Doi: 10.32677/IJCH.2017.v04.i04.022

Original Article

Comparative study of cord blood hematological profile of neonates born to mothers with and without pregnancy-induced hypertension: A prospective case–control study

Naim Eman[1], Ali Syed Manazir[1], Firdaus Uzma[1], Noor Nasreen[2]

From Departments of [1]Pediatrics and [2]Obstetrics and Gynaecology, Jawaharlal Nehru Medical College, Aligarh Muslim University, Aligarh, Uttar Pradesh, India

Corresponding to: Ali Syed Manazir, Department of Pediatrics, Jawaharlal Nehru Medical College, Aligarh Muslim University, Aligarh, Uttar Pradesh, India. Phone: +91-9837142555. E-mail: manazir1958@yahoo.com

Received – 28 March 2017 Initial Review – 26 April 2017 Published Online - 02 August 2017

ABSTRACT

Background: The neonates born to mothers with pregnancy-induced hypertension (PIH) are prone to have abnormalities in their umbilical cord blood hematology. However, the exact pattern of the derangements and their clinical correlations has not been defined. **Objectives:** The purpose of this study is to compare the hematological profile of cord blood of neonates born to mothers with and without PIH (gestational hypertension, pre-eclampsia, and eclampsia), and to evaluate short-term clinical outcomes in the two groups. **Methods**: A prospective case–control study was done on cord blood of 155 neonates born to mothers with PIH (cases) and compared with that of 155 neonates born to normotensive mothers (controls). 2 ml cord blood was collected at birth and was analyzed for - hemoglobin (Hb), various red cell indices including nucleated red blood cell (NRBC), reticulocyte count, total leukocyte count (TLC), differential leukocyte count, absolute neutrophil count (ANC), absolute lymphocyte count (ALC), platelet count, and cord blood smear examination. The cases and controls were followed up during their hospital stay for the clinical outcome. **Results**: The mean red cell distribution width, NRBC, and reticulocyte count in cases were 14.64±2.14%, 11.18±2.33/100 white blood cells (WBCs) and 5.18±0.49% as compared with 11.84±0.78%, 4.32±1.32/100 WBCs, and 3.83±3.59% in controls ($p<0.05$). The mean TLC, ANC, and ALC in cases were 11642.70±6049.96/µL, 5682.30±2936.56/µL, 4955.91±2735.42/µL as compared with 13677.56±5711.14/µL, 6905.12±2932.99/µL, 6276.89±2649.98/µL in controls ($p<0.05$). The mean platelet count in cases was 164660.65±73817.05/µL as compared with 181148.39±60921.05/µL in controls ($p<0.05$). Erythrocyte changes were found in 78 (50.32%) cases and 44 (28.38%) controls ($p<0.05$).The relative risk (RR) of sepsis in PIH with respect to controls was >1 (1.64), with a significant increase in mortality as compared to controls. **Conclusions**: PIH increased the RR of sepsis (although not significantly) and mortality rate in the neonate, which can be related to cord blood hematological profile findings of leukopenia, absolute neutropenia, and thrombocytopenia, and increased NRBC count.

Key words: *Clinical correlation, Cord blood hematology, Pregnancy-induced hypertension*

Hypertensive disorders of pregnancy are a group of clinical conditions presenting in pregnant women with raised blood pressure (BP), with or without proteinuria and convulsions [1,2]. It affects about 5-10% of the total pregnancies globally, causing high maternal and neonatal morbidity and mortality [3]. In India, the incidence of pregnancy-induced hypertension (PIH) is around 15%. The incidence of pre-eclampsia and eclampsia is reported to be 8-10% and 0.71% of total pregnancies, respectively. During the past decade, the incidence of eclampsia has declined due to the increased awareness about antenatal checkups and early identification of high-risk pregnancies [4-8]. The hypertensive disorders of pregnancy are classified into four clinical categories: (1) Gestational hypertension, (2) pre-eclampsia and eclampsia syndrome, (3) chronic hypertension of any etiology, and (4) pre-eclampsia superimposed on chronic hypertension [9-11].

