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Original Research Article

Predictive value of pre-induction cerebroplacental ratio for caesarean delivery due to foetal distress following induction of labour: a prospective observational study

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ABSTRACT

Background: Induction of labour is a commonly performed obstetric intervention when delivery is considered safer than continuation of pregnancy. Traditional parameters like the amniotic fluid index, estimated foetal weight and modified bishop score have been used to identify the development of foetal distress. This study focuses on the Cerebroplacental Ratio derived from Doppler assessment of the middle cerebral and umbilical arteries which provides information regarding foetal adaptation and the risk of foetal compromise during labour.
Methods: A prospective observational study was conducted over 12 months among 305 antenatal women with singleton, cephalic pregnancies beyond 32 weeks of gestation undergoing induction of labour. Pre-induction Cerebroplacental ratio (CPR), amniotic fluid index (AFI), estimated foetal weight (EFW), and Modified Bishop Score were assessed within 24 hours before induction. The predictive performance of CPR was compared with AFI, EFW and Modified Bishop Score using appropriate statistical and diagnostic measures.
Results: Among 305 women undergoing induction of labour, 213 (70%) had normal vaginal delivery and 92 (30%) underwent caesarean section. A CPR ≤1.1 was significantly associated with caesarean delivery and adverse neonatal outcomes. CPR ≤1.1 was also significantly associated with Apgar score <7 at 1 and 5 minutes. Among the parameters studied, CPR showed the highest sensitivity (45.54%), positive predictive value (58.08%) and diagnostic accuracy (39.02%) for adverse outcome.
Conclusion: Pre-induction cerebroplacental ratio was found to be a better predictor of adverse perinatal outcome compared with AFI, estimated foetal weight and Modified Bishop Score in women undergoing induction of labour.

Keywords: Cerebroplacental ratio, Induction of labour, Doppler ultrasound, Amniotic fluid index, modified bishop score, Estimated foetal weight

INTRODUCTION

Induction of labour is becoming an increasingly popular obstetric technique. It is often performed with the purpose of reducing the risks to both the mother and the unborn child that are associated with longer gestation or difficulties during pregnancy. There is a high chance of cesarean section during induction, particularly owing to intrapartum foetal distress, which poses both immediate and long-term hazards for both the mother and the child. Recent advances focus on the utilisation of a number of antepartum predictors, specifically the CPR, the AFI, the EFW, and the modified bishop score, for the purpose of individualising labour management and optimising perinatal outcomes. Several studies have demonstrated the usefulness of CPR as a sensitive indicator of foetal compromise in both low-risk and high-risk pregnancies. This ratio is generated from the Doppler ultrasonography assessment of the pulsatility indices of the umbilical artery (UA) and the MCA of the foetus. Abnormal levels of this

ratio show that blood flow is redistributed in favour of essential organs such as the brain, a process that is widely referred to as the "brain-sparing effect".[1] Lower values are associated with an increased risk of severe perinatal outcomes, such as intrapartum foetal distress and emergency caesarean section.[2]

Traditional methods have been used to assess the likelihood of successful induction and foetal health. The Modified Bishop Score takes into account cervical dilation, effacement, consistency, position, and foetal station and is a fundamental component in determining whether or not the cervical region is prepared for labour induction.[3] Sonographic parameters such as AFI and EFW are also routinely assessed before induction. However, these parameters provide information about cervical readiness, amniotic fluid volume and foetal size, rather than directly reflecting foetal circulatory adaptation to reduced oxygen availability.

Including CPR with other antenatal tests could significantly enhance the prediction of unfavourable intrapartum events and aid therapeutic decision-making in women who are undergoing labour induction. In contrast to static measurements such as EFW or AFI, CPR dynamically reflects the foetal hemodynamic condition. This offers the possibility of detecting foetuses who are at risk for distress during the strains of birth, which may not otherwise be apparent on conventional parameters. For example, Khalil et al conducted a prospective cohort study in which they revealed that women who had a low pre-induction CPR had considerably greater rates of caesarean delivery for non-reassuring foetal state.[2,4,5] When compared to models that were exclusively based on EFW and AFI, Morales-Roselló et al showed that the incorporation of CPR into pre-induction assessment models resulted in a considerable improvement in the identification of foetuses that were at risk for academia and adverse neonatal outcomes.[6]

METHODS

Study type

It was prospective observational study.

