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Hydronephrosis Index as a New Method for the Evaluation and Follow-up of Fetal Hydronephrosis

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ABSTRACT

Background: The present study was conducted to compare the efficiency of hydronephrosis index (HI) with those of pelvic anteroposterior (AP) diameter and parenchymal thickness in the diagnosis of fetal hydronephrosis in the prenatal period, as well as 1, 6, and 12 months after birth.

Methods: This study was conducted on pregnant women with the pregnancy age of > 30 weeks whose fetus was suspected of hydronephrosis. The study participants were collected via the consecutive sampling method. The HI, pelvic AP diameter, and parenchymal thickness were measured at the baseline and 1, 6, and 12 months after delivery using ultrasound. According to the study design, the study participants were divided into three groups. Group A consisted of cases with decreased HI and higher hydronephrosis severity. Group B was composed of subjects with relatively constant HI, and group C entailed individuals with increased HI and lower hydronephrosis severity. All of the study measurements and analyses were performed on the three study groups.

Results: The results revealed a negative association between HI and pelvic AP diameter but a positive association with parenchymal thickness. On the other hand, HI showed a significant correlation with parenchymal thickness in the diagnosis and prognostic assessment of fetal hydronephrosis.

Conclusion: The HI correlated with parenchymal thickness and pelvic AP diameter scores in all follow-up stages. Accordingly, HI can be concluded to be a good alternative to parenchymal thickness or pelvic AP diameter as a grading factor for hydronephrosis. It is suggested to perform further studies to carefully assess the efficiency of HI in the diagnosis, prognosis, and clinical outcome of hydronephrosis.

Keywords: Anteroposterior pelvis diameter, Hydronephrosis index, Parenchymal thickness, Prognosis

Introduction

Fetal hydronephrosis (FHN) is the most common prenatal anomaly, which might need careful postnatal follow-up. The prevalence of FHN has been reported to range from 0.5% to 1.4% by some clinicians. The management of this condition is regarded as a clinical challenge. Some FHN cases have spontaneous remission or progression (1). Ultrasound studies have been used as screening and diagnostic procedures to determine pediatric urologic disorders, such as hydronephrosis (2). Different systems have been developed to grade and assess the severity of FHN (3). Clinicians have no consensus on the most suitable criteria for the management of FHN. It seems that FHN severity is correlated with renal anomalies (4).

Currently, the criteria determined by the Society of Fetal Urology (SFU) are used as the diagnostic and management criteria for FHN. However, SFU is a qualitative operator rather than a quantitative index (5). Pelvic anteroposterior (AP) diameter has been suggested as another common diagnostic criterion for FHN grading. The pelvis in some patients with FHN is extrarenal and does not affect the kidneys. However, in a study, the dilatation of this organ was reported to cause no renal parenchymal lesion (5). It seems that both SFU and pelvic AP diameter criteria have some disadvantages and are not suitable for most of FHN patients. Accordingly, investigators search to find new quantitative indices for the diagnosis of prenatal and postnatal hydronephrosis.

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Hydronephrosis index (HI) has been suggested as a new criterion and assessed in few studies. For instance, in a study performed by Stephen et al., HI was reported to be a reproducible method for the assessment of hydronephrosis severity and have high sensitivity for the control of FHN prognosis (2). Similarly, Venkatesan et al. reported that HI and SFU had a positive correlation, especially in the differentiation of severe SFU grade from mild SFU grades (6). In another study, Vivian et al. reported that HI is a better ultrasonographic reference for the prenatal assessment of FHN in comparison with other indices (7).

Based on the literature review, although HI has been used in few fetal follow-up studies, there is no study examining the use of HI for the diagnosis of FHN. Regarding this, the present study was conducted to investigate the application of HI in FHN diagnosis at the prenatal stage, as well as until the first year of life in different follow-up time points (i.e., 1, 6, and 12 months post-delivery). To this end, a comparison was made between our HI measurement and the AP diameter of the pelvis and parenchymal thickness in all follow-up stages.

