagnosis of intrapartum fetal distress was defined by the physician based on abnormal CTG tracing according to the FIGO classification system [6].

Statistical analysis

All pregnancies that fit the inclusion criteria were included and those that fit the exclusion criteria were excluded. Intrapartum risk factors were considered as important confounders for the adverse outcomes investigated in this study. Data were shown as mean + standard deviation or as a number (percentage). The adverse perinatal outcome was defined by an admission or need for resuscitation at birth, Cord arterial PH < 7.10 , Apgar 5 min < 7 . Categorical data were presented as number (%) and were compared using the Fisher exact test or χ^2 test. Comparison of continuous variables included t-test for independent sample and 2-tailed t-test, statistical significance was set at $P < 0.05$. The analysis was performed using the statistical software packages SPSS 20.0 (IBM Corp, Armonk, NY, USA); and Graph Pad Prism 5.0 for Windows (Graph Pad Software Inc., San Diego, CA).

Result

148 women were identified with fetal ultrasound and Doppler assessment in the latent phase and in time of uterine contraction of delivery at over one-year period. All the patients were low-risk, term, singleton and AGA pregnant women who were admitted to the delivery ward due to spontaneous onset labor. The subgroup differences were assessed by CPR (Normal or lower 5th centile) and mean uterine artery PI (Normal or upper 95th centile). Maternal demographics,

intrapartum parameters, the distribution of Doppler values according to the mode of delivery and labor outcomes of the included cases are summarized in Table 1. The mean maternal age was 28 ± 5.5(18–42), the mean birth weight was 3291(2821–4246) g, and the mean GA at ultrasound examination was 39.1 (38–39.4) weeks for delivery. The overall operative delivery in cesarean section (in this study, there were no cases of instrumental delivery) for a presumed fetal compromise was 28 cases (77.8%) with CPR lesser than 5th centile and 8 cases (7.1%) with normal CPR and 7 cases (19.4%) and was 12 cases (22.6%) with UtA PI upper 95th centile with mean UtA PI upper 95th centile. Cases with CPR < 5th centile were compared in terms of demographics, labor and perinatal outcomes with those with normal CPR, as shown in Table 2 and the effect of mean uterine UtA PI > 95th centile on the adverse pregnancy outcome is shown in Table 3. As regards the considered perinatal outcomes, fetuses with CPR < 5th centile showed a significantly higher rate of APGAR < 7 at 5 minutes (83.3% vs. 26.8%, p < 0.001) and cord arterial PH < 7.10 (86.1% vs. 23.2%, p < 0.001), and in the case of uterine artery and its effect on adverse pregnancy complications, no significant effect was observed in the study between patients with mean UtA PI > 95th centile and other patients. In this group, each of low PH level and low Apgar score was 49.1%, while in other patients each of these of factors was 32.6% and 35.8%. The rate of NICU admission in this group was 32.1% and in the group with normal uterine artery PI 26.3%. Clearly, pregnancy complications in patients with normal uterine artery PI were better than the group with uterine artery PI above 95th centile. In other words, patients with high uterine artery PI had an adverse pregnancy complication, lower fetal PH, lower fetal Apgar and

higher incidence of NICU admission; but in those with uterine artery PI in the normal range (< 95th centile) the fetal PH was better, the fetal Apgar was better and the possibility of NICU admission was also lower as shown in Table 2.

Within the population of low risk term pregnancies, CPR was the only independent predictor of operative delivery due to fetal distress (OR: 10.889, 95% CI: 5.461–21.714) and NICU admission (OR: 4.575, 95% CI: 2.807–7.457), as shown in Table 3. In patients with CPR < 5th centile vaginal delivery occurred in 8 women (22.2%), while in the remaining cases delivery was accomplished by cesarean section (28 cases, 77.8%) and showed an over ten-times higher incidence of operative delivery due to fetal distress (28/36, 77.8% vs. 8/112, 7.1%, p < 0.001), while in the group with mean UtA PI > 95th centile, the rate of cesarean section was 22% (12 patients) due to fetal distress and in the group with mean UtA PI < 95th centile, the rate of cesarean section was 18% (18 patients); although it was higher, the difference was not statistically significant. 57 infants were born with PH < 7.10, of which only 26 patients showed evidence of fetal distress in FHR monitoring during labor and 40.12% were missed just based on the reassurance of FHR tracing. Therefore, it can be concluded that the necessity of using fetal Doppler assessments in term fetuses' labor to avoid adverse fetal complications is inevitable. 53 patients had UtA PI < 95th centile, among them 12 patients had caesarean delivery due to fetal distress; while only 7 infants had PH < 7.10 after birth and the other 5 infants were born having normal PH and Apgar. Hence it can be said that if UtA PI < 95th centile is the decision criterion regarding operative delivery it

