The Cerebro-placental Ratio as a Prognostic Factor of Foetal Outcome in Patients with Third Trimester Hypertension.

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Background: ***Hypertensive disorders of pregnancy can cause complications in both the maternal and fetal circulations resulting in poor fetal outcome. These circulations can be safely and non-invasively assessed using arterial Doppler indices of the umbilical and middle cerebral arteries to obtain the cerebro-placental ratio. The study objective was to determine the role of the cerebro-placental ratio as a prognostic factor of fetal outcome in patients with hypertensive states of pregnancy delivered at least 32 weeks of gestation by dates.***
Methods: ***This was a prospective cohort study undertaken at Kenyatta National Hospital, a tertiary referral hospital in Nairobi. A total of 160 gravid patients of median age 28 years and at least 32 weeks gestations were recruited from labor ward over a 9 month study period by consecutive sampling method. Doppler ultrasound analyses of the foetal umbilical and cerebral arteries were done and the cerebro-placental ratio calculated.***
Results: ***At sonography, the average ultrasound age was 31 weeks. The median gestation at admission was 34 weeks. Twenty nine percent had an abnormal Cerebro-placental ratio (<1.0).125/160 (78%) delivered via caesarean section and 35/160(22%) delivered vaginally.51/160(32%) severe pre-eclamptic toxaemia out of which 39% had cerebro-placental ratio<1.0 109/160(68%) had mild pre-eclamptic toxaemia out of which 24% had cerebroplacental ratio <1.0 Still births were 12.5 times more likely in mothers with cerebro-placental ratio <1.0 than those with CPR ≥ 1.0 (p value ≥ 0.05). A foetal birth score < 7 was 66 times more often in mothers with cerebro-placental ratio< 1.0 than mothers with CPR≥ 1.0. (P ≥ 0.05). Low birth weight was 4.7 times more likely among mothers with cerebroplacental ratio < 1.0.as compared to those with mothers with CPR≥1.0 (95% CI 2, 11.1; p≥0.001). A foetal birth score < 7 was 66 times more likely among neonates delivered vaginally as compared to those born via caesarean section(95% CI 1.3, 23; p=0.02). Still births were 14.5 times more often than among neonates born vaginally as compared to those born via caesarean section (95% CI 3, 84; p≥0.001). The prognostic Odds Ratio for cerebro-placental ratio was 12.5 for live births (95% CI 2, 74; p=0.005), 66 for fetal birth score <7 (95% Confidence interval 13, 340; p< 0.001) and 4.7 for low birth weight (95% CI 2, 11.1; p< 0.001) and 1.1 (95% CI 0.9, 1.4; p=0.327).***
Conclusion: ***Cerebro-placental ratio is significantly predictive of adverse perinatal outcome when used to monitor mothers with hypertensive states of pregnancy. Cerebro-placental ratio.***

Key words: Cerebro-placental Ratio, Prognostic Factor, Foetal Outcome, Third Trimester, Hypertension

Introduction

Hypertensive states of pregnancy (HSP) are defined as conditions in which there is development of new arterial hypertension in pregnant women typically after 20 weeks of gestation without the proteinuria[1]. These hypertensive states include pre-eclampsia/eclampsia (PE), chronic hypertension, gestational hypertension and chronic hypertension with superimposed pre-eclampsia[2]. HSP causes both maternal and fetal complications like haemorrrhagic disorders, multi-organ failure, intrauterine growth restriction and fetal death.

Doppler ultrasound allows assessment of the foeto-placental circulation safely, non-invasively and rapidly using arterial indices to assess the quality of flow in vessels[3,4]. The Resistive Index (RI) is the most commonly used index as it is easier to calculate. It is an indicator of the resistance of an organ to perfusion and is reflective of end-organ vascular resistance [2]. RI is calculated by measuring peak systolic velocity (PSV) and subtracting end-diastolic velocity (EDV) from it and then dividing that result by peak systolic velocity[2], RI= (PSV-EDV)/PSV

