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The Fetal Stomach Circumference/Abdominal Circumference Ratio : A Possible Parameter in Assessing Fetal Stomach Size

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Nonvisualized, dilated or even a small fetal stomach can be associated with a variety of anomalies and poor fetal outcome. Therefore, we attempted to evaluate the stomach circumference (SC) / abdominal circumference (AC) ratio to assess normal limits of fetal stomach size. A total of 363 fetuses ranging from 15 to 39 weeks' gestation were prospectively evaluated with ultrasonography. The SC was measured from a plane that is perpendicular to the fetal longitudinal axis at the level where the largest axial circumference of the stomach was obtained using a digitizer. The AC was also measured at the same section and the ratio was calculated by dividing the SC by the AC and multiplying by 100. The SC increased linearly from 15 to 24 weeks and showed fluctuations in size thereafter to 39 weeks. A strong correlation was noted between gestational age and both SC (r: 0.842, $P<0.0001$) and AC (r: 0.975, $P<0.0001$). The SC/AC ratio was normally distributed with a mean of 20.4±3.9% and ranged between 14.8% and 27.03% throughout pregnancy (r: 0.021, $P>0.05$). Although the fetal stomach is a dynamically changing organ, the SC/AC ratio can be considered as a potentially useful parameter in assessing fetal stomach size.

Key Words: Fetus gastrointestinal tract (stomach), fetus growth and development, Ultrasonography

Since a nonvisualized fetal stomach can be associated with a variety of fetal anomalies and poor fetal outcome, and marked dilation of the fetal stomach can be observed in cases of gastrointestinal obstruction such as duodenal atresia, the American Institute of Ultrasound in Medicine guidelines recommend that a view of the fluid-filled fetal stomach be obtained in all obstetric sonographic studies (Bovicelli *et al.* 1983; Leopold, 1986; Millener *et al.* 1993). It has also recently been reported that abnormal outcomes occurred in 52% of fetuses with a small fetal stomach (McKenna *et al.* 1995). Therefore, it seems that the determination of normal limits of the fetal stomach size will continue to be an important part of routine obstetrical sonographic examination. We observed that when the fetal abdominal circumference was measured during routine obstetrical sonography, the axial section of the fetal stomach was almost always identified as a circular-ovoid anechoic structure in the left upper abdomen on the same scan, so we attempted to investigate the relationship between the stomach circumference (SC) and the abdominal circumference (AC) in evaluating normal limits of the stomach size during pregnancy.

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MATERIALS AND METHODS

Fetal population

In this prospective cross-sectional study, 363 uncomplicated singleton fetuses were examined during routine obstetrical sonography. The fetuses ranged from 15 to 39 weeks of gestation. The week of gestation was calculated from the date of the last menstrual period and subsequently confirmed using ultrasound measurements of crown-rump length, before 11 weeks of gestation. Fetal growth was assessed using biparietal diameter, femur length and abdominal circumference. Each of the three parameters was within mean value±1.5 S.D for each gestational week. Fetuses were found to have no detectable anomalies in utero by ultrasound examination and amniotic fluid volume was within the normal range of 3~8 cm in depth by the single pocket size method. All mothers were followed in the Obstetric Unit of Trakya University Hospital in Edirne, Turkey and gave informed consent to participation in this study.

Data acquisition and parameter definition

Real-time ultrasonographic equipment (Hitachi EUB 350, Tokyo, Japan) with a 3.5-Mhz linear array transducer was used. The fetal stomach was visualized in the left upper abdomen as an echolucent organ that appears elliptical in longitudinal section and circular in transverse section with the mother in a semi-recumbent position. The axial circumference of the fetal stomach (SC) was measured from a plane that is perpendicular to the fetal longitudinal axis at the level where the maximum (largest) axial circumference of the stomach was obtained in axial cross-section (Fig. 3). The abdominal circumference (AC) was also measured at the same level, and the ratio of SC/AC was calculated by dividing the SC by the AC and multiplying by 100. Each fetus was taken into evaluation only once. In cases with a bean-shaped fetal stomach, measurement of the SC was attempted as accurately as possible at approximated values (Fig. 3C). The measurements were obtained in millimeters by direct planimetric method using a digitizer by one of the authors (GP). Serial measurements of AC and SC were made within a five-minute period.

Reproducibility of measurements

One of the authors sampled 10 fetuses (not included this study) from 15 to 39 weeks of gestation. Another author (not given any information about the fetuses) performed the same procedure. The process of image selection, freezing and measuring was repeated 10 times within a few minutes on each fetus. From the mean values and standard errors (SE) of the SC/AC ratio, the mean coefficient of variation was calculated to be 14.2%.