In normal pregnancy, there is mutual immunologic tolerance between the maternal tissue and the fetal (paternal) allograft. The endovascular trophoblasts of the placental villi destroy the muscular layer and autonomic innervations of the spiral arteries of the pregnant uterus. Meanwhile, endothelium of the affected arteries increases synthesis of vascular relaxing factors, prostacyclin, and nitric oxide. These changes result in uterine vasodilatation [12,13]. In pre-eclampsia, immunological uteroplacental maladaptation leads to disorder of trophoblastic invasion in the spiral arteries. The insufficient invasion and ingrowth of the trophoblasts inhibit vessel dilation, reducing maternal blood supply to the intervillous space, and thus reducing perfusion and causing hypoxia. The poorly perfused trophoblasts release some toxic substance causing vascular endothelial dysfunction and damage leading to pre-eclampsia. This leads to

uteroplacental insufficiency putting the fetus at risk of suboptimal intrauterine growth [4,14].

Therefore, the neonates of the mothers with PIH are at risk of intrauterine death, premature delivery, and small for gestational age, respiratory distress syndrome, transient tachypnea of new born, persistent pulmonary hypertension, bronchopulmonary dysplasia, and respiratory failure [15-17]. The derangement in the hematological parameters of these neonates and their association with clinical outcomes in newborn has shown variable results. Although thrombocytopenia has been a consistent finding in all studies, the results regarding neutropenia and red blood cell (RBC) indices are variable. This has left lacunae in understanding the burden of hematological derangement and its clinical implication [17-20].

Hence, the present study was planned to compare the cord blood hematological profile of neonates born to mothers with and without PIH (gestational hypertension, preeclampsia, and eclampsia), and to evaluate short-term clinical outcomes in the two groups.

METHODS

This study was a prospective case–control study, carried out at Neonatal division of Department of Pediatrics in collaboration with the Department of Obstetrics and Gynecology and Department of Pathology, Jawaharlal Nehru Medical College and Hospital, AMU, Aligarh. The study period was from January 2015 to October 2016. Pregnant females admitted for delivery and their neonates were included in the study. Neonates born to mothers diagnosed with gestational hypertension, pre-eclampsia or eclampsia were included as cases and neonates born to normotensive mothers without any complications were included as controls.

Following neonates were excluded from the study: (1) Pregnancy complicated by risk factors associated with increased maternal or fetal morbidity and mortality such as Rh incompatibility, diabetes mellitus, and twin pregnancies; (2) medical illness such as renal disease, heart disease, and connective tissue disease; (3) those who received drugs such as aspirin which are likely to cause changes in hematological profile; (4) chronic hypertension; (5) neonates with significant congenital malformations; (6) severe perinatal asphyxia in the neonate; and (7) premature rupture of membranes (PROM).

A neonate born before 37 completed weeks of gestation was taken as preterm. Preterm neonates included neonates from 25 to 36 weeks gestation [21]. neonates with birth weight <10th percentile for their gestational age were taken as small for gestational age [21]. Mother who had more than 2 antenatal visits in the pregnancy was considered as a booked case. PROM was defined as rupture of membranes before the onset of labor. Membrane rupture that occurs before 37 weeks of gestation is referred to as preterm PROM [10]. Severe perinatal asphyxia is defined as no breathing efforts at birth or an Apgar score of 0-3 at 1 min of age.

The pregnant females were diagnosed as having PIH, based on the working group (National High Blood Pressure Education Program) definition and American College of Obstetricians and Gynecologists criteria: [9,11]

1. BP ≥140/90 mmHg.
2. Proteinuria >1+ on dipstick urine protein testing.
3. +/-Edema.
4. +/-Grand mal seizures.
5. In the absence of proteinuria, thrombocytopenia (<100000 platelets/cu mm), oliguria (<400 ml urine in 24 h) and/or impaired renal functions, persistent headache and visual symptoms, epigastria pain and/or impaired liver functions, respiratory distress, and cyanosis (pulmonary edema) were looked for, to establish the diagnosis of pre-eclampsia.

During the study period, 264 females were diagnosed as having PIH. Informed written consent (including consent for cord blood sampling) was obtained from parents/legal guardians of eligible participants. Out of 264 gravidas, 109 were excluded (reasons detailed in Fig. 1) and 155 cases were included in the study. For every case, a matched control was taken. Matching was done for age and parity of the mother, gestational age of the neonate, antenatal visits (booked/unbooked).

Maternal data - age, parity, antenatal visits, gestational age, onset of symptoms, BP recording, and presence of seizures and proteinuria were noted. Details of labor including mode of delivery, duration of labor, rupture of membranes, and presence of any complications during labor were also recorded. Neonatal data such as sex, date of birth, time of birth, Apgar scores at 1 and 5 min were noted. Gestational age was assessed by New Ballard's scoring system. Clinical examination of the neonates was done and findings were noted in pro forma. Anthropometric parameters such as length, weight, head circumference, and chest circumference were recorded in the standard manner.

