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Standardization of Reference Values for Fetal Gastric Size in Normal Gestation

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ABSTRACT

Background: On ultrasound, the stomach may be seen in the fetal abdomen's left upper quadrant as an echolucent organ. At around 14 weeks of gestation, the larger and lesser curvatures, the fundus, the body, and the pylorus can all be seen as part of the stomach's distinctive structure. Numerous malformations and a poor fetal outcome can be linked to a fetal stomach that is non-visualized, dilated, or even tiny.

Objectives: The aim of the current study was to establish standardized reference values for fetal stomach size throughout normal pregnancy as demonstrated during routine antenatal ultrasonography.

Patients and methods: This was a longitudinal multicentric study of 260 normal singleton Pregnancies, sonographic evaluation was carried out between the 14th and 40th weeks of gestation. The pregnant women entered the study during the period from January 2020 to October 2022 and were evaluated in the unit of ultrasonography of Menoufia University Hospitals.

Results: Fetal gastric area was found more significant correlated with gastric circumference (r=0.991, P-value <0.001) and gastric volume (r=0.988, P-value <0.001), however fetal gastric area was found less significant correlated with gestational age (r=0.962, P-value <0.001) and gastric longitudinal diameter (r=0.968, P-value <0.001). Fetal gastric area was more significant correlated with abdominal volume (r=0.928, P-value <0.001) and abdominal area (r=0.914, P-value <0.001), however fetal gastric area was less significant correlated with Abdominal longitudinal (r=0.863, P-value <0.001) and abdominal anterior posterior diameter (r=0.866, P-value <0.001).

Conclusions: In a healthy pregnancy, fetal stomach dimensions are correlated with gestational age, and a nomogram of fetal gastric development may be helpful in determining if the fetus is developing normally and whether any digestive system abnormalities exist.

Keywords: Fetal abdomen, Fetal gastric size, Fetal stomach\abdomen ratio, Gastric area, Normal gestation.

INTRODUCTION

On ultrasound, the stomach may be seen in the fetal abdomen's left upper quadrant as an echolucent organ. After 10 weeks of gestation, measurements of the stomach region and sonographic vision of the fetal stomach are both feasible. At around 14 weeks of gestation, the fundus, body, and pylorus, as well as the larger and lesser curvatures, may be seen as the stomach's unique anatomy [(1)].

For the determination and measurement of gastric longitudinal dimensions, the ultrasonic plane that supplied the biggest stomach area, including the pylorus, on a transverse and oblique slice, was utilized. Transverse and anterior-posterior dimensions were measured using the transverse slice at the gastric corpus's center. Also measured were the circumferences of the abdomen. Abdominal circumference and stomach size are significantly correlated [(2)].

Numerous malformations and a poor fetal outcome can be linked to a fetal stomach that is non-visualized, dilated, or even tiny. In order to determine the normal limits of fetal stomach growth, efforts were made to measure the stomach circumference (SC)/abdominal circumference (AC) ratio.

Despite being an organ that is always evolving, the fetal stomach can be estimated by using the SC/AC ratio as a possible measure [(3)].

Fetal gastric volume measures, obtained using sonography, seem to be helpful in evaluating digestive system abnormalities [(4)].

An appropriate selection of transabdominal ultrasound pictures is necessary for fetal AC measurement. The stomach bubble (SB) and the portal segment from the umbilical vein (UV), which has the recognizable "hockey-stick" look, must be present in the typical AC plane [(5)].

The interplay of at least four processes—swallowing, stomach secretion, stomach absorption, and stomach emptying—determines the size of the fetal stomach. Because stomach filling and emptying are dynamic processes, regular pregnancies can result in changes in gastric size over time [(6)].

The aim of the current study was to establish standardized reference values for fetal stomach size throughout normal pregnancy as demonstrated during routine antenatal ultrasonography.

PATIENTS AND METHODS

This was a longitudinal multicentric study of 260 normal singleton Pregnancies, sonographic evaluation was carried out between the 14th and 40th weeks of gestation.

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The pregnant women were enrolled in the study during the period from January 2020 to October 2022 and were evaluated in the unit of ultrasonography of Menoufia University Hospitals (Radiology Department), the unit of ultrasonography of Birket El-sab General Hospital (Radiology Department), the unit of ultrasonography Shebin ElKom Educational Hospital (Radiology Department) and in a Private radiology center, using different types of ultrasound machines e.g., LOGIQ E10, LOGIQ P7 and Siemens Acuson X300.

Inclusion criteria:

Singleton pregnancies, precise gestational ages based on the last menstrual date modified with ultrasound data, gestational ages between 14 and 40 weeks, and normal amniotic fluid volumes are all signs of low risk pregnancy.

Exclusion criteria:

Any fetal abnormality especially esophageal atresia and duodenal atresia, multiple pregnancies, pregnant women who have medical or emergency obstetric complications e.g., preeclampsia, hydrops fetalis and abnormal vaginal bleeding and Oligohydramnios (amniotic fluid index <5).

Methods of examination:

- **Clinical examination of pregnant women:** Taking history of last menstrual period to detect gestational age of the pregnancy. Clinical history if the patient has any medical problem.
- **Obstetric ultrasound examination:** By using 2D ultrasound (convex transducer 2.5-3.5 MHz) doing standard obstetric ultrasound.

Technique of Trans-abdominal obstetric ultrasonography:

- Essential patient's information was entered into the ultrasound system including patient's name and date of last menstrual period.
- Patient preparation: the patient lied comfortably in a recumbent position with hips and knees extended and the upper trunk slightly inclined upward.

In order to prevent overextending the operator's arm and get precise measurements, it was crucial to position the patient near to the side of the table where the ultrasound equipment is mounted. The probe was applied to the patient's abdomen and moved in the coronal and sagittal planes in relation to the structures to be studied after the patient was instructed to sufficiently expose the belly.

Fetal biometric measures: Gestational age was confirmed by first trimester crown-rump length measurement or assessment of head biometry (BPD and HC), abdominal circumference (AC) and femur length (FL) at second and third trimester. Then scanning of fetal stomach and fetal abdomen and measuring of fetal stomach and fetal abdomen transverse, longitudinal and anterior posterior dimensions, circumference, area, and volume **(Figure 1)**.

Thereafter, the fetal stomach/the fetal abdominal measurements ratios including fetal gastric transverse diameter/fetal abdominal transverse diameter, fetal gastric longitudinal diameter/fetal abdominal longitudinal diameter, fetal gastric anterior posterior diameter/fetal abdominal anterior posterior diameter, fetal gastric circumference/fetal abdominal circumference, fetal gastric area/fetal abdominal area and fetal gastric volume/fetal abdominal volume were measured.

Ethical Consideration:

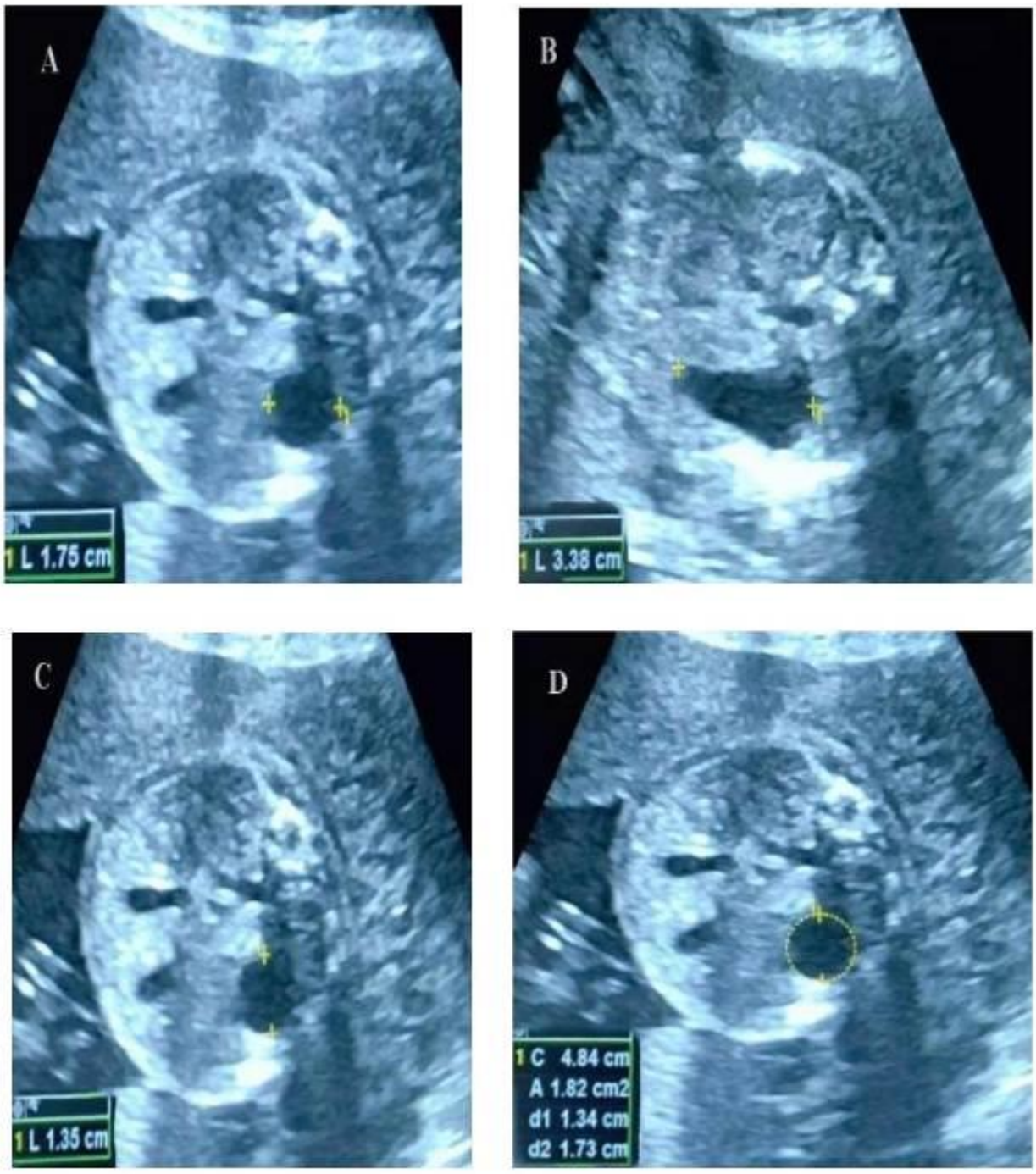
This study was ethically approved by the Institutional Review Board of the Faculty of Medicine, Menoufia University (IRB approval number: 191119 RAD23). The selection of patients for the research was made based on predetermined standards. All patients were made aware of the examination and verbally consented to have it done. This study was executed according to the code of ethics of the World Medical Association (Declaration of Helsinki) for studies on humans.

Statistical Analysis

The collected data were introduced and statistically analyzed by utilizing the Statistical Package for Social Sciences (Armonk, New York: IBM Corp., IBM SPSS Statistics) version 20 for windows. Tables and graphs were used to display the results.

The frequencies of qualitative characteristics were described as a trimester distribution. Mean and standard deviation (SD) were used to characterize continuous data such as gestational age, fetal gastric sizes, etc. Pearson's correlation coefficient was employed to assess the degree and direction of relationship between two qualitative variables.

The method of polynomial regression is one of many available for curve fitting. In polynomial regression, a polynomial function is used to estimate the data. A polynomial is a function that takes the form $f(x) = c0 + c1\ x + c2\ x2 \cdots cn\ xn$ where n is the degree of the polynomial and c is a set of coefficients. P value ≤ 0.05 was considered to be statistically significant.


A
1 L 1.75 cm
B
1 L 3.38 cm
C
1 L 1.35 cm
D
1 C 4.84 cm
A 1.82 cm2
d1 1.34 cm
d2 1.73 cm

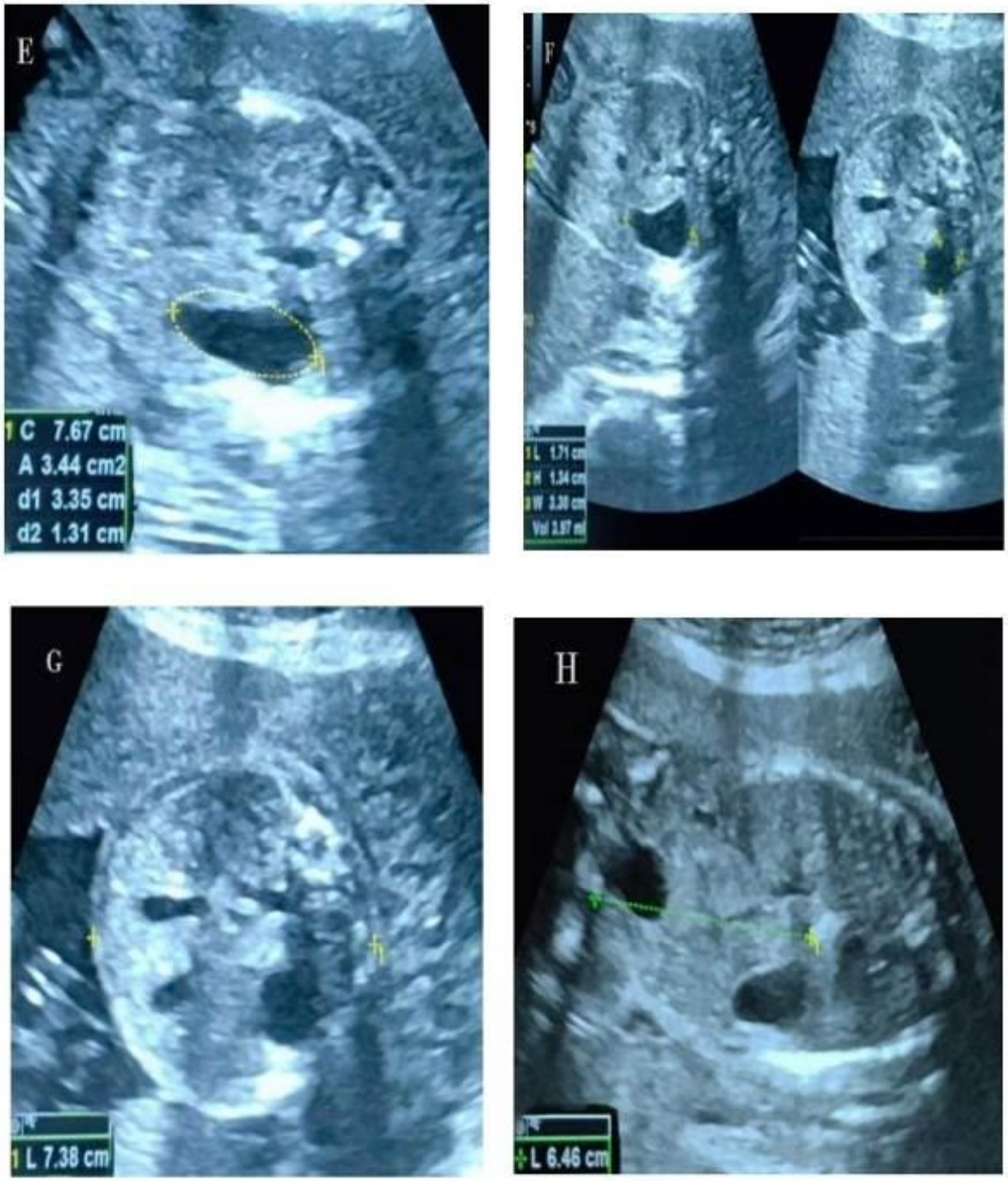

E
C 7.67 cm
A 3.44 cm2
d1 3.35 cm
d2 1.31 cm
F
G
L 7.38 cm
H
L 6.46 cm

Figure (1): (A) gastric transverse diameter, (B) gastric longitudinal diameter, (C) gastric anterior-posterior diameter, (D) gastric circumference, (E) gastric area, (F) gastric volume, (G) abdominal transverse diameter, (H) abdominal longitudinal diameter, (I) abdominal anterior-posterior diameter, (J) abdominal circumference and area, (K) abdominal volume.

RESULTS

A total of 260 singleton pregnant women were recruited into this study and we obtained observations of the different gastric and abdominal diameters at the period from 14 to 40 weeks of pregnancy, 42.7% of the studied women were in their 2nd trimister and 57.3 of the in their 3nd trimister **(Figure 2)**. The gestational age renged between 14 weeks to 40 weeks with mean gestational age 28.2 weeks and standard deviation 7.513.

