

## Relationship between childhood blood pressure and birth weight

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### Abstract

**Background** Low birth weight has been associated with cardiovascular mortality and morbidity. Some studies have reported a significant relationship between elevated blood pressure in children with low birth weight.

**Objective** To assess blood pressure differences in primary school students who had low and normal birth weights.

**Methods** This cross-sectional study was conducted in 170 children aged 6 to 12 years in March 2011 at a Medan primary school, North Sumatera. Blood pressure was measured with a standard mercury sphygmomanometer. A parental questionnaire was used to collect information on birth weight. Data were analyzed by student's T-test for numerical data and Spearman's correlation test for a relationship between blood pressure and birth weight.

**Results** The subjects consisted of 85 children with low birth weight and 85 children with normal birth weight. The mean systolic (SBP) and diastolic blood pressures (DBP) were significantly higher in children with low birth weight than those with normal birth weight [SBP: 106.7 vs. 99.8 mmHg, respectively, ( $P=0.0001$ ); and DBP: 69.2 vs. 63.5 mmHg, respectively, ( $P=0.0001$ )]. There were relationships between elevated SBP and DBP and low birth weight, as indicated by correlation coefficient [ $r=-0.365$  and  $r=-0.425$ , respectively, ( $P=0.0001$ )].

**Conclusion** Blood pressure is significantly higher in children with low birth weight than in those with normal birth weight. Birth weight was inversely related both to systolic and diastolic blood pressure. [Paediatr Indones. 2015;55:117-20].

**Keywords:** blood pressure, birth weight, children

The Barker hypothesis proposes that adult-onset disease has a fetal and early-life origin.<sup>1-3</sup> The association of fetal and early-life indicators and adult-onset disease has been well-documented in many populations worldwide.<sup>1-4</sup> More recent analyses have been refined with cohort-based studies, finding that low birth weight is associated with higher blood pressures and altered glucose and insulin metabolism in children and adults.<sup>3-5</sup>

The fetal origins hypothesis suggests that an adverse early life environment has, on average, a lasting effect on health in later life.<sup>6</sup> In particular, low birth weight, possibly as a surrogate for poor fetal nutrition, has been shown to have an inverse association with blood pressure and hypertension at various stages in later life.<sup>7,8</sup> Possible mechanisms include changes in fetal blood flow, resulting in abnormalities of the vasculature or disruption of nephrogenesis.<sup>8</sup> Babies with low birth weight tend to exhibit a more rapid

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early postnatal growth (catch-up) than babies born with normal weight. This clearly creates difficulties associated with separating the effect on blood pressure of fetal development from that of later development and environmental influences.<sup>8</sup>

A number of studies have investigated, and most found, an inverse relationship between birth weight and blood pressure in childhood, adolescence, and adulthood. A study in Europe found that birth weight consistently had a negative association with systolic blood pressure across all cohorts.<sup>9</sup> A cross-sectional study in Australia found that low birth weight was significantly associated with higher blood pressure in adult life.<sup>10</sup> To date, no studies have been published examining the relationship between birth weight and blood pressure in North Sumatera.

The aim of this study was to assess for a relationship between childhood blood pressure and birth weight.

## Methods

This cross-sectional study was conducted at a Medan primary school, North Sumatera, in March 2011. The inclusion criteria were children aged 6 to 12 years. Children with renal disease, heart disease, obesity, hypertensive parents, malignancy or those who consumed steroids were excluded. Informed consent was obtained from parents after giving an explanation of the study procedure.

We used questionnaires to obtain information about the personal identities of the children, their birth weights, history of disease and drug usage, as well as their activities and exercises. Normal birth weight (NBW) was defined as born at term with BW  $\geq$  2500 g. Low birth weight (LBW) was defined as born at term with BW < 2500 g. Subjects were collected

by consecutive sampling until we got 85 children with NBW and 85 children with LBW who met the inclusion criteria.

Subjects' blood pressures were measured using mercury sphygmomanometers (*Richter*, Germany). Appropriately-sized cuffs were used (cuff width 40% of midarm circumference) with cuff bladders covering 80-100% of the arm circumference and approximately two-thirds of the length of the upper arm without overlapping. Sphygmomanometer readings at the first, fourth, and fifth Korotkoff phases were recorded. The readings at the first and the onset of the fifth Korotkoff phases were taken to be the systolic and diastolic blood pressures, respectively. Blood pressure was measured after five minutes resting with the child seated and the arm supported at chest level. All subjects underwent three blood pressure measurements, one minute apart, on the right arm. A *Nova Reister* and *Littmann Classic II* Pediatric stethoscope was used during blood pressure measurements.

This study was approved by Medical Ethics Committee of the University of North Sumatera Medical School. Data were analyzed with student's T-test for numerical data and Spearman's correlation for a possible relationship between blood pressure and birth weight, using *SPSS version 15.0*. Results were considered to be significant for P values < 0.05.