At birth, 2 ml cord blood was collected in the ethylenediaminetetraacetic acid vial and was analyzed (within an hour) for hemoglobin (Hb), red cell indices: Packed cell volume (PCV), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), MCH concentration (MCHC), red cell distribution width (RDW), nucleated red blood cell (NRBC) count, reticulocyte count, total leukocyte count (TLC), differential leukocyte count (DLC), absolute neutrophil count (ANC), absolute lymphocyte count (ALC), platelet count, and cord blood smear examination. Hb, PCV, MCV, MCH, MCHC, RDW, TLC, DLC, and platelet count was estimated using Nihon Kohden automated cell counter method. General blood picture and nucleated RBCs (per 100 white blood cells) were examined using the smear stained with Fleishman's stain, under Nikon E 100 microscope. For reticulocyte count, the smear was stained with methylene blue (supravital stain) and examined under oil immersion (×100).

The cases and controls were followed up during their hospital stay for clinical outcome. The presence of early-onset sepsis, respiratory distress, and deaths were noted and were diagnosed as per the standard protocols. Respiratory distress was defined as the presence

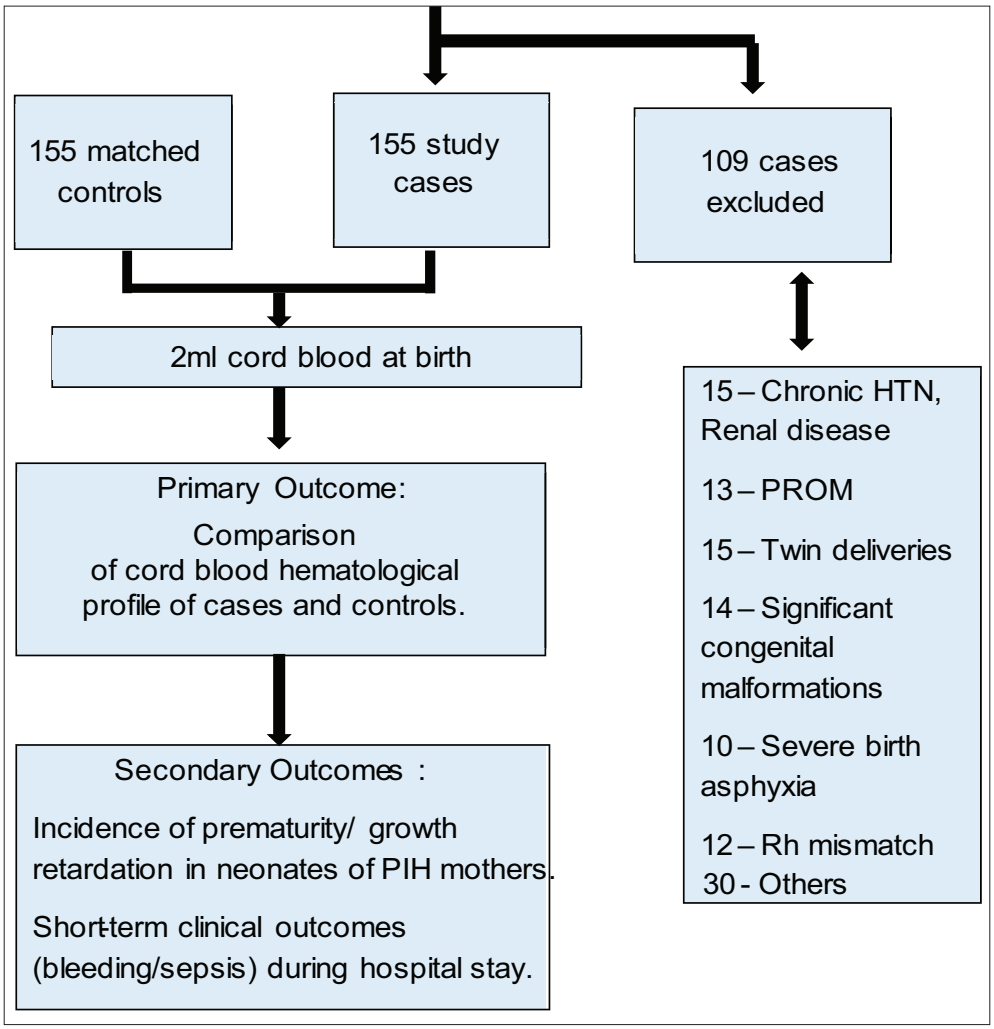

Figure 1: Study flowchart

of any two of the following features: (a) Respiratory rate >60/min; (b) subcostal/intercostal retractions; and (c) expiratory grunt [38]. Early-onset sepsis was defined as a clinical syndrome characterized by signs and symptoms of infection with or without accompanying bacteremia in the first 72 h of life [38]. Hb concentration <14 g/dL was taken as anemia. TLC <5000/mm^3 was taken as leukopenia. ANC <1500/mm^3 was taken as neutropenia [12]. Platelet <1.5 laces/mm^3 was taken as thrombocytopenia. Cell morphologies were examined in cord blood smear for spherocytosis, anisocytosis, poikilocytosis, and polychromasia in erythrocytes, hypersegmented neutrophils, and giant thrombocytes.

Statistical analysis was done using SPSS version 20. Results were expressed as mean±standard deviation and percentage. Univariate analysis was performed using Chi-Square test for categorical variables and independent *t*-test, factorial ANOVA+Tukey's *post hoc* tests for continuous variables. Bivariate correlation was tested using Pearson's product-moment correlation coefficient. The $p<0.05$ was considered statistically significant, with a confidence interval (CI) of 95%. Relative risk (RR) of sepsis was calculated as ratio of probability of sepsis in case group to probability of sepsis in control group, and an RR of >1 means the event is more likely to occur in the experimental group than in the control group.

RESULTS