The Umbilical Artery Resistive Index (UA-RI) is reflective of placental vascular resistance. If the umbilical artery waveform shows abnormality, the fetal systemic vessels to vital structures need to be investigated further, to evaluate the fetal status[5]. The middle cerebral artery (MCA) is used to assess the fetal cerebral circulation. RI of both the middle cerebral artery and umbilical artery are obtained and their ratio (MCA-RI to UA-RI) gives the cerebroplacental ratio (CPR). A cerebroplacental ratio <1.0 is indicative of high resistance in utero-placental circulation and is considered abnormal. This results in brain-sparing effect where the chronic hypoxia causes circulatory adaptation which is seen as cerebral vasodilatation in order to preserve blood flow to the brain. This is demonstrated by a lower value of MCA-RI relative to gestational age and UA-RI. Its disappearance is a critical event and precedes fetal death[5].

Patients and Methods

Ethical approval for the study was obtained and the sample size calculation using the Peduzzi method was set at 160. Gravid patients at least 32 weeks gestations by dates were recruited from labor ward after obtaining informed consent. Consecutive sampling method was used. Using structured data collection sheets age, parity, blood pressure recording, and urinalysis report were recorded. An obstetric ultrasound scan was carried out on request by the clinician and coded for fetal presentation, placental position, foetal heart rate, estimated ultrasonographic age, BPPS, UA-RI and MCA-RI Doppler ultrasound analyses and the cerebroplacental ratio calculated. Follow-up to evaluate the foetal outcome, 5- minute fetal birth (Apgar) score and birth weight was made.

The ultrasound machines used were Philips HD11 and GE Logiq 7. The transducer frequency was 3.5 – 5.0 MHz curvilinear probe, the Doppler sample volume was 2 mm and the wall filter was 50–100 Hz. The examination was performed with the mother in a semi-recumbent position during relative fetal inactivity and apnea. This is because the end-diastolic flow (EDF) decreases with decreasing fetal heart rate and fetal breathing movements increase variability in the Doppler measurements. This was assured as it was done while observing fetal behavior.

The UA was sampled at the middle of a free loop of umbilical cord preferably at the level of the foetal bladder. For the MCA, a transverse image of the foetal head was obtained at the level of the sphenoid bones. Color Flow imaging was used to display the circle of Willis. The MCA in the near field was isolated about 1 cm distal to its origin from the internal carotid artery. By using the optimal spectral trace from each artery, the Resistive Index was calculated from the mean of a minimum of five consecutive waveforms on a frozen image. A series of three readings were taken for each artery to avoid errors. The cerebral/placental ratio was calculated from the MCA- RI and UA-RI.

A structured questionnaire was used to collect data. The data was entered manually into a database (Ms Access 2007) via user-defined forms. The data entry forms had quality control checks in order to ensure accuracy of the data. The data base security features ensured confidentiality and access to the participants' data. All data was cleaned and exported for statistical analysis. Statistical Package for Social Sciences (SPSS 17.0) was used for the analysis. A 5% level of significance was used to determine if a variable contribute significantly to the prediction of the outcome variable.

Results

Tables 1 to 9 summarize the findings. A total of 160 patients were recruited into the study**.** All the mothers presented for care at 34 weeks of gestation (IQR: 33, 37). The CPR < 1.0 was observed in 47 (29%) of the study population.62% of the mothers were given dexamethasone antenatally to hasten surfactant production while 38% were not given the dexamethasone antenatally. This depended on gestation and clinical decision. Caesarean section was performed on 125 mothers (78%) of the mothers while SVD was carried out on 35 mothers (22%). SVD was carried out in patients unless there was an indication for C/S like breech presentation, failed induction or foetal distress. Sixteen mothers (10%) delivered still births. Out of which 69% delivered SVD and 31% via C/S. Twenty seven (17%) of the infants had low birth weights (defined as less than tenth percentile of expected weight at that gestation). The median foetal birth Apgar score (at 5 minutes) was 9 (IQR: 8, 10); 30 (19%) has an Apgar score of less than 7. Forty two neonates (26%) were admitted in the newborn unit for various reasons including low birth weight, prematurity and respiratory distress. This was indicative of neonatal morbidity. There was evidence of association between the Cerebral/Placental Ratio (p<0.001), mode of delivery (p<0.001), Biophysical Profile score (p<0.001) and foetal outcome among mothers in the study population.