Study place

The study was carried out by the principal investigator in the Institute of Obstetrics and Gynaecology, Egmore and ISO Government KGH Hospital, Triplicane, Chennai.

Study duration

Study duration was October 2023 to September 2024.

Inclusion criteria

The study included all antenatal women beyond 32 weeks of gestation who were undergoing induction of labour, had a singleton pregnancy with cephalic presentation, and were willing to provide written informed consent.

Exclusion criteria

Women with a gestational age below 32 weeks, any contraindication to induction of labour, previous caesarean section, previous myomectomy, hysterectomy or other uterine surgery, uterine anomalies, malpresentation, multifetal gestation, herpes simplex warts, non-reactive cardiotocograph or foetal alarm signal, eclampsia, intrauterine death, vertical transmission disease in vaginal delivery, meconium-stained liquor in the latent phase of labour, cord prolapse, abruption following induction of labour in the latent phase, placenta previa, cephalopelvic disproportion, scarred uterus, or congenital foetal anomalies were excluded. Patients who did not provide consent or were unwilling to participate in the study were also excluded.

Procedure

After obtaining consent from the study participants, all the study participants were evaluated through a semi-structured questionnaire which includes demographic details. A detailed history including name, age, parity, menstrual history, pre-existing medical illness and family history was obtained. Transabdominal ultrasound was performed to measure the amniotic fluid index, estimated foetal weight, cerebro placental ratio and cervical length. The patient was followed throughout the pregnancy and outcomes analysed.

Ethical approval

Ethical principles such as respect for the persons, beneficence and justice were adhered. The approval to conduct the present study was obtained from the Institutional Ethics Committee.

Statistical analysis

The data was collected using a proforma, entered and analysed with the SPSS software Version 24.0. Categorical variables are expressed as proportions. Continuous variables are expressed as mean and standard deviation. The Chi square test was used for association of categorical variables. Student t test and anova test are used for finding of association of continuous variables. Data has also been represented using appropriate pictorial representations using MS Excel. A p value less than 0.05 ($p<0.05$) was considered to be statistically significant.

Based on the inclusion and exclusion criteria the study participants were recruited and the final sample size was 305. Informed written consent was obtained from the study participants/ primary caregivers, after explaining the risks and benefits in a language comfortable to them. All procedures were done under the supervision of a trained and experienced guide. Confidentiality of the study

participants was maintained throughout the study. The study participants constituted the vulnerable population, so the principal investigator was available to address the queries of the study participants throughout the course of the study.

RESULTS

26-30 years of age was the most common age group 153(50%) followed by ≤25 years 137(45%). Multigravida was predominant in the study 164(54%) while 141(46%) were Nulligravida. 214 (70%) of the study participants were in the gestation period 38-41weeks. 82 (27%) of the study participants were in 36-38 weeks of gestation.

The demographic characteristics of the study participants are presented in Table 1. The majority of the participants were aged 26–30 years (153, 50%), followed by those aged ≤25 years (137, 45%). Multipara constituted 164 (54%) of the study participants, while 141 (46%) were nullipara. Most participants were in the gestational age group of 38–41 weeks (214, 70%), followed by 36–38 weeks (82, 27%) (Table 1).

Majority of the study participants have CPR in the range of 1-1.2 177(58%). This is followed by 1.21-1.38 118 (39%). In cerebroplacental ratio less than or equal to 1.1 majority are delivered through cesarean section. In Cerebroplacental ratio >1.1 116 (54%) delivered through normal vaginal delivery. Abnormal outcome was found more in Cerebroplacental ratio ≤1.1 37 (76%) and the difference was found to be statistically significant ($p<0.005$) (Table 2). Most of the study participants have amniotic index >8 80 (59%) followed by 4-8 index 125(41%). Normal vaginal delivery149(70%) was found more in study participants with Amniotic index ≥8. The cesarean section was found more in amniotic index 61 (66%) and the difference is statistically significant (Table 3).