Out of 155 cases of PIH, 47.09% (n=73) with pre-eclampsia constituted the majority, 36.77% (n=57) had gestational hypertension and remaining 16.14% (n=25) had eclampsia. Besides hypertension, swelling over feet and proteinuria were universally present in the pre-eclampsia group. The mean systolic and diastolic BP in cases were 153.46±9.81 mmHg and 117.14±8.76 mmHg, respectively, whereas in the control group, mean systolic and diastolic BP were 101.29±6.03 mmHg and 79.48±3.49 mmHg, respectively. The number of lower segment cesarian section deliveries in cases was 53.55% (n=83) as compared with 30.32% (n=47) in controls ($p<0.05$). Baseline characteristics of the cases and controls are presented in Table 1.

The difference in mean values of Hb, PCV, MCV, MCH, and MCHC of neonates born to PIH cases and controls were not statistically significant as shown in Table 2. However, the difference in mean values of nucleated RBCs, RDW, and reticulocyte count between cases and controls were statistically significant. The difference in mean values of leukocyte indices (TLC, ANC, and ALC) of cases and controls was also significant. Similarly, the difference in incidence of leukopenia and absolute neutropenia between cases and controls was significant (Table 2). The platelet

counts and incidence of thrombocytopenia between cases and controls were significant different. The difference in platelet count between cases with gestational hypertension, pre-eclampsia, and eclampsia groups was also statistically significant (Table 2).

In our study, a significant correlation was found between severity of maternal hypertension and neonatal platelet count in the cases, (Table 3).

During hospital stay, 18 neonates developed sepsis, 7 bled, 11 had respiratory distress, and 5 expired among the cases, whereas 11 neonates developed sepsis and 9 had respiratory distress among the controls (Table 4). The difference in the incidence of bleeding and deaths between cases and controls was statistically significant. Nonetheless, the RR of sepsis in cases with respect to controls was 1.64 and there was significant difference in the incidence of sepsis between neutropenia and non-neutropenic neonates born to PIH mothers (Tables 5 and 6).

Of 155 cases in the PIH group, 71 neonates (45.8%) were born preterm, whereas 40 neonates were small for gestational age (25.8%).

Table 1: Baseline characteristics of cases and controls

Parameter	Cases	Controls	p value
Booked status	124 (80%)	127 (82%)	0.664
Mean maternal age (years)	24.76+2.73	25.61+2.86	0.125
Primiparity	77 (49.67%)	74 (47.74%)	0.733
Mean gestational age (weeks)	36.18+1.62	36.21+1.81	0.869
Number of male neonates	93 (60%)	87 (56%)	0.49
Number of female neonates	62 (40%)	68 (44%)	0.49

DISCUSSION

There was no significant difference between the PIH cases and controls in terms of mean Hb concentration and anemia (p>0.05). These results are in coherence with the study results of Prakash et al. and Sivakumar et al., who reported no significant difference in mean Hb concentration in their study [17,18]. Bolat et al. in their study on 32 PIH cases with controls, reported no significant

Table 2: Comparative study of cord blood complete hemogram, cord blood smear examination, and clinical outcomes of cases and controls