Table 1. Clinical Observations

Characteristics / Clinical findings	Number (%) Median (IQR)
Blood pressure-	
• **Systolic**	154 (143, 170)
• **Diastolic**	104 (95, 113)
PET	
• **Severe**	51 (32%)
• **Mild**	109 (68%)
Ultra-sound findings	
Foetal presentation	
• **Cephalic**	143 (89%)
• **Breech**	17 (11%)
Foetal heart rate	**138(132,140)**
Urinalysis	2 (2,3)
Biophysical profile score	8(6,8)
Approximate ultrasound age	31(33,35)
Umbilical Artery Resistive Index	0.64(0.548,0.72)
Middle Cerebral Artery Resistive Index	0.74(0.646,0.817)
Cerebral/Placental Ratio	
<1.0	47(29%)
≥ 1.0	113(71%)

The CPR had 87.5% (95% CI 64%, 96.5%) sensitivity, 77% (70%, 83.2%) specificity, 30% positive predictive value, and 98.2% negative predictive value for neonatal mortality.

However, there was no significant difference in maternal age (p=0.2), marital status (p=0.4), occupation (p=0.6), foetal presentation-Cephalic vs. Breach (p = 0.7) and parity (p = 0.4) on foetal outcome. In the univariate analysis, in patients with CPR < 1.0, the still births were 0.42 (95% CI 0.23, 0.78) times more likely than live births and 23 (OR 23; 95% CI 5, 108) times more often relative to hypertensive mothers with CPR ≥ 1.0.). For every unit increase in the biophysical score, we expect the odds of a live birth to increase by 2.01 (95% CI 1.5, 2.8). Among SVD neonates, a still birth was 11 (95% CI 3.5, 34.5) times more likely than among CS newborns.

In multivariate analysis, adjusting for biophysical score and mode of delivery, still births among hypertensive mothers with CPR < 1.0 were 12.5 (OR 12.5; 95% CI 2, 74; p=0.005) times more often than mothers with CPR ≥ 1.0. On adjusting for CPR and mode of delivery, for a unit increase in biophysical score, we expect about 70% increase in the odds of a live birth. On adjusting for biophysical score and CPR, still births among SVD neonates were 14.5 (OR 14.5; 95% CI 3, 84; p<0.001)) times more often than Caesarian section neonates. There was evidence of association between the Cerebral/Placental Ratio (p<0.001), Biophysical score (p<0.001) mode of delivery (p=0.002) and APGAR (5 minutes) score in the study population. The CPR had 93.3% (95% CI 79%, 98%) sensitivity, 85.4% (95% CI 78.3%, 90.4%) specificity, 60% positive predictive value, and 98.2% negative predictive value for 5 minute Apgar score. However, there was no significant difference in marital status (p=0.8), occupation (p=0.1), fetal presentation-Cephalic vs. Breech (p=0.9) or parity (p=0.8) on neonate's Apgar score. In the univariate analysis, among infants of mothers with hypertensive disorder during pregnancy with CPR < 1.0, an Apgar score < 7 was 1.47 (95% CI 0.8, 2.6; p<0.001) times more likely than a score ≥ 7 and 82 (OR 82; 95% CI 18, 372; p<0.001) times more likely relative to hypertensive mothers with CPR ≥ 1.0). Among SVD neonates, an Apgar score < 7 was 3.75 (95% CI 1.6, 8.83; p=0.002) times more likely than in CS newborns.