Majority of the study participants have bishop score of 3/13 to 5/13 140 (46%). This is followed by 6/13 to 8/13 110(36%). Majority of the Study participants with Bishop score >6 underwent normal vaginal delivery. Study participants with bishop score ≤6 majority delivered through cesarean section 69 (75%) and the difference is statistically significant (Table 4).

In birthweight <2.5 kg 71 (77%) underwent Cesarean section and in birthweight >2.5 kg majority delivered through normal vaginal delivery 128(60%) and the difference is statistically significant. Cerebro placental ratio ≤1.1 has apgar score <7 27(82%) and the difference was found to be statistically significant (Table 5). Majority of the study participants with cerebroplacental ratio has apgar score <7 25 (76%) and the difference is found to be statistically significant (Table 6).

The sensitivity was found more in cerebroplacental index 45.54 followed by modified bishop score 44.6%. Specificity was found more in amniotic index 33.7. PPV was found more in cerebroplacental index 58%followed by modified bishop score 57.9% (Table 7).

Table 1: Demographic characteristics of the study participants.

Demographic characteristics	Category	N %)
Age (in years)	≤25	137 (45)
	26–30	153 (50)
	31–35	9 (3)
	≥35	6 (2)
Parity	Nullipara	141 (46)
	Multipara	164 (54)
Socioeconomic status	Upper middle	18 (6)
	Lower middle	24 (8)
	Upper lower	107 (35)
	Lower	156 (51)
Gestational age (in weeks)	32–35+6	9 (3)
	36–38	82 (27)
	38–41	214 (70)

Table 2: Cerebroplacental ratio.

CPR	Number (N)	%
0.8-0.99	1	0.3
1-1.2	177	58
1.21-1.38	118	39
>1.39	9	2.9
Total	305	100

Table 3: Amniotic fluid index.

AFI	Number (N)	%
4-8	125	41
>8	180	59
Total	305	100

Table 4: Modified bishop score.

Modified bishop score	Number (N)	%
0/13-2/13	24	8
3/13-5/13	140	46
6/13-8/13	110	36
≥8	31	10
Total	305	100

Table 5: Association of APGAR at 1 minute and cerebro placental ratio.

Cerebro placental ratio	≥7	<7	P value
≤1.1	142 (52%)	25 (76%)	
>1.1	130 (48%)	8 (24%)	<0.001*
Total	272 (100%)	33 (100%)	

*Statistically significant.

Table 6: Association of cerebroplacental ratio and APGAR at 5 min.

Cerebro placental ratio	≥7	<7	P value
≤1.1	142 (52%)	25 (76%)	
>1.1	130 (48%)	8 (24%)	<0.001*
Total	272 (100%)	33 (100%)	

*Statistically significant.

Table 7: Comparison of diagnostic accuracy in cerebroplacental ratio, amniotic index and modified bishop score.

	Cerebroplacental index	Amniotic index	Modified bishop score	Estimated weight
Sensitivity	45.54	30.05	44.6	39.91
Specificity	23.91	33.7	25	22.93
PPV	58.08	51.2	57.9	54.49
NPV	15.94	17.2	16.31	14.09
DA	39.02	31.15	38.69	34.75

DISCUSSION

In the present study, the majority of participants belonged to the 26–30-year age group (50%), followed by those aged ≤25 years (45%). This indicates that most women undergoing induction of labour in the study population were in the younger reproductive age groups. In terms of parity, multigravida women constituted 54% of the study population, while nulligravida women constituted 46%. The predominance of multigravida women is consistent with the obstetric characteristics of the study population. Regarding gestational age, the majority of participants (70%) were between 38 and 41 weeks, while 27% were between 36 and 38 weeks. This indicates that most inductions in the present study were performed at term or near term. Previous studies have evaluated multiple pre-induction clinical and ultrasonographic parameters simultaneously. Tan et al assessed parity, Bishop score, amniotic fluid index and estimated fetal weight among women undergoing induction at term and found that the predictive value of individual parameters varied, with nulliparity and cervical length emerging as independent predictors of caesarean delivery.[7] The predominance of term pregnancies is relevant because foetal tolerance to labour and the indication for induction may vary with gestational age.

