SMALL-FOR-GESTATIONAL AGE, PONDERAL INDEX AND NEONATAL POLYCYTHAEMIA: A STUDY OF THEIR ASSOCIATION WITH MATERNAL HYPERTENSION AMONG NIGERIAN WOMEN

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Abstract

Background/Objective: To examine the influence of maternal hypertension on rate of delivery of small-for-gestation age (SGA) infants, incidence of neonatal polycythaemia and mean ponderal indices of the resultant newborn infants.

Methods: From the birth weights and lengths, the ponderal indices of SGA infants born to mothers with chronic hypertension were compared with those of their counterparts born to mothers with pregnancy–induced hypertension. In addition, the spun venous haematocrit values of 265 infants born to mothers whose pregnancies were complicated by hypertension were compared with those of 804 infants born to control mothers.

Results: The rates of delivery of SGA infants were 82.0 and 54.7 per 1000 live births among hypertensive and normotensive mothers respectively (p>0.05). The prevalence of neonatal polycythaemia was 8.2% and 2.2% for infants of hypertensive and control mothers respectively (p<0.001). The rate of delivery of SGA infants was 18.6 times higher in mothers with chronic hypertension than in mothers with pregnancy–induced hypertension (p<0.001). SGA infants born to mothers with chronic hypertension had normal mean ponderal index (≥2.3) while their counterparts born to mothers with pregnancy-induced hypertension had low mean ponderal index (<2.3). The prevalence of neonatal polycythaemia was 52.9% and 5.0% in infants born to mothers with chronic hypertension and infant of mothers with pregnancy-induced hypertension respectively (p<0.001).

Conclusion: Maternal hypertension is associated with an increased incidence of neonatal polycythaemia and delivery of SGA infants. This risk is dramatically higher in women with chronic hypertension. Chronic maternal hypertension causes proportionate foetal growth retardation while pregnancy-induced hypertension causes disproportionate foetal growth retardation.

Key words: Maternal hypertension, small for gestational age, ponderal index, neonatal polycythaemia

Mots Clés: Hypertension maternelle, petit par rapport à l’âge gestationnel, index pondéral, polycythémie néonatale

Résumé


Méthodes: A partir de la longueur et du poids de naissance, l’indice pondéral d’enfants petits par rapport à l’âge gestationnel de mères souffrant d’hypertension chronique a été comparé à celui d’enfants nés de mères ayant une hypertension gravidique. De même la valeur de l’hématocrite de sang centrifugé de 265 enfants nés de mères dont la grossesse s’était compliquée d’hypertension a été comparée à celle de 804 enfants nés de mères témoins.

Résultats : Le taux d’accouchement d’enfants petits par rapport au poids de naissance était de 82 et de 54,7 pour1000 naissances vivantes,
Introduction

Hypertension is estimated to complicate approximately 7-10% of pregnancies. In some instances, the disease precedes pregnancy while in others it occurs as a complication of pregnancy. Hypertensive disorders in pregnancy (HDP) are believed to predispose to acute or chronic utero-placental insufficiency. In fact, Gant and Worley have observed that in patients with hypertension in pregnancy the utero-placental blood flow drops to 50-65% after 3 to 4 weeks of the disease. Shallow trophoblastic invasion of the decidua arteries can precipitate pre-eclampsia, reduce placental perfusion and cause insufficient transport of nutrients. Thus, the resultant utero-placental insufficiency and insufficient transport of nutrients in HDP lead to foetal growth restriction.

There exist various body proportionality indices of which the Rohrer’s ponderal index is the most useful in categorizing growth-retarded foetuses into proportionate and disproportionate subgroups. The use of ponderal index as a body proportionality index at birth has some advantages. First, it can capture information about timing of the growth retardation as well as the nutritional status of the newborn. Secondly, it is useful for predicting outcome in small-for-gestational age (SGA) babies, particularly where there is no reliable information on gestational age.

It is well known that relative foetal hypoxia stimulates the release of erythropoietin, which in turn promotes erythropoiesis thereby leading to neonatal polycythaemia. In fact, Brazzy et al have reported that venous hematocrits after birth averaged 5% higher in infants of hypertensive mothers than in those of normotensive mothers. However, they neither stated the prevalence of neonatal polycythaemia among infants born to hypertensive mothers nor the subtype of HDP associated with highest risk.

The purpose of this study is to determine the incidence of SGA and neonatal polycythaemia in the resultant newborn infants of hypertensive mothers and to examine which subtype of HDP is associated with higher prevalence of SGA and neonatal polycythaemia. In addition, to compare the ponderal indices of growth retarded babies born to mothers with chronic hypertension with those of their counterparts born to mothers with pregnancy induced-hypertension.

