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Original article

Fetal Kidney Length as a Useful Adjunct Parameter for Better Determination of Gestational Age

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Abstract

Background: Fetal kidney length (FKL) is an accurate parameter in late pregnancy. Moreover, FKL was investigated between 24 and 38 weeks pregnant women and FKL has more accurate predictive value than the other fetal biometric parameters. **This study aimed to** measure the efficacy of fetal kidney length in the measurement of gestational age **Methods:** This cross sectional study was conducted on 120 pregnant women was recruited among cases. All patients were subjected demographic data collection, complete history taking, routine antenatal investigations, clinical examination and routine laboratory investigations: Complete blood count (CBC), liver function test, kidney function test, random blood sugar (RBS). **Results**: There were a statistically significant positive correlation between mean fetal kidney length and (GA LMP, BPD, BPD GA, HC, HC GA, AC, AC GA, FL and FL GA). There were statistically significant positive correlation between GA by LMP and BPD GA, HC GA, AC GA, FL GA , Predicted GA using Rt fetal kidney length, Predicted GA using Lt fetal kidney length and Predicted GA using mean length of both fetal kidneys. **Conclusion:** Kidneys are easy to identify and measure. Our study revealed that the mean fetal kidney length was a significant predictor for the gestational age estimation. FKL can be measured readily, and in combination with BPD, HC, AC and FL gives a better prediction of GA, especially in late second and early third trimester (beginning from 24th week – 34th weeks).

Keywords: Fetal Kidney Length, Gestational Age, Ultrasound, biparietal diameter

Introduction

Gestational age (GA) is a key piece of data used by healthcare providers to determine the timing of various screening tests and assessments of the fetus and mother throughout pregnancy (1). Errors in determining the exact GA may interfere with critical management decisions, such as in preterm labor as well as growth disorders that are considered the leading cause of neonatal morbidity and mortality (2). In the first trimester, the mean gestational sac diameter and crown-rump length (CRL) are reliable measurements for this purpose (3).

Ultrasound has emerged as the more accurate method of assessing fetal GA, especially in the first trimester. Both transvaginal and transabdominal probe assessments are used to obtain a more accurate measurement of GA. Transvaginal is more helpful in first trimester pregnancies. Multiple parameters have been described using ultrasound to aid in calculating GA (4).

In the second trimester, biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), femur length (FL), and trans-cerebellar diameter are feasible useful parameters. These parameters might be inaccurate in late pregnancy, especially when a pregnant woman cannot recall her LMP. Furthermore, there is substantial evidence that the standard derivation for these indices, are widen as pregnancy progresses, and this will be even worse if the head is too low or an obvious plane cannot be obtained, which together will mislead the measurement of BPD and HC (5).

Fetal kidney length (FKL) is an accurate parameter in late pregnancy. Moreover, FKL was investigated between 24 and 38 weeks pregnant women and FKL has more accurate predictive value than the other fetal biometric parameters such as BPD, FL, HC and AC (6).

Fetal kidney growth is constant, increases ≈1.7 mm fortnightly throughout pregnancy and unchanged by growth disorders, which makes using it more reliable than other parameters in complicated pregnancies. The length of the kidney remains largely unchanged in a small GA fetus (7).

The purpose of this study was to measure the efficacy of fetal kidney length in the measurement of gestational age.

Patients and methods

This cross sectional study was conducted on 120 pregnant women recruited among cases. The study was carried out in the Obstetrics and Gynecology Department of Benha University Hospital from February 2023 to February 2024.

An informed written consent was obtained from the patients. Every patient received an explanation of the purpose of the study and had a secret code number. The study was done after being approved by the Research Ethics Committee, Faculty of

Medicine, Benha University **(MS 25-3-2024**.)

Inclusion criteria was healthy pregnant women who are sure of their LMP and had prior regular menstrual cycles with uncomplicated pregnancy, All cases with singleton pregnancies in the third trimester (28 to 40 weeks), normal antenatal pregnant women with no associated risk factors, dating of pregnancy since early pregnancy (1^{st} trimester) was sharply known determined by both measuring of CRL and sure LMP which coincide with GA.