Parameter	Cases	Controls	p value
Red cell indices			
Mean Hb (g/dL)	16.85±3.41	16.34±3.37	0.913
Hb <14 (g/dL)	27 (17.4%)	33 (21.3%)	0.439
Hb 14-20 (g/dL)	106 (68.38%)	102 (65.8%)	0.782
Hb >20 (g/dL)	22 (14.19%)	20 (12.9%)	0.758
PCV	46.93±12.03	45.28±6.21	0.130
MCV (fL)	102.72±13.53	101.48±4.68	0.281
MCH (pg)	36.51±4.35	36.22±7.04	0.669
MCHC (g/dl)	35.19±3.22	35.40±4.50	0.644
RDW	14.64±2.14	11.84±0.78	0.000
NRBCs (/100 WBCs)	11.18±2.33	4.32±1.32	0.000
Reticulocyte count (%)	5.18±0.49	3.83±3.59	0.000
White cell indices			
Mean TLC (/µL)	11642.70±6049.96	13677.56±5711.14	0.003
Absolute TLC <5000	24 (15.48%)	05 (03.23%)	0.000
Mean ANC (µL)	5682.30±2936.56	6905.12±2932.99	0.000
ANC <1500 (/µL)	24 (15.48%)	2 (1.29%)	0.000
Mean ALC (/µL)	4955.91±2735.42	6276.89±2649.98	0.000
Mean platelet count (/µL)	164660.65±73817.05	181148.39±60921.05	0.033
Platelet count (/µL) in			
Gestational hypertension	177349.12±82492.56		0.0001
Pre-eclampsia	173458.90±61947.33		
Eclampsia	110040±62030.56		
Platelet distribution in PIH			
<1.5 lac	80 (51.61%)	49 (31.61%)	0.006
General blood picture			
Erythrocyte changes	78 (50.32%)	44 (28.38%)	0.000
Neutrophil hypersegmentation	25 (16.13%)	24 (15.48%)	0.876
Giant thrombocytes	02 (1.29%)	0	0.156

Hb: Hemoglobin, PCV: Packed cell volume, MCV: Mean corpuscular volume, MCH: Mean corpuscular hemoglobin, MCHC: Mean corpuscular hemoglobin concentration, RDW: Red cell distribution width, NRBCs: Nucleated red blood cells, TLC: Total leukocyte count, ANC: Absolute neutrophil count, ALC: Absolute lymphocyte count, (p<0.05)–significant

Table 3: Distribution of neonatal platelet count according to maternal blood pressure in cases. Pearson's correlation (p<0.05 significant, CI 95%)

Maternal BP (mmHg)	Neonatal platelet count (lac/µL)					p value
	<1	1-1.5	1.5-2	2-3	>3	
Systolic BP						0.000
140-149	06	21	24	12	06	
150-159	01	24	19	07	01	
≥160	20	08	02	03	01	
Diastolic BP <90	0	0	0	0	0	0.013
0-99	04	32	21	09	04	
100-109	09	17	19	09	03	
≥110	14	04	04	04	02	

BP: Blood pressures, CI: Confidence interval

Table 4: Clinical outcomes during hospital stay

Parameter	Cases	Controls	p value
Sepsis	18 (11.61%)	11 (7.09%)	0.172
Bleeding	08 (5.16%)	0	0.004
Respiratory distress	11 (7.09%)	09 (5.80%)	0.644
Deaths	05 (3.23%)	0	0.024

(Chi-Square, p<0.05 significant with CI 95%), CI: Confidence interval

Table 5: Relative risk of sepsis in cases and controls

Risk	Sepsis present	Sepsis absent	RR
PIH	18	137	1.64
Non-PIH	11	144	

PIH: Pregnancy-induced hypertension, RR: Relative risk

Table 6: Sepsis in neutropenia and non-neutropenia patients

Cases	Total	Sepsis	p value
Neutropenia	24	08 (33.33%)	0.00
Non-neutropenia	131	10 (7.63%)	

(Chi-square, p<0.05 significant, CI 95%), CI: Confidence interval

difference in anemia, similar to our results [22]. The difference in mean PCV, mean MCV, mean MCH, and mean MCHC of PIH cases and controls were not statistically significant. Similar results were reported by Prakash et al. [18]; however, Sivakumar et al. showed a significant difference in mean MCV, which is contrary to our findings [17].