Table 1. Characteristics of the cohort study and the perinatal outcome according to CPR

Pregnancy variables	Normal CPR N=112	CPR<5 th centile N=36	P- value Chi-Square Tests
Maternal age, y (median)	28.65 (27.62- 29.68)	27.42 (25.54- 29.29)	.244
Gestational age at ultrasound, wk. (median)	39.1 (38.00- 39.2)	39.1 (38.6- 39.4)	.942
Nulliparous, n (%)	36 (32.1%)	13 (36.1%)	.660
PH, mean (%)	7.21 (7.19- 7.22)	7.07 (7.04-7.09)	.000
Birth weight, g (median)	3358 (3295- 3421)	3225 (3137- 3313)	.016
Operative delivery, n (%)	8(7.1%)	28 (77.8%)	.000
Vaginal delivery, n (%)	104 (92.9%)	8 (22.2%)	.000
PI Uterine < 95 th centile, n (%)	66 (58.9%)	29 (80.6%)	.019
PI Uterine > 95 th centile, n (%)	46 (41.1%)	7 (19.4%)	
APGAR < 7 at 5 minutes, n (%)	30 (26.8%)	30 (83.3%)	.000
Cord arterial PH<7.10, n (%)	26 (23.2%)	31 (86.1%)	.000
NICU admission, n, (%)	17 (15.2%)	25 (69.4%)	.000

Table 2. The perinatal outcome according to mean UtA PI

Pregnancy variables	Mean UA PI <95 th centile N=95	Mean UA PI >95 th centile N=53	P- value Chi-Square Tests
Cord arterial, PH<7.10, n (%)	31 (32.6%)	26 (49.1%)	.049
APGAR < 7 at 5 minutes, n (%)	34 (35.8%)	26 (49.1%)	.115
NICU admission, n (%)	25 (26.3%)	17 (32.1%)	.456
Operative delivery, n (%)	18 (18.94)	12 (22.6%)	.722
Operative delivery, n (%)	24 (25.3%)	12 (22.6%)	.722
APGAR < 7 at 5 minutes, n (%)	34 (35.8%)	26 (49.1%)	.115

Table 3. Estimation of the relative risk of neonatal complications and CPR

Variable	RR	CI (95% Confidence Interval)
Cord arterial PH<7.10	3.709	2.584 - 5.325
Operative delivery	10.889	5.461- 21.714
NICU admission	4.575	2.807 - 7.457
APGAR < 7 at 5 minutes	3.111	2.216 - 4.368
Nulliparous	1.123	.674 - 1.873

may impose unnecessary cesarean delivery in 41.6% of cases, While in cases with CPR< 5th centile, 28 patients underwent cesarean delivery due to suspicion of fetal distress and most infants showed definite evidence of fetal distress and low PH after birth. Despite suspected FHR monitoring, only 6 infants had normal PH after birth. It can be concluded that if CPR< 5th centile is the decision criterion for cesarean delivery, the probability of confusion and imposition of unnecessary cesarean delivery will be 27.2%.

There were no cases of stillbirth or neonatal death in the study group. A significantly lower birth weight was recorded in the cases with CPR<5th centile (3225 vs. 3358); however birth weight percentile was not significantly different between the two groups (p=0.016). There was no difference from other data, for example gestational age at the time of delivery (mean GA 39+1 in both groups p=0.942), maternal age (27.42vs. 28.65, p=.244) and nulliparous (36.1% vs. 32.1%, p=0.660) were similar in both groups and maternal. As for the effect of CPR<5th centile on the uterine PI>95th centile, it should be noted that according to our study RR CPR <5th centile for uterine PI>95th centile vs. Normal CPR was 1.367 with CI 1.094 - 1.708. In total, CPR < 5th centile proved to be a poor predictor of operative delivery due to fetal distress and composite adverse perinatal outcome. Even though positive predictive value was for NICU admission (69.4%) and low APGAR (83.3%) (Table 4).