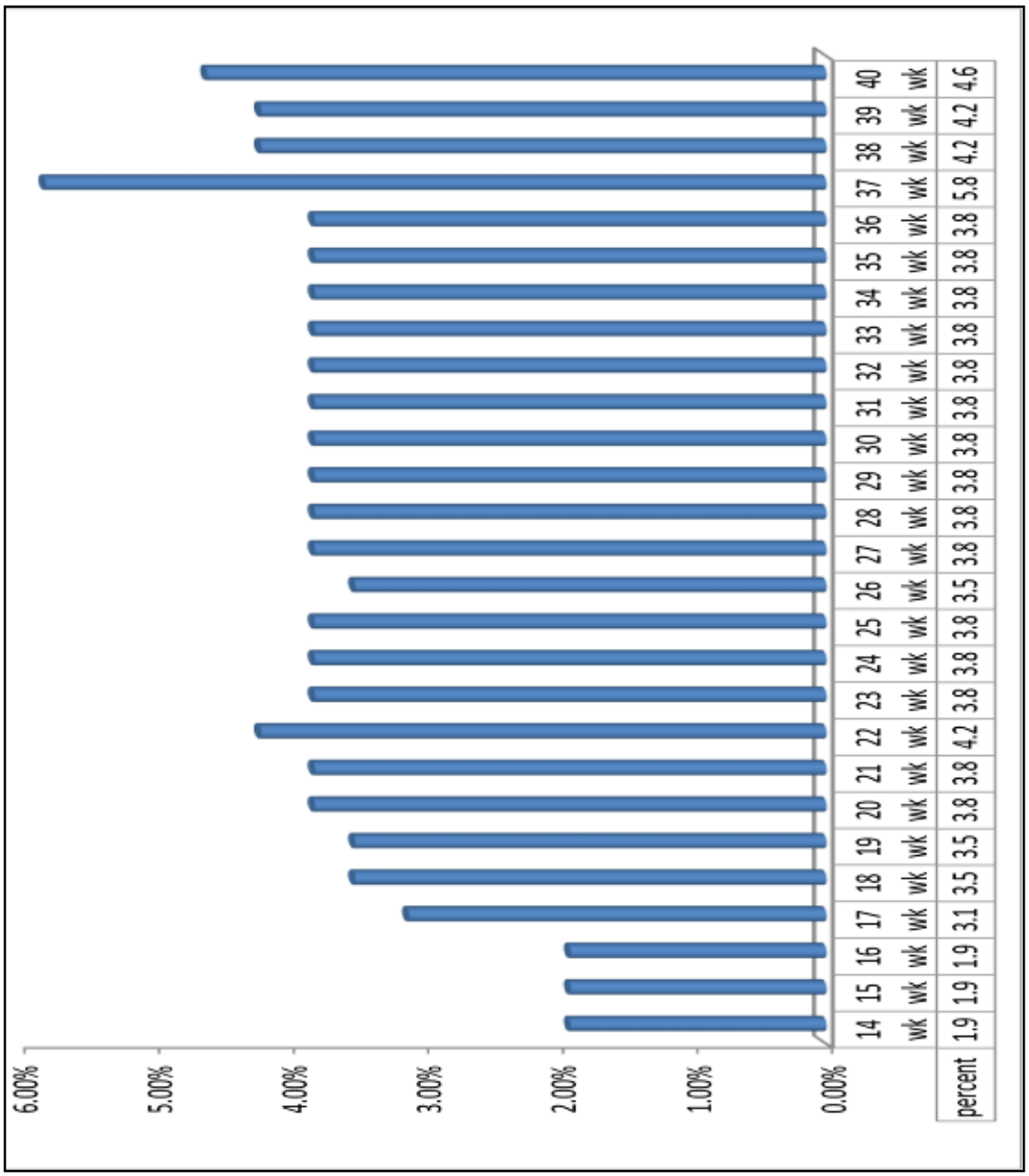
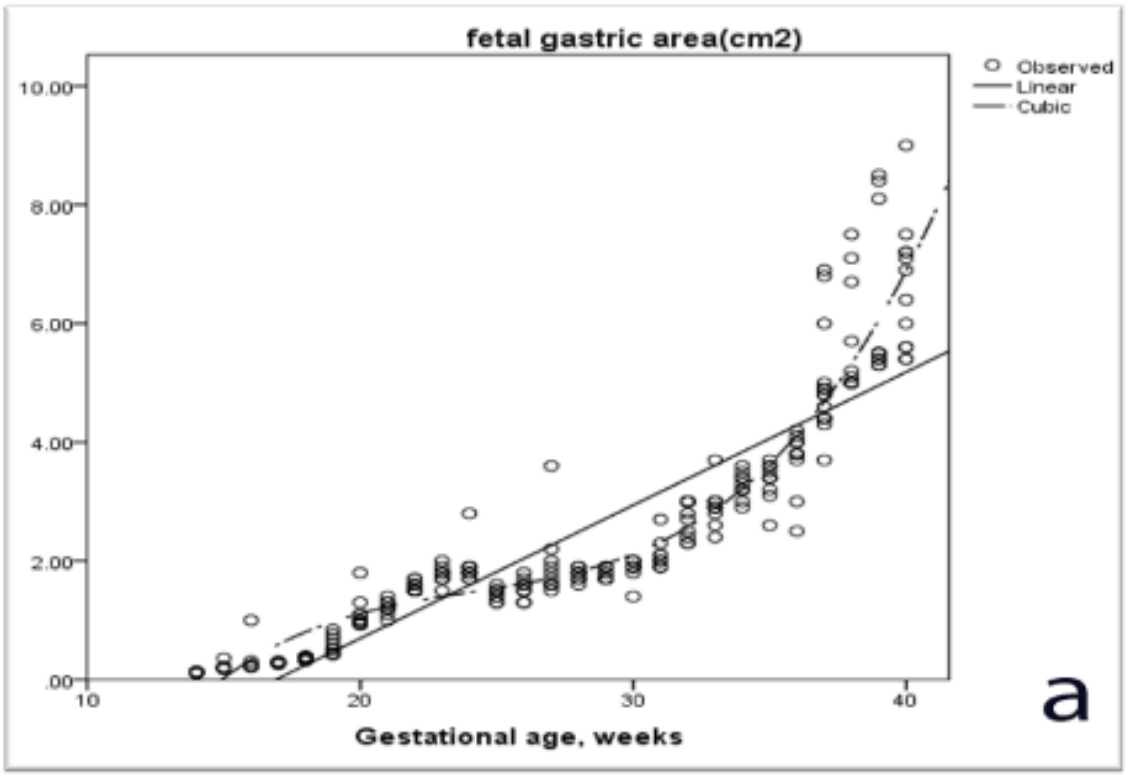


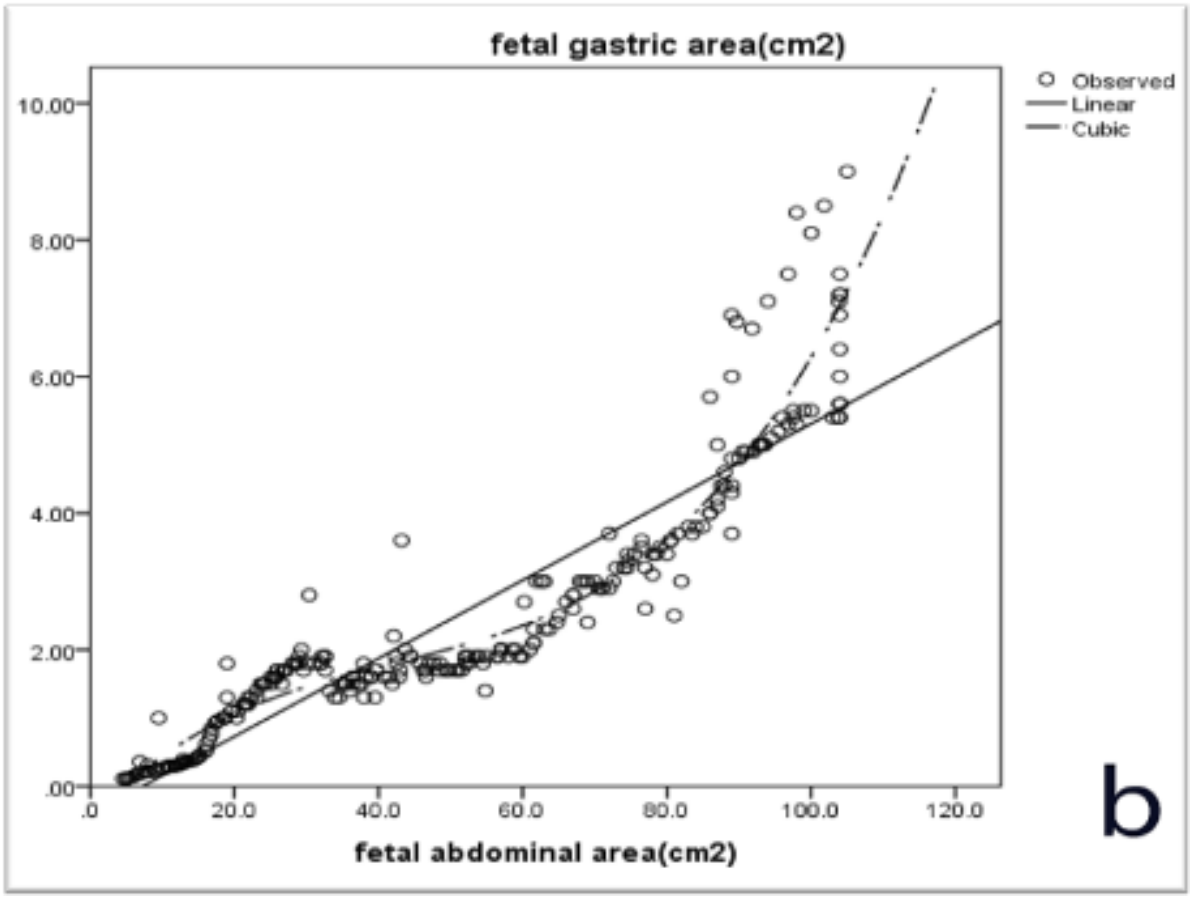
Figure (2): histogram showing the distribution of gestational age of the studied pregnant women.