Statistical analysis

Data were analyzed using a statistical computer package program, Minitab Release 5.1 on an IBM system (IBM 3090 Main Frame Computer). Linear regression and Student's test were used to determine the relationship between gestational age and ultrasonic parameters.

RESULTS

Three hundred and sixty-three patients with uncomplicated pregnancies were studied. Three patients (1.3%) were excluded due to nonvisualization of the stomach, but we did not find any cause for nonvisualization. For further analysis 360 patients were included.

Strong correlation was noted between gestational age and both the fetal SC (r=0.842, R^2: 0.708%, $P<$ 0.0001) and AC (r=0.975, R^2: 0.951%, $P<0.0001$). The correlation between SC and AC was also high (r=0.892, R^2: 0.795%, $P<0.0001$). The measurements of SC throughout pregnancy are presented in Table 1 and Fig. 1. The mean fetal stomach circumference increased almost linearly from 15 to 24 weeks' gestation and decreased thereafter to 28 weeks' gestation. It increased nonlinearly again from 28 weeks to 37 weeks and then decreased from 37 weeks to 38~39 weeks of gestation.

There was no correlation between the SC/AC ratio and the gestational age (r=0.021, R^2: 0.0%, $P>$ 0.05), and the SC/AC ratio was normally distributed

Table 1. Fetal SC and SC/AC ratio throughout pregnancy

Gestational age (week) ratio	Number of cases	Minimum SC	Maximum SC	Mean±SD SC	Mean±SD SC/AC
15	9	14.3	24.1	18.6±3.6	19.3±3.1
16	13	17.4	24.8	21.3±2.6	19.7±2.9
17	17	18.6	27.8	22.7±3.1	20.2±2.1
18	15	22.5	36.1	27.5±4.0	20.2±3.3
19	13	24.1	36.8	30.3±4.3	19.6±2.8
20	19	28.6	37.1	33.1±3.1	20.0±3.2
21	11	23.7	49.4	36.0±8.1	21.9±4.4
22	13	27.1	52.5	38.3±8.8	22.2±3.5
23	18	30.9	52.8	40.9±7.5	22.8±3.2
24	17	40.8	54.7	47.7±4.9	19.1±3.2
25	12	30.9	50.1	41.7±6.9	21.2±3.3
26	19	34.9	56.5	48.0±7.9	17.5±1.8
27	12	32.9	50.2	40.9±5.0	16.0±1.2
28	16	35.6	43.7	39.1±2.6	21.5±2.1
29	12	48.9	72.1	58.0±7.6	22.1±3.0
30	15	48.7	82.4	64.6±10.1	18.4±1.0
31	17	41.9	57.9	50.1±4.7	20.2±2.9
32	19	43.9	83.7	59.7±11.3	18.2±3.0
33	14	33.9	72.5	50.8±11.5	23.5±3.4
34	13	51.9	88.3	71.4±10.0	19.7±2.8
35	14	46.9	88.1	62.4±11.9	21.6±2.7
36	12	53.9	82.6	69.9±9.4	23.3±2.8
37	18	60.9	100.5	83.2±11.0	17.6±2.3
38	15	43.9	68.2	59.5±8.0	19.1±2.2
39	17	53.5	80.4	64.6±9.3	20.4±3.3

SC: stomach circumference (mm), AC: abdominal circumference, SD: Standard deviation