Table 2. Clinical Management and Fetal Outcome

Characteristics	Number (%) Median (IQR)
Foetal Outcome	
• **Alive**	144 (90%)
• **Still birth**	16 (10%)
Infant weight (at birth)	2,100 (1,700, 2638)
• **Low-less than 10th percentile than expected**	27 (17%)
• **Normal-that expected at gestation**	133 (83%)
Mode of delivery	
• **Caesarean section**	125(78%)
• **SVD**	35(22%)
APGAR score(5 minutes)	
• **< 7**	30 (19%)
• **≥ 7**	130 (81%)
Infant admitted in NBU	
• **Yes**	42 (26)
• **No**	118 (74)

In multivariate analysis, adjusting for mode of delivery and biophysical score, an APGAR score < 7 among infants of hypertensive mothers with CPR < 1.0 was 66 (OR 66; 95% CI 13, 340; p< 0.001) times more often than among infants of mothers with CPR ≥ 1.0. On adjusting for CPR and mode of delivery, for every unit increase in biophysical score, there was about 1.3 (95% CI 0.9, 1.9; p=0.07) increase in the odds of an Apgar score ≥ 7. However, the increase was not statistically significant. On adjusting for CPR and biophysical score, an Apgar score < 7 among SVD neonates was 6 (OR 6; 95% CI 1.3, 23; p=0.02)) times more often than Caesarian section neonates.

Table 3. Correlates of Foetal Outcome among hypertensive pregnant mothers

	Foetal Outcome		
	Still birth	**Live birth**	
Characteristics	**No (%) or Median (IQR)**	**No (%) or Median (IQR)**	**p-value**
Cerebral/Placental Ratio			
• **< 1.0**	14 (87.5)	33 (23)	< 0.001
• **≥ 1.0**	2 (12.5)	111 (77)	
Maternal age	31 (26, 34)	28 (24, 32)	0.2[m]
Marital Status			
• **Married**	13 (81)	128 (89)	0.4*
• **Not married**	3 (19)	16 (11)	
Occupation			
• **With Employed**	6 (37.5)	63 (44)	0.6
• **Not employed**	10 (62.5)	81 (56)	
Presentation			
• **Cephalic**	14 (87.5)	129 (89.6)	0.7*
• **Breech**	2 (12.5)	15 (10.4)	
Parity			
• **1 or none**	10 (62.5)	105 (73)	0.4*
• **≥ 1**	6 (37.5)	39 (27)	
Mode of delivery			
• **SVD**	11 (69)	24 (17)	
• **C/Section**	5 (31)	120 (83)	< 0.001*
	16 (100%)	144 (100%)	
Estimated conditional probabilities for fetal outcome prognosis **Estimated 95% Confidence Interval for sensitivity and specificity computed using Wilson Score Method** *** Fisher Exact Tests used** **m –Mann Whitney test used**			

There was evidence of association between the Cerebroplacental Ratio (p < 0.001), biophysical profile score (p=0.003) and neonate birth weight among the study population. The CPR had 45.1% (95% CI 35%, 56%) sensitivity, 87.2% (95% CI 78%, 93%) specificity, 79% positive predictive value, and 60.2% negative predictive value for neonate's birth weight. However, there was no significant difference in maternal age (p=0.5), marital status (p=0.4), occupation (p=0.3), foetal presentation; Cephalic vs. Breech (p=0.8), parity (0.3) or mode of delivery (p=0.2).

Table 4. Logistic Regression for the Correlates of Foetal Outcome among Hypertensive Pregnant Mothers

	Foetal Outcome		Prognostic Odds Ratio			
Characteristics	**No. still birth/n**	**Odds (95% CI)**	**Unadjusted OR (95% CI)**	**p-value**	**Adjusted OR (95% CI)**	**p-value**
Cerebral/Placental Ratio						
• **< 1.0**	14/47 (29.8%)	0.42 (0.23, 0.78)	23 (5, 108)	< 0.001	12.5 (2, 74)	0.005
• **≥ 1.0**	2/113 (1.8%)	0.018 (0.005, 0.07)	Ref		ref	
Biophysical score			2.01 (1.5, 2.8)	< 0.001	1.7 (1.1, 2.5)	0.009
Mode of delivery						
• **SVD**	11/35 (31.4%)	0.458 (0.23, 0.92)	11 (3.5, 34.5)	< 0.001	14.5 (3, 84)	< 0.001
• **Caesarian Section**	5/125 (4%)	0.042 (0.02, 0.1)	Ref		ref	