The difference in mean nucleated RBCs, RDW, and reticulocyte count of cases and controls was statistically significant (p<0.05), which is similar to results of the studies done by Krishna and Mahankali, Prakash et al., and Bolat et al. [18,20,22]. The increased NRBC count, RDW, and reticulocyte count in neonates born to PIH cases was probably due to stimulation of erythropoiesis in PIH, in response to tissue hypoxia, which leads to release of erythropoietin. Philip and Tito had postulated that elevated NRBCs may reflect chronic intrauterine hypoxia; although, the duration of hypoxemia required elevating NRBC count is not certain [23].

The difference in mean values of leukocyte indices (TLC, ANC, and ALC) of cases and controls was significant, (p<0.05). Similarly, the difference in incidence of leukopenia and absolute neutropenia between cases and controls was significant. Our results were similar to Bolat et al. who reported significant difference in TLC, ANC, and ALC [22]. Sivakumar et al. reported no significant difference in TLC and ANC, which was in conflict with our findings [17]. Nash et al. and Tsao et al. reported significant association of PIH with neonatal leukopenia and absolute neutropenia which is in coherence with our results [24,25].

PIH is known to be a risk factor for neutropenia, thus predisposing to infections. Koenig and Christensen suggested that neutropenia was caused by a decrease in growth factors, decrease in response of progenitor cells to growth factors and presence of inhibitor substance inhibiting neutrophil production [26]. Kuntz et al. reported fas–fas ligand interaction to be involved in leukopenia in pre-eclampsia [27]. Moallem and Koenid reported that in PIH, the balance of erythropoiesis and granulopoiesis is shifted to the direction of erythropoiesis, and because of hypoxia and the resulting increase in reticulopoiesis in normal hematopoiesis regulation, no adequate stem cells were left for granulopoiesis. As a result, inadequate granulopoiesis was observed and dysgranulopoiesis developed [28].

The platelet count and incidence of thrombocytopenia between cases and controls were significant different. Our results were similar to the results shown by Kumar and Haricharan, Prakash et al., Bolat et al., and Sivakumar et al. [17,18,22,29]. Kumar and Haricharan also reported significant difference in platelet count between gestational hypertension, pre-eclampsia, and eclampsia groups as seen in our study; however, it was contrary to results shown by Bolat et al., who reported no significant difference for the same. In our study, a significant correlation was found between severity of maternal hypertension and neonatal platelet count in the cases (p<0.05). However, Prakash et al. and Kumar and Haricharan could not found significant correlation for the same.

Although the pathophysiologic mechanism underlying thrombocytopenia is not clear, there are studies reporting that it arises from pathology at the placental level [30]. Kleckner et al. reported that abnormal placental endothelial surface caused thrombocyte destruction, and the resulting thrombocytopenia improved in a short time after delivery [31]. Moodley et al. reported that an undefined factor which leads to disseminated intravascular coagulation (DIC) was transported by the placenta and caused thrombocytopenia in the newborn [30]. Akcan et al. suggested the role of mediators in developing thrombocytopenia. Normally, vascular endothelial growth factor (VEGF) and placental growth factor (PlGF) are responsible for maturation of megakaryocyte and participate in the regulation of megakaryocyte development. The activity of these two factors is suppressed by sFlt 1 and soluble Enderlin, which are found to be raised in pre-eclampsia pregnancies. Low levels of PlGF and VEGF are shown in the cord blood of pre-eclampsia mothers' neonates [32]. Platelet counts were more affected in neonates of eclamptic and pre-eclampsia mothers than in mothers with gestational hypertension, suggesting that the severity as well as the duration of hypertension is

important in influencing the platelets of neonates born to mothers with gestational hypertension, pre-eclampsia and eclampsia and eventually the final neonatal and perinatal outcome.

Erythrocyte changes were found in 78 (50.32%) cases and 44 (28.38%) controls, and the difference was statistically significant ($p<0.05$). Our results were in coherence with Bolat et al., who reported significant difference in the erythrocyte changes between cases and controls [22]. Because of uteroplacental hypoxia, there is stimulation of erythropoiesis in PIH, which leads to abnormal findings on peripheral smear, including spherocytosis, anisocytosis, and polychromasia [33-35]. No significant difference in giant thrombocytes on peripheral smear examination suggests that the present thrombocytopenia was caused by a moderate response of bone marrow.