Methods

This study was conducted on pregnant women with the pregnancy age of > 30 weeks and pelvic AP diameter of > 8 mm or SFU grade 2 or higher (suspected of hydronephrosis) in their fetus. The study population was selected using the consecutive sampling method. The participants were referred from a gynecology clinic to a radiology center for undergoing the routine radiological examinations. The study protocol was approved by the Research Ethics Committee of Hamadan University of Medical Sciences, Hamadan, Iran, and all of the study participants signed the research informed consent.

Before the implementation of ultrasonography, the pregnant women were required to drink 1-2 glasses of water in order to prevent from maternal dehydration. Ultrasonography was performed by one radiologist using the same device (Voluson E6, GE, USA) for all pregnant women with 3.5- and 5-MHz curvilinear array transducers. The HI in pregnant women was calculated via the study instruction and formula. To this end, firstly, an image was prepared from the hydronephrotic kidney in a sagittal view. The kidney perimeter was outlined by a pointer, and the kidney area was automatically calculated in cm^2 by the software. The HI was calculated via the following formula:

HI (%)=100 × (Total area of the kidney – area of dilated pelvis and calices/total area of the kidney)

In addition to HI, the AP diameter of the pelvis and kidney parenchymal thickness were measured at the baseline and one, six, and 12 months after delivery (figures 1 and 2). According
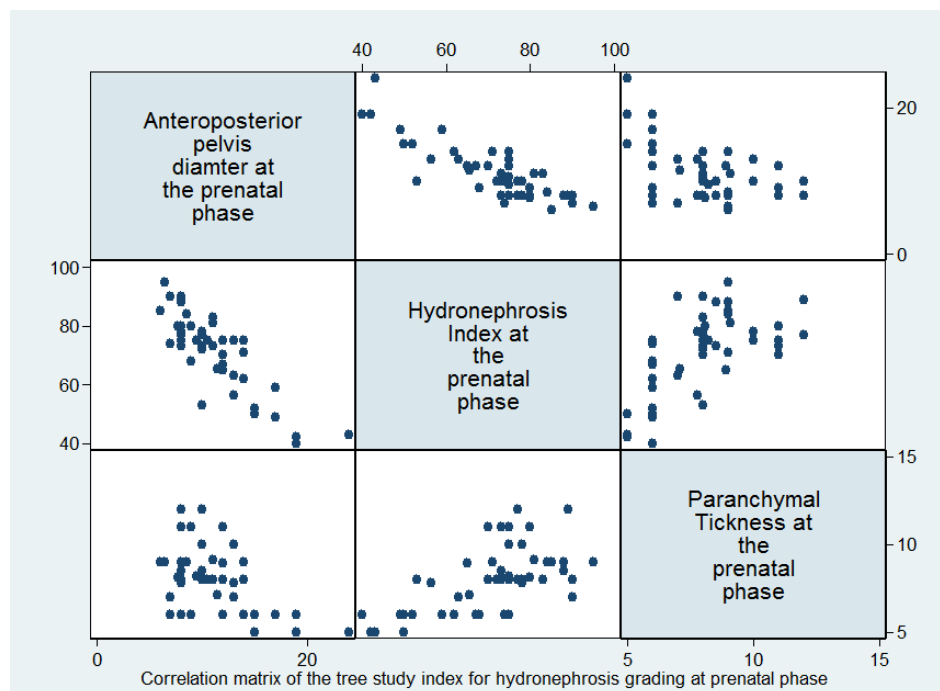

