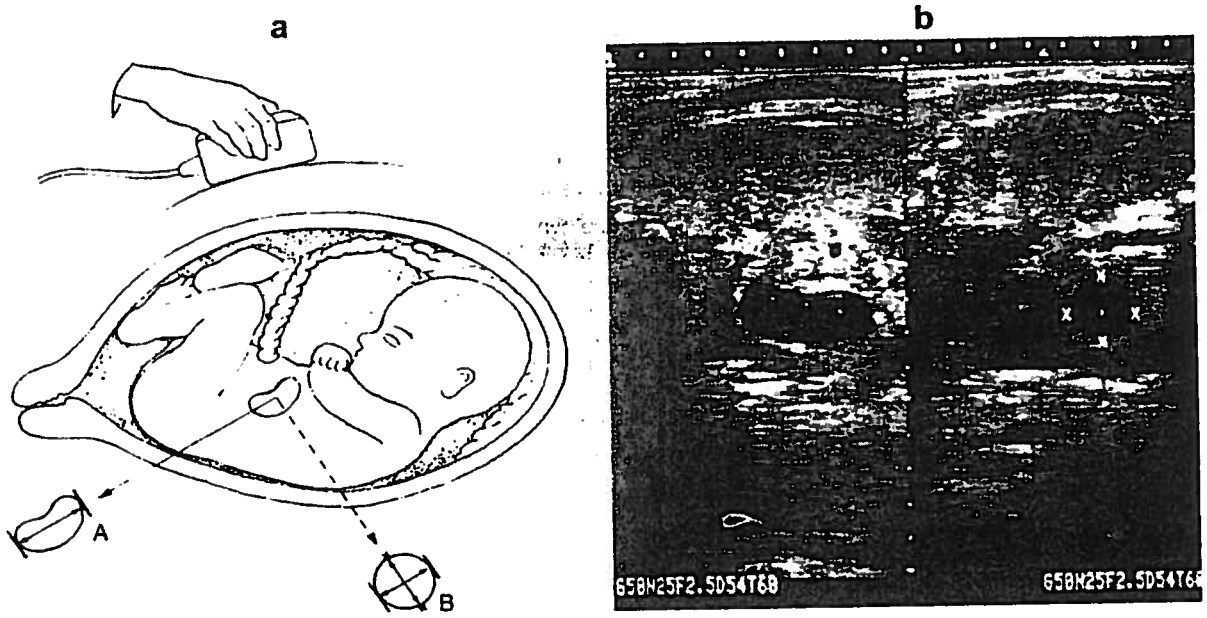

Figure 1 (a) Diagram representing the method of measurements of the fetal gastric size. (b) Ultrasonographic appearance of longitudinal (on left) and tranverse section (on right) of the fetal stomach.

menstrual period and ultrasonographic measurements of the crown-rump length before 12 weeks. Biparietal diameter (BPD), abdominal circumference (AC) were also measured. The ultrasonographic equipment was the Siemens Sonoline scanner with a linear and convex array transducer of 3.5 MHz.

The fetal stomach, i.e., the largest area including the pyloric site on a transverse or oblique section, was observed in the left upper quadrant of the fetal abdomen on routine ultrasonographic examination. The longitudinal dimension of the stomach was measured. Transverse and anteroposterior dimensions were measured at the transverse section of the gastric corpus center (Figure 1a and 1b). In cases where the fetal stomach area was visible, we measured the dimensions at least twice and recorded the largest measurement. In cases where the fetal stomach area was not immediately visible, we performed at least two more measurements at 15–30 min intervals and recorded the measurements where applicable. When these repeat exams consistently failed to visualize the fetal stomach even after the third observation, we repeated ultrasonographic screening on another day. All measurements were performed by one observer.