Exclusion criteria were women who delivered before 28 weeks of GA with an unknown or inaccurate date of their LMP, irregular menstrual cycles, oligohydramnios, polyhydramnios, diabetic mother, pregnancy induced hypertension, preeclampsia, fetal abnormalities, renal anomalies, intrauterine growth restriction (IUGR), indistinct adrenal or renal borders, abnormal uterine bleeding, use of combined oral contraceptive (COC) for three months prior to the study.

All patients were subjected to the following: Demographic data collection included (age, residence, occupational and education), complete history taking including: present history of date of LMP, past history of menstrual cycles regularity and risk factors of previous pregnancies, past History of other diseases like hypertension, diabetes mellitus liver or renal diseases, collagen diseases or any other condition that may affect fetal growth. **Routine antenatal investigations** like blood grouping and typing, a complete hemogram, serology for HIV, HbsAg, and VDRL; thyroid function test; Glucose tolerance test; urine albumin, urine sugar, and urine microscopy. **Clinical examination** was done including general and local examination: Measurement of weight, height and body mass index (BMI) and Assessment of vital signs (pulse and blood pressure), abdominal examination was done: (fundal level, lie and presentation of the fetus, auscultation of fetal heart rate (FHR), presence of scar of previous operations). **Routine laboratory investigations:** Complete blood count (CBC), liver function test, kidney function test, random blood sugar (RBS).

The expected date of delivery was calculated according to Naegle's formula: EDD = LMP + 7 days - 3 months + 1-year**.** Three measurements were taken per kidney to minimize intra-observer error, and the average value in millimeters was recorded in a worksheet, GA in weeks was determined from the patient's LMP using Naegele's rule, thus representing GA by LMP, while the estimated GA was determined from the Hadlock's chart of predicted fetal measurements at specific menstrual weeks for BPD, HC, FL, and AC, using well defined reference points. The calculated Gestational Age (CGA) in weeks, was derived as an average of the measured biometric indices (BPD, HC, FL, and AC), were similarly document in the worksheet. Gestational age was calculated from mean FKL (5). This value was then compared with actual GA derived from sure LMP calculated mean GA done by fetal biometry, each of them was subjected

to serial ultra-sonographic biometry and FKL measurements at 24, 28, 32, 36 and 38 weeks of gestation. Same radiologist performed all the measurements using a 2D real-time mode with GE Logic 200 Pro 2.5 to 5 MHz convex probes.

Biometric measurements were obtained using well defined reference points and FKL measurements obtained the fetus was scanned in the transverse plane until the kidneys were visualized just below the stomach. The probe was then rotated through 90 degree to outline the longitudinal axis of the kidneys. Markers were placed on the image of the renal capsule, taking care to exclude the adrenal gland, lower pole of the kidney was clearly distinguished from the gastrointestinal tract. All measurements were obtained during fetal apnea, the right fetal kidney length was measured as the maximal longitudinal renal axis; the two calipers were positioned in relation to the upper and lower poles of the kidney. A regression equation was generated as follows: The predicted (GA) = α (constant) + βX ± the Standard Error (SE) of estimate in weeks, where X represented the measurement and β was the regression coefficient (8).

The evaluation of the AFI was done with the modified four-quadrant technique. The uterine cavity was divided into four quadrants. The vertical diameter of the largest pocket in each quadrant was measured. The AFI was the sum of those four quadrants. An AFI chart was obtained expressing the average volume of the amniotic fluid in millimeters based on the gestational age in weeks. **Figure 1**

Sample size calculation:

The sample size calculation was performed using G. power 3.1.9.2 (Universität Kiel, Germany). The sample size was calculated according to the strong positive correlation between GA and FKL (r=0.947, p=0.001), compared to the moderate negative correlation between GA and AFI (r=-0.499, p=0.001), according to a previous study (5). Based on the following considerations: 0.05 α error and 90% power of the study. Six cases were added to overcome dropout. Therefore, 120 patients were allocated.

Statistical analysis:

Statistical analysis was done by SPSS v26 (IBM Inc., Chicago, IL, USA). Shapiro-Wilks test and histograms were used to evaluate the normality of the distribution of data. Quantitative parametric data were presented as mean and standard deviation (SD). Quantitative non-parametric data were presented as median and interquartile range (IQR). Qualitative variables were presented as frequency and percentage (%), Pearson correlation was done to estimate the degree of correlation between two quantitative variables, logistic regression is also used to estimate the relationship between a dependent variable and one or more independent variables.

