Correlation between Cerebroplacental ratio and umbilical artery Doppler with pregnancy outcome in postdates

Original Article

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ABSTRACT

Background: Postdate pregnancy is a real problem in modern obstetrics. Its incidence has been reported to be between 4-14% with an average of 10.5%. Postdate pregnancy is associated with increased risk of perinatal morbidity and mortality. Assessment of fetal wellbeing is a corner stone in the management of prolonged pregnancy**.**

Aim: To assess the usefulness of cerebroplacental ratio (CPR) compared with umbilical artery Doppler alone in prediction of the intrapartum fetal hypoxia and the adverse perinatal outcome in uncomplicated pregnancies (low risk pregnancy) beyond 40 weeks.

Patients and Methods:This study was carried out on 60 pregnant women with uncomplicated postdate pregnancies beyond 40 weeks gestation attending the antenatal clinics of Al-Zahraa University Hospital for antepartum assessment of CPR.

Results:CPR had a high predictive value in postdate pregnancy with sensitivity, specificity, PPV and NPV (85.7%, 73.9%, 50%, and 94.4%), respectively, in comparison to other parameters, with cut off value (0.94).

Conclusion:CPR had the highest sensitivity and NPV in prediction of neonatal outcome. Cerebroplacental ratio less than 0.94 were the best predictor of adverse perinatal outcome and neonatal ICU admission.

Key Words: Cerebroplacental ratio, pregnancy, postdates, umbilical artery Doppler

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INTRODUCTION

The estimation of pregnancy dates is important for the mother, who wants to know when to expect the birth of her baby, and for her health care providers, so they may choose the way in which to perform various screening tests and assessments. The three basic methods used to help estimate gestational age (GA) are menstrual history, clinical examination and ultrasonography[1].

Postdate pregnancies account about 4-14% of the deliveries and are known to be associated with increased risk for perinatal complications[2].

The mechanism of fetal complications associated with postdate pregnancy has attributed to progressive placental insufficiency, particularly in the presence of decreased amniotic fluid[2].

Placental dysfunction is considered to be the pathophysiologic event leading to intrapartum asphyxia and meconium aspiration. However, the principal mechanism leading to intrapartum fetal distress is umbilical cord compression due to oligohydramnios[3].

Also, prepartum meconium aspiration is the potential danger in postdate pregnancy. Meconium staining of amniotic fluid serves as a primary ingredient in the lower APGAR scores and higher incidence of meconium aspiration syndrome and fetal distress encountered in the postdate group[3].

Postdate infants, particularly those with macrosomia and post maturity, are at increased risk for hypoglycemia because post mature infants has decreased storage of glycogen, subcutaneous fat and possibly an increased metabolic rate. It is important that postdate infants with macrosomia or signs of post maturity have glucose evaluations especially during the first 12 hours[4].

Postdate pregnancies are also associated with maternal risks namely discomfort, anxiety and increased cesarean

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delivery due to cephalopelvic disproportion. Also, there is a risk for cervical tears due to the fetal macrosomia[5].

Ultrasound examination plays a very important role in the diagnosis of postdate pregnancies which is used for assessment of both gestational age and amniotic fluid volume. The amniotic fluid index (AFI) and biophysical profile (BPP) have both been used to assess fetal well-being[6].

Doppler information may play a role in the surveillance of uncomplicated postdate pregnancies. Data from reliable, well-constructed normal curves during this gestational age are lacking[7].

A few studies had looked into the Doppler blood flow changes in postdate pregnancies and came up with varying results. Some demonstrated redistribution of blood flow in the fetal cerebral circulation in postdated pregnancies were reported with adverse perinatal outcome. Such brain-sparing phenomenon is thought to result in oligohydramnios[8]. However, others reported insignificant difference in Doppler indices for postdated pregnancies with and without oligohydramnios[2].

Evaluation of the cerebral blood flow in the fetus has become an integrated part of the assessment of high-risk pregnancies. The middle cerebral artery (MCA) has been studied extensively, and its Doppler recordings are incorporated regularly into the management of fetuses at risk of developing placental compromise and fetal anemia. Combining the Doppler waveform analysis of the middle cerebral artery (MCA) with that of the umbilical artery (UA) by a common cerebroplacental ratio, has been suggested as a useful clinical simplification[9].

