

Correlation of renal volume to renal function and blood pressures in low birth weight children

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Abstract

Background Disruption of nephrogenesis in low birth weight (LBW) infant leads to decreases in nephron number and renal volume, resulting in renal hyperfunction and eventually, hypertension.

Objective To assess for a possible correlation of renal volume to renal function and blood pressures in low birth weight children aged 7-8 years.

Methods We conducted a retrospective cohort study on children aged 7-8 years in Manado, who were born LBW or normal birth weight (NBW). Renal function was assessed by measuring blood cystatin-C level while renal volume was determined using ultrasound measurements of renal length x width x thickness (cm³). T-test was used to compare renal volume and cystatin-C levels in LBW children to NBW children. Pearson's correlation test was used to assess the relationship of renal volume to renal function and blood pressure in low birth weight children.

Results Subjects were 48 LBW and 48 NBW children. Mean renal volumes were 78.28 (SD 7.96) cm³ in the LBW group and 103.68 (SD 12.52) cm³ in the NBW group ($P < 0.01$). The mean cystatin-C levels, as a measure of renal function, were 0.81 (SD 0.07) mg/L in the LBW group and in 0.73 (SD 0.06) mg/L in the NBW group ($P < 0.01$). There was no correlation between renal volume and cystatin-C level ($r = -0.169$; $P > 0.05$) as well as between renal volume and systolic ($r = -0.07$, $P > 0.05$) and diastolic blood pressure ($r = -0.123$, $P > 0.05$).

Conclusion Mean renal volume is lower in the LBW group than in the NBW group, but is not correlated to decreased renal function or blood pressures. [Paediatr Indones. 2014;54:73-6].

Keywords: renal volume, renal function, low birth weight, blood pressure

Low birth weight (LBW) has been found to be associated with various adulthood diseases, such as hypertension, cardiovascular diseases, insulin resistance, and terminal stage renal diseases.^{1,2} In LBW children, impaired fetal embryonic development may lead to hypertension as adults.^{3,4} Kidney structure and nephron number, in particular, are major determinants of renal function and blood pressure.⁵ In LBW infants, disrupted nephrogenesis causes nephron developmental disorder, in which the number of nephrons is reduced, resulting in decreased renal volume, which may be assessed by ultrasound.⁶⁻⁸ Currently, the best method to assess renal function is glomerular filtration rate (GFR). However, several studies have shown that cystatin-C is a good approximation of GFR, thus acting as a sensitive marker to changes in the renal function.⁹⁻¹²

The aim of this study was to assess for a possible correlation between renal volume to renal function and blood pressures in LBW and NBW children.

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Methods

This retrospective cohort study was conducted between March to June 2012 on children aged 7-8 years in Manado. Subjects were born at Manado General Hospital in healthy condition, and had either a history of LBW (full term small gestational age) or NBW (full term appropriate gestational age). Their parents agreed to participate in this study and signed an informed consent. We excluded children with a history of kidney diseases, such as nephrotic syndrome, acute glomerulonephritis, acute renal failure, chronic glomerulonephritis, chronic renal failure, as well as those who were obese or had reached puberty. Low birth weight was defined as weighing < 2500 grams at the time of birth. Blood pressure was measured by a calibrated mercury sphygmomanometer. Hypertension was defined as average systolic or diastolic blood pressure \geq 95th percentile, according to sex, age, and height. Renal volume was measured by a radiologist with ultrasound, with the subject in a supine position, and calculated using the ellipsoid formula, i.e., length x width x thickness x 0.5233, with the results in cm³. Total renal volume was defined as the sum of

the left and right renal volumes. Serum cystatin-C was measured by particle-enhanced nephelometric immunoassay (PENIA), with a normal value of 0.57-0.96 mg/L. Statistical analyses used were T-test and Pearson's correlation using SPSS version 20. This study was approved by The Ethics Committee at Sam Ratulangi University Medical School, Manado.

Results

During the study period, there were 48 LBW and 48 NBW children met the eligible criteria. The characteristics of subjects are listed in **Table 1**. **Table 2** shows the comparison of laboratory and ultrasound results between LBW and NBW groups. Although the LBW mean cystatin-C level was in normal range, the mean cystatin-C level in the LBW group was higher than that of the NBW group. Mean renal volume in the LBW group was significantly lower than that of the NBW group (78.28 cm³ vs. 103.68 cm³, respectively, $P < 0.01$). However, no relationship had been found between renal volume and decreased renal function ($r = -0.169$; $P > 0.05$) or with increase in systolic blood

Table 1. Characteristics of subjects

Characteristics	Low birth weight group (LBW)	Normal birth weight group (NBW)
Age, years		
Median	7.5	7.5
Mean (SD)	7.5 (0.3)	7.5 (0.4)
Gender, n (%)		
Males	20 (41.7)	27 (56.2)
Females	28 (58.3)	21 (43.8)
Birth weight, grams		
Median	2,300	3,100
Mean (SD)	2,182.7 (271.1)	3,224.4 (420.9)
Body weight, grams		
Median	21,000	21,000
Mean (SD)	21,260 (2,250)	21,395 (2,447)
Systolic blood pressure, mmHg		
Median	90.0	90.0
Mean (SD)	95.3 (7.4)	93.3 (6.6)
Diastolic blood pressure, mmHg		
Median	60.0	60.0
Mean (SD)	62.2 (4.8)	61.4 (4.5)

Table 2. Comparison of cystatin-C level and renal volume

Variables	LBW group	95%CI	NBW group	95%CI	P value
Mean cystatin C, mg/L (SD)	0.81 (0.07)	0.79 to 0.83	0.73 (0.06)	0.71 to 0.75	<0.001
Mean renal volume, cm ³ (SD)	78.28 (7.96)	75.97 to 80.59	103.68 (12.52)	100.07 to 107.31	<0.001

