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Original Article

Maternal hypertensive diseases negatively affect offspring motor development

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ABSTRACT

Objective: Hypertension in pregnancy and preeclampsia have been linked to poor outcomes in cognitive, mental and psychomotor development; however, few longitudinal studies have researched their effect on offspring motor development, particularly in late childhood and adolescence. The purpose of this study was to determine if maternal hypertensive diseases during pregnancy are a risk factor for compromised motor development at 10, 14, and 17 years.

Study design: Longitudinal cohort study using data from the Western Australian Pregnancy Cohort Study (Raine).

Main outcome measure: Offspring ($n = 2868$) were classified by their maternal blood pressure profiles during pregnancy: normotension ($n = 2133$), hypertension ($n = 626$) and preeclampsia ($n = 109$). Offspring motor development, at 10, 14, and 17 years was measured by the Neuromuscular Developmental Index (NDI) of the McCarron Assessment of Motor Development (MAND).

Methods: Linear mixed models were used to compare outcomes between pregnancy groups.

Results: Offspring from pregnancies complicated by preeclampsia had poorer motor outcomes at all ages than offspring from either normotensive mothers ($p \leqslant 0.001$) or those with hypertension ($p = 0.002$).

Conclusion: Hypertensive diseases during pregnancy, in particular preeclampsia, have long term and possibly permanent consequences for motor development of offspring.

Introduction

Hypertension in pregnancy, and preeclampsia have been linked to poor outcomes in cognitive, mental and psychomotor development; however, few longitudinal studies have researched their effect on offspring motor development, particularly in late childhood and adolescence. It is already well established that fetal growth restriction (FGR), premature birth, small for gestational age (SGA) status, maternal stress, smoking and alcohol consumption are risk factors for compromised motor development in early [1–5] and late [6] childhood. Maternal hypertensive diseases such as hypertension and preeclampsia have been linked to SGA, FGR, prematurity [2]

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and poorer cognitive development in early [7] and late childhood [8].

A differential effect of hypertension and preeclampsia has been reported in studies investigating mental health and behavior, with hypertension linked to a higher risk of negative outcomes, and preeclampsia associated with a lower risk in some cases [9,10]. Other findings [11] have indicated a possible reduction in the future risk of breast cancer in female offspring born to mothers with preeclampsia. Together these findings suggest different pathways through which hypertension and preeclampsia may influence mental health development, behavioral outcomes and hormonal activity in the long term.

While preeclampsia may be associated with a positive effect on mental health and behavioral outcomes, research indicates that the impact is more likely to be negative for physical development. Reduced heart size and heart function have been reported in five to eight year old children born to mothers with preeclampsia [12] and delays in both mental and psychomotor development were found in up to 76% of one year old infants born to mothers with severe preeclampsia [13].

One possible mechanism that may explain the association between maternal preeclampsia and offspring physical and motor outcomes may be a decrease in oxygen delivery to the developing fetus via the placenta that is seen in pregnancies complicated by preeclampsia [14]. Pitcher et al. [2] report that during the third trimester, the most common time for preeclampsia to occur, the developing fetal brain may be more vulnerable to hypoxic and ischemic insults. During this time, the cerebellum (an area responsible for some aspects of motor development such as coordination, precision and accuracy of movement) is rapidly developing and suboptimal maternal nutrition or deficits in the delivery of nutrients via the placenta at this time may result in developmental problems, particularly in the motor domain [15,16]. In order to examine the effect of hypertension and preeclampsia on motor development and explore the theory of restricted placental blood flow as a potential mechanism we used data from the Western Australian Pregnancy Cohort (the Raine Study). This large cohort has been followed longitudinally over twenty years and provided the opportunity to examine the longer term impact of hypertension and preeclampsia on motor development and the potential role played by restricted placental blood flow through the use of Doppler flow velocity waveform data.

The effects of various perinatal risk factors on motor development have been previously reported in the Raine cohort by Hands et al. [6] who found that hypertensive diseases were linked to poorer outcomes in females at 10 years. The purpose of this study was to extend these findings by using both cross sectional and linear mixed models to identify the longer term consequences of maternal hypertensive diseases on the motor development of offspring as they matured from 10 to 14 and 17 years.

We predicted that the motor development of offspring at 10, 14 and 17 years would be negatively affected by the hypertensive status of the mother, with preeclampsia in particular contributing to a poorer motor outcome. Furthermore those mothers with preeclampsia were more likely to have experienced restricted placental blood flow, indicated by abnormal Doppler waveforms.

Method

Participants

Participants ($n = 2900$) were part of the Western Australian Pregnancy Cohort (Raine Study) and were recruited through the King Edward Memorial Hospital between 16 and 20 weeks gestation. The Raine Study is a randomized control study, with women being allocated to either an intensive ultrasound group or a regular ultrasound group [17]. Women in the intensive group had ultrasound and Doppler flow studies performed at approximately 18 weeks gestation, then again at 24, 28, 34 and 38 weeks gestation. Women in the control group had one ultrasound around 18 weeks and further scans only if requested by her physician. Full cohort details and enrollment criteria have previously been reported [17]. From the 2900 pregnancies, 2868 children were recruited for long-term follow-up. Ultrasound and Doppler data were available for 1429 children born to mothers in the intensive ultrasound group and 1428 children born to those in the regular ultrasound (control) group.

Original data collection was by questionnaire, undertaken at enrollment with data obtained regarding maternal health, SES and psychosocial characteristics. The second data collection was administered at 34 weeks gestation. Obstetric data were obtained from antenatal, postnatal, and neonatal periods. Follow up data pertaining to motor development reported in this paper were obtained from the participants' offspring at 10, 14, and 17 years.

Measures

Hypertension and preeclampsia

Maternal blood pressure and other physiological data were recorded during antenatal visits in the first phase of the study [17]. Hypertension and preeclampsia diagnoses were confirmed by obstetricians and midwives after reviewing medical records. Essential hypertension was defined by a history of hypertension prior to pregnancy. Gestational hypertension was defined as an increase in systolic blood pressure $\geqslant 140$ mmHg and/or an increase in diastolic blood pressure $\geqslant 90$ mmHg in women who were normotensive previous to 24 weeks gestation [17]. Women with both essential ($n = 72$) and gestational ($n = 554$) hypertension were included in the hypertension group. Preeclampsia was defined as gestational hypertension with the addition of proteinuria (300 mg/24 h). Women who had preeclampsia and gestational hypertension ($n = 68$) and preeclampsia superimposed on essential hypertension ($n = 41$) were included in the preeclampsia group. Three pregnancy groups were formed, indicating whether the offspring was from a mother who had normotension (N; $n = 2132$), hypertension (HT; $n = 627$), or preeclampsia (PE; $n = 109$) based on the diagnostic criteria.