

## Assessment on fetal renal volume and function in normal and growth restricted fetuses

M. SITEPU<sup>1</sup>, R. HARYONO ROESHADI<sup>1</sup>, D. SIDDIK<sup>1</sup>, D. PRASMUSINTO<sup>2</sup>

**SUMMARY: Assessment on fetal renal volume and function in normal and growth restricted fetuses.**

M. SITEPU, R. HARYONO ROESHADI, D. SIDDIK, D. PRASMUSINTO

**Background.** IUGR (Intrauterine Growth Restriction) increases the morbidity and mortality of fetuses and, in the future, it will lead to fetal programming such as hypertension, diabetes mellitus, stroke and kidney failure.

**Objective.** To determine renal volume and function in Normal and Growth Restricted Fetuses at 36 weeks gestation.

**Methods.** A cohort study was conducted for 28 up to 36 weeks gestation in 20 IUGR fetuses compared with normal fetuses by examining renal volume, the volume of the secretion of urine, amniotic fluid index. Examination of renal volume is conducted with 3D VOCAL technique with 30° rotation, as well as upon the volume of the bladder.

**Results.** The mean left kidney volumes of IUGR and normal

fetuses were 6.47 ml, SD 1.85 ml and 11.09, SD 2.91 ml respectively. It was statistically and significantly different based on Mann-Whitney test at  $p < 0.001$ . On the other side, the mean right kidney volumes of IUGR fetuses and the normal ones were also statistically and significantly different. They were 6.07 ml, SD 1.9 and 10.75 ml, SD 3.35 ml respectively.

The mean of urine volume per hour of IUGR fetuses was 8.21 ml, SD 3.48 ml and the normal ones were 19.23 cc, SD 5.79 which was statistically different. Although it had not reached oligohydramnios but the amount of amniotic fluid of IUGR fetuses was less than that of the normal ones, it signified 6.57 ml, SD 2.28 ml compared to 11.85 SD 2.53 respectively. Such different figures were statistically and significantly different at  $p < 0.001$ .

**Conclusion.** Fetal renal volume with growth restriction is lower than that of the normal ones and so does the secretion of urine between the two groups of the fetuses. It is also discovered that the volume of amniotic fluid index of IUGR fetuses is lower too than that of the normal fetuses.

KEY WORDS: IUGR - Fetal programming - 3D VOCAL.

### Introduction

IUGR is fetal growth failure to achieve normal potential growth of particular fetus caused by genetic and environmental factors (1-3). Based on fetal weight  $<$  than the 10<sup>th</sup> percentile, it triggers inconsistent term between Small for Gestational Age (SGA) and Intrauterine Growth Restriction (IUGR), obviously 70% of babies are small but healthy. The im-

portant factor in assessing fetal growth is weight gain that continues to rise in accordance with the normal growth chart, if there is a decline in growth percentiles it was then classified Intrauterine Growth Restriction (IUGR) (4-6).

On the examination of fetal renal volume at 20-40 weeks gestation by using 3D ultrasound, it was discovered that the volume of fetal kidney increased with the aging pregnancy and the kidney size of IUGR fetuses was smaller than that of the normal fetuses which was below the 10<sup>th</sup> percentile of normal kidney nomogram (7-9).

Konje (1996) (10) reported that difference of kidney size between normal and growth restricted fetuses mainly occurred on 26-34 weeks gestation therefore the alleged critical period of nephrogenesis

<sup>1</sup> Department of Obstetrics and Gynecology, Faculty of Medicine, Universitas Sumatera Utara, H. Adam Malik General Hospital, Medan, Indonesia

<sup>2</sup> Department of Obstetrics and Gynecology, Faculty of Medicine, Universitas Indonesia, Cipto Mangunkusumo General Hospital, Jakarta, Indonesia

Corresponding author: Anditha Sitompul, e-mail: anditha.namira@gmail.com

growth was at 26-34 weeks. Fetal nephrons formation was perfect until the age of 36 weeks gestation and no further growth after birth.

The state of hypoxemia and acidemia in IUGR fetus will cause a redistribution of blood to vital organs such as brain, heart, and adrenal gland but to other organs, the redistribution reduces including to the renal artery. This could result in reduced fetal urine production and when it prolongs would lead to oligohydramnios. Hypoxemia also stimulates the secretion of arginine vasopressin which causes water reabsorption by nephrons leading to reduced fetal urine production (11-13).

## Methods

It was a cohort study performing a series of ultrasound examinations every 2 weeks.

Cases were at 28-36 weeks gestation with IUGR, while the controls were normal pregnancy with the same gestational age. The cases were examined by using ultrasound every 2 weeks until 36 weeks of gestation, when there was improvement they were then excluded from the study.

As for the ultrasound examination, it was performed by using USG Samsung Madison A30 with Probe 2D, 3D, 4D Krezt and the measurement of BPD, HC, AC and FL for cases and controls. If growth of improvement with a ratio of HC/AC < 1.1 was discovered during the observation, the cases were then excluded from the study.

At 36 weeks of gestation in which a time of nephrogenesis ended, the examination of biometry was measured as well as the volume of left and right fetal kidneys by using 3D VOCAL with rotation angle of 30° taken by cutting the sagittal direction of the spine. Besides that, ultrasound 3D VOCAL of bladder with coronal cuts was also examined every half an hour and then multiplied the difference in volumes by 2, the results of this multiplication was the secretion of fetal urine every hour. Examination of amniotic fluid index was also performed semi quantitatively with four quadrants.