A low cerebroplacental ratio reflects redistribution of the cardiac output to the cerebral circulation and has been shown to improve accuracy in predicting adverse outcome compared with MCA or UA Doppler alone[10].

AIM OF THE WORK

The aim of this study was to assess the usefulness of Cerebroplacental ratio (CPR) compared with umbilical artery Doppler alone in prediction of the intrapartum fetal hypoxia and the adverse perinatal outcome in uncomplicated pregnancies (low risk pregnancy) beyond 40 weeks.

PATIENTS AND METHODS

This prospective study was carried on 60 pregnant ladies who were admitted to Al- Zahraa University Hospital during the period starting from May 2018 to January 2019 and verbal consent was taken from patients on the day of admission.

The aim of this study was to assess the usefulness of Cerebroplacental ratio (CPR) compared with umbilical artery Doppler alone in prediction of the intrapartum fetal hypoxia and the adverse perinatal outcome in uncomplicated pregnancies (low risk pregnancy) beyond 40 weeks.

All pregnant women with gestational age of more than 40 weeks were admitted for termination and for assessment of Cerebroplacental ratio (CPR).

The included patients with ages ranged from twenty (20) years to thirty five (35) years and gestational age more than 40 weeks

Women with risk factor as diabetes mellitus, pregnancy induced hypertension, systemic lupus and RH negative blood group, with multiple pregnancies and cases with fetal Congenital or chromosomal abnormality or oligohydraminos were excluded from the study.

All patients were subjected to the following:

1- Full history was taken (personal, past menstrual, obstetric and past medical and surgical histories). Thorough menstrual history taking to be sure of the last menstrual period and calculation of actual gestational age. Special emphasis was done to obtain a report of ultrasound in the first or early second trimester of pregnancy for accurate estimation of gestational age.

2- Examination was performed in the form of general, abdominal and obstetric examinations. 3- Ultrasound and Doppler studies were formed to assess the following: Gestational age determination by fetal biometry including Biparietal diameter, Head Circumference, Femur Length, Abdominal Circumference, Amniotic Fluid Index. Fetal weight estimation. Placental site assessment. Middle cerebral artery pulsatility index (MCA-PI), resistance index (RI), Systolic/Diastolic (S/D) ratio. Umbilical artery pulsatility index (UA-PI), resistance index (RI), Systolic/ Diastolic (S/D) ratio. Cerebro-placental ratio (CPR) was calculated by dividing the Doppler resistance index of the middle cerebral artery (MCA) by the umbilical artery (UA) resistance index. Biophysical profile including ultrasound parameter as (AFI, FHR, repiratory movment, fetal movment and NST).

All cases were observed till either spontaneous onset or induction of labor. Then observed for any intra-partum fetal distress as determined by intermittent fetal heart auscultation or cardiotocogaphy (CTG) or meconium staining of the amniotic fluid. Route of delivery was registered for all pregnant ladies.

The patients who were complicated with fetal distress, failed induction or failure of progress, were terminated by cesarean section.

The neonatal conditions were assessed by fetal birth weight and Apgar scoring at 1- minutes and 5- minutes. Follow up all neoborns for development of adverse pregnancy outcome as the presence of one or more of the following conditions: Presence of thick meconium stained liquor, meconium aspiration syndrome, cesarean delivery for fetal distress, min Apgar score is less than 6 and neonatal intensive care unit (NICU) admission.

STATISTICAL ANALYSIS:

Recorded data were analyzed using the statistical package for social sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA). Quantitative data were expressed as mean± standard deviation (SD). Qualitative data were expressed as frequency and percentage.

The *p-value* was considered significant as the following: Probability (*P-value*) *P-value* < 0.05 was considered significant. *P-value* <0.001 was considered as highly significant. *P-value* ≥0.05 was considered insignificant.

RESULTS

The present study included 60 pregnant ladies with gestational age of more than 40 weeks for assessment of Cerebroplacental ratio (CPR).

In the present study, the mean±SD of maternal age is (23.973.55±), GA (wks) 41.540.33±, also mode of delivery CS (66.7%) and NVD (33.3%). Indications for C.S. delivery were failed induction (17.5 %), failure to progress (57.5 %) and fetal distress (25 %) in group.