## Results

A total of 170 children met the inclusion criteria and were eligible for analysis. The characteristics of children with low birth weight were similar to those with normal birth weight (**Table 1**).

We found an association between children's blood pressure and their birth weight (P=0.0001). The analysis revealed significant higher mean SBP

**Table 1.** Characteristics of subjects

Characteristics	Low birth weight group (n=85)	Normal birth weight group (n=85)
Gender, n (%)		
Male	35 (41.1)	37 (43.5)
Female	50 (58.8)	48 (56.4)
Mean age (SD), years	8.6 (1.92)	9.0 (2.02)
Mean body weight (SD), kg	30.4 (8.91)	31.5 (10.02)
Mean body height (SD), cm	130.8 (11.66)	132.6 (13.19)

and DBP in the low birth weight children compared to normal birth weight children (Table 2).

From the correlation analysis we found a negative correlation between blood pressure and birth weight, with low birth weight associated with increased

birth weight.<sup>18,19</sup> A recent study of kidneys in adult Caucasians who died in accidents revealed that those with a history of essential hypertension had significantly fewer glomeruli per kidney, and greater glomerular volume than matched normotensive controls.<sup>19</sup>

**Table 2.** Association between blood pressures and birth weight

Mean blood pressures	Low birth weight group (n=85)	Normal birth weight group (n=85)	P value
Systolic (SD), mmHg	106.7 (9.99)	99.8 (6.96)	0.0001
Diastolic (SD), mmHg	69.2 (5.64)	63.5 (6.25)	0.0001

blood pressure (systolic and diastolic). Based on the correlation value ( $r$ ), we found a weak correlation between SBP and birth weight ( $r=-0.365$ ), and a moderate correlation between DBP and birth weight ( $r=-0.425$ ) (Table 3).

**Table 3.** Correlation between blood pressure and birth weight

Variables	Correlation coefficient ( $r$ )	P value
Systolic blood pressure	- 0.365	0.0001
Diastolic blood pressure	- 0.425	0.0001

## Discussion

The Indonesian Health Ministry reported a prevalence of low birth weight of 14% in 2000 in Indonesia.<sup>11</sup> Infants who are small at birth or in infancy have high rates of coronary heart disease, stroke, hypertension, and diabetes in adult life.<sup>12-15</sup> A UK study found an inverse association between adult hypertension and low birth weight.<sup>10</sup>

Infants who are smaller at birth tend to grow more rapidly (exhibit catch-up growth) than normal birth weight infants. Several reports suggested that this rapid, early, postnatal growth contributes to raised body mass indices and higher blood pressures later in life.<sup>16,17</sup> Our study did not include data on weight, other than at birth and at the time of the study, so we could not evaluate the effect of early postnatal growth in our subjects.

A cohort study found that children with intrauterine growth retardation had fewer nephrons but similar glomerular volume, while another study found that children with birth weight below 2.5 kg had fewer nephrons and larger glomerular volume than children with higher birth weights. They observed a mean reduction in nephrons of 20% in children with low

Another study compared the relationship between kidneys of neonates who died within 2 weeks of birth and their birth weights. Significant inverse correlations were found between glomerular number and glomerular volume, and between birth weight and glomerular volume, independent of sex and race.<sup>18</sup> Low birth weight may be associated with a congenital deficit in nephron number, which would predispose an individual to reduced renal sodium excretion and, therefore, increased susceptibility to essential hypertension. This hypothesis was also based on the knowledge that in a setting of nephron loss, remaining glomeruli undergo compensatory hypertrophy (glomerulomegaly) and hyperfiltration (increased single nephron glomerular filtration rate) to sustain adequate renal function.<sup>18-20</sup>

We found that mean SBP and DBP were significantly higher in children with low birth weight than in children with normal birth weight (both  $P=0.0001$ ). Similarly, a Spanish study showed that children who had lower birth weight tended to have not only the highest blood pressure, but also the highest blood pressure variability.<sup>21</sup>

We assessed for a correlation between blood pressure and birth weight using Spearman's analysis and found that both independent variables had negative correlations with dependent variables. Based on the correlation value ( $r$ ), SBP had a weak correlation to birth weight ( $r=-0.365$ ), while DBP had a moderate correlation to birth weight ( $r=-0.425$ ). Similarly, a cross-sectional study of primary school children aged 9 to 11 years in Guildford and Carlisle, found that birth weight was inversely related to both systolic and diastolic blood pressures.<sup>22</sup> Furthermore, a prospective cohort study found that systolic blood pressure at 5 years of age was inversely related to birth weight.<sup>23</sup>

Some limitations of our study were possible selection bias, as subjects were not from the general population, and recall bias, as some data was based on parental memory. More study is required, including intervention trials, to assess whether efforts to reduce the incidence of low birth weight and improve antenatal care will reduce the prevalence of hypertension among future generations.