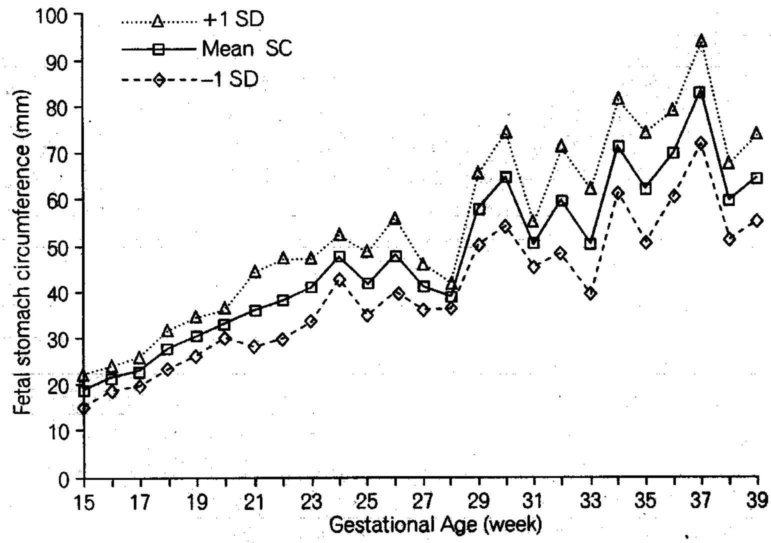

Fig. 1. Fetal stomach circumference measurements (mm) throughout pregnancy

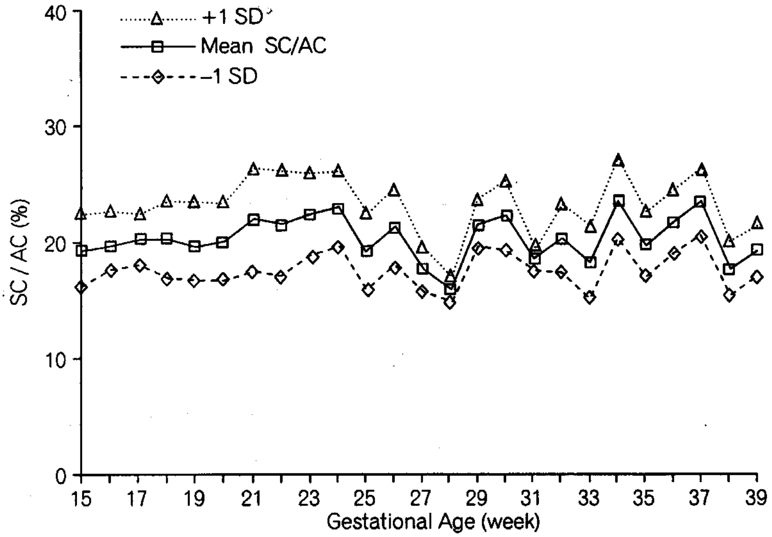

Fig. 2. SC/AC percentiles throughout pregnancy

with a mean of 20.40±3.39% (median, 20.20%). The mean values of the SC/AC ratio for each week of gestation are displayed in Table 1 and Fig. 2. The minimum and maximum values of the SC/AC ratio were 14.8% at 28 weeks and 27.03% at 34 weeks, respectively (Fig. 3). The differences in the mean values of the SC/AC ratios throughout pregnancy were statistically significant ($P<0.05$).

DISCUSSION

The fluid-filled fetal stomach can appear as early as 9 weeks' gestation and is always detectable by 14 weeks' gestation in the left upper abdomen as an echolucent organ (Goldstein *et al.* 1987; Millener *et al.* 1993). Gastric visualization can be related to the onset of the swallowing mechanism which is closely associated with the intact central nervous system by approximately the 12th to 13th weeks of gestation. Nonvisualization of the fetal stomach was found in 0.8% of our cases and all cases were normal newborns. This ratio was reported to be between 0.02% and 2% of all pregnancies (Bovicelli *et al.* 1983; Millener *et al.* 1993; McKenna *et al.* 1995).

Since the section orthogonal to the axis of the fetal stomach was considered a circle and the most encountered pattern of fetal stomach was the standard shape (in 90% of the cases), it was possible to measure both the axial circumference of the fetal stomach and abdomen on the same section using the planimetric method (Hawass *et al.* 1991; Nagata *et al.* 1994). We observed that the axial shape of the fetal stomach was ovoid or circular in most cases but occasionally it was bean-shaped (Fig. 3C). In cases with a bean-shaped stomach, measurement of the SC could be made in approximated values and we believe that in most cases this does not cause any problem in reflecting real measurements.

Several authors have investigated the developmental profile of the stomach at advanced stages of gestation using real-time ultrasound (Vanderberghe and De Wolf, 1980; Wladimiroff *et al.* 1980; Goldstein *et al.* 1987; Nagata *et al.* 1990; Mastronardi *et al.* 1993). Goldstein *et al.* have evaluated the longitudinal, anteroposterior, and transverse diameters of the fetal stomach and stated that the growth of the fetal stomach was linear throughout gestation (Goldstein *et al.* 1987). Mastronardi *et al.* reported that a high degree of correlation was observed between gestational age and stomach circumference (Mastronardi *et al.* 1993).