By comparing the studied group as regard umbilical artery, middle cerebral artery Doppler and CPR, showed that the Umbilical artery-RI abnormal (28.3%), Middle cerebral artery-RI abnormal (18.3%) and Cerebroplacental ratio abnormal ≤0.94 24 (40.0%) and normal >0.94 36 (60.0%).

In our study abnormal biophysical profile <6 was found in 10%,nonreassuring NST was found in 16.7% of pregnancies ,after birth neonates had abnormal Apger score after 5 min (≥6) 11.7% were admitted to NICU .

This showed that CPR had a high predictive value in postdate pregnancy with sensitivity, specificity, PPV and NPV 85.7%, 73.9%, 50%, 94.4% respectively in comparison to other parameters, with cut off value≤ 0.94.

Table 1: Comparison between admitted to ICU and not admitted to ICU according to maternal age, gestational age, fetal weight and mode of delivery

Maternal parameters		Admitted (n=14)	Not admitted (n=46)	t/x2#	*p-value*
Age (years)		26.71±4.08	23.74±3.38	3.481	0.028*
GA (wks)		41.71±0.16	41.32±0.28	4.635	0.041*
Fetal weight (gm)	Normal (3000 - < 4000gm) (n=50)	7 (50%)	43 (93.5%)	11.646	<0.001**
	Macrosomia (≥ 4000gm) (n=10)	7 (50%)	3 (6.5%)		
	Range [Mean±SD]	4193.57±303.89	4070.98±388.03		
Mode of delivery					
NVD		3 (21.4%)	17 (37.0%)	5.284#	0.047*
CS		11 (78.6%)	29 (63.0%)		
*Failed induction		1 (9.1%)	6 (20.7%)	0.743	0.389
*Failure of progress		3 (27.3%)	20 (69.0%)	5.673	0.017*
*Fetal distress		7 (63.6%)	3 (10.3%)	12.079	0.001**

Significant values are indicated with * for *p<0.05* and with ** for values *<0.01*

Table 2: Comparison between admitted to ICU and not admitted to ICU according to Doppler indices

Doppler indices	Admitted (n=14)	Not admitted (n=46)	x2	*p-value*
Umbilical artery-RI				
Normal ≤0.62	4 (28.6%)	39 (84.8%)	14.048	0.002*
Abnormal >0.62	10 (71.4%)	7 (15.2%)		
Middle cerebral artery-RI				
Normal >0.67	5 (35.7%)	44 (95.7%)	21.907	<0.001**
Abnormal ≤0.67	9 (64.3%)	2 (4.3%)		
Cerebroplacental ratio				
Abnormal ≤0.94	12 (85.7%)	12 (26.1%)	15.901	<0.001**
Normal >0.94	2 (14.3%)	34 (73.9%)		
x2	1.724	8.425		
P-value	0.422	0.015		

Significant values are indicated with * for *p<0.05* and with ** for values *<0.01*

Table 3: Comparison between admitted to ICU and not admitted to ICU according to neonatal outcome

Neonatal outcome	Admitted (n=14)	Not admitted (n=46)	t/x2#	*p-value*
Biophysical profile				
<6	6 (42.9%)	0 (0.0%)		
≥6	8 (57.1%)	46 (100.0%)	17.402#	<0.001**
Range [Mean±SD]	7.14±1.03	8.39±0.80		
NST				
Reassuring	7 (50%)	43 (93.5%)	11.646	<0.001**
Nonreassuring	7 (50%)	3 (6.5%)		
Apgar score 1 min.	5.14±1.29	7.02±0.39	76.594	<0.001**
Apgar score 5 min.	6.36±1.34	8.04±0.36	60.778	<0.001**
Birth weight (gm)				
Normal (3000 - 4000gm)	7 (50%)	43 (93.5%)	11.464#	<0.001**
Macrosomia (≥ 4000gm)	7 (50%)	3 (6.5%)		

Significant values are indicated with * for *p<0.05* and with ** for values *<0.01*

Table 4: Correlation between Cerebroplacental ratio and Doppler indices, maternal age, gestational age and neonatal outcomes

	Cerebroplacental ratio	
	r	*p-value*
Middle cerebral artery-RI	0.617	<0.001**
Umbilical artery-RI	-0.294	0.023*
Age (years)	-0.162	0.218
GA (wks)	0.012	0.928
Fetal weight (gm)	-0.003	0.983
Biophysical profile	0.349	0.006*
Apgar score 1 min.	0.560	<0.001**
Apgar score 5 min.	0.538	<0.001**
Birth weight	0.026	0.844