The findings of this study suggest the need for monitoring blood pressure in children, especially with regards to their birth weight. Therefore, pediatricians have an important role in educating families and children to prevent hypertension. In conclusion, blood pressure in children with a history of low birth weight is significantly higher than in those with normal birth weight. Birth weight is inversely related both to systolic and diastolic blood pressures.

### Conflict of interest

None declared

### References

1. Hall WD, Ferrario CM, Moore MA, Hall JE, Flack JM, Cooper W, et al. Hypertension-related morbidity and mortality in the southeastern United States. *Am J Med Sci.* 1997; 313:195–209.
2. Martin JA, Hamilton BE, Ventura SJ, Menacker F, Park MM. Birth: final data for 2000. *Nat Vital Stat Rep.* 2002;50:1–104.
3. Barker DJ, Osmond C, Golding J, Kuh D, Wadsworth ME. Growth in utero, blood pressure in childhood and adult life, and mortality from cardiovascular disease. *BMJ.* 1989;298:564–7.
4. Lackland DT, Egan BM, Ferguson PL. Low birth weight as a risk factor for hypertension. *J Clin Hypertens.* 2003;5:133–6.
5. Huxley RR, Shiell AW, Law CM. The role of size at birth and postnatal catch-up growth in determining systolic blood pressure: a systematic review of the literature. *J Hypertens.* 2000;18:815–31.
6. Barker DJ, Osmond C. Infant mortality, childhood nutrition and ischaemic heart disease in England and Wales. *Lancet.* 1986;1:1077–81.
7. Brenner BM, Chertow GM. Congenital oligonephropathy and the etiology of adult hypertension and progressive renal injury. *Am J Kidney Dis.* 1994;23:171–5.
8. Primates P, Falaschetti E, Poulter NR. Birth weight and blood pressure in childhood: results from the Health Survey for England. *Hypertension.* 2005;45:75–9.
9. Hardy R, Sovio U, King VJ. Birthweight and blood pressure in five European birth cohort studies: an investigation of confounding factors. *Eur J Public Health.* 2006;16:21–30.
10. Davies AA, Smith GD, May MT, Ben-Shlomo Y. Association between birth weight and blood pressure is robust, amplifies with age, and may be underestimated. *Hypertension.* 2006;48:431–6.
11. Departemen Kesehatan Republik Indonesia. Penyakit penyebab kematian bayi baru lahir dan sistem pelayanan kesehatan yang berkaitan di Indonesia. [cited 2012 February] Available from: [www.digilib.litbang.Depkes.go.id](http://www.digilib.litbang.Depkes.go.id).
12. Barker DJ. Fetal origins of coronary heart disease. *Br Heart J.* 1993;69:195–6.
13. Barker DJ, Winter PD, Osmond C, Margetts B, Simmonds SJ. Weight in infancy and death from ischaemic heart disease. *Lancet.* 1989;2:577–80.
14. Barker DJ, Bull AR, Osmond C, Simmonds SJ. Fetal and placental size and risk of hypertension in adult life. *BMJ.* 1990;301:259–62.
15. Hales CN, Barker DJ, Clark PM, Cox LJ, Fall C, Osmond C, et al. Fetal and infant growth and impaired glucose tolerance at age 64. *BMJ.* 1991;303:1019–22.
16. Williams S, Poulton R. Birth size, growth, and blood pressure between the ages of 7 and 26 years: failure to support the fetal origins hypothesis. *Am J Epidemiol.* 2002;155:849–52.
17. Adair LS, Cole TJ. Rapid child growth raises blood pressure in adolescent boys who were thin at birth. *Hypertension.* 2003;41:451–6.
18. Reyes L, Manalich R. Long-term consequences of low birth weight. *Kidney Int.* 2005;68:107–11.
19. Vikse BE, Irgens LM, Leivestad T, Hallan S, Iversen BM. Low birth weight increases risk for end-stage renal diseases. *J Am Soc Nephrol.* 2008;19:151–7.
20. Zandi-Nejad K, Luyckx VA, Brenner BM. Adult hypertension and kidney disease: the role of fetal programming. *Hypertension.* 2006;47:502–8.
21. Lurbe E, Torro I, Rodriguez C, Alvarez V, Redon J. Birth weight influences blood pressure values and variability in children and adolescents. *Hypertension.* 2001;38:389–93.
22. Whincup P, Cook D, Papacosta O, Walker M. Birth weight and blood pressure: cross sectional and longitudinal relations in childhood. *BMJ.* 1995;311:773–6.
23. Levitt NS, Steyn K, De Wet T, Morrel C, Edwards R, Ellison GT, et al. An inverse relation between blood pressure and birth weight among 5 year old children from Soweto, South Africa. *J Epidemiol Community Health.* 1999;53:264–8.