Figure 1. Correlational matrix among the three research variables at the prenatal phase
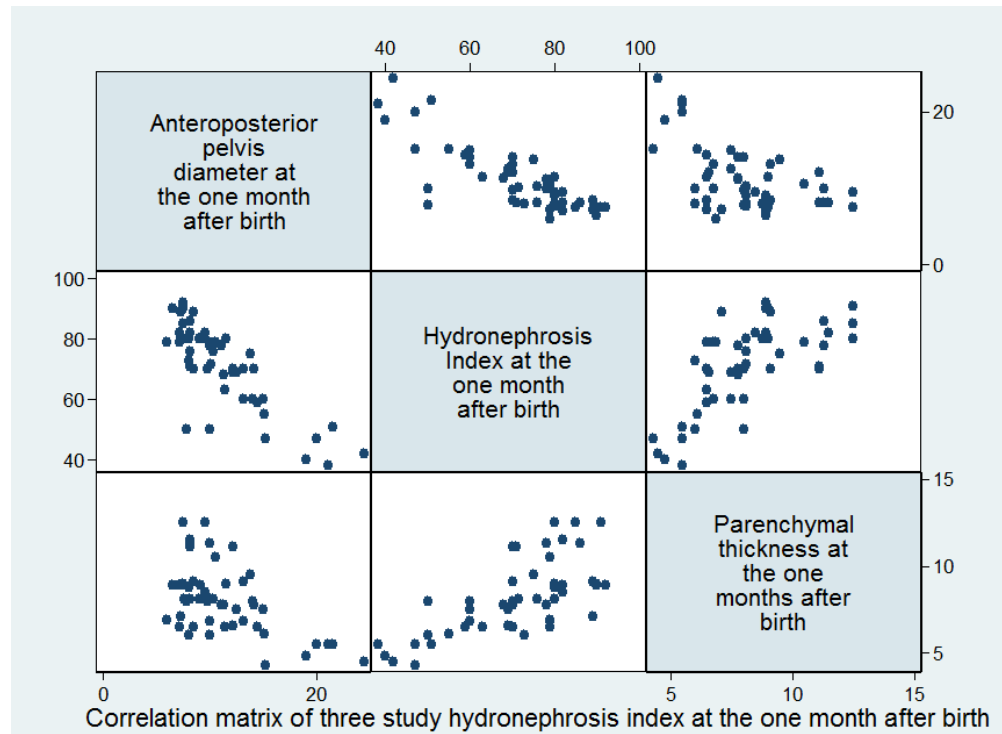
Figure 2. Correlational matrix among the three research variables one month after birth

to the study design, the participants were divided into three groups of A, B, and C. Group A consisted of people with decreased HI and high HN severity, group B was composed of individuals with relatively constant HI, and group C entailed the subjects with increased HI and low HN severity. All study measurements and analyses were performed on the three study groups.

Ethical considerations
The study protocol was reviewed and approved by the Ethics Committees of Hamadan University of Medical Sciences (Number: IR.UMSHA.REC.1397.239). There was no funding/ support for this study.

Statistical analysis
The data were analyzed in SPSS software (version 22.0), and all two tailed p-values less than 0.05 were considered statistically significant. The qualitative and quantitative variables were analyzed using the Chi-square and Student's t-test, respectively. In addition, the associations between the studied variables at the four follow-up stages were evaluated via the correlation matrix. The three groups were also compared at each of the follow-up stages by appropriate statistical tests. A p-value less than 0.05 was considered statistically significant.

Results
In the present study, a total of 52 subjects were analyzed in three groups. According to the study criteria, groups A, B, and C contained 25, 9, and 18 neonates, respectively.

Comparison of the mean fetal anteroposterior diameter of the pelvis, hydronephrosis index, and parenchymal thickness indices among the study groups
The results revealed no significant difference among the three study groups in terms of the mean fetal AP diameter of the pelvis, HI, and parenchymal thickness. Furthermore, fetal HI showed a negative correlation with the fetal AP diameter of the pelvis (ρ=-0.85; P<0.001) and a positive correlation with fetal parenchymal thickness (ρ=0.61; P<0.001). In addition, the fetal AP diameter of the pelvis was negatively correlated with fetal parenchymal thickness (ρ=-0.51; P<0.001; Figure 1).