Patients and Methods

All Nigerian mothers with HDP who presented at the University of Benin Teaching Hospital (UBTH) during the two-and-half year study period (1st January 1992 to 30th June 1994) were recruited into the study. For each case of maternal hypertension, three consecutively admitted healthy normotensive pregnant Nigerian mothers were recruited as controls following informed verbal consent. The rate of delivery of SGA infants and the haematocrit values of the resultant newborn infants of both groups of mothers were compared. The rate of delivery of SGA infants with their ponderal indices and the prevalence of neonatal polycythaemia in babies born to mothers with chronic hypertension were compared with those of their counterparts born to mother with pregnancy induced-hypertension. Criteria for diagnosis of HDP and inclusion into the study were:

1. A documented history of hypertension (blood pressure (BP) ≥140/90mmHg before pregnancy).
2. An increase in either systolic or diastolic BP > 30mmHg or 15mmHg respectively above the booking BP.
3. An intrapartum BP ≥ 140/90mmHg obtained on at least two occasions not less than six hours apart during delivery.
4. Mothers of control infants were normotensive throughout pregnancy and upon admission for delivery. They also had no known exposure to
diuretics and drugs with anti-hypertensive properties.
5. Both groups of mothers did not smoke and were free of major diseases such as diabetes mellitus, sickle-cell anaemia, renal failure, heart diseases and bronchial asthma. Twin pregnancies were also excluded.
6. None of the pairs of groups differed significantly in terms of maternal height, marital or socio-economic status. Socio-economic status (social class) was obtained through a scoring index combining a woman’s level of education with the occupation if her husband, which allocates each woman to social class I to V, social class V being at the bottom of the social stratification. The suitability and application of this Social Classification System for our environment have been well-tested and presented elsewhere.13
7. Both groups of infants did not have delayed clamping of the cord, post-maturity, Beckwith’s syndrome, neonatal thyrotoxicosis and dysmorphic features suggestive of genetic trisomies such as trisomies 13, 18 and 21.

In the classification of HDP, the method recommended by Khan14 was used because it was more closely related to the methods adopted.

Patients whose hypertension started early in pregnancy were identified and subsequently followed up closely by the obstetrician as an outpatient unless they develop complications requiring hospitalisation. Clinic visits were scheduled fortnightly until 32 weeks of gestation and weekly thereafter. At each visit, the BP and urine test for protein was performed using Albustix(R) and the results were recorded.

Gestational age was determined by maternal dates and by a Dubowitz et al.15 gestational age examination of the infant 12 to 24 hours after birth by one of the authors (ANO). If a discrepancy of more than two weeks existed, the gestational age was assigned from the Dubowitz score. The babies were weighed naked using a Waymaster weighing scale. The scale was standardized with known weights and was checked daily for zero error. The birth length was measured using Holtain infant measuring table. All measurements were carried out within the first two hours of birth. From the birth weight and length data so obtained, the Rohrer’s ponderal indices4 of all SGA babies were calculated. The mean ponderal index of SGA babies born to mothers with chronic hypertension was compared with that of babies born to mothers with pregnancy-induced hypertension using Miller and Hassanein criteria.16 The haematocrit values of all infants were determined by one of the authors (ANO) using venous blood sample obtained from antecubital vein as recommended by Guha17 and Letsky.18 Spun haematocrit values were used for screening as recommended by Letsky.18

The following terms have been defined:
1. Neonatal polycythaemia refers to venous haematocrit ≥ 65% on two samples taken from a large free flowing antecubital vein.17,18
2. SGA infants are infants whose birth weights were below 2 standard deviation for gestational age by Olowe’s charts.19
3. Rohrer’s ponderal index = 100 times the birth weight in grammes divided by the cube of the birth length in centimetres.1
4. Chronic hypertension is defined as hypertension present before the 20th week of pregnancy or hypertension present before pregnancy.12
5. Pregnancy-induced hypertension refers to hypertension beginning after 20th week of pregnancy.12

Z-test was used in ascertaining the level of significance of differences, which was set at p<0.05.

Results
Of the 3780 pregnancies delivered during the study period, 272 (7.2%) were complicated by hypertension. Out of the 272 babies delivered by hypertensive mothers, 16(5.9%) were stillbirths: 11(68.8%) were fresh while the remaining 5(31.2%) were macerated stillbirths. Of the 816 babies delivered by normotensive mothers, 12(1.5%) were stillbirths: 5(4.7) were fresh while the remaining 7(53.8%) were macerated stillbirths (stillbirth rate: study group versus control group Z-statistic = 14.071 p<0.001). Available for analysis, therefore, were 256 and 804 live babies delivered by hypertensive and normotensive mothers respectively. Transient hypertension was present in 19 (0.5%), mild to moderate pre-eclampsia 123 (3.3%) severe pre-eclampsia 89 (2.3%), eclampsia 13 (0.6%), chronic hypertension 13 (0.3%), and chronic hypertension with superimposed pre-eclampsia 7 (0.2%).