Fetal gastric area was found more significant correlated with gastric circumference (r=0.991, P value <0.001) and gastric volume (r=0.988, P value <0.001), however fetal gastric area was found less significant correlated with gestational age (r=0.962, P value <0.001) and gastric longitudinal diameter (r=0.968, P value <0.001). The best regression model correlated fetal gastric area (cm^2) with gestational age (weeks), fetal gastric area (cm^2) with abdominal area (cm^2) and fetal gastric circumference (mm) with gestational age (weeks) were expressed by a cubic polynomial regression formula **(Table 1 and Figure 3)**.

Table (1): Cubic polynomial regression formula of relationship of gastric area (cm^2) with gestational age in weeks, gastric area (cm^2) with abdominal area (cm^2) and gastric circumference (mm) with gestational age in the studied population.

Regression equations	
Gastric area (cm^2)	$-9.321 + 1.016\ GA - 0.041GA^2 + 0.001\ GA^3$
ANOVA test; 869.6	p value; <0.001, R^2 0.911, GA; gestational age
Gastric area (cm^2)	$-0.485 + 0.110AA - 0.002AA^2 + 1.56\ AA^3$
ANOVA test; 933.29	p value; <0.001, R^2 0.961, AA; abdominal area (cm^2)
Gastric area (cm^2)	$-209.845 + 26.51SC - 0.948SC^2 + 0.012\ SC^3$
ANOVA test; 966.711	P value; <0.001, R^2 0.919, SC; stomach circumference (mm)


fetal gastric area(cm2)
Observed
Linear
Cubic
10.00
8.00
6.00
4.00
2.00
.00
10
20
30
40
Gestational age, weeks
a


fetal gastric area(cm2)
Observed
Linear
Cubic
10.00
8.00
6.00
4.00
2.00
.00
.0
20.0
40.0
60.0
80.0
100.0
120.0
fetal abdominal area(cm2)
b

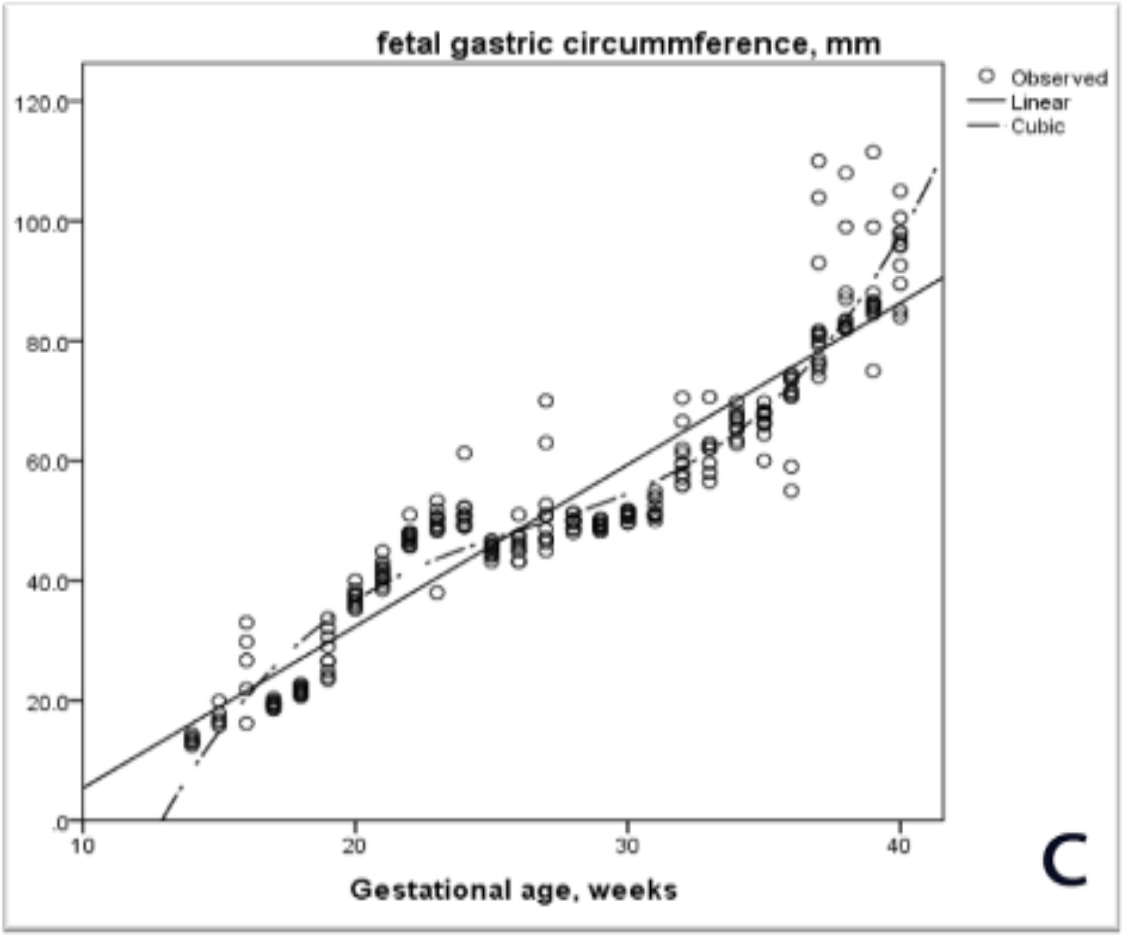


Figure (3): Correlation between gastric area and gestational age (a), gastric area and abdominal area (b), gastric circumference and gestational age (c) in the studied population. Correlations were R^2 0.911(P value <0.001), R^2 0.961 (P value <0.001), R^2 0.919 (P value <0.001), respectively.