Discussion

Findings of the study demonstrate that mean uterine artery PI and CPR assessment in early labor can be helpful in prediction and prevention of adverse perinatal outcome that can be regarded if FHR tracing is not reassured in patients with subclinical placental impairment, as a CPR < 5th centile was associated with an over tenfold higher risk of operative delivery due to fetal distress and a four and a halftimes higher incidence of adverse perinatal outcome. This study defines a CPR and mean UtA PI role that are surrogates for placental insufficiency in AGA fetuses (the relationship between mean UtA PI and fetal outcomes is lower than that of CPR); this group can be identified prenatally using these CPR. Encompassing uterine artery Doppler in the surveillance of AGA fetuses might detect a group of pregnancies at high risk, even though the umbilical artery Doppler was normal. Within the cohort, an independent relationship is originally reported between CPR <5th and mean UtA PI >95th centile measured in early spontaneous labor and intrapartum fetal distress.

In the present study, the positive predictive value of abnormal Doppler in determining at least one adverse outcome was 88.3%. Patients with both elevated mean UtA PI and CPR <5th centile in the Doppler were found to be at the maximum risk of adverse pregnancy outcomes, especially NICU admissions. 29 patients had CPR <5th centile and UtA PI >95th centile concurrently. 23 patients underwent emergency cesarean delivery due to suspected fetal distress, among them 19 patients had low ph after birth too. Therefore, it can be concluded that concurrency of CPR <5th centile and UtA PI >95th centile improves decision making accuracy and avoids unnecessary cesarean

delivery, because in the patients under this study only 21% of cesarean deliveries were unnecessary. Therefore, the association of these two factors increases the specificity in detection of high-risk fetuses.

FHR monitoring during labor is a routine part of care during labor and an accepted method for diagnosis intrapartum fetal compromise or at risk of hypoxia [24,25].

Doppler ultrasound is likely to be used more in the future and could be suitable for analysis of FHR tracing and this may be correct for normal weight infant in the clinical practice [26]. It is important to establish the value of this assay as an adjunct to FHR monitoring, tracing, but there is little evidence to support their use.

Although Doppler ultrasound is an accepted and often favored mode of fetal assessment in high-risk pregnancy and IUGR fetuses [27] and seeks to identify those babies who are truly compromised and need to be born immediately with operative delivery, there were no reported data suitable for analysis and the use of Doppler ultrasound in low risk and fetuses with birth weight above the 10th centile (AGA fetuses) that considered to be healthy and to adopt preferred position in labor. However, AGA pregnancies may be along with fetal cerebral and placental blood flow redistribution which is indicative of fetal hypoxemia. Although using Doppler ultrasonography of UA is a common method for evaluating utero-placental circulation and predicting perinatal adverse outcomes, [28] recent studies have proposed the importance of MCA Doppler assessment for antenatal monitoring [29]. The present study evaluated the alterations in fetal MCA and UtA PI in term and AGA pregnancies. Results of study indicate that this risk is also present in AGA fetuses with low CPR and raise of uterine artery PI, presumably as a consequence of placental insufficiency and fetal hypoxemia [30]. The most important finding of the present study was that the CPR compared to the UtA PI has a greater effect on the outcome of the infant.

It is currently considered as an early sign of placental chronic hypoxia because Umbilical, fetal middle cerebral and uterine artery pulsatility indices and umbilical vein blood flow are surrogates for placental under perfusion in small fetuses and growth restricted ones [31-33]. Hence, previous evidence shows that abnormal Doppler findings of maternal uterine arteries or fetal cerebral circulation in small for gestational age (SGA) fetuses are associated with labor distress or adverse perinatal outcomes [34-36]. The placental histological abnormalities typical of FGR in about 25% of term AGA pregnancies, suggesting the presence of occult chronic placental insufficiency [37]. Although studies for evaluated association between AGA and Doppler indices are very limited, However, studies showed that the fetal cerebroumbilical ratio can identify fetuses at high and low risk of a subsequent diagnosis of intrapartum compromise, and may be used to risk stratify pregnancies before labor [1]. Another benefit of this assessment is to be reassured of the obstetricians and to avoid intrapartum hasty decisions in patients with normal CPR.