Table 1 shows that the risk of delivery of an SGA infant was 1.5 times higher in pregnancies complicated by hypertension than in control pregnancies. The table also shows that the subtype of HDP associated with the highest incidence of delivery of an SGA infant was chronic hypertension with superimposed pre-eclampsia. Tables 2 and 3 show that the prevalence of neonatal polycythaemia was 3.7 times in infants born after hypertensive than in control pregnancies.

Table 4 shows that the rate of delivery of an SGA infant was 18.6 times higher in mothers with chronic hypertension than in their counterparts with pregnancy-induced hypertension (Z-statistic=6.008 p<0.001). It also shows that SGA infants born to mothers with chronic hypertension had normal mean ponderal index, indicating proportionate foetal growth retardation while their counterparts born to mothers with pregnancy-induced hypertension had low mean ponderal index, indicating disproportionate foetal growth retardation . The prevalence of neonatal polycythaemia was 10.5 times higher in infants born to mothers with chronic hypertension than in their counterparts born to mothers with pregnancy-induced hypertension (Z-statistic= 3.930 p<0.001).
Table 1: Distribution of SGA infants according to subtype of hypertensive disorder in pregnancy

<table>
<thead>
<tr>
<th>Type of HDP</th>
<th>Total No. Newborn infants</th>
<th>No. Live-newborn infants</th>
<th>SGA Infants No. (Rate per 1000 live birth)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transient hypertension</td>
<td>19</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>Mild to moderate pre-eclampsia</td>
<td>123</td>
<td>122</td>
<td>2 (16.0)</td>
</tr>
<tr>
<td>Severe pre-eclampsia</td>
<td>89</td>
<td>82</td>
<td>7 (95.0)</td>
</tr>
<tr>
<td>Eclampsia</td>
<td>21</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>Chronic hypertension</td>
<td>13</td>
<td>13</td>
<td>8 (538.0)</td>
</tr>
<tr>
<td>Chronic hypertension with superimposed pre-eclampsia</td>
<td>7</td>
<td>4</td>
<td>4 (1000)</td>
</tr>
<tr>
<td>Total study group</td>
<td>272</td>
<td>256</td>
<td>21 (82.0)</td>
</tr>
<tr>
<td>Total control group</td>
<td>816</td>
<td>804</td>
<td>44 (54.7)</td>
</tr>
</tbody>
</table>

SGA delivery rate in HDP versus control group: $Z$-statistic = 1.481 $p > 0.05$

Table 2: Comparison of prevalence of neonatal polycythaemia in infants of hypertensive mothers and in control group

<table>
<thead>
<tr>
<th>Variable assessed</th>
<th>Infant of hypertensive mothers</th>
<th>Infants of control mothers</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of live-births</td>
<td>256</td>
<td>804</td>
</tr>
<tr>
<td>No. with polycythaemia*</td>
<td>21</td>
<td>18</td>
</tr>
<tr>
<td>Prevalence (%) of polycythaemia</td>
<td>8.2</td>
<td>2.2</td>
</tr>
</tbody>
</table>

* $Z$-statistic = 13.676 $p < 0.001$

Table 3: Prevalence of neonatal polycythaemia according to subtypes of hypertensive disorder in pregnancy

<table>
<thead>
<tr>
<th>Type of HDP</th>
<th>No. of live-birth</th>
<th>No. with polycythaemia</th>
<th>Prevalence (%) of polycythaemia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transient hypertension</td>
<td>19</td>
<td>1</td>
<td>5.3</td>
</tr>
<tr>
<td>Mild to moderate pre-eclampsia</td>
<td>122</td>
<td>4</td>
<td>3.3</td>
</tr>
<tr>
<td>Severe pre-eclampsia</td>
<td>82</td>
<td>6</td>
<td>7.3</td>
</tr>
<tr>
<td>Eclampsia</td>
<td>16</td>
<td>1</td>
<td>6.3</td>
</tr>
<tr>
<td>Chronic hypertension</td>
<td>13</td>
<td>7</td>
<td>53.8</td>
</tr>
<tr>
<td>Chronic hypertension with superimposed pre-eclampsia</td>
<td>4</td>
<td>2</td>
<td>50.0</td>
</tr>
<tr>
<td>Total study group</td>
<td>256</td>
<td>21</td>
<td>8.2</td>
</tr>
<tr>
<td>Total control group</td>
<td>804</td>
<td>18</td>
<td>2.2</td>
</tr>
</tbody>
</table>