Results

The mean age ±sd, of studied females was 23.2±4.1 years, weight (73.7±10.3) kg, height (167.5±6.12) cm and BMI (29.1±2.81) (kg/m^2).

The percentage of Gravidity 1-3 (80%), >3 (20%), Parity 1-2 (83.3%), 3-4 (16.7%), Abortion 1-2 (82.6%), > 2 (17.4%). The mean of Gestational age (36.5±2.6) (w). **Table 1**

The mean of BPD (mm) was (87.7±8.9), HC (mm) (322.8±18.1), AC (mm) (316±29.4) and FL (mm) (71.1±8.9), Length of RT kidney was (38.06±3.27), Length of LT kidney was (37.5±3.42), and Mean length of both kidneys (mm) was (37.7±3.09). The mean of BPD GA (w) was (36.0±2.72), HC GA (w) was (35.8±2.70), AC GA (w) was (36.5±2.9) and FL GA (w) was (35.5±2.73). The mean of LMP GA was (35.8±2.71), BPD GA was (36.5 ± 2.92), HC GA was (35.8 ± 2.70), AC GA was (36.5±2.9), FL GA was (35.5 ± 2.73), and there was significant difference between calculated BPD, HC and AC GA from LMP GA. **Table 2**

The Mean of LMP GA was (35.8 ± 2.71), Predicted GA using RT fetal kidney length (mm) was (35.47±1.11), Predicted GA using Lt fetal kidney length (mm) was (35.45±1.41), and Predicted GA using mean length of both fetal kidneys (mm) was (35.47±1.17). **Table 3**

There were a statistically significant positive correlation between mean fetal kidney length and (GA LMP, BPD, BPD GA, HC, HC GA, AC, AC GA, FL and FL GA). There were statistically significant positive correlation between GA by LMP (w) and BPD GA, HC GA, AC GA, FL GA , Predicted GA using Rt fetal kidney length (mm), Predicted GA using Lt fetal kidney length (mm) and Predicted GA using mean length of both fetal kidneys (mm). **Table 4**

The simple linear regression analysis showed that the mean fetal kidney length was a significant predictor for the gestational age. The mean kidney length of 18.2 mm can predict the GA of 29 w, the mean kidney length of 20.8 mm can predict the GA of 30 w, the mean kidney length of 23.4 mm can predict the GA of 31 w, the mean kidney length of 26.1 mm can predict the GA of 32 w, the mean kidney length of 28.7 can predict the GA of 33 w, the mean kidney length of 31.3 mm can predict the GA of 34 w, the mean kidney length of 33.9mm can predict the GA of 35 w, the mean kidney length of 36.6 mm can predict the GA of 36 w, the mean kidney length of 39.2 mm can predict the GA of 37 w, the mean kidney length of 41.8 mm can predict the GA of 38 w, the mean kidney length of 44.5 mm can predict the GA of 39 w, the mean kidney length of 47.1 mm can predict the GA of 40 w, the mean kidney length of 49.7 mm can predict the GA of 41 w. **Table 5**

Table 1: Basic characteristics, obstetric and gynecological and Gestational age by LMP

Variable (n=120)		**Mean ±SD**	**Range**
Age (years)		23.2 ± 4.07	16-35
Weight (kg)		73.7 ± 10.3	53-105
Height (cm)		167.5 ± 6.12	150-175
BMI (kg/m^2)		29.1 ± 2.81	24 - 35
Variable		No.	%
Gravidity (n=120)	**1-2**	91	75.8
	≥3	29	24.2
	Median (Range)	2.0 (1-5)	
Parity (n=100)	**1-2**	83	83.0
	3-4	17	17.0
	Median (Range)	1.0 (1-4)	
Abortion (n=20)	**1**	16	80.0
	≥ 2	4	20.0
	Median (Range)	1.0 (1-3)	
Gestational age (w) (n=120)	**Mean ±SD**	35.8 ± 2.71	
	Median (Range)	37.0 (29w-41w)	

BMI: body mass index

Table 2: Fetal biometric parameters, calculated gestational ages among the studied