Statistical analyses were performed with SPSS for Windows (SPSS 10.0; SPSS Inc, Chicago, IL). Descriptive statistics are reported as mean and $\pm$SD, and percentage; probability values of <0.05 were considered to indicate a statistically significant difference between means. Statistical comparisons were performed by a one-way analysis of variance (ANOVA), followed by Student t test. Pearson correlation coefficients were used for gastric size dimensions with gestational age and AC.

Results

A total of 250 patients participated in our prospective study. The mean maternal age was 25.74 ± 4.1 years (range, 18–40 years). The mean gravidity was 2.0 ± 0.9 (range, 1–5) and a median parity was 0.9 ± 0.8 (range, 0–3). The gestational age was 13 to 39 weeks with a median of 26.14 ± 6.5.

Measurement of fetal gastric longitudinal dimension was significantly ($P=0.001$) correlated with gestational age ($r=0.736$) and AC ($r=0.732$). There were positive correlations between fetal gastric transverse dimension and gestational age ($r=0.495$) or AC ($r=0.489$), ($P<0.01$). Fetal gastric anteroposterior dimension was also significantly correlated ($P<0.01$) with gestational age ($r=0.707$) and AC ($r=0.702$). In addition to these calculations, we found a constant parameter of 1/3 as the ratio of fetal gastric anteroposterior dimension to fetal AC.

We constructed a nomogram for fetal gastric size dimensions measurements ± 2 SD by gestational age with (bi-weekly intervals; Table 1). The fetal gastric size dimensions linearly increased with gestational age (Figure 2).

Discussion

The developmental profile of the human fetal stomach was investigated using real-time ultrasonography. Growth charts for fetal stomach dimensions have been previously described and reported that the fetal stomach is an index, reflecting the physical and pathological condition in the digestive tracts. Some studies also reported prognostic significance of the absent fetal stomach in ultrasonography [1, 2, 5, 7, 8]. Fetuses with persistently nonvisualized stomachs have an increased incidence of

Table 1 Nomogram of fetal gastric size dimension including mean ± SD according gestational age.

Gestational age	n	Longitudinal dimension (mm)	Transverse dimension (mm)	Anteroposterior dimension (mm)
13–15	10	6.0±2.5	3.9±2.2	3.5±1.9
16–18	20	10.6±4.8	6.1±3.4	8.7±6.3
19–21	36	11.9±5.5	8.3±5.2	10.8±4.9
22–24	48	16.6±9.4	9.1±5.0	12.5±7.2
25–27	32	19.6±12.4	8.5±4.1	15.8±11.2
28–30	43	22.3±15.4	12.8±14.4	20.9±13.3
31–33	16	26.3±18.5	10.8±6.4	19.3±16.9
34–36	34	26.7±16.5	12.5±6.9	23.4±16.9
37–39	11	30.8±12.4	12.1±2.2	26.8±1.9

structural defects and amniotic fluid (AF) abnormalities. Brumfield et al. [2] reported 26 fetuses with a persistently nonvisualized stomach that had structural anamolies in 65% and a 29% survival rate. 35% of fetuses with no structural defect had abnormal AF volume, and the overall perinatal survival was only 50%. However, no accepted standards exist for fetal gastric size to evaluate congenital abnormalities of the gastrointestinal tracts [12].

We constructed a nomogram for a standardized fetal gastric size dimensions throughout pregnancy. In our study, there was a significant correlation between fetal gastric size dimensions and gestational age or AC. In other words, fetal gastric size dimensions increased linearly from 13 to 39 weeks' gestation as the AC increases with gesatational age ($P<0.01$). Goldstein et al. [3] reported a nomogram including mean and ±SD values of fetal gastric size dimensions (longitudinal, transverse and anteroposterior) by gestational age in 152 fetuses between 9 to 40 weeks of gestation. Similar to our finding, they found a positive correlation between fetal gastric dimensions and gestational age.