Over the last few years a great interest has been arisen for the role of CPR in AGA fetuses based on the assumption that late onset placental insufficiency may not be associated with fetal smallness but may increase the risk of adverse perinatal outcome [6]. The results of this study show that fetal CPR calculation and mean UtA PI at term is associated with operative delivery cause to fetal distress and risk of admission to the NICU due to low Apgar infant and Cord arterial PH<7.10. The available data on low-risk term pregnancies in early labor showed that while reduced CPR is associated with a higher risk of obstetric intervention due to fetal distress and composite adverse

Table 4. Positive predictive value (PPV) and negative predictive value (NPV) for CPR measure and adverse neonatal outcome (Low APGAR) and NICU admission.

CPRmeasure		PPV	NPV
Adverse neonatal outcome (Low APGAR)	CPR<5 th centile	83.3%	16.7%
	Normal CPR	26.8%	73.2%
NICU admission	CPR<5 th centile	69.4%	30.6%
	Normal CPR	15.2%	84.8%

perinatal outcome, it is a poor predictor of adverse perinatal outcome that is subjected to placental insufficiency, fetal hypoxemia and adverse perinatal events [12,16]. The previously published data on low risk non-laboring women showed that infants delivered by cesarean section for fetal compromise had significantly lower cerebroumbilical ratios than those born by spontaneous vaginal delivery (1.52 vs. 1.82, $P \leq .001$) [12]. These findings are consistent with a recent study where the investigators developed a clinical prediction model to assess the risk of adverse perinatal outcomes in uncomplicated term pregnancies with measured early labor cerebroplacental ratio, using data gathered from 562 singleton pregnancies [16]. Furthermore, association $CPR < 5$ th centile with the need for emergency operative delivery for abnormal fetal heart rate patterns matches the previous studies [38] our findings also confirm the results of these studies. Fetuses that had low CPR were at increased risk of intrapartum compromise and were less likely to be delivered vaginally [39]. This association supports the concept that even AGA infants could suffer from placental insufficiency and fail to meet their genetic growth potential at term [36,40]. Hence fetal Doppler assessment has been proposed as a potentially better marker for diagnosis FGR and emphasis on the fetal Biometry alone has been challenged [41]. The results of this study demonstrate that $CPR < 5$ th centile leads to an increase in cesarean sections. Fetal distress frequency was increased in fetuses with a low CPR and Low CPR may be a part of the adaptive mechanisms providing metabolic preparedness for hypoxic episodes; moreover, fetal distress seems to be a common endpoint of different circulatory-metabolic disturbances [42].

These findings are in accordance with those of the current study which also demonstrates that fetal Doppler indices ($CPR < 5$ th centile and mean UA PI > 95 th centile) are capable to predict acidemia secondary to placental insufficiency in term AGA pregnancies [40,43]. It is important to note that uterine contractions are associated with up to a 60% decline in uterine artery flow velocity, and the related reduction in uterine perfusion may have a more significant impact on misdiagnosed conditions of suboptimal placental perfusion and influenced measuring CPR in early labor [40]. However, Maternal hyper oxygenation using 60% oxygen concentration over a 20-min period does not influence fetal umbilical or middle cerebral artery Doppler in appropriately grown fetuses [44].

In the retrospective cohort study that performed in over a 14-year period, from 2000 to 2013, 9772 pregnancies were identified with fetal ultrasound and Doppler assessment within 2 weeks of delivery at term demonstrated that the rate of operative delivery for presumed fetal compromise was higher in AGA fetuses with low CPR than in SGA fetuses with normal CPR, indicating that CPR is more strongly associated with fetal compromise due to placental insufficiency than is BW [40]. Comparing infant outcome base on CPR ratio in a study showed a significant difference between groups in low baby Apgar scores at five minutes and patients who had low CPR had higher rates of caesarean section for fetal distress [45]. In the other study, 2927 singleton term fetuses that had an ultrasound scan within 14 days of delivery fetuses were divided according to birth weight centile and CPR; then, the acid-base status was compared between weigh centile groups with and without low CPR. The main aim of this study which was performed in two tertiary centers was to evaluate to what extent arterial and venous umbilical cord blood pH at birth is associated with birth weight and fetal CPR. The study concluded that CPR was better correlated with umbilical cord blood pH because AGA fetuses with low CPR were more acidemic than those with normal CPR ($P = 0.0359$) [27]. Even though $CPR < 5$ th centile had a very high positive predictive value for NICU admission and operative delivery, we know that CPR as a

single marker is not a strong predictor of intrapartum fetal compromise [12]. In contrast, a prospective observational study on 47,211 women with singleton pregnancies undergoing routine ultrasound examination at 35 – 37weeks' gestation, including measurement of UA-PI and CPR, was performed in UK to investigate the predictive performance of screening for adverse perinatal outcome by the cerebroplacental ratio (CPR) measured and demonstrated that routine antenatal assessment at 35 - 37 weeks' gestation. Measurement of CPR provides a poor prediction of adverse perinatal outcome in both SGA and AGA fetuses and this study may have declined the role of CPR as an effective method for screening intrapartum fetal compromise [46].