Comparison of the mean anteroposterior diameter of the pelvis, hydronephrosis index, and parenchymal thickness indices one month after delivery
The results were indicative of a significant difference among the three groups regarding the mean AP diameter of the pelvis (P=0.04),
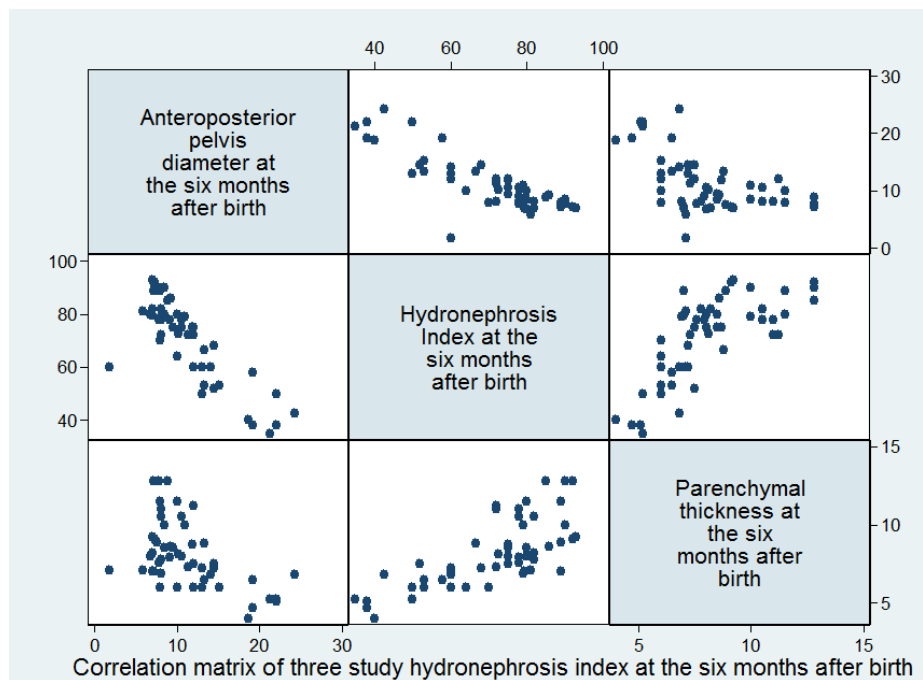
Figure 3. Correlational matrix among the three research variables six months after birth

HI (P<0.001), and parenchymal thickness (P=0.013) one month after delivery. The HI had a negative correlation with the AP diameter of the pelvis (ρ=-0.82; P<0.001) and a positive correlation with parenchymal thickness (ρ=0.68; P<0.001). Additionally, there was a negative association between the AP diameter of the pelvis and parenchymal thickness (ρ=-0.55; P<0.001; Figure 2).

Comparison of the mean anteroposterior diameter of the pelvis, hydronephrosis index, and parenchymal thickness indices six months after delivery

Six months after delivery, there was a significant difference among the three groups considering the mean AP diameter of the pelvis (P=0.02), HI (P<0.001), and parenchymal thickness (P=0.013). Based on the results, HI had a negative correlation with the AP diameter of the pelvis (ρ=-0.84; P<0.001) and a positive correlation with parenchymal thickness (ρ=0.72; P<0.001). In addition, the AP diameter of the pelvis was found to negatively correlate with parenchymal thickness (ρ=-0.53; P<0.001; Figure 3).

Comparison of the mean anteroposterior diameter of the pelvis, hydronephrosis index, and parenchymal thickness indices one year after delivery