The whole data obtained from the 20 cases and controls were verified and then followed it up in data processing descriptively (number, size and picture) accompanied by analysis of *unpaired t test* and if normal distribution was unavailable, Mann-Whitney with SPSS version 19 with the significance level of 5% would be applied.

## Results

It was discovered that the number of 20 cases with IUGR up to 36 weeks gestation and 20 controls with the same normal gestational age delivered the babies with their mean birth weight was 2952.5 grams and 3306.75 grams respectively.

Most gravidas' ages in cases with IUGR were 31-35 with a number of 7 persons (35%) meanwhile most controls' ages were 26-30 and the number of them were 11 (55%). Most gravidas in cases were gravidas 1, 14 persons (70%) and the most gravidas in controls were gravidas 2, 8 persons (40%). The most education of cases was undergraduate degree, 11 persons (55%) meanwhile the most education of controls was also the same, 14 persons (70%). There were no significant differences in characteristics between cases and controls with  $p > 0.05$  (Table 1).

The mean size of the left kidney of IUGR fetuses is 6.47 ml, SD 1.86 ml and control is 11.09 ml, SD 2.91 ml. These differences are statistically significant with  $p = 0.001$  (Table 2).

The mean size of the right kidney of IUGR fetuses is 6.07 ml, SD 1.9 ml, meanwhile controls are 10.75 ml, SD 3.35 ml. These differences are statistically significant with  $p = 0.001$  (Tables 3, 4).

On examination of the urinary bladder of the fetuses that was a representation of fetal urine production per hour, it was found that the urine production was 3.48 ml, SD 8.21 ml in IUGR fetuses and 19.23 ml, SD 5.79 ml in normal fetuses. Those signified statistical and significant differences between IUGR fetuses and the normal ones. Mean amniotic fluid index measured semi quantitatively on a four-quadrant was 6.57 ml, SD 2.28 ml for IUGR fetuses and 11.85 ml, SD 2.54 ml for normal fetuses and those figures differed statistically and significantly.

## Discussion

In the study, IUGR fetal volume in both right and left kidneys is smaller than those of normal fetuses and these differences are statistically and significantly different. This case is consistent with research conducted by Konje, 1996, stating that the critical period of nephrogenesis is on gestational age of 26-34 weeks and in case of impaired fetal growth there would be 20% reduction in the number of nephrons where in this study the fetal renal volume at 36 weeks of gestation were measured. It was the last

TABLE 1 - DIFFERENCES IN THE LEFT RENAL VOLUME BETWEEN IUGR AND NORMAL FETUSES.

	Group	n	mean	Std. Deviation	p-value *
Left Kidney Size	IUGR	20	6.4728	1.85488	0.001
	Normal	20	11.0990	2.91149	

\* Mann-Whitney

TABLE 2 - DIFFERENCES IN THE RIGHT RENAL VOLUME BETWEEN IUGR AND NORMAL FETUSES.

	Group	n	mean	Std. Deviation	p-value *
Right Kidney Size	IUGR	20	6.0700	1.90076	0.001
	Normal	20	10.7495	3.35249	

\* Mann-Whitney

TABLE 3 - DIFFERENCES IN URINE VOLUME PER HOUR BETWEEN IUGR AND NORMAL FETUSES.

	Group	n	mean	Std. Deviation	p-value *
The volume of urine / hour	IUGR	20	8.2100	3.47497	0.001
	Normal	20	19.2285	5.78424	

\* T-test

TABLE 4 - AMNIOTIC FLUID INDEX OF IUGR AND NORMAL FETUSES UNTIL 36 WEEKS OF GESTATION.

Group	n	Amniotic Fluid Index		p-value *
		mean	SD	
IUGR	20	6.57	-/+ 2.28	0.001
Normal	20	11.85	-/+ 2.53	

\* T-test

phase of the growth of nephrons. If it is compared with normal fetal renal volume, the reduction in volume of the left kidney of IUGR fetuses is 41.65% and the right kidney is 43.48%. Reduced number of nephrons in IUGR and preterm fetuses will lead to the occurrence of hypertension in young adulthood (14-16).

Urine production of normal fetuses in the third trimester was 6-10 ml/kg/h at 30-40 weeks gestation and it was found in this study that urine production of IUGR fetuses was 8.2 ml, SD 3.48 ml and normal fetuses was 19.23 ml, SD 5.78 ml. It is seen that reduction in the secretion of urine of IUGR fetuses depicts

a decrease of blood circulation in renal arteries and if it is prolonged, it will lead to reduced volume of amniotic fluid. Oligohydramnios was a complication that occurs in pregnancy associated with placental insufficiency in IUGR. If fetal anomalies is not found, then oligohydramnios is a sign of fetal hypoxemia caused by the reduced production of urine (17-22).

The reduced number of nephrons in the IUGR fetuses would cause a compensation mechanism in the form of glomerulomegaly and increased hydrostatic pressure in the intra glomerular capillary which gradually caused damage to the capillary walls. The damage caused proteinuria and low Glomerular Fil-

tration Rate (GFR), in the future could cause hypertension (23, 24).

A study has discovered a direct link between birth weight and the number of nephrons, where the increase in the number of nephrons is 250,000 for each kidney for every kilogram of weight gain. Birth weight is directly proportional to the number of nephrons and inversely proportional to the mean volume of the glomerulus (25).

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