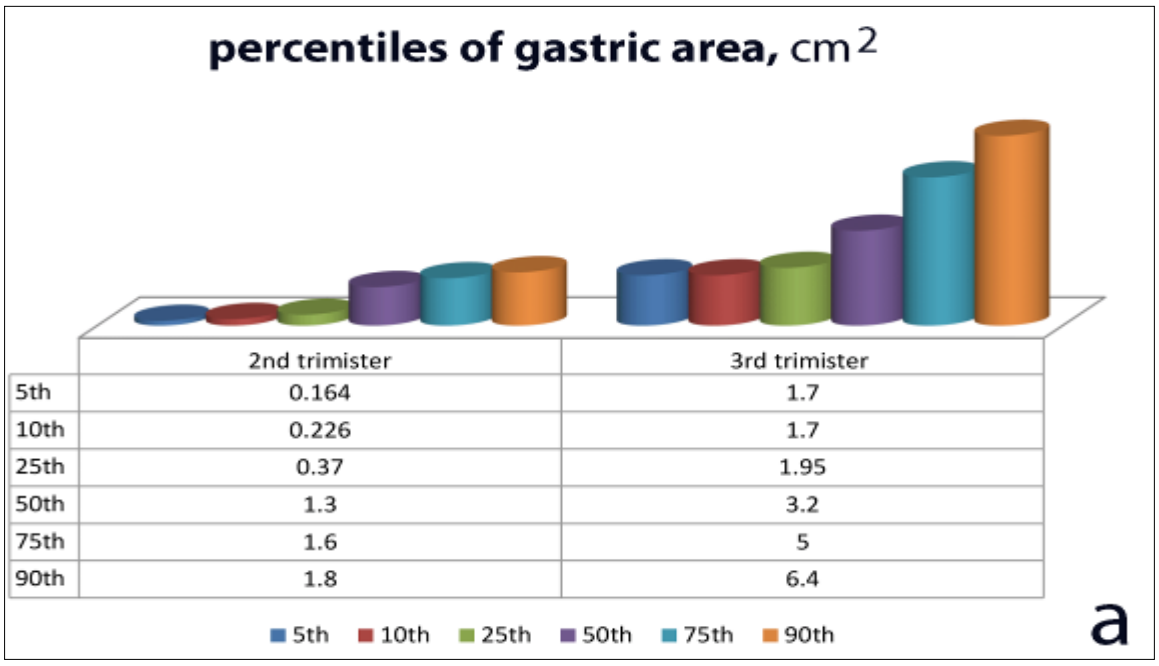
The 5th percentile of fetal gastric area (cm^2) ranges from 0.11 cm^2 in the 14th gestational age (weeks) to 5.4 cm^2 in the 40th gestational age (weeks), the 90th percentiles of fetal gastric area (cm^2) ranges from 0.136 cm^2 in the 14th gestational age (weeks) to 8.55 cm^2 in the 40th gestational age (weeks). The 5th percentile of stomach circumference (mm) ranges from 12.5mm in the 14th gestational age (weeks) to 84mm in the 40th gestational age (weeks), the 90th percentiles of fetal stomach circumference (mm) ranges from 14.1mm in the 14th gestational age (weeks) to 103.65 mm in the 40th gestational age (weeks).

The 5th percentile of stomach volume (ml) ranges from 0.046 ml in the 14th gestational age (weeks) to 9.0 ml in the 40th gestational age (weeks), the 90th percentiles of fetal stomach volume (ml) ranges from 0.095 ml in the 14th gestational age (weeks) to 23.7 ml in the 40th gestational age (weeks). The 5th percentile of stomach transverse diameter (mm) ranges from 5.5 mm in the 14th gestational age (weeks) to 34.0 mm in the 40th gestational age (weeks), the 90th percentiles of fetal stomach transverse diameter (mm) ranges from 6.3 mm in the 14th gestational age (weeks) to 41.19 mm in the 40th gestational age (weeks).

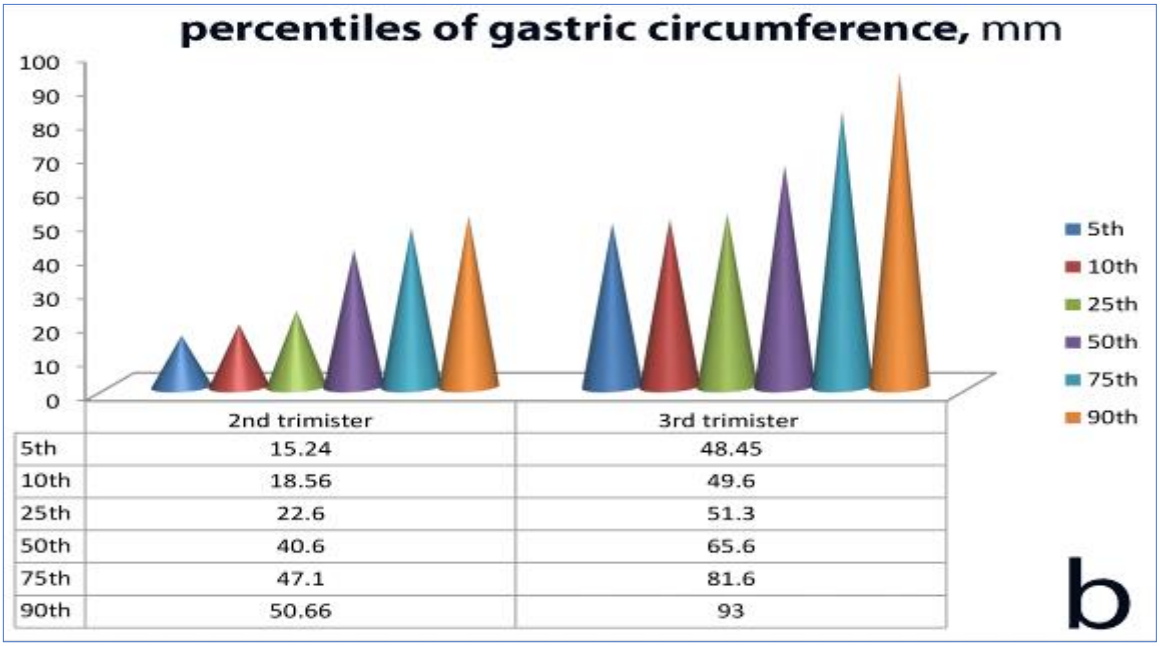
The 5th percentile of stomach longitudinal diameter (mm) ranges from 6.5 mm in the 14th gestational age (weeks) to 38.0 mm in the 40th gestational age (weeks), the 90th percentiles of fetal stomach transverse diameter (mm) ranges from 7.52 mm in the 14th gestational age (weeks) to 48.0 mm in the 40th gestational age (weeks). The 5th percentile of stomach antero-posterior diameter (mm) ranges from 2.5 mm in the 14th gestational age (weeks) to 13 mm in the 40th gestational age (weeks), the 90th percentiles of fetal stomach transverse diameter (mm) ranges from 3.2 mm in the 14th gestational age (weeks) to 25.4 mm in the 40th gestational age (weeks) **(Table 2 and Figure 4).**

Table (2): Percentiles of fetal gastric area (cm^2), circumference (mm), volume (ml), transverse diameter (mm), longitudinal diameter (mm) and anterior posterior diameter (mm) on gestational age in the studied population.