Significant values are indicated with * for $p<0.05$ and with ** for values <0.01

Table 5: Diagnostic Performance of Doppler indices in Discrimination of admission to ICU

Doppler	Cut-off	Sensitivity	Specificity	PPV	NPV	Accuracy
CPR	0.94	85.7%	73.9%	50.0%	94.4%	76.7%
UA-RI	0.62	57.1%	76.1%	38.9%	83.3%	70.0%
MCA-RI	0.67	50.0%	60.9%	30.8%	82.4%	60.0%

DISCUSSION

Postdate pregnancies account for about 5-10 % of the deliveries and are known to be associated with increased risk for perinatal complications[2].

Evaluation of fetoplacental circulation with Doppler ultrasonography uses color flow imaging for detection of any alteration in cerebral circulation before changes in fetal heart rate pattern occurs by hypoxia. Therefor cerebroplacental ratio has been introduced as an indicator of brain-sparing effect, which is one of the main fetal mechanisms to respond to chronic hypoxia[11].

The intrapartum management of postdate pregnancies is a unique challenge to the obstetrician, as the perinatal outcome is adverse after 40 completed weeks. In such cases, intrapartum asphyxia and meconium aspiration are associated with almost three fourths of all perinatal deaths[3].

This study aimed to assess the usefulness of Cerebroplacental ratio (CPR) compared with umbilical artery Doppler alone in prediction of the intrapartum fetal hypoxia and the adverse perinatal outcome in uncomplicated pregnancies (low risk pregnancy) beyond 40 weeks.

The present study included 60 pregnant ladies with gestational age of more than 40 weeks for assessment of Cerebroplacental ratio (CPR).

In this study showed statistically significant difference between admitted and not admitted to ICU according to maternal age (26.71 ± 4.08, 23.74 ± 3.38), GA (41.71 ± 0.16, 41.32 ± 0.28) and mode of delivery and high statistical significant difference between admitted (4193.57 ± 303.89) and not admitted to ICU (4070.98 ± 388.03) according to fetal weight (*p>0, 05*) (Table 1).

These results agree with case-control study by Usha *et al.*[12] who found that the term-group of patients were successfully matched to the post term group as regard age, with no statistically significant difference.

These results agree with case-control study carried out by Tasic *et al.*[13] who found significant difference between two groups of patients, showing that prolonged pregnancy increased in advanced maternal age and there was higher incidence of operative management of delivery in pregnancy after 40 gestation week group of women. In that group, the incidence of caesarian section in studied group was 14,58% vs. 9,07% in the control group. The most frequent indication for caesarian section was intrauterine fetal hypoxia (40, 35%) and dystocia (36, 84%).

However, Ross *et al.*[17] found that increase admission to ICU with prolonged pregnancy, advanced maternal age and with C.S. delivery in postdate group.

Contrary results had been shown in a study by Arif *et al.*[18] on 150 pregnant women of >41 weeks gestation that most of cases had spontaneous vaginal delivery (76%) compared to (15%) had C.S. delivery with statistically significant difference as most of the cases in the study were primigravida. The indications for C.S. were fetal distress (11%), failed induction (2.5%) and failure of progress (1.5%).

This was in agreement with Tasic *et al.*[13] study that reported higher incidence of neonatal macrosomia was higher in postdate pregnancy. An explanation might be that in uncomplicated prolonged pregnancy, even though placental senescence limits nutrient transfer, this bottle neck is overridden by enhanced placental flow indeed, it would explain the observation that macrosomia is a common feature of prolonged pregnancy and found 60 % of admitted to ICU were macrosomic.

Similarly, Lee *et al.*[2] reported that large for gestational age (LGA) particularly infants with a birth weight greater than 4 kg, is one of the important problems encountered in post-date pregnancy, with an incidence of 25.5 % at 41 week vs. 4% for those delivered between 38 and 40 week.

Post-date had higher birth weight these results agree with Matijevia[14] there was highly statistically significant difference between postdate and control groups as regard birth weight where post-date group had higher birth weight than control group.

In this study, no low birth weight babies were detected as all complicated cases like diabetes and hypertension were excluded.