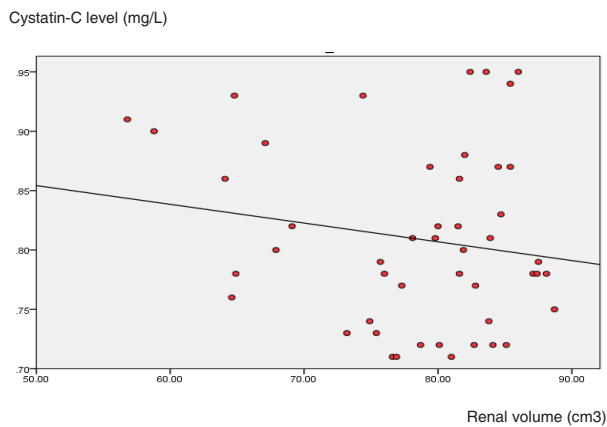


Figure 1. Correlation between renal volume and cystatin-C levels in LBW children

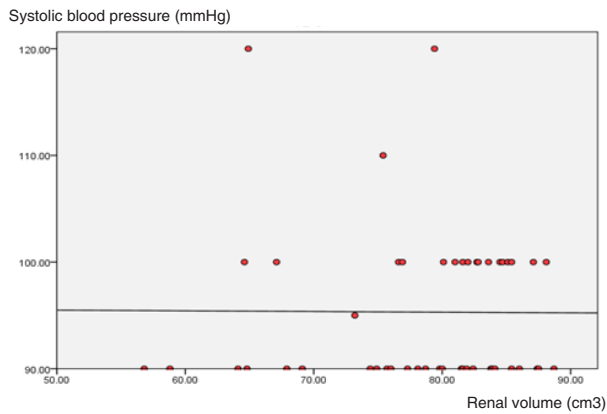


Figure 2. Correlation between renal volume and systolic blood pressure in LBW children

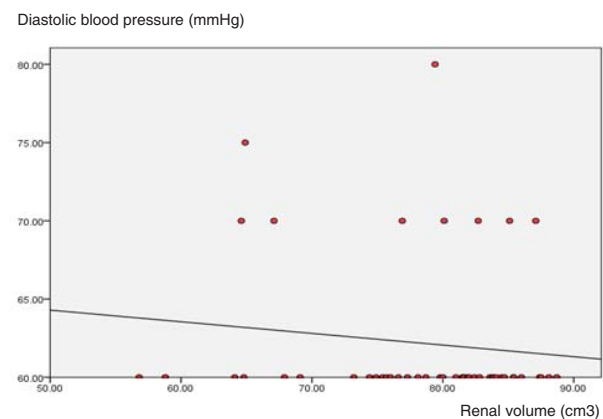


Figure 3. Correlation between renal volume and diastolic blood pressure

pressure and diastolic blood pressure ($r = -0.007$ and $r = -0.123$, $P > 0.05$). This relationship can be seen in **Figure 1**, **Figure 2**, and **Figure 3**.

Discussion

Full term, LBW children may have a reduction in nephron number due to disturbances during the intrauterine process.^{6,7} Renal volume, measured by ultrasound, may be used to assess nephron number,¹³ as decreased renal volume indicates decreased nephron number.¹⁴⁻¹⁶ In our study, LBW children had significantly lower mean renal volume than those of the NBW children. Kwinta *et al.* found that 78 LBW children aged 6-7 years had a mean renal volume smaller than NBW (81 cm^3 vs 113 cm^3 , respectively, $P < 0.01$).¹⁷ In addition, Rakow *et al.* found that LBW children aged 9-12 years had a lower mean renal volume than NBW children (162 cm^3 vs. 182 cm^3 , respectively, $P < 0.05$).⁸

Cystatin C is an endogenous marker of renal function, as cystatin C serum levels depend on the GFR. It is a more accurate biomarker than creatinine for estimating renal function and predicting cardiovascular events, especially in a state of lightly impaired renal function.¹¹ As renal function decreases, the cystatin C blood concentrations increase.¹⁸ Hence, serum cystatin C depicts an accurate assessment of GFR and profitable as it is perfectly filtered by glomerulus.¹³ Cystatin C concentration can be used as an indicator for GFR in children born with LBW, comparable to creatinine serum level. However, cystatin C is not affected by muscle mass and body weight.^{20,21} In our study, the mean cystatin C level in LBW children was higher than in NBW children. However, the LBW mean cystatin C level was in the normal range, indicating no impairment in renal function. Franco *et al.* also found higher mean cystatin C in LBW children than in NBW children aged 8-13 years in Brazil (1.01 mg/L vs 0.83 mg/L , respectively, $P < 0.05$). This study concluded that the LBW is associated with increased levels of cystatin C in children aged 8-13 years who were born full term.¹⁹

In humans, a high incidence rate of hypertension has been associated with a reduction in nephron number,²² an inverse relationship between the total number of nephrons and the risk of developing hypertension in later life.⁴ We found no correlation

between renal volume and systolic and diastolic blood pressures. The age of subjects may be a factor, as Zhang *et al.* concluded that the age of 7 years is too early for the manifestations of hypertension.²³ Furthermore, Zaffanello *et al.*²⁴ found no increase in blood pressure in LBW preschool children with small renal volume. We observed no correlation between renal volume and cystatin C concentration.

In conclusion, LBW children have significantly lower renal volume than NBW children, but this does not correlate to decreased renal function or increased blood pressures. Further follow up on these children at an older age is needed to assess for changes in renal function and blood pressures as they age.

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