Table 4: Comparison of rates of SGA delivery, mean ponderal indices and prevalence of neonatal polycythaemia in infants born to mothers with chronic hypertension and in infants born to mothers with pregnancy-induced hypertension

<table>
<thead>
<tr>
<th>Variables assessed</th>
<th>Type of maternal hypertension</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Chronic hypertension</td>
</tr>
<tr>
<td>No. of live-births</td>
<td>17</td>
</tr>
<tr>
<td>No. of SGA infants</td>
<td>12</td>
</tr>
<tr>
<td>SGA delivery rate per 1000 live births</td>
<td>706.0</td>
</tr>
<tr>
<td>Mean ponderal index ± SD</td>
<td>2.45±0.14</td>
</tr>
<tr>
<td>Range of ponderal index</td>
<td>2.38-2.55</td>
</tr>
<tr>
<td>No with polycythaemia</td>
<td>9</td>
</tr>
<tr>
<td>Incidence (%) of polycythaemia</td>
<td>52.9</td>
</tr>
</tbody>
</table>

Discussion

The higher rate of delivery of an SGA infant in hypertensive than in control pregnancies reported here is in keeping with the report of other investigators.20-22 The implication is that the delivery of an SGA infant should be anticipated in all hypertensive pregnant mothers and strategies should be instituted to prevent the occurrence of the common neonatal problems of such infants (SGA). This approach will also allow...
for prompt treatment of these problems if they occur. This finding may be explained by the utero-placental insufficiency and inadequate transport of nutrients which hypertension in pregnancy engenders. Further analysis according to various subtypes of HDP, showed that although the number was small, 60% of the babies delivered by mothers with chronic hypertension with or without superimposed pre-eclampsia were SGA. This is in sharp contrast with the absence of SGA babies among those delivered by mothers with either transient hypertension or eclampsia. Comparison was not possible because of scarcity of similar studies. This may imply that in subtypes of HDP, which are acute in nature, the disease process has not lasted long enough to severely compromise the placental function with its attendant placental insufficiency and foetal growth restriction. The highest risk of delivery of an SGA baby was found among mothers with chronic hypertension with superimposed pre-eclampsia. This suggests that chronic hypertension with superimposed pre-eclampsia might be associated with greater degree of reno-vascular compromise with attendant adverse effect on placental development and function.

Comparison using mean ponderal index revealed that SGA babies born to mothers with chronic hypertension manifested proportionate growth retardation in contrast to disproportionate growth retardation manifested by their counterparts born to mothers with pregnancy-induced hypertension. Similar observation has been previously documented.

This identification of different patterns of growth retardation is of great potential importance because disproportionate intrauterine growth retarded (IUGR) infants are known to be at a greater risk of neonatal problems of IUGR infants than their proportionate IUGR counterparts. In addition, postnatally, disproportionate IUGR infants have greater early gains in weight, length and head circumference that proportionate IUGR infants and show a greater tendency to catch up with their normally grown peers. Thus, this different patterns of IUGR may influence not only their treatment in the neonatal unit, but also, their post-neonatal follow up. The different patterns of IUGR may be explained by the fact that foetuses experiencing insults early in pregnancy (before 20 weeks gestation as is the case of chronic hypertension) will show alterations in both weight gain and length growth. On the other hand, foetuses experiencing insults later in pregnancy (after 20 weeks gestation, as is the case in pregnancy-induced hypertension) will show a greater reduction in weight gain than in length growth.

In this study, the prevalence of neonatal polycythaemia was significantly higher in babies born to mothers whose pregnancies were complicated by hypertension (8.2%) than in babies of control mothers, indicating the need to routinely check the haematocrits of all infants of hypertensive mothers. Comparison with results of other studies was not possible because they did not state the prevalence of neonatal polycythaemia. The relative foetal hypoxia suffered by the foetus in pregnancy complicated by hypertension stimulates the release of erythropoietin, which in turn promotes erythropoiesis leading to neonatal polycythaemia. The prevalence of 2.2% being reported here in the control babies falls within the range of 0.45% and 4.0% reported for otherwise healthy neonates by other investigators. The prevalence of neonatal polycythaemia varied with the subtype of HDP with chronic forms of hypertension being the subtype associated with the highest prevalence of neonatal polycythaemia. This implies that infants born to this category of mothers must be kept under close surveillance for neonatal polycythaemia. It is possible that chronic foetal hypoxia stimulates higher production and release or erythropoietin and hence a greater prevalence of neonatal polycythaemia.

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References

3. Robert JM, Redman CW. Pre-eclampsia: more than pregnancy-induced hypertension. Lancet 1993; 341:1447-1451
5. Rosso P. Intrauterine growth retardation. 18th Nestle nutrition workshop series, Rio de Janeiro, Brazil. 1987; 25-28th March