Sase et al. [12] collected a total of 386 fetal gastric measurements from routine ultrasonographic examinations of women with normal singleton pregnancies between 18 and 39 weeks' gestation and constructed a growth chart for a standardized fetal stomach dimension throughout pregnancy. They found that the fetal gastric area was significantly correlated with gastric volume ($r=0.91$) and gestational age ($r=0.74$). However, the correlation coefficient for gastric area with gestational age was smaller than those for the BPD ($r=0.97$) and abdominal transverse area ($r=0.97$). In our study there was also a positive correlation between the fetal gastric dimension and gestational age and AC. In addition, the correlation coefficient for all gastric dimensions with gestational age were larger than those for the AC. Sase et al. [12] suggested that the gastric area ratio, defined as the ratio of the fetal gastric area divided by the area of the fetal abdominal transverse section, is a preferable method to evaluate the gastric size of the fetus because the gastric area ratio is constant during pregnancy. Moreover, they reported that the standard deviation of the normal gastric measurements increases markedly with advanced gestational age thus limiting the ability to use abnormalities of stomach size in cases with congenital digestive tract anomalies, particularly in mid to late gestation.

In the study of Nagata et al. [9], measurements of the fetal gastric maximal longitudinal and anteroposterior dimensions were obtained by real-time ultrasound imag-

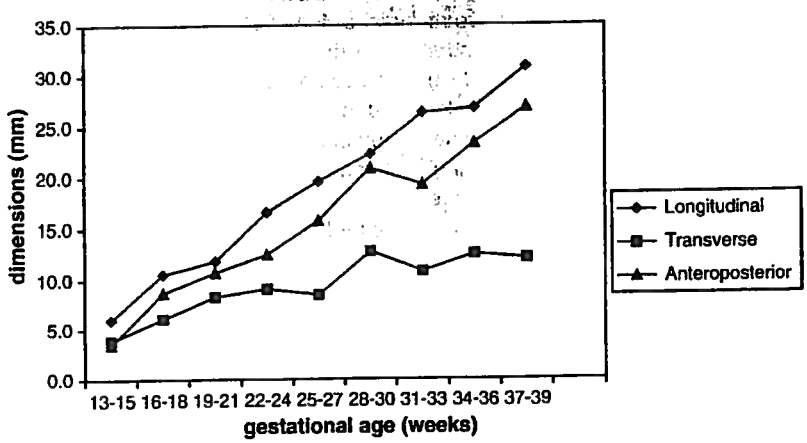

Figure 2 Correlation between fetal gastric size dimensions and gestational age.

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CHAPTER 18 Fetal Bowel

Lyndon Hill

Introduction

The sonographic diagnosis of markedly dilated fetal bowel is not difficult. However, the detection of the early stages of bowel dilatation requires a knowledge of the normal increase in the diameter of small bowel and colon as menstrual age advances.

Materials/Methods

The colon can be identified by its location around the periphery of the abdominal cavity. The small bowel is centrally located. The maximal internal diameter of the bowel loops are measured.

Discussion

There is a linear correlation ($r = 0.82$[1] to 0.859[2]) between colon diameter and menstrual age. The diameter of the colon increases from 4 to 6mm at 22 weeks' menstrual age to 10 to 18mm at term (Fig. 18-1).[1] There is a gradual increase in meconium content as gestation advances. As a result, the colonic contents gradually become more echodense (Fig. 18-2). The sigmoid colon is significantly larger than the ascending colon; the difference between the other parts of the colon is not significant.[2] In order to diagnose dilated bowel, the confidence intervals about the mean diameter are required. Table 18-1 provides the mean and 95% confidence intervals