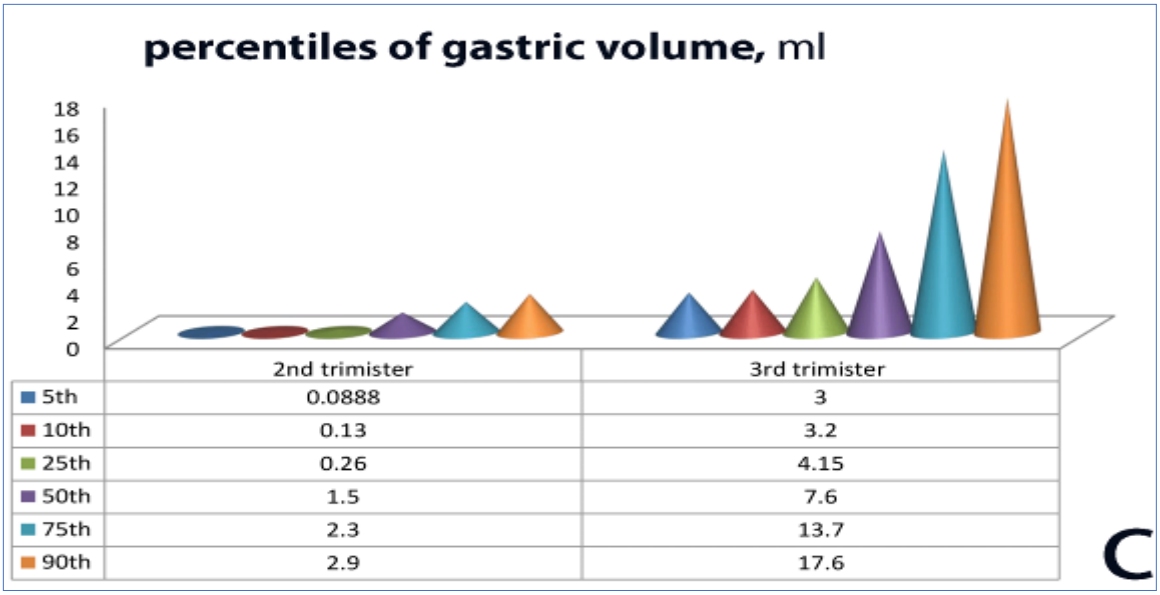
GA	Area			Circumference			Volume			Transverse diameter			Longitudinal diameter			Anterior posterior diameter		
	5th	50th	90th	5th	50th	90th	5th	50th	90th	5th	50th	90th	5th	50th	90th	5th	50th	90th
14	0.11	0.12	0.136	12.500	13.300	14.1	0.046	0.055	0.0951	5.5	5.8	6.3	6.5	6.8	7.52	2.5	2.7	3.2
15	0.18	0.2	0.304	15.800	16.900	18.2	0.1	0.12	0.15	6.5	7	8.3	8.5	8.7	9.21	3.5	3.7	3.92
16	0.21	0.25	0.724	16.200	26.700	30.4	0.12	0.13	0.61	6	6.6	11.02	9.1	9.3	13.25	4	4.3	6.4
17	0.26	0.29	0.303	18.500	19.400	20.03	0.16	0.19	0.201	7.3	7.6	8.1	9.6	10	10.6	4.5	4.8	5.8
18	0.32	0.36	0.391	20.700	21.800	22.80	0.22	0.25	0.295	8.1	8.5	8.95	10.3	10.8	12.1	5.1	5.4	6.1
19	0.42	0.52	0.776	23.500	26.600	31.01	0.32	0.44	0.720	9.3	11	13.21	11.8	13	14.2	5.7	6	8.12
20	0.93	1	1.75	35.300	36.900	39.850	0.92	1.05	1.48	14	14.65	15	15	15.9	20.93	8.5	8.9	9.95
21	1	1.2	1.39	38.500	41.150	44.720	1.3	1.55	1.79	15.5	16.9	18.9	18.5	18.85	19	9	9.35	9.59
22	1.5	1.6	1.7	45.700	47.200	50.420	1.9	2	2.48	19.1	19.7	20.4	19	20	22.4	10	10.3	10.68
23	1.5	1.8	1.99	38.000	49.800	53.150	2.5	2.75	3.18	13	20.75	22.9	22.6	23.55	24.45	10.6	11	11
24	1.7	1.8	2.71	49.000	50.800	60.400	2.8	3	3.84	20	21.25	24.7	24.6	24.95	27.11	10.8	11.05	11.39
25	1.3	1.5	1.59	43.200	45.450	46.690	1.9	2.15	2.3	18	19	20	21	21.85	22.49	9	9.85	10.29
26	1.3	1.6	1.72	43.200	45.800	47.80	1.6	2.3	3.1	18	18	20.1	18	23	25.2	9.5	10.7	12.58
27	1.5	1.75	3.46	45.000	49.650	69.300	2.1	3	6.63	17	20.5	26	25.5	26.25	28	10	11.4	17.36
28	1.6	1.8	1.9	48.000	50.000	51.300	2.5	3.2	3.4	20	20.5	21.9	24	27.55	27.99	10	10.9	11.79
29	1.7	1.75	1.9	48.200	49.250	50.290	3.1	3.45	3.69	20.1	20.35	20.5	28.1	29.35	30.09	10.5	11	11.59
30	1.4	1.9	2	49.600	50.900	51.800	3	3.95	4.3	20.5	20.75	21	30.2	32.05	32.5	8.8	11.8	12
31	1.9	2	2.66	50.000	51.250	54.810	3.5	4.25	4.89	20	20.5	21.95	32.5	32.85	33.09	10	12.35	12.99
32	2.3	2.75	3	55.900	59.500	70.110	5.1	5.75	7.36	21	23	28.75	30	35.25	37.9	11	13.7	17.8
33	2.4	2.9	3.63	56.500	62.000	69.820	5.4	7.5	8.32	21	23.5	27.7	33	38.1	39	15	16	16.95
34	2.9	3.25	3.59	62.800	66.150	69.650	7.2	8.45	9.37	25.5	25.9	27.55	39.1	39.55	39.79	14.5	16	17.45
35	2.6	3.4	3.69	60.000	67.050	69.650	6.3	8.3	9.17	23	25	26.9	30	36.85	37.59	14.8	17.35	17.95
36	2.5	3.8	4.19	55.000	71.550	74.460	3.9	9.75	11.26	19	28.5	29.47	24	38.55	40.9	16	17.65	18
37	3.7	4.8	6.84	74.000	80.800	106.340	8.5	14	20.62	30	32.5	44.2	36	44.2	49.2	14	18.5	19
38	5	5.1	7.42	81.900	83.200	106.200	12.4	14.8	19.44	33	34	44	33	44	45	19	19.5	20
39	5.3	5.5	8.48	75.000	86.000	109.000	11	16.6	20.86	27	34.5	45	39	46	49.4	17	20	20.4
40	5.4	6.65	8.55	84.000	96.000	103.650	9	20.2	23.7	34	38.5	41.19	38	45	48	13	22.2	25.4
Total	0.2605	1.9	5.4	19.115	50.7	85	0.1315	3.35	15.07	7.30	20.65	34.29	9.31	28	44.59	4.305	11.3	19



	2nd trimister	3rd trimister
5th	0.164	1.7
10th	0.226	1.7
25th	0.37	1.95
50th	1.3	3.2
75th	1.6	5
90th	1.8	6.4

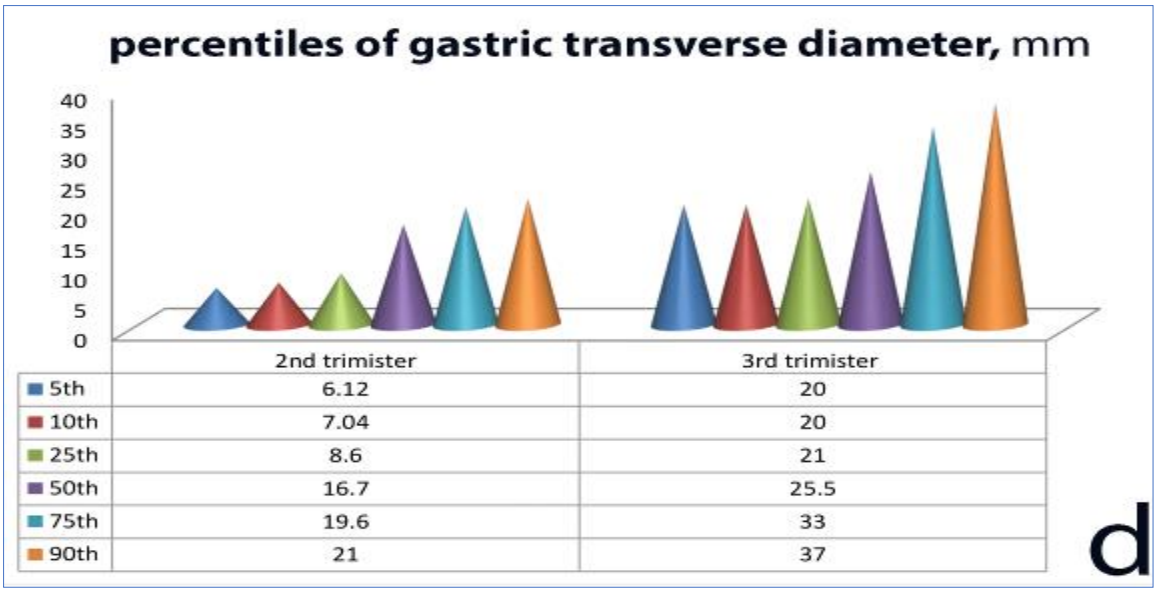


	2nd trimister	3rd trimister
5th	15.24	48.45
10th	18.56	49.6
25th	22.6	51.3
50th	40.6	65.6
75th	47.1	81.6
90th	50.66	93