Variable (n=120)	Mean ±SD	Median	Range	Multiple comparisons by Bonferroni adjusted Wilcoxon (p value)
BPD (mm)	83.9 ± 11.5	75.2	44.7 - 98.6	----
HC (mm)	320.6 ± 19.3	327.6	265 - 359.9	----
AC (mm)	306.4 ± 36.3	314.5	233.5 - 364.4	----
FL (mm)	68.97 ± 14.4	75	36 - 99.5	----
Length of RT kidney (mm)	40.6 ± 3.27	37.8	30.6 - 49.7	----
Length of LT kidney (mm)	39.5 ± 3.42	37.9	30-50.5	----
Mean length of both kidneys (mm)	42.1 ± 6.09	38.5	30 - 51.2	----
BPD GA (w)	36.0±2.72	36.4	28w, 4d-40 w, 3d	----
HC GA (w)	35.8±2.70	35.3	28w – 39 w, 4d	----
AC GA (w)	36.5±2.9	36.2	28w – 39w, 6d	----
FL GA (w)	35.5±2.73	37.1	29w – 40w, 3d	----
LMP GA (w)	35.8 ± 2.71	37.0	29 w-41w	Reference
BPD GA (w)	36.5 ± 2.92	36.4	28w-40 w, 3d	4.5 (<0.001)
HC GA (w)	35.8 ± 2.70	35.3	28w – 40 w, 5d	6.27 (<0.001)
AC GA (w)	36.5 ± 2.9	36.2	28w – 39w, 6d	6.91 (<0.001)
FL GA (w)	35.5 ± 2.73	37.1	29w – 40w, 3d	0.72 (0.47)
Friedman test (p value)	134.1 (<0.001, HS)			

Table 3: Comparing the predicted gestational ages from fetal kidney measurements with LMP gestational age

Variable (n=100)	Mean ±SD	Median	Range	Multiple comparisons by Bonferroni adjusted Wilcoxon (p value)
LMP GA (w)	35.8 ± 2.71	37.0	29 w-41w	Reference
Predicted GA using Rt fetal kidney length (mm)	35.47±1.11	36.5	32 w- 40w, 6d	0.60 (0.54)
Predicted GA using Lt fetal kidney length (mm)	35.45 ±1.41	36.8	33w – 40w,3d	0.67 (0.5)
Predicted GA using mean length of both fetal kidneys (mm)	35.47 ±1.17	36.5	33w, 6d – 40w, 5d	0.66 (0.50)
Friedman test	5.61 (0.13, NS)			
(p value)				

Table 4: Correlation between mean fetal kidney length and the studied biometric variables and between LMP GA and the calculated and predicted GA

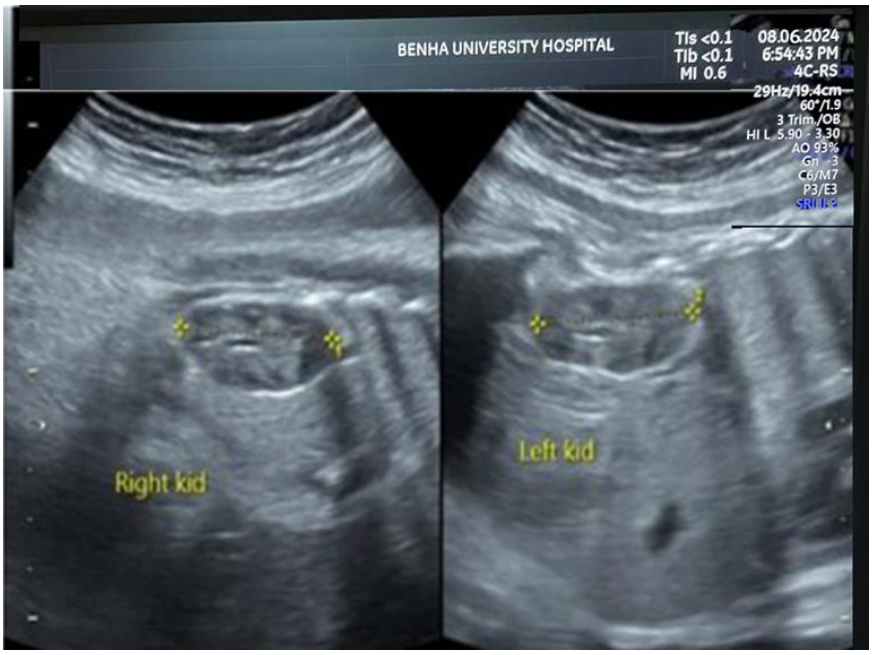
	Mean fetal kidney length (mm)	
	Rho	**P**
GA LMP (w)	0.597	**<0.001 (HS)**
BPD (mm)	0.354	**0.028 (S)**
BPD GA (w)	0.425	**0.001 (HS)**
HC (mm)	0.554	**<0.001 (HS)**
HC GA (W)	0.330	**0.001 (HS)**
AC (mm)	0.296	**0.003 (S)**
AC GA (W)	0.338	**0.001 (HS)**
FL (mm)	0.729	**<0.001 (HS)**
FL GA (W)	0.663	**<0.001 (HS)**
	GA by LMP (w)	
	Rho	**P**