In our study, the incidence of bleeding episodes and deaths between cases and controls was significantly different, whereas it was non-significant for sepsis and respiratory distress. We also found the increased risk of sepsis in cases and in the neonates with neutropenia. Our results were similar to Bhaumik et al., who reported an increased RR (non-significant) of sepsis in neonates born to PIH mothers [36]. Fuks et al. reported no significant difference in the incidence of respiratory distress between pre-eclampsia cases and controls, which is in accordance with our findings [37]. Sivakumar et al. reported no significant difference in the neonatal morbidity of the cases and controls, which was in conflict with our findings [17]. Bleeding and death in the neonates of PIH cases was due to fulminant sepsis and DIC.

However, our study has few limitations as the study was done at tertiary center, so the results cannot be extrapolated to the general population. Second, neonates born to PIH mothers were not followed up for the course of hematological abnormalities with time. Furthermore, the long-term clinical outcomes were not studied which would have been more beneficial to assess the long-term impact of PIH in the neonates. Further larger studies are needed to find out the exact relation of clinical outcomes to the derangements in cord blood hematology.

CONCLUSION

Our study concludes that there are significant differences in the cord blood hematological profile of neonates born to mothers with and without PIH. Furthermore, PIH increased the RR of sepsis, but not significantly, with significant increase in bleeding and mortality in the neonate, which was reflected in their cord blood hematological profile in the form of leukopenia, absolute neutropenia, and thrombocytopenia, as well as increased NRBC count. Therefore, the umbilical cord blood hematological examination can be performed in neonates born to mothers with PIH, to anticipate, diagnose, and treat neonatal morbidity and prevent mortality.

REFERENCES

1. Singnarpi E, Bhattacharjee D, Baidya JL, Jamatia SNN. Study of changes in hemoglobin level and leukocyte counts in cord blood of newborns of hypertensive mothers in AGMC and GB pant hospital. J Evol Med Dent Sci. 2014;3(63):13905-12.
2. Dolea C, Zahr CA. Global burden of hypertensive disorders of pregnancy in the year 2000. GBD 2000 Working Paper. Geneva: World Health Organization; 2003.
3. Hutcheon JA, Lisonkova S, Joseph KS. Epidemiology of pre-eclampsia and the other hypertensive disorders of pregnancy. Best Pract Res Clin Obstet Gynaecol. 2011;25(4):391-403.
4. Zhang J, Zeisler J, Hatch MC, Berkowitz G. Epidemiology of pregnancy-induced hypertension. Epidemiol Rev. 1997;19(2):218-32.
5. Dutta DC. Text Book of Obstetrics. Calcutta: New Central Book Agency; 2004.
6. Jeyabalan A. Epidemiology of preeclampsia: Impact of obesity. Nutr Rev. 2013;71 Suppl 1:S18-25.
7. Sajith M, Nimbargi V, Modi A, Sumariya R, Pawar A. Incidence of pregnancy induced hypertension and prescription pattern of antihypertensive drugs in pregnancy. Int J Pharm Sci Res. 2014;5(4):163-70.
8. Osungbade KO, Ige OK. Public health perspectives of preeclampsia in developing countries: Implication for health system strengthening. J Pregnancy. 2011;2011:481095.
9. Program NH. Report of the national high blood pressure education program working group on high blood pressure in pregnancy. Am J Obstet Gynaecol. 2000;183(1):1-22.
10. ACOG Committee on Practice Bulletins-Obstetrics. ACOG Practice Bulletin No 80: Premature rupture of membranes. Clinical management guidelines for obstetrician-gynecologists. Obstet Gynecol. 2007;109:1007-19.
11. American College of Obstetricians and Gynecologists Women's Health Care Physicians; Committee on Health Care for Underserved Women. Committee Opinion No 569: Oral health care during pregnancy and through the lifespan. Obstet Gynecol. 2013;122:417-22.
12. Teng RJ, Wu TJ, Garrison RD, Sharma R, Hudak ML. Early neutropenia is not associated with an increased rate of nosocomial infection in very low-birth-weight infants. J Perinatol. 2009;29(3):219-24.
13. Voto LS, Lepidus AM, Margulies M. Effects of preeclampsia on the mother, fetus and child. Gynaecol Forum. 1999;4(1):25-7.
14. Dudell GG, Jain L. Hypoxic respiratory failure in the late preterm infant. Clin Perinatol. 2006;33(4):803-30.
15. Jain L. Respiratory morbidity in late-preterm infants: Prevention is better than cure! Am J Perinatol. 2008;25(2):75-8.
16. Backes CH, Markham K, Moorehead P, Cordero L, Nankervis CA, Giannone PJ. Maternal preeclampsia and neonatal outcomes. J Pregnancy. 2011;2011:214365.
17. Sivakumar S, Bhat BV, Badhe BA. Effect of pregnancy induced hypertension on mothers and their babies. Indian J Pediatr. 2007;74(7):623-5.
18. Prakash PL, Kumar PS, Murthy MV, Haricharan KR. Assessment of haematological profile of newborn at birth, born to mothers with gestational hypertension, preeclampsia and eclampsia syndrome. J Evol Med Dent Sci. 2013;1(2):6360-9.
19. Catarino C, Rebelo I, Belo L, Rocha S, Castro EB, Patricio B, et al. Relationship between maternal and cord blood hemostatic disturbances in preeclamptic pregnancies. Thromb Res. 2008;123(2):219-24.
20. Krishna PV, Mahankali A. A predictor of neonatal outcome-umbilical cord blood nucleated RBCs. Int J Sci Res. 2016;5(6).
21. Singh M. Care of the Newborn. New Delhi: Sagar Publications; 2004.
22. Bolat A, Gursel O, Kurekci E, Atay A, Ozcan O. Blood parameters changes in cord blood of newborns of hypertensive mothers. Eur J Pediatr. 2013;172(11):1501-9.
23. Philip AG, Tito AM. Increased nucleated red blood cell counts in small for gestational age infants with very low birth weight. Am J Dis Child. 1989;143(2):164-9.
24. Nash PL, Gillespie K, Devaskar UP. Effect of early onset bacterial sepsis or pregnancy induced hypertension (PIH) on neonatal white blood cell and platelet counts in infants less than 1,200 grams. J Matern Fetal Med. 1993;2(1):1-4.
25. Tsao PN, Teng RJ, Tang JR, Yau KI. Granulocyte colony-stimulating factor in the cord blood of premature neonates born to mothers with pregnancy-induced hypertension. J Pediatr. 1999;135(1):56-9.
26. Koenig JM, Christensen RD. The mechanism responsible for diminished neutrophil production in neonates delivered of women with pregnancy-induced hypertension. Am J Obstet Gynecol. 1991;165(2):467-73.
27. Kuntz TB, Christensen RD, Stegner J, Duff P, Koenig JM. Fas and Fas ligand