Table 5. Correlates of Infant's 5 Minutes APGAR Score of Mothers with Hypertensive Disorder during the Index Pregnancy

	Infant's APGAR score		
	< 7	**≥7**	**p-value**
Characteristics	**No (%) or Median (IQR)**	**No (%) or Median (IQR)**	
Cerebral/Placental Ratio			
• **< 1.0**	28 (93.3)	19 (14.6)	< 0.001
• **≥ 1.0**	2 (6.7)	111 (85.4)	
Maternal age	29 (24, 33)	28 (24, 33)	0.8[m]
Marital Status			
• **Married**	24 (80)	117 (90)	0.2*
• **Not married**	6 (20)	13 (10)	
Occupation			
• **With Employed**	9 (30)	60 (46)	0.1
• **Not employed**	21 (70)	70 (54)	
Presentation			
• **Cephalic**	27 (90)	116 (89)	0.9*
• **Breech**	3 (10)	14 (10)	
Biophysical score	4 (4, 8)	8 (6,8)	< 0.001[m]
Parity			
• **1 or none**	21 (70)	94 (72.4)	0.8
• **≥ 1**	9 (30)	36 (27.7)	
Mode of delivery			
• **Caesarian Section**	17 (57)	108 (83)	0.002
• **SVD**	13 (43)	22 (17)	
	30 (100%)	130 (100%)	

Estimated conditional probabilities for fetal outcome prognosis Estimated 95% Confidence Interval for sensitivity and specificity computed using Wilson Score Method
*** Fisher Exact Tests used.** **m –Mann Whitney test used**

Table 6. Logistic regression for the correlates of Infant's APGAR (5 minutes) Score among mothers with hypertensive disorder during the index pregnancy

	Infant's Apgar score		Prognostic Odds Ratio			
Characteristics	**APGAR score (< 7)/n**	**Odds (95% CI)**	**Unadjusted OR (95% CI)**	**p-value**	**Adjusted OR (95% CI)**	**p-value**
Cerebral/Placental Ratio						
• **< 1.0**	28/47 (59.6%)	1.47 (0.8, 2.6)	82 (18, 372)	< 0.001	66 (13, 340)	< 0.001
• **≥ 1.0**	2/113 (1.8%)	0.018 (0.005, 0.07)	Ref		ref	
Biophysical score			1.8 (1.4, 2.3)	< 0.001	1.3 (0.9, 1.9)	0.07
Mode of delivery						
• **SVD**	13/35 (37.1%)	0.6 (0.3, 1.16)	3.75 (1.6, 8.83)	0.002	6 (1.3, 23)	0.02
• **Caesarian Section**	17/125 (13.6%)	0.16 (0.09, 0.3)	Ref			

Table 7. Correlates of Infant's birth weight among mothers with hypertensive disorder during the index pregnancy

	Infant birth weight		
	Low†	**Normal**	**p-value**
Characteristics	**No (%) or Median (IQR)**	**No (%) or Median (IQR)**	
Cerebral/Placental Ratio			
• **< 1.0**	**37 (45.1)**	**10 (12.8)**	**< 0.001**
• **≥ 1.0**	**45 (54.9)**	**68 (87.2)**	
Maternal age	**29 (24, 33)**	**27 (23, 33)**	**0.5[m]**
Marital Status			
• **Married**	**74 (90.2)**	**67 (85.9)**	**0.4**
• **Not married**	**8 (9.8)**	**11 (14.1)**	
Occupation			
• **With Employed**	**32 (39)**	**37 (47.4)**	**0.3**
• **Not employed**	**50 (61)**	**41 (52.6)**	
Presentation			
• **Cephalic**	**73 (89)**	**70 (89.7)**	**0.8**
• **Breech**	**9 (11)**	**8 (10.3)**	
Biophysical score	**6 (4, 8)**	**8 (6, 8)**	**0.003[m]**
Parity			
• **1 or none**	**62 (75.6)**	**53 (67.9)**	**0.3**
• **≥ 1**	**20 (24.4)**	**25 (32.1)**	
Mode of delivery			
• **Caesarian Section**	**68 (82.9)**	**57 (73.1)**	**0.2**
• **SVD**	**14 (17.1)**	**21 (26.9)**	
	30 (100%)	**130 (100%)**	