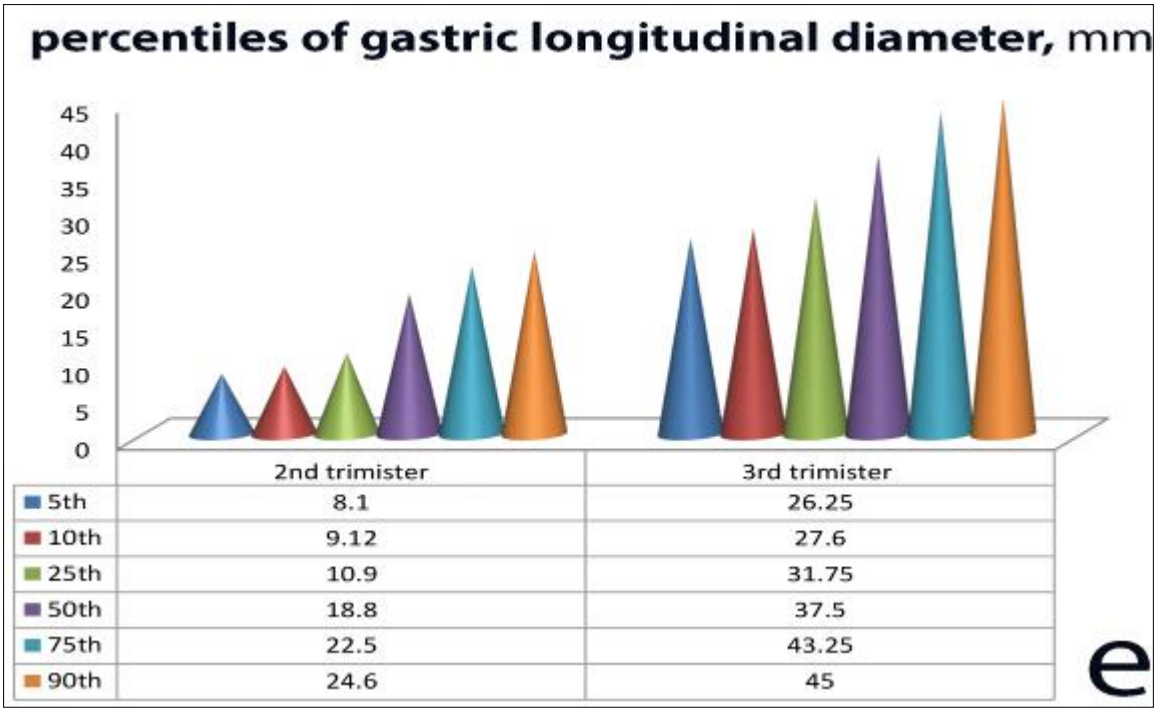
	2nd trimister	3rd trimister
5th	0.0888	3
10th	0.13	3.2
25th	0.26	4.15
50th	1.5	7.6
75th	2.3	13.7
90th	2.9	17.6

c



	2nd trimister	3rd trimister
5th	6.12	20
10th	7.04	20
25th	8.6	21
50th	16.7	25.5
75th	19.6	33
90th	21	37

d



	2nd trimister	3rd trimister
5th	8.1	26.25
10th	9.12	27.6
25th	10.9	31.75
50th	18.8	37.5
75th	22.5	43.25
90th	24.6	45

e

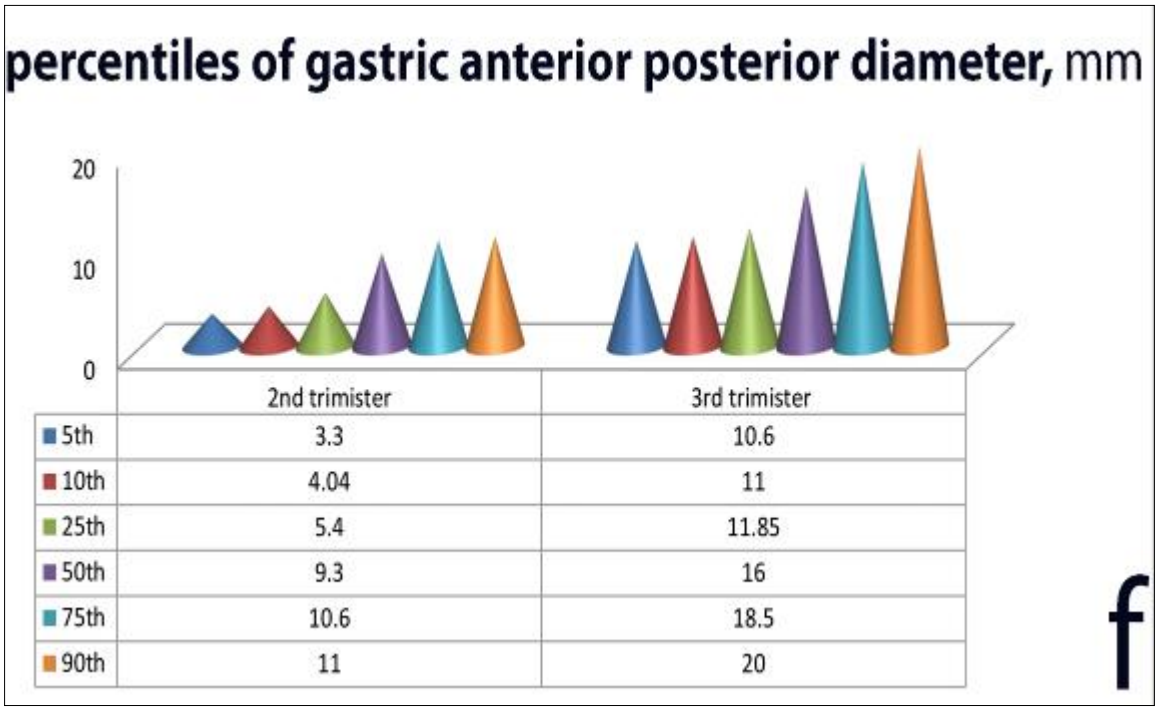


Figure (4): Percentiles of gastric area (a), gastric circumference (b), stomach volume (c), gastric transverse diameter (d), gastric longitudinal diameter (e) and gastric anterior posterior diameter (f) regarding the second and third trimester of pregnancy in the studied population.

The mean of fetal gastric area (cm^2) in the 2nd trimester in the studied women was 1.08 (SD 0.626) and ranges from 0.11 cm^2 to 2.8 cm^2 while, in the third trimester; the mean was 3.61 (SD 1.805) and ranges from 1.4 cm^2 to 9.0 cm^2. The mean of fetal stomach circumference (mm) in the 2nd trimester in the studied women was 36.56 (SD 12.68) and ranges from 12.5 mm to 61.3 mm while, in the third trimester; the mean was 67.85 (SD 16.79) and ranges from 12.5 mm to 111.5 mm. The mean of fetal stomach volume (ml) in the 2nd trimester in the studied women was 1.46 (SD 1.07) and ranges from 0.046 ml to 3.9 ml while, in the third trimester; the mean was 9.108 (SD 5.65) and ranges from 2.1ml to 24ml.The mean of fetal stomach transverse diameter (mm) in the 2nd trimester in the studied women was 14.85 (SD 5.48) ranges from 5.5 mm to 25 ml while, in the third trimester; the mean was 17.25 (SD 5.93) and ranges from 6.5 mm to 27.3 mm.

The mean of fetal stomach transverse diameter (mm) in the 2nd trimester in the studied women was 17.25 (SD 5.93) and, ranges from 6.5 mm to 27.3 mm while, in the third trimester; the mean was 36.84 (SD 6.74) and ranges from 24.0 mm to 51.0 mm. The mean of fetal stomach anterior posterior diameter (mm) in the 2nd trimester in the studied women was 50.85 (SD 12.85) and ranges from 24.4 ml to 71.1 ml while, in the third trimester; the mean was 94.65 (SD 13.19) and ranges from 24.4 ml to 122 ml.

Fetal gastric area was more significant correlated with abdominal volume (r=0.928, P-value <0.001) and abdominal area (r=0.914, P-value <0.001), however fetal gastric area was less significant correlated with Abdominal longitudinal (r=0.863, P-value <0.001) and abdominal anterior posterior diameter (r=0.866, P-value <0.001).

The best regression model correlated fetal gastric area/abdominal area ratio on gestational age was expressed by a cubic polynomial regression formula [r=0.452] **(Figure 5)**.