The analysis of the data 12 months post-

delivery showed a significant difference among the three study groups in terms of the mean AP diameter of the pelvis, HI, and parenchymal thickness (P<0.001). The HI was negatively correlated with the AP diameter of the pelvis (ρ=-0.75; P<0.001) but positively correlated with parenchymal thickness (ρ=0.74; P<0.001). The results were also suggestive of a negative correlation between the AP diameter of the pelvis and parenchymal thickness (ρ=-0.66; P<0.001; Table 1, Figure 4).
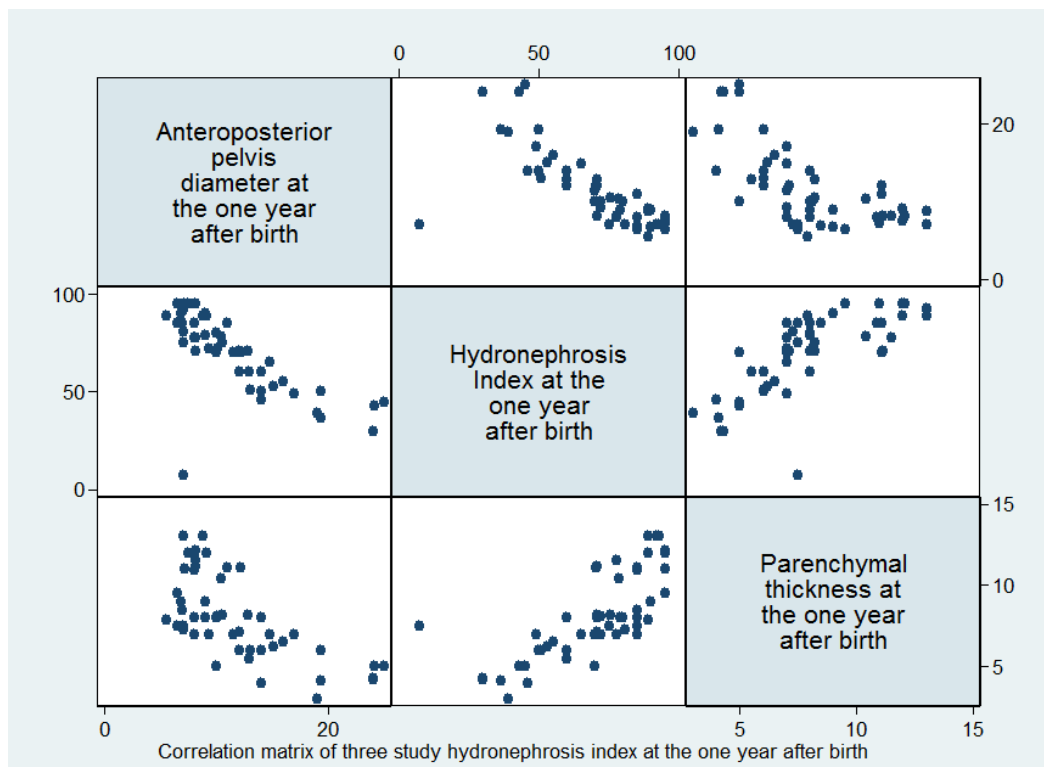
Discussion

According to the literature, the degree of the AP diameter of the pelvis based on gestational age determines the likelihood of postnatal abnormality (8). The present study involved the assessment of the capacity of HI as a more definite indicator to be used for the diagnosis and prognosis assessment of fetal hydronephrosis. In our study, HI was found to have a negative association with the AP diameter of the pelvis and a positive association with parenchymal thickness. Accordingly, it can be argued that HI is sufficiently correlated with parenchymal thickness in the diagnosis and prognosis assessment of fetal hydronephrosis. In the recent guidelines, ultrasonography has been suggested as a preferred device for the diagnosis and prognosis assessment of hydronephrosis at both prenatal and infancy stages (9).

Table 1. Comparison of the mean anteroposterior diameter of pelvis, hydronephrosis, and parenchymal thickness among study participants at four research stages

Measurement points	Study groups	AP diameter of pelvis	Hydronephrosis	Parenchymal thickness	P-value
Baseline	Decreased HI	11.43±3.86	70.52±15.79	7.72±1.31	0.34
	Constant HI	11.72±5.13	69.01±12.79	8.67±2.24	0.39
	Increased HI	9.92±2.45	75.50±9.90	8.44±2.19	0.29
After 1 month	Decreased HI	12.19±4.49	66.21±15.54	7.29±1.42	0.04
	Constant HI	11.87±5.22	69.17±12.76	8.79±2.45	0.004
	Increased HI	9.07±2.31	80.17±8.42	8.99±2.20	0.013
After 6 months	Decreased HI	12.57±5.35	62.78±15.30	6.82±1.33	0.018
	Constant HI	11.87±5.14	69.44±13.01	9.23±2.02	<0.001
	Increased HI	8.59±2.05	83.53±8.02	9.36±2.13	<0.001
After 12 months	Decreased HI	14.03±1.47	56.20±18.47	6.19±1.47	<0.001
	Constant HI	11.84±5.12	69.62±13.26	9.17±2.39	<0.001
	Increased HI	7.99±1.70	88.01±6.35	9.94±2.18	<0.001