BPD GA (w)	0.893	<0.001 (HS)
HC GA (w)	0.902	<0.001 (HS)
AC GA (w)	0.900	<0.001 (HS)
FL GA (w)	0.914	<0.001 (HS)
Predicted GA using Rt fetal kidney length (mm)	0.310	0.002 (S)
Predicted GA using Lt fetal kidney length (mm)	0.341	0.001 (HS)
Predicted GA using mean length of both fetal kidneys (mm)	0.397	<0.001 (HS)

Table 5: Simple linear regression analysis and equation to predict Gestational age from mean fetal kidney length and predicted GA from the known FKL

	R^2		Adjusted R^2	SEE	F	P-value
Model summary	**0.084**		**0.277**	**4.15**	**56.2**	**0.001 (HS)**
Variable	**Unstandardized Coefficients**		**Standardized Coefficients**	**95% CI of B**	**T**	**P**
	B	**Std. Error**	**Beta**			
(Constant, b_0)	20.7	1.83	---	15.5-25.9	9.38	<0.001 (HS)
Mean length of both fetal kidneys	0.45	0.118	0.442	0.33-0.64	5.77	<0.001 (HS)
Equation:	**$Y=b_0+Xb$**					
	GA= 20.7 + 0.45 x Mean kidney length (mm)					
Mean kidney length (mm)	**Predicted GA (w)**					
18.2	29					
20.8	30					
23.4	31					
26.1	32					
28.7	33					
31.3	34					
33.9	35					
36.6	36					
39.2	37					
41.8	38					
44.5	39					
47.1	40					
49.7	41					

(A)



(B)

Figure 1: (A) Ultrasound of Rt kidney 3.56mm.Lt kidney 3.81mm. (B) ultrasound of Rt kidney 3.56mm.Lt kidney 3.64mm

Discussion

Mean fetal kidney length (MFKL) can be used as an accurate new parameter for estimation of gestational age in combination with biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC) & femur length (FL) especially in late second and early third trimester (beginning from 24th week – 34th week). Using regression equation: Gestational age by date (weeks) = 1.56+ 0.97 (MKL in mm) (9).

In the current study, the mean age ± sd, of studied females was 23.2±4.1 years, weight (73.7±10.3) kg, height (167.5±6.12) cm and BMI (29.1±2.81) (kg/m2).

In line with us, a prospective observational study including 500 women was conducted to measure the length of fetal kidney in normal singleton pregnancies in late second and early third trimesters, its correlation with GA derived from the first day of patient known LMP and comparison with GA derived from other conventional biometric methods. They reported that the mean age of those women was 26.31 ± 4.87 years, while mean body mass index was 19.84 ± 1.20 kg/m^2 (9).

In the current study, the percentage of Gravidity 1-3 (80%), >3 (20%), Parity 1-2 (83.3%), 3-4 (16.7%), Abortion 1-2 (82.6%), > 2 (17.4%). The median parity was 1 and abortion was 1 with range of both was (1-4) and (1-3) respectively.

The mean of Gestational age was (36.5±2.6) (w) and the median (range) was 37.0 (29w-41w).