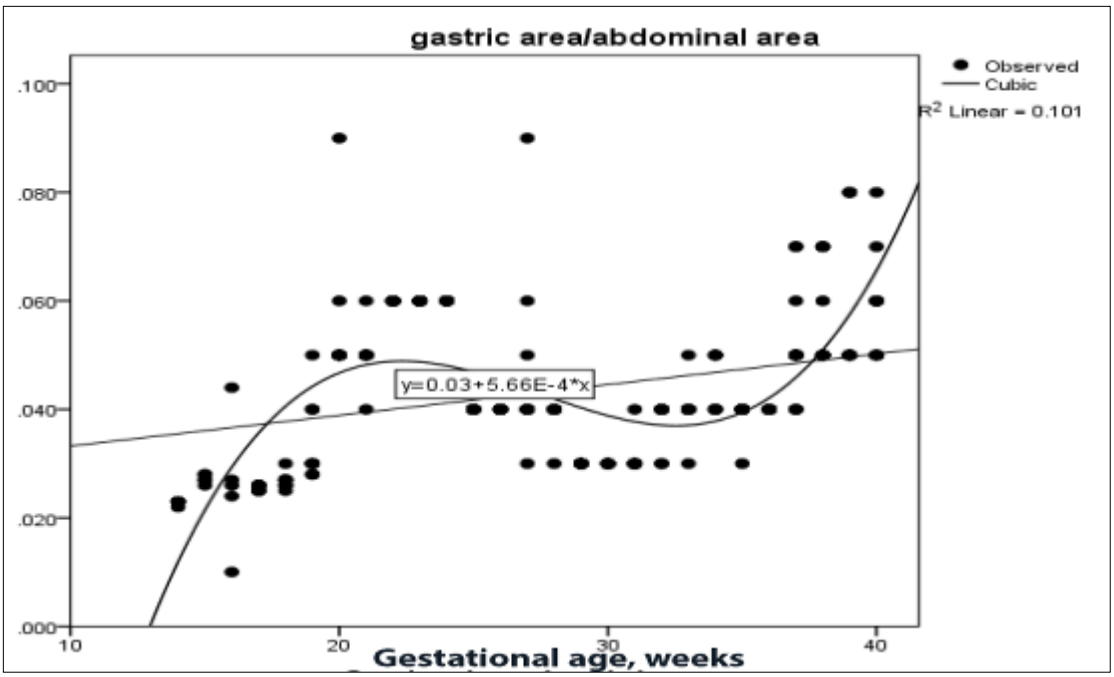


Figure (5): Correlation between fetal gastric area/abdominal area ratio on gestational age in the studied population.

The fetal gastric area/abdominal area ratio was significantly correlated with gastric age (weeks) [r=0.343, P-value <0.001].

DISCUSSION

The present study was carried out on 260 pregnant women with normal singleton pregnancy that came for routine antenatal ultrasonography on fetuses with no apparent external pathology or anomaly and aged 14–40 weeks of gestation. Any fetal abnormality especially esophageal atresia and duodenal atresia, multiple pregnancies, pregnant women who have medical or emergency obstetric complications were excluded from the study.

The inclusion criteria for the patients in this study were the same as those in **Kassif *et al.*** [7] study on the development of the fetal stomach: normal charts and clinical implications. The study was a cross-sectional prospective study carried out at a single tertiary care facility between 14 and 40 weeks of gestation. Conditions in the mother or the placenta known to impair fetal development were not included in the research.

The gestational age of the studied pregnant women ranged from 14 to 40 weeks. More than half of the included pregnant women were in their third trimester of pregnancy mainly in 37 weeks of gestation**.**

In the present study, an accurate estimation of gestational age was achieved by performing a routine obstetric ultrasound with a two-dimensional ultrasound (convex transducer, 2.5–3.5 MHz). Thereafter fetal stomach and abdomen were scanned, and fetal transverse, longitudinal, anterior, and posterior dimensions were measured. Also, the fetal stomach/the fetal abdominal measurements ratios were measured.

The methods used in this study were similar to those used in the **Kassif *et al.*** [7] study, which measured the maximum stomach length in the longitudinal plane as well as the anterior, posterior, and latero-lateral diameters in the axial plane, with the mean being used to calculate the reference range.

The present study found that the fetal gastric area was significantly associated with gestational age.

The results supported those of the **Kassif *et al.*** [7] study, which found a strong correlation between gestational age, estimated fetal weight, and estimated fetal weight percentile for the raw stomach data, axial and length diameter.

Kepkep *et al.* [8] study of the fetal stomach size development during a typical pregnancy found a strong correlation between the fetal gastric longitudinal, anterior posterior and transverse dimensions and gestational age.

The present study found that the fetal gastric area was significantly correlated with different gastric diameters including transverse, longitudinal, anterior posterior, circumference and gastric volume.

The results of the study concurred with a study by **Sase *et al.*** [9] on fetal stomach size in normal and abnormal pregnancies. The study came to the conclusion that fetal gastric area coincides with measurements of stomach volume obtained by ultrasonography and appears to be helpful in determining digestive system defects.

The prenatal ultrasonography assessment of the fetal stomach size as a predictor of postnatal development of GERD was the subject of a research by **Toscano *et al.*** [10] the study showed that a typical value of 9.0 cm or more for the anterior posterior diameter was assigned for a normal fetal stomach measurement

at 25 to 27 weeks. Additionally, a longitudinal measurement with a normal value of 9.0 cm or above at the same gestational ages permitted a diagnosis of GERD with a sensitivity and specificity of 80% and 85%, respectively.

The prognostic relevance of an enlarged fetal stomach in the second trimester was researched by **Richardson *et al.*** [11], who concluded that the detection of an isolated larger stomach in the second trimester appears to have a positive prognosis with no related feeding issues.

The current study found that the best regression model correlated with gastric area with an equation using cubic polynomial regression was used to express gestational age.

The results matched those of the **Ennen *et al.*** [12] study on temporal and linear assessments of fetal stomach size. According to the study, fetal gastric size grows with gestational age.

Kassif *et al.* [7] study reported that the best regression model correlated the stomach data on axial and length diameter with an equation using cubic polynomial regression was used to express gestational age.

The percentiles range for fetal gastric area on gestational age that established in the current study showed increased growth with gestational age.

The current findings agreed with **Kassif *et al.*** [7] study that demonstrated a linear growth of the fetal stomach throughout gestation.

Furthermore, **Hata *et al.*** [2] study of the foetal stomach's sonographic volume measurement found that the maximum and lowest gastric volumes were curvilinearly related to gestational age.

The study showed that a significant correlation between the fetal gastric area with different abdominal diameters

The study finding was agreed with **Hoopmann *et al.*** [13] study about measurement of gastric circumference in fetuses with esophageal atresia. The study reported, there is a substantial correlation between abdominal and stomach circumference.

The findings demonstrated a significant increase of the diameter of stomach circumference with advancing gestation. The linear regression model was the best regression model correlate with stomach circumference with gestational age.

Our findings were in agreement with **Hoopmann *et al.*** [13] study. They reported a significant association between gastric circumference and gestational age.

The median (50th percentile) for stomach circumference on gestational age in the present study was 50.7 cm and the 5th percentile was 19.115 cm.

Hoopmann *et al.* [13] study reported that the average gastric circumference in the normal fetuses amounted to 43 mm and in fetuses with and without fistula to 33.8 mm and 0.9 mm.

The variations seen may have been based on the different age groups of the studied population, racial characteristics, statistical analyses, and study designs. Additionally, some differences in reference ranges are observed, which are probably influenced by equipment, sonologist expertise and angle correction.

In addition, **Sletner *et al.*** [14] observed racial differences in fetal size, body proportions, and growth from week 24 of pregnancy to birth, which were only partially explained by key maternal determinants.

The current study demonstrated that the best regression model correlated with fetal gastric area/abdominal area ratio on gestational age was expressed by a cubic polynomial regression formula. There were significant positive correlations between different ratios of gastric/abdominal measures.

The study findings were disagreed with previous studies that reported gastric growth occurs in distinct periods, with remarkably nonlinear increases and decreases in growth rates during fetal development. In addition, there is some discrepancy between the fetal gastric growth and overall fetal growth throughout pregnancy, as evidenced by the fact that the correlation coefficient of the gastric surface area with gestational age is lower than that of the fetal biparietal diameter with gestational age. This is further supported by the rising standard deviation of average stomach size with gestational age [15].

The current study gave the formulas needed to compute conditional reference intervals that are specific to a single serial measurement. It is important to build a normal modelled reference interval chart for the average and maximum fetal stomach size between 14 and 40 weeks of gestation.

CONCLUSIONS

In a healthy pregnancy, fetal stomach dimensions are correlated with gestational age, and a nomogram of fetal gastric development may be helpful in determining if the fetus is developing normally and whether any digestive system abnormalities exist. Nomograms of the unborn stomach may help to avoid needless testing for erroneously thought to have tiny or big stomachs and may enhance the in-utero diagnosis of real illnesses.

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