The findings of our study support the assertion that the fetal cerebroplacental ratio (CPR) and mean UtA PI measured at the time of delivery could identify those likely to require obstetric intervention for intrapartum fetal compromise. Therefore, CPR and mean UtA PI measurement may be just as good at predicting AGA fetuses at risk of compromise as it is at predicting SGA fetuses at risk. Therefore, it can be concluded from the studies that when fetal UA PI is upper 95th centile and CPR is low at term, the risks of operative delivery for fetal compromise and NICU admission are significantly increased in both SGA and AGA fetuses. It is found that low risk pregnancies with AGA fetuses at term, $CPR < 5$ th centile at the beginning of labor yields 69.4% PPV for NICU admission and 83.3% for adverse perinatal outcomes (low APGAR). In contrast, a normal CPR proved to be a very good predictor of normal outcome as witnessed by over 84.8% NPV both for NICU admission and adverse perinatal outcome.

However, the difference between this study and the previous ones was represented in women not in labor who was submitted to an ultrasound assessment due to clinical indication and the clinicians responsible for the intrapartum care were blinded to Doppler findings. These findings highlight the relative importance of Doppler indices of fetal hypoxemia compared to fetal heart monitoring in the risk stratification for birth and neonatal outcome. By using the concept of optimal CPR and UtA PI established from fetuses on the upper BW centiles, a stronger relationship has been revealed between umbilical cord PH and CPR mean UtA PI compared to BW. Moreover, in a low-risk cohort, both the CPR and EFW individually and in combination predicts adverse obstetric and perinatal outcomes when measured late in pregnancy and the predictive value was enhanced when both were used in combination [47].

These findings generally challenge the convention of using EFW to assess the at-risk fetus at term and suggest that fetal arterial Doppler assessment may have a more important role here.

It is important to note that women, health practitioners, and policy makers need to consider these results carefully in the absence of short-term and long-term benefits for the mother and the baby. Trials need to collect information on women's views and experiences. They also need to examine factors that may influence adherence to monitoring protocols, as well as assessing health service costs that can use CPR and mean UtA PI to reassure the physician and patients about fetal health to monitor and continuation of labor. In other words, Doppler ultrasound is not necessary for all pregnant women and has the potential to cause anxiety by detecting clinically insignificant abnormality of MCA blood flow, but it does not need to be an inevitable cesarean section as these can be disregarded if FHR tracing is reassured in patients with subclinical placental impairment, hence, it should be safely possible to Doppler ultrasound.

Conclusion

We conclude that the fetal CPR <5th centile is correlated with umbilical cord blood PH acidosis and APGAR < 7 at 5 minutes in AGA fetuses at term pregnancy. Patients with mean UtA PI >95th centile had more pregnancy complications such as cesarean section due to fetal distress, low Apgar score, and NICU admission. This difference was so significant; however, there was no significant statistical difference in the study's sample size. The study demonstrated that CPR and UtA PI normal ranges at term are significantly influenced by the inclusion of AGA pregnancies suffering from occult placental insufficiency and it had the strongest association with adverse labor outcomes among all the determinable characteristics.

Limitation

As a cross sectional study, this analysis is prone to the confounding factors. The recommendations to limit its routine usage during labor indicate that a regular reassessment of this practice is warranted.

The effect of the CPR ratio of long term follow up data, such as neurological development, requires further studies. Although the reduction in perinatal asphyxia associated with the MCA blood flow is important, it must be interpreted cautiously in the absence of good quality long term follow up data. Another limitation of the present study was the lack of statistically significant difference in the result of the study in patients with uterine PI > 95th centile. Despite the fact that adverse pregnancy complications were more in these patients, it was not statistically significant due to the little sample size.

Among the strengths of the present study is performing the Doppler scan by the same operator, uterine being in contraction and latent phase, short interval between ultrasound and delivery and blindness of the health care professionals providing the intrapartum care.

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