In this study, the axial circumference of the fetal stomach was almost linearly increased from 15 weeks to 24 weeks' gestation. This increase is com-

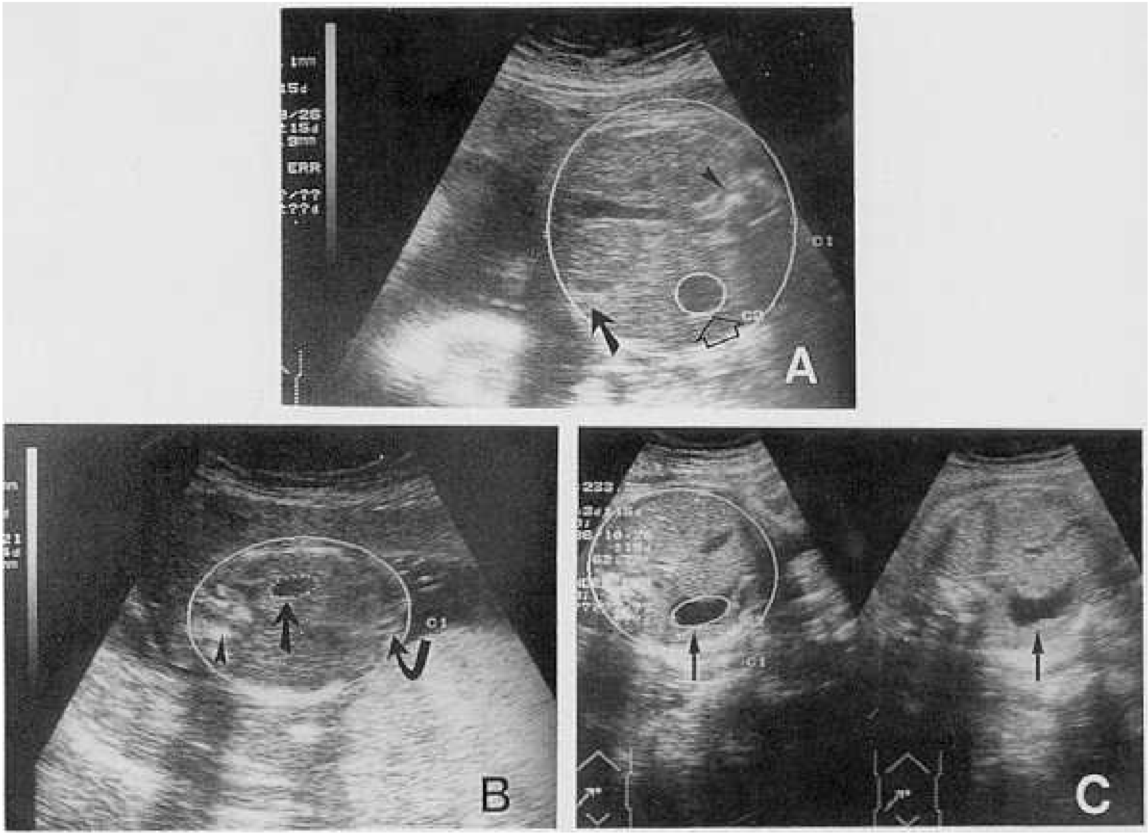

Fig. 3. Measurement of the fetal stomach and abdominal circumference is demonstrated. The section was obtained at the level where the largest axial circumference of the stomach visualised from a plane that is perpendicular to the fetal longitudinal axis. A) In a fetus 29 weeks' gestation, the axial shapes of both the stomach and abdomen is a circle. The SC/AC ratio is 46.9/255.1 ×100=18.3, (Stomach; large open arrow, spine; arrowhead, umbilical vein; black arrow). B) In another fetus 20 weeks gestation, the axial shapes of both of the stomach and abdomen is an ellipsoid. The SC/AC ratio is 30.1/153.5 ×100=19.6, (Stomach; black arrow, spine; arrowhead, umbilical vein; curved arrow). C) A fetus 27 weeks gestation, the fetal stomach is bean shaped and the measurement is made as accurate as possible. The SC/AC ratio is 62/233=26.6 (Stomach; arrowed).