There was statistically significant difference of RI in umbilical artery, middle cerebral artery Doppler and CPR admitted and not admitted to ICU according to cerebroplacental ratio with (*p<0.05*) (Table 2).

This results show that in the postdate there are changing in the Doppler indices which agree with Figueras *et al.*[15]. It was reported that mean value of UA-RI in postdated group was 0.66 the mean value of MCA in postdate group was 0.69. The mean values of CPR were 0.98 in postdate group.

This in agreement with the case-control study carried by Kürşad *et al.*[19] who reported that the umbilical artery RI values of the prolonged pregnancies in the study group were high in admitted to ICU and RI values were low compared to not admitted to ICU. Also, the middle cerebral artery RI mean value in the prolonged pregnancies was significantly lower in dmitted to ICU than not admitted to ICU and this is a finding in favor of the protection mechanism established for the brain.

In contrast, the study conducted by Zamora *et al.*[7] on 140 women, 10 women for each gestational day between 287 and 300 day of gestation and Doppler parameters were assessed. They reported that umbilical artery RI values have decreased while RI values have increased as the duration of pregnancy progress in prolonged pregnancies which most propably associated with placental insufficiency.

The present study shows that there was statistically significant difference between admitted and not admitted to ICU as regard NST, BPP<6 and 5 min Apgar score<6 ($p<0.05$) (Table 3).

These results agree with study by Thorngren-Jerneck and Herbst[16] that made a population-based study of 1 million term births, found that low Apgar score at 5-min (less than 7) was with postdate pregnancies.

Meconium aspiration syndrome (MAS) was present in (15%) of cases in postdated group and (2.5%) of cases in control group which show statistically significant. 5-min Apgar score less than 7 shows statistically significant as (12.5%) of cases in postdate group their Apgar score at 5min were <7. However, (2.5%) of cases in control group.

These results was in agreement with Jamal *et al.*[20] who carried a case control study on 200 postdated pregnancies to evaluate the diagnostic value of the BPP of the perinatal outcome and reported that there was significant difference between admitted and not admitted to ICU as regard BPP. This difference is due to small number of cases of the current study.

But,this disagree with Lalor *et al.*[21] who included five trials of postdated pregnancies, reported that available evidence from randomized controlled trials does not support the use of BPP as a test of fetal wellbeing and found no significant differences between the groups in perinatal outcome when biophysical profile (BPP) was compared with the nonstress test (NST).

Doppler velocimetry is a well-established non-invasive tool for assessment of blood flow and various aspects of the fetal circulation.

This result agree with Pragati *et al.*[22] who conducted a descriptive study of 596 low-risk, cephalic, singleton pregnancies beyond 40 weeks gestation and noticed that meconium aspiration was highest in babies with Apgar score <7 and most of them were admitted in the NICU.

But, Delaney *et al.*[23] found that gestational age of 41 weeks or more had higher incidence of perinatal complications as: fetal distress, meconium staining liquor (but no difference as regards Apgar score < 7 at 1 and 5 min, NICU admission and meconium aspiration syndrome) in comparison with those whom gestational age < 41 weeks.

This coincided with Thorngren and Herbst[16] that made a population-based study of 1 million term births, found that low Apgar score at 5-min was more with postdate pregnancies.

The present study show that positive correlations and significant between cerebroplacental ratio with middle cerebral artery-RI, biophysical profile, Apgar score at 1 min. and Apgar score at 5 min. Negative correlation was found with umbilical artery-RI (Table 4).

They agree with Zimmerman *et al.*[24] that found no correlation between UA resistance and placental maturity using Grannum's grades. Moreover, fetuses that showed signs of some degree of distress had Doppler values within normal ranges. These observations could be explained by the fact that UA velocimetry is a test of placental function that does not always directly reflect fetal status.

The study found that:

• CPR with a cut-off values of ≤ 0.94 has a sensitivity of 85.7% specificity of 73.9% positive predictive value of 50%, negative predictive value of 94.4% with diagnostic accuracy of 76.7% for ICU admission

• UA-RI with a cut-off value of > 0.62 has a sensitivity of 57.1% specificity of 76.1% positive predictive value of 38.9%, negative predictive value of 83.3% with diagnostic accuracy of 70% for ICU admission.