A prospective observational study conducted by Gunay et al revealed the significant role of abnormal CPR in predicting adverse fetal outcome in singleton pregnancies with scheduled induction of labor. Their analysis revealed association of normal CPR values with later labor

induction (cut-off value of >38.3 weeks, p=0.001), higher birth weight (cut-off value of >2460 g, p=0.022) and higher umbilical artery pH (cut-off value of >7.31, p=0.007).[8] With regard to pre-induction Doppler assessment, 58% of participants had a CPR between 1.0 and 1.2, while 39% had a CPR between 1.21 and 1.38. The concentration of participants within these CPR ranges indicates that most of the study population had CPR values within the relatively lower ranges assessed in the study. Participants with CPR ≤1.1 were more frequently associated with caesarean delivery, whereas among those with CPR >1.1, 116 (54%) underwent normal vaginal delivery. This suggests that a lower pre-induction CPR may be associated with reduced foetal tolerance to labour. A meta-analysis by Moreta et al showed abnormal CPR can predict the need for operative delivery due to foetal distress. CPR was found to be useful to identify foetuses with higher risk of operative delivery due to foetal distress, low Apgar score, NICU admission, neonatal morbidity as well as stillbirth and neonatal death rates.[9]

The present study also demonstrated an important association between CPR and adverse neonatal outcomes. Overall, an adverse outcome was observed in 49 participants (16.06%). Among these, 37 (76%) had a CPR ≤1.1, and this association was statistically significant. This finding suggests that a low CPR may identify foetuses with reduced ability to tolerate the physiological stress associated with labour. Similar findings were reported by Fiolna et al who observed an association between low CPR and adverse neonatal outcomes.[10]

A significant association was also observed between CPR and Apgar scores. Among participants with CPR ≤1.1, 27 (82%) had an Apgar score <7 at one minute, with the difference being statistically significant. Similarly, at five minutes, 25 (76%) of those with Apgar scores <7 had CPR ≤1.1. These findings suggest that a lower pre-induction CPR may be associated with poorer immediate neonatal adaptation following delivery. Comparable findings were reported by Sangeereni et al in whom a lower CPR was associated with a higher proportion of neonates having an Apgar score <7.[11]

A cross-sectional study by Bahadori et al similar to the findings, supports the use of CPR to evaluate maternal and neonatal outcomes in term pregnant women undergoing labor induction or augmentation.[12] Abnormal CPR was found to be significantly associated with higher cesarean rates, increased NICU admission, and reduced cord arterial pH. The study also indicates that CPR has limited value as a standalone screening test, and many fetuses destined for adverse outcomes will have normal CPR values and thus, CPR should not be used to guide clinical decision-making in isolation.

The amniotic fluid index was another parameter assessed in the study. Most participants had an AFI ≥8, while 41% had an AFI between 4 and 8. Normal vaginal delivery was more frequent among women with AFI ≥8, accounting for 149 (70%) of normal vaginal deliveries. In contrast, caesarean delivery was more frequent among women with lower AFI, with 61 (66%) of caesarean deliveries occurring in the 4–8 AFI group. This association was statistically significant. A study by Makles et al aimed at evaluating the value of the CPR and AFI in pregnancies after 41 weeks as prognostic factors of terminating pregnancy with cesarean section after induction of labour. They concluded that an integrated model of evaluation after 41 weeks of gestation using CPR, AFI and cardiotocography might allow to avoid making early decisions on performing labour induction, and thus, reduce the number of cesarean sections.[13] These findings suggest that reduced amniotic fluid may be associated with an increased likelihood of operative delivery during induction.