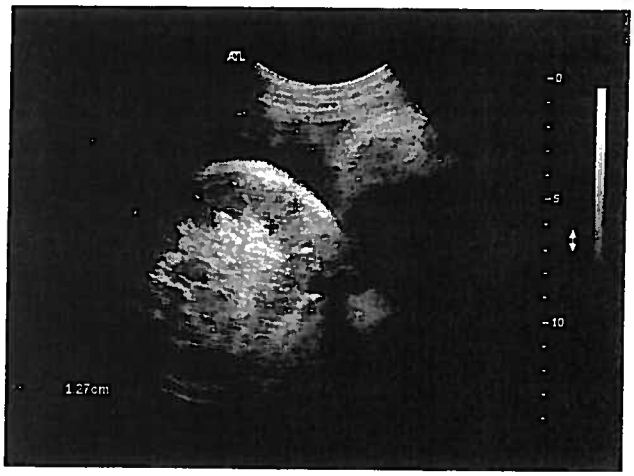

Figure 18-1
Large bowel diameter (calipers) at 37 weeks' menstrual age.

Figure 18-2
Meconium-filled large bowel (calipers) at 40 weeks' menstrual age.

Table 18-1 Descending colon and rectal diameters according to gestational age

Week of gestation	Number	Descending colon diameter (mm)		Rectal diameter (mm)	
		Mean	95% CI	Mean	95% CI
19-20	10	3.52	0.79-6.26	3.64	1.45-5.82
21	16	3.59	0.86-6.32	3.79	1.61-5.97
22	28	3.69	0.96-6.41	3.95	1.78-6.13
23	29	3.82	1.09-6.54	4.14	1.97-6.31
24	29	3.98	1.26-6.7	4.34	2.17-6.52
25	29	4.18	1.46-6.9	4.57	2.40-6.74
26	13	4.43	1.70-7.15	4.82	2.64-6.99
27	7	4.71	1.99-7.43	5.08	2.91-7.26
28	7	5.04	2.32-7.76	5.38	3.20-7.55
29	7	5.42	2.69-8.14	5.69	3.52-7.87
30	8	5.84	3.12-8.57	6.04	3.86-8.21
31	10	6.32	3.60-9.05	6.41	4.23-8.58
32	11	6.86	4.13-9.58	6.80	4.63-8.98
33	17	7.45	4.72-10.17	7.23	5.05-9.40
34	14	8.10	5.37-10.82	7.68	5.51-9.85
35	29	8.81	6.09-11.53	8.17	5.99-10.34
36	32	9.59	6.87-12.31	8.68	6.51-10.85
37	18	10.44	7.71-13.16	9.23	7.06-11.40
38	26	11.35	8.63-14.08	9.81	7.64-11.98
39	17	12.34	9.61-15.07	10.43	8.25-12.61
40	22	13.40	10.66-16.15	11.08	8.89-13.26

From Zalel Y, Perlitz Y, Gamzu R, et al: In-utero development of the fetal colon and rectum: sonographic evaluation. Ultrasound Obstet Gynecol 2003;21:161-164.

Table 18-2 Descending colon diameter (mm) at various menstrual ages

	Descending Colon (mm)		
Menstrual Age (wks)	**Malas[5]**	**Zalel[3]**	**Goldstein[6]**
21	3.22	3.59	—
22	4.08	3.69	—
23	4.44	3.82	—
24	4.80	3.98	—
25	5.00	4.18	—
26	6.00	4.43	5
27	6.11	4.71	5
28	6.55	5.04	6
29	7.10	5.42	7
30	7.33	5.84	8
31	8.11	6.32	8
32	8.66	6.86	9
33	8.70	7.45	10
34	8.86	8.10	11
35	9.00	8.81	11
36	9.20	9.59	12
37	10.23	10.44	13
38	10.30	11.35	14
39	10.66	12.34	15
40	11.33	13.40	16
N	131	379	289
Study	Autopsy	Sonographic	Sonographic
Country	Turkey	Israel	USA
Measurement	Outer-to-outer diameter	Internal diameter	Outer-to-outer diameter

for the maximum internal diameter of the descending colon. Malas et al[2] measured the ascending, transverse, descending, and sigmoid colon diameters from the outermost edges in 131 autopsied fetuses who did not have external pathology or anomalies. The descending colon diameter was consistent with the sonographically obtained inner diameter measurement reported by Zalel et al (Table 18-2).