HI: hydronephrosis index, AP: anteroposterior

Figure 4. Correlational matrix among the three research variables twelve months after birth

As indicated in the previous clinical experiences and related studies, urinary dilation is not equal to urinary tract obstruction in all situations (10). Accordingly, in the present study, we searched for a suitable device facilitating the longitudinal assessment of patients with hydronephrosis. In most of the previous studies, some markers, such as SFU grading or the AP diameter of the renal pelvis, have been suggested only for describing and monitoring hydronephrosis among patients (11). It seems that more than a diagnostic indicator or device, we need to find alternative or new devices

and indices for following up patients with hydronephrosis and monitoring their condition in different hydronephrosis stages.

The present study was aimed to present and discuss HI as an alternative index for monitoring hydronephrosis patients. It is known that external hydronephrosis is less harmful than internal hydronephrosis. Accordingly, more attention has been paid to the internal enlargement of the renal pelvis (12). In a study performed by Stephen et al., investigating HI using 60 fetuses with hydronephrosis, half of the patient showed a

decrease in hydronephrosis incidence, while 28% of them showed an increase in hydronephrosis occurrence. In the mentioned study, the objectivity of HI was reported as 99.8% (13). Accordingly, it can be concluded that HI is a more accurate and better method for monitoring hydronephrosis than the AP diameter of the renal pelvis.

The prevention of the renal parenchyma lesions and maintenance of the healthy state of the urinary tract system require the observation and control of hydronephrosis with different indices and observations. The importance of the accurate determination of renal damage and improvement of vesicoureteral reflux encouraged us to assess new indices. Regarding this, based on the results of the present quantitative study, HI can be introduced as a better method for hydronephrosis assessment (11). Not only is HI more easily calculated than other methods but also it is less dependent on the ultrasonography operator. In order to examine our hypothesis, in the first place, it was attempted to only show the correlation of HI with other currently approved methods for the assessment of HN prognosis and clinical changes.

New studies emphasize the value of three-dimensional (3D) ultrasound in the determination of HI. Juan J et al. confirmed the efficiency of 3D ultrasound in estimating the volumetric HI and introduced it as a safe, quick, inexpensive, and definite modality for the evaluation of the severity of hydronephrosis and its postnatal outcome (14). In another study carried out by Jamari Wang et al., novel 3D ultrasound was reported to have an effective role in the prognosis evaluation of fetal hydronephrosis (15). In the mentioned study, the measurement and determination of renal parenchymal volume/kidney volume had a high predictive value in the evaluation of hydronephrosis severity. They also emphasized that the combined indicators had higher accuracy in evaluating and predicting the medical treatment or surgery than the single indicator (15).

The present study entailed a number of limitations. Firstly, the HI cannot be completely proven as a better indicator for hydronephrosis prognosis than the current indices. This end requires the presentation of information regarding the final outcome of the study participants and implementation of regression analysis or receiver operating characteristic curve analysis for proving the accuracy of HI. Secondly, in the current study, there was no report of the significant clinical conditions occurring in the study participants. Moreover, we had no 3D

option in our ultrasound device. It seems that one of the important criteria for accepting a new prognostic method for any disorders is its capacity for the prediction of main clinical outcomes in the affected patients before their occurrence.

Conclusion

Antenatal hydronphrosis is one of the most common abnormalities detected via antenatal ultrasound. Based on the results of the present study, it can be concluded that HI is a more accurate and better method for monitoring hydronphrosis than the AP diameter of the pelvis.

Acknowledgments

Conflicts of interest
The authors have no conflicts of interest.

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