patible with previous studies and is explained by the development of the anatomical structure of the fetal stomach itself, complementary to fetal growth, and the immaturity of gastrointestinal motility leading to minimal propagation from the stomach to the intestine in this period (Mclain, 1963; Pritchard, 1966; Abramovich, 1970). The mean SC/AC ratio also ranged between 19% and 22% from 15 weeks to 24 weeks of gestation in our cases, probably due to proportional growth of both the abdominal and stomach circumference in this period. After 24 weeks' gestation, the stomach circumference is minimally decreased at 27~28 weeks' gestation and then increases with fluctuations in size until 37 weeks. The mean ratio of the SC/AC was at its lowest value (16.0%, mean) of the whole pregnancy at 28 weeks' gestation and also showed variations (ranging from 16%~23%) between 24~39 weeks' gestation. Nagata *et al.* reported that anteroposterior and longitudinal dimensions of the fetal stomach increased from 16~17 to 26~27 weeks, remained fairly constant between 26~27 and 32~33 weeks, and then increased again from 32~33 to 36~37 weeks (Nagata *et al.* 1990). In another study, Nagata *et al.* also reported that the ultrasonographically reconstructed three-dimensional shape of the stomach volume increased linearly from 20 to 37 weeks gestation (Nagata *et al.* 1994). This increase in size was attributed to the development of gastric function, in utero, to retain swallowed amniotic fluid and send it to the intestine in this period (McLain, 1963; Nagata *et al.* 1994). Initiation of lower oesophageal sphincter activity may also have a role by 32∼33 weeks (Boix-Ochoa and Canals, 1976). Therefore, we believe that these physiological changes which affect the fetal stomach size begin after 24 weeks' gestation and are responsible for the variations in the SC values and the SC/AC ratios between 24∼39 weeks. The SC and the SC/AC ratio were also decreased from 37 weeks to 38∼39 weeks' gestation in this study. Nagata *et al.* reported the same findings in two different studies and it is suggested that the decrease in turnover of amniotic fluid, as indicated by the decrease in the flow volume of the umbilical vein, urine production, and the total volume of amniotic fluid is responsible for the decreasing size of the fetal stomach in this period (Queenan *et al.* 1972; van Otterlo *et al.* 1977; Kurjak and Rajhvajn, 1982; Nagata *et al.* 1990; Nagata *et al.* 1994). Disturbances in amniotic fluid volume as oligohydramnios or polihydramnios may also affect the size of the fetal stomach. However, these cases were not included in this study, so that further studies are needed to reveal the relationship between these abnormalities and the SC/AC ratio.

Wladimiroff *et al.* reported that fetal stomach filling is non-linear with respect to time and the filling time ranged between 10 and 30 minutes (Wladimiroff *et al.* 1980). However, Vanderberghe and De Wolf and Goldstein *et al.* reported that no significant changes in stomach dimensions or volume were noted on continuous observations (Vanderberghe and De Wolf, 1980; Goldstein *et al.* 1987). Devane *et al.* investigated the rates of filling and emptying of the fetal stomach between 26-40 weeks and reported a periodicity of 35∼55 min (Devane *et al.* 1993). On the other hand, Zimmer *et al.* recently reported that caution should be excised in the diagnostic use of stomach measurements owing to their dynamically changing nature (Zimmer *et al.* 1992). They made serial measurements of the stomach 20 minutes apart in 146 fetuses and found that the mean percentage change between each of the paired measurements was 16.6% to 24% for the different stomach dimensions and 41.3% for stomach volume. However, Nagata *et al.* reported that the mean coefficients of variations in repeated measurements of the fetal stomach, over a period of a few minutes, were 6.8% and 12.5% in the longitudinal and anteroposterior dimensions, respectively (Nagata *et al.* 1990). In our study, the mean coefficient of variation was 14.2%, which is similiar to the results of Nagata *et al.* but significantly different from the results of Zimmer *et al.* We believe this was caused by the fact that our measurements were performed within just a few minutes, not within 20 minutes.

Since abnormal changes in the size of the stomach may indicate fetal abnormalities or poor fetal outcome, sonographic determination of the fetal stomach size is of importance and an objective parameter may be required during routine obstetrical sonographic examination. The SC/AC ratio can easily be measured in routine obstetrical sonographic examination while the abdominal circumference is routinely being obtained. We believe that measurement of the fetal SC/AC can be considered as an easier, more age-independent and practical way than measurements of the gastric dimensions in evaluation of the fetal stomach size. Although fetal stomach is a dynamic organ which has periods of filling and emptying, we believe it occurs within certain limits. Our results show that the range of the mean SC/AC ratio varies between 16% and 23% (practically ranging between 15∼25%) throughout pregnancy. If the SC/AC ratio is out of those ranges, ultrasonographical follow-up is recommended since this can be caused by either the filling-emptying phase of the stomach or an abnormal situation. However, this study should be considered as an initial study of the range of normal age-independent fetal gastric measurements which we plan to follow with a study evaluating the positive and negative predictive values of this test for fetal anomalies or adverse outcomes.

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