In addition, it was found that nearly 34% of all patients were nulliparous, while 44% were the mothers of one child. All the patients were more or less evenly distributed among different GA. Of 152 patients, 66 were between 28 and 32 weeks, 55 belonged to 33 to 36 weeks, and rest 34 were between 37 and 40 weeks (10).

In the current study, the mean of BPD (mm) was (87.7±8.9), HC (mm) (322.8±18.1), AC (mm) (316±29.4) and FL (mm) (71.1±8.9), length of RT kidney was (38.06±3.27), length of LT kidney was (37.5±3.42), and mean length of both kidneys (mm) was (37.7±3.09).

In line with us, previous studied found that the mean left FKL was slightly but significantly longer than mean right FKL at each gestational period observed (11-14).

In disagreement with us, it was found that the average fetal kidney length was 29.88 ± 3.33 mm. (9)

We showed that, the mean of BPD GA (w) was (36.0±2.72), HC GA (w) was (35.8±2.70), AC GA (w) was (36.5±2.9) and FL GA (w) was (35.5±2.73). The mean of LMP GA was (35.8±2.71), BPD GA was (36.5 ± 2.92), HC GA was (35.8 ± 2.70), and there was significant

difference between calculated BPD, HC and AC GA from LMP GA.

In line with us, (5) found that the mean fetal biometry parameters including BPD of the study population was 31.97±4.35 weeks, FL was 31.76± 4.36 weeks, HC was 31.98 ± 4.32 weeks, and AC was 31.62±4.75 weeks. The mean FKL measurement of patients was 35.66±6.61 mm (range 19-49 mm).

In the current study, there were statistically significant positive correlation between mean fetal kidney length and (GA LMP, BPD, BPD GA, HC, HC GA, AC, AC GA, FL and FL GA).

In the current study, the mean of LMP GA was (35.8 ± 2.71), predicted GA using RT fetal kidney length (mm) was (35.47±1.11), predicted GA using Lt fetal kidney length (mm) was (35.45±1.41), and predicted GA using mean length of both fetal kidneys (mm) was (35.47±1.17).

Also, it was revealed that the positive correlation coefficient between EGA and FKL was significant, just like those of the standard routine biometry parameters (15).

In the current study, there were statistically significant positive correlation between GA by LMP (w) and BPD GA, HC GA, AC GA, FL GA, predicted GA using Rt fetal kidney length (mm), predicted GA using Lt fetal kidney length (mm) and predicted GA using mean length of both fetal kidneys (mm).

In parallel with us, it was reported that there was a very strong positive correlation between GA and BPD (r=0.975, p=0.001), HC (r=0.974, p=0.001), FL (r=0.967, p=0.001), and AC (r=0.852, p=0.001) (5).

In the present study, the simple linear regression analysis showed that the MFKL was a significant predictor for the gestational age. The mean kidney length of 18.2 mm can predict the GA of 29 w, the mean kidney length of 20.8 mm can predict the GA of 30 w, the mean kidney length of 23.4 mm can predict the GA of 31 w, the mean kidney length of 26.1 mm can predict the GA of 32 w, the mean kidney length of 28.7 can predict the GA of 33 w, the mean kidney length of 31.3 mm can predict the GA of 34 w, the mean kidney length of 33.9 mm can predict the GA of 35 w, the mean kidney length of 36.6 mm can predict the GA of 36 w, the mean kidney length of 39.2 mm can predict the GA of 37 w, the mean kidney length of 41.8 mm can predict the GA of 38 w, the mean kidney length of 44.5 mm can predict the GA of 39 w, the mean kidney length of 47.1 mm can predict the GA of 40 w, the mean kidney length of 49.7 mm can predict the GA of 41 w.

Also, **Gayam et al. (2018)** conducted a cross-sectional, observational studs to ascertain the precision of the ultrasonographic fetal kidney length measurement as a reliable parameter for

determination of GA in third trimester and included 171 pregnant women. They found that FKL (r = 0.991, P = 0.000) was closer to LMP derived gestational age than other fetal growth parameters (16).

Conclusion

Kidneys are easy to identify and measure. Our study revealed that the mean fetal kidney length was a significant predictor for the gestational age estimation. FKL can be measured readily, and in combination with BPD, HC, AC and FL gives a better prediction of GA, especially in late second and early third trimester (beginning from 24th week – 34^{th} weeks).

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