• MCA-RI with a cut-off value of ≤ 0.67 has a sensitivity of 50% specificity of 60.9% positive predictive value of 30.8%, negative predictive value of 82.4% with diagnostic accuracy of 60% for ICU admission.

This showed that CPR had a high predictive value in postdate pregnancy with sensitivity, specificity,

PPV and NPV 85.7%, 73.9%, 50%, 94.4%, respectively, in comparison to other parameters, with cut off value ≤ 0.94(Table 5).

This agrees with Kürşad *et al.*[19] who reported that the CPR <1.1 can be used as a sign of adverse perinatal outcomes in postdate pregnancies with sensitivity, specificity, PPV and NPV (76.6%, 85.2%, 81.8%, 80.7%).

Also, coincides with Ropacka *et al.*[25] who studied Doppler parameters of 148 uncomplicated postdated pregnancies and reported that C/U ratio showed the highest sensitivity in prediction of adverse neonatal outcome (87.8%) with cut off <1.0.

On the other hand, Bhide *et al.*[26] disagree with this result. They found that CPR not predictive of unfavorable outcome in postdated pregnancies. As there was no significant difference in the proportion of unfavorable outcomes between the two groups defined using the CPR cut off value 0.98%. It has been postulated that placental aging with increasing uteroplacental insufficiency is responsible for the adverse outcomes in postdate pregnancy and their study inclued the nulliparity, low birth weight and oligohydramnios which were independently associated with adverse outcome in prolonged pregnancies.

CONCLUSION

In the surveillance of the uncomplicated postdate pregnancy, Doppler information plays a role in differentiating which pregnancies may be followed by expectant management or determines whether induction is a better option.

Cerebroplacental ratio had a high predictive value in postdate pregnancy with sensitivity, specificity, PPV and NPV 85.7%, 73.9%, 50%, and 94.4%, respectively, in comparison to middle cerebral artery and umbilical artery with cut off value of CPR is 0.94.

Cerebroplacental ratio less than 0.94 were the best predictor of adverse perinatal outcome and neonatal ICU admission.

CONFLICT OF INTEREST

There are no conflicts of interests.

REFERENCES

1. Yuxin NG, Mongelli M, Chew S, Biswas A (2014): Third-trimester ultrasound dating algorithms derived from pregnancies conceived with artificial reproductive techniques. Ultrasound Obstet Gynecol; 26(2):129-31.

2. Lee CP, Lam H, Leung WC and Lao TT (2016): The use of fetal Doppler cerebroplacental blood flow and amniotic fluid volume measurement in the surveillance of postdated pregnancies. Acta Obstet Gynecol Scand; 84(9): 844-848.

3. Raghavan S, Niveditta G and Dasari P (2018): The maximal vertical pocket and amniotic fluid index in predicting fetal distress in prolonged pregnancy. Int J Gynecol Obstet; 96: 89-93.

4. Machelln H, Sims ME and Waltter FJ (2016): Neonatal morbidity and mortality long-term outcome of postdate infants. J Clin Obstet Gynecol; 32; (2): 285-293.

5. Westergaard JG, Olesen AW and Olesen J (2015): Perinatal and maternal complication related to postterm delivery: a national register-based study. 1978-1993. Am J Obstet Gynecol; 189(1): 222-7.

6. Doherty DA, Magann EF and Field K (2015): Biophysical profile with amniotic fluid volume assessments. Am J Obstet Gynecol 104 (255): 5-18.

7. Zamora L, Palacio M, Figueras F, Jiménez JM, Puerto B, Coll O, Cararach and Vanrell JA (2016): Reference ranges for umbilical and middle cerebral artery pulsatility index and cerebroplacental ratio in prolonged pregnancies. Ultrasound Obstet. Gynecol.;24(6):647-53.

8. Ozcan T, Koksal R and Selam B (2014): Fetal arterial and venous Doppler parameters in the interpretation of oligohydramnios in post-term pregnancies. Ultrasound Obstet Gynecol; 15(7): 403-22.

9. Rasmusssen S, Ebbing C and Kiserud T (2015): Middle cerebral artery blood flow velocities and pulsitility index and the cerebroplacental pulsitility ratio: longitudinal reference ranges and terms for serial measurements. Ultrasound Obstet Gynecol; 30(8): 287-296.