The modified bishop scores also showed a significant association with mode of delivery. Participants with a Bishop Score >6 were more likely to undergo normal vaginal delivery, whereas those with a Bishop Score ≤6 had a higher proportion of caesarean deliveries. Among caesarean deliveries, 69 (75%) occurred in women with a Bishop Score ≤6. This finding is consistent with the established role of cervical favourability in determining the outcome of induction. A higher Bishop Score indicates a more favourable cervix and therefore a greater likelihood of successful induction and vaginal delivery.

A cohort study by Garcia et al concluded that a combined use of the Bishop score and CPR improve the ability to predict overall Cesarean section, emergency Cesarean section for fetal distress, and neonatal admission after labor induction in the presence of normal umbilical artery Doppler recordings in small for gestational age fetuses.[14] Birth weight also demonstrated a statistically significant association with mode of delivery. Among participants with birth weight <2.5 kg, 71 (77%) underwent caesarean delivery, whereas among those with birth weight ≥2.5 kg, 128 (60%) underwent normal vaginal delivery.

When the diagnostic performance of the different pre-induction parameters was compared, CPR demonstrated the highest sensitivity (45.54%), followed by the Modified Bishop Score (44.6%). AFI had the highest specificity (33.7%) and negative predictive value (17.2%), whereas CPR demonstrated the highest positive predictive value (58%), followed closely by the Modified Bishop Score (57.9%). In a recent prospective cohort by Rathore et al it was found that CPR measurement has good negative predictive value for fetal outcome in low-risk pregnancy.[15]

A systemic review and meta-analysis done in 2018, found CPR to outperform MCA doppler and UA doppler in predicting adverse perinatal outcomes. However, a large variation was observed in reported sensitivities and specificities, and in thresholds used. Risk of bias or suboptimal reporting was detected in 120/128 studies (94%) and substantial heterogeneity was found, which limited subgroup analyses for fetal growth and gestational

age. Hence the effectiveness of the CPR in guiding clinical management needs to be evaluated.[16] The poor predictive value of CPR was also described in a recent study by Ortiz et al the relationship between CPR and the need for operative delivery due to intrapartum fetal compromise and adverse perinatal outcome were evaluated. CPR <10th percentile showed a significantly higher rate of operative delivery for intrapartum fetal compromise yet not a significantly higher rate of adverse perinatal outcome. However, the predictive values for CPR for operative delivery due to intrapartum fetal compromise and adverse perinatal outcome showed sensitivities of 26 % and 19 % and specificities of 87 % and 84 % respectively.[17] These findings suggest that CPR may have an advantage over the other parameters in identifying women at increased risk of adverse delivery outcomes, particularly because it provides information regarding foetal circulatory status rather than solely assessing cervical favourability, amniotic fluid volume or foetal size. However, the poor sensitivity and heterogeneity of CPR limit its efficiency as an independent indicator.

The sample size was relatively small, which may affect the strength of the findings. As the study was conducted in a single centre, the results may not be directly generalised to the wider population. There may also be some interobserver variability while assessing the doppler parameters and calculating the cerebroplacental ratio.

CONCLUSION

The findings of the study demonstrate that pre-induction CPR was significantly associated with mode of delivery, adverse neonatal outcome and Apgar scores, with lower CPR values being associated with poorer outcomes. Although AFI, Modified Bishop Score and birth weight also demonstrated significant associations with mode of delivery, CPR showed the highest sensitivity and positive predictive value among the parameters studied. Therefore, CPR may serve as a useful additional parameter in pre-induction assessment, particularly when used in conjunction with conventional clinical and ultrasonographic parameters. However, the relatively modest diagnostic performance observed in the present study suggests that CPR should complement, rather than replace, established methods of foetal and labour assessment.

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