expression in maternal blood and in umbilical cord blood in preeclampsia. Pediatr Res 2001;50(6):743-9.
28. Moallem M, Koenig JM. Preeclampsia and neonatal neutropenia. Neo Rev. 2009;10(9):454-9.
29. Kumar S, Haricharan KR. Neonatal thrombocytopenia associated with gestational hypertension, preeclampsia and eclampsia: A case-control study. Int J Contemp Pediatr. 2016;3(1):16-21.
30. Moodley J, Naidu S, Chetty D, Adhikari M, Gouws E. Neonatal thrombocytopenia in preeclamptic women with low platelet counts. Hypertens Pregnancy. 1996;15(3):297-304.
31. Kleckner HB, Giles HR, Corrigan JJ Jr. The association of maternal and neonatal thrombocytopenia in high-risk pregnancies. Am J Obstet Gynecol. 1977;128(3):235-8.
32. Akcan AB, Oygucu SE, Ozel D, Oygür N. Mean platelet volumes in babies of preeclamptic mothers. Blood Coagul Fibrinolysis. 2011;22(4):285-7.
33. Gordon EA. Polycythemia and hyper viscosity of the newborn. J Perinat Neonatal Nurs. 2003;17(3):209-21.
34. Huang SC, Chang FM. The adverse effect on fetal hemogram by preeclampsia-arked anisocytosis with normocytic, normochromic erythrocythemia as well as thrombocytopenia. Early Hum Dev. 1994;37(2):91-8.
35. Mashiloane CD, Moodley J. Induction or caesarean section for preterm pre-eclampsia? J Obstet Gynaecol. 2002;22(4):353-6.
36. Bhaumik S, Ghosh S, Haldar KK, Mitra PK, Manna B. Risk of early onset neonatal septicemia in babies born to mothers with pre-eclampsia. Indian Pediatr. 2000;37(7):775-9.
37. Fuks A, Seifi F, Rothschild T, Akinnawonu F, Salafia C. Neonatal outcomes in preterm severe preeclampsia as compared to other etiologies of prematurity. Obstet Gynecol. 2016;127:95-6.

Funding: None; Conflict of Interest: None Stated.

How to cite this article: Eman N, Manazir AS, Uzma F, Nasreen N. Comparative study of cord blood hematological profile of neonates born to mothers with and without pregnancy-induced hypertension: A prospective case–control study. Indian J Child Health. 2017; 4(4):554-560.