10. Andreotti C, Vergani P, Roncalgia N, Locatelli A, Crippa I, Pezzullo JC and Ghidini A (2016): Antenatal predictors of neonatal outcome in fetal growth restriction with absent end-diastolic flow in the umbilical artery. Am J Gynecol; 193(85): 1213-1218.

11. Cermik D,Bahado-Singh RO, Oz AU, Hsu C, Stiller R, Kovanci E, Deren O, Onderoglu L and Mari G. (2016): Middle cerebral artery Doppler velocimetric deceleration angel as a predictor of fetal anemia in Rh-allo immunized fetuses without hydrops. Am J Obstst & Gynecol; 183(1): 746-767.

12. Usha G, Suhasini C, Narula MK (2016): Value of middle cerebral artery to umbilical artery ratio by Doppler velocimetry in pregnancies beyond term J Obstet Gynecol Indi; 56 (1): 37-40.

13. Tasic M, Lilic V, Milosevic J, Antic V and Stefanovic M (2015): Placental insufficiency in pregnancy after 40th weeks of gestation. Acta Medica Medianae;14(46):26-29.

14. Matijevia R. (2015): Outcome of Post-Term pregnancy: Am- atched-Pair case control study. Coration Medical Journal, 39 (4): 55-61.

15. Figueras F., Lanna M., Palacio M., Zamora L., Puerto B., Coll O., Cararach V. and Van-Rell A. (2014): Middle cerebral artery Doppler indices at different sites: Prediction of umbilical cord gases in prolonged pregnancies. Ultrasound Obstet. Gynecol., 24: 529-533.

16. Thorngren-J and Herbst (2014): Low 5-min Apgar score: a population-based register study of 1 million term births. Obstet gynecol; 98(1): 65-70.

17. Ross N, Sahlin L, Ekman-Ordeberg G, Kieller H, Stephansson O. (2014): Maternal risk factors for postterm pregnancy and cesarean delivery following labor induction. Acta Obstet Gynecol Scand 89(8): 1003-1010.

18. Arif A, Khan NR and Zeb L (2015): Mode of delivery and fetal outcome in patients with pro- longed pregnancy undergoing elective induction at 41 & 41+ weeks. J Postgrad Med Inst; 29(4): 227-30.

19. Kürşad Sayan, Cemile Dayangan Sayan, Mahmut Kuntay Kokanali (2014): The Relationship between Doppler parameters and perinatal outcomes in postdate pregnancies. Orijinal makale/Original article J Turgut Ozal Med Cent.:21(4):264-269.

20. Jamal A, Marsoosi V, Eslamian L and Noori K. (2016): Prospective trial of the fetal biophysical profile versus modified biophysical profile in the management of high risk pregnancies. Acta medica iranica, vol. 45, NO. 3:204-208.

21. Lalor JG, Fawole B, Alfirevic Z, Devane D.(2015): Biophysical profile for fetal assessment in high risk pregnancies. Cochrane Database Syst Rev. 23;(1): CD000038.

22. Pragati T, Lata R, Meena B, Mohan M (2016): A descriptive study of adverse perinatal outcome associated with pregnancy beyond 40 weeks among pregnant women attending obg department, sms medical college Jaipur. ISSN 2349-0756, Volume 3, Issue 1.

23. Delaney M, Roggensack A, Leduc DC, Ballermann C, Biringer A (2018): guidelines for the management of pregnancy at 41+0 to 42+0 weeks. J obstet gynaecol can.; 30(9):800-23.

24. Zimmerman P., Alback T., Koskimen J., Vaalmo P., Tuimala R. and Ranta (2016): Doppler flow veloci-metry of the umbilical artery, uteroplacental arteries and fetal middle cerebral artery in prolonged pregnancy. Ultrasound Obstet. Gynecol., 5: 189-197.

25. Ropacka M, Tomasz K, Joanna Ś, and Grzegorz B (2015): Cerebroplacental ratio in prediction of adverse perinatal outcome and fetal heart rate disturbances in uncomplicated pregnancy at 40 weeks and beyond. Arch Med Sci.; 11(1): 142-148.

26. Bhide A, Acharya G, Bilardo CM, Brezinka C, Cafici D, Hernandez-Andrade E (2013): ISUOG practice guidelines: use of Doppler ultrasonography in obstetrics. Am J Ultrasound Obstet Gynecol; 41(2):223-39.