Estimated conditional probabilities for fetal outcome prognosis
Estimated 95% Confidence Interval for sensitivity and specificity computed using Wilson Score Method
† Low Birth weight <10th percentile of the expected weight for gestation
*** Fisher Exact Tests used**
m –Mann Whitney test used

Table 8. Logistic Regression for the Correlates of Infant's Birth Weight among Mothers with Hypertensive disorder During the Index Pregnancy

	Infant's birth weight		Prognostic Odds Ratio			
Characteristics	**% Low birth weight**	**Odds (95% CI)**	**Unadjusted OR (95% CI)**	**p-value**	**Adjusted OR (95% CI)**	**p-value**
Cerebral/Placental Ratio						
• **< 1.0**	37/47 (78.7%)	3.7 (1.9, 7.3)	5.6 (2.5, 12.4)	< 0.001	4.7 (2, 11.1)	< 0.001
• **≥ 1.0**	45/113 (39.8%)	0.66 (0.45, 0.96)	Ref		Ref	
Biophysical score			1.3 (1.1, 1.6)	0.006	1.1 (0.9, 1.4)	0.327

Table 9. Patients According To Severity of PET and CPR

Characteristic	Number and percentage of patients(160)	
	Total number	**Percentage (%)**
Severe PET	51/160	32%
• **CPR< 1.0**	20/51	39%
• **CPR≥ 1.0**	31/51	61%
Mild PET	109/160	68%
• **CPR≤ 1.0**	27/109	24%
• **CPR≥1.0**	82/109	76%

In the univariate analysis, among infants of mothers with hypertensive disorder during pregnancy with CPR < 1.0, low birth weight (<10th percentile of expected weight at gestation week) was 3.7 (95% CI 1.9, 7.3) times more likely than normal weight and 5.6 (OR 5.6; 95% CI 2.5, 12.4; p<0.001) times more likely relative to infants of hypertensive mothers with CPR ≥ 1.0.). The odds of a low birth weight among infants of mothers with hypertensive disorder during pregnancy with CPR ≥ 1 was 0.66 (95% CI 0.45, 0.96). For every unit increase in the biophysical score, we expect the odds of normal birth weight to increase by 30% (95% CI 10%, 60%).

In the multivariate analysis, adjusting for biophysical score, infants of hypertensive mothers with CPR < 1.0 were 4.7 (OR 4.7; 95% CI 2, 11.1; p< 0.001) times more likely to have low birth weight than among infants of mothers with CPR ≥ 1.0. On adjusting for CPR, for every unit increase in biophysical score, we expect about 1.1 (95% CI 0.9, 1.4; p=0.327) increase in the odds of normal birth weight. However, the increase is not statistically significant. A total of 51 patients out of 160(32%) were found to have severe PET. Among the patients with severe PET, 20 of them (39%) had CPR <1.0 and 31(61%) had CPR ≥ 1.0. A total of 109 patients out of 160 (68%) were found to have mild PET.

Among the patients with mild PET, 27 out of 109 patients (24%) were found to have CPR <1.0 and 82 out of 109 patients (76%) had CPR ≥ 1.0. This demonstrates that more patients had mild PET at time of performing the ultrasound scan and among the patients with mild PET, there were less patients with CPR<1.0 as compared to those with severe PET.

Discussion

The main aim of this study of 160 patients with hypertensive states in pregnancy was to determine the CPR as a predictive factor of foetal outcome. The median gestation was 34 weeks which is a gestation where the foetus has achieved a good foetal weight. This is a younger gestation than that Odibo et al[11] where mean gestation was 35 weeks[10] and that of Lakhkar et al[10] where gestation was also 35 weeks. The gestation is also younger than Serap Yalti et al[11] where it was 37 weeks. This means either our patients show up for care earlier or that intervention is carried out earlier.

Nearly a third (32%) out of 160 patients was found to have severe PET (blood pressure >160/110 mmHg and proteinuria >2 grams in a 24 hour period) which was a lower finding when compared to the 68% reported by Yalti et al[12]. This could mean that we have fewer patients with severe PET as compared to Yalti et al study population. It could also mean that patients presented earlier in this study as compared to Yalti et al[12] thus our patients were found earlier and attended to earlier. Out of these 39% were found to have a CPR <1.0 and 61% had CPR≥ 1.0. This is much higher than the population studied by Lakhkar et al[10] showing 11% to have severe PET thus we have a higher population presenting with severe PET.

This was not explained by any of the etiological causes of PET though it would be worth carrying out other studies to find out why our patients have severe PET. The number of patients with severe PET that had an abnormal CPR was not studied in other studies and it is important as it is significant number with severe PET that has an abnormal CPR. The majority (68%) had mild PET out of which 24% had an abnormal CPR (<1.0) while 76% had a normal CPR (≥1.0). This is also significant as even a significant number of patients with mild PET had an abnormal CPR (<1.0) thus they also require close monitoring. It shows that fetuses of patients with mild PET also suffer from cerebral hypoxia resulting in an abnormal cerebroplacental ratio. Therefore these patients also need monitoring.

In all, 29% had a CPR <1.0 which was abnormal and 71% had a CPR ≥1.0 which was normal. The findings of this in Yalti et al[12] were 68% with a normal CPR and 32% with abnormal CPR which is similar to the findings in this study. This was not documented in the other studies by Lakhkar et al [10] or Odibo et al [11]. This is an important finding as it shows that a third of the sample size presented with an abnormal CPR which would imply that we have patients with fetuses that are having impending fetal distress and could have adverse perinatal outcome. The median ultrasonographic foetal heart rate (done on all fetuses in the study and statistical median calculated) was found to be 138 beats per minute which is within normal range (120-160).

A total of 78% had delivery via caesarean section delivery which is much higher than the 62% demonstrated by Lakhkar et al[10]. The 22% vaginal delivery in our series was higher than that 5% reported by Lakhkar et al. This could be due to the smaller sample size which was 58 in Lakhkar et al[10] study as opposed to 160 patients in this study. It could also mean that we have more patients with hypertensive states in pregnancy as compared to other comparative studies. Most caesarean sections were carried out on these patients was due to failed induction of labor.

The neonates delivered via cesarean section had better outcome as compared to those delivered vaginally in terms of Apgar score and number of still births. This was not a study

variable in the other three comparative studies. Therefore, delivery via caesarean section is best as it improves on perinatal outcome.

The CPR had a 93.3% (95% CI 79%, 98%) sensitivity, 85.4% (95% CI 78.3%, 90.4%) specificity, 60% positive predictive value, and 98.2% negative predictive value for adverse perinatal outcome. This contrasts with findings by Lakhkar et al[10] who had a CPR sensitivity of 47.2%, specificity of 86.3%, PPV of 85% and NPV of 50% which could be due to a smaller sample size of 58 in the Lakhkar study as contrasts to this study which had a sample size of 160 while that of Odibo et al[11] showed the CPR to have a sensitivity of 67%, specificity of 66%, PPV of 69% and NPV of 64%. The CPR has been found to be predictive of adverse perinatal outcome and therefore very good in antenatal monitoring of mothers with hypertensive states of pregnancy. This should thus be used in antenatal and perinatal centers for antenatal monitoring of patients with hypertensive states of pregnancy.

Twenty seven (17%) neonates had low birth weight(less than tenth percentile of expected) which is much higher than that of Lakhkar et al[10] who had a percentage of 6.8%. This could be due to patients being delivered at an earlier gestation (at 32-34 weeks) as compared to 36 weeks in Lakhkar et al study or more patients with severe PET causing low birth weight in these fetuses. Further studies should be carried out to determine why our sample population has a severe PET.

Conclusion

- The CPR is predictive of adverse perinatal outcome and therefore very good in antenatal monitoring of mothers with hypertensive states of pregnancy.
- Algorithm for management of hypertensive mothers should recommend caesarean section as this mode of delivery compared to SVD improves perinatal outcomes among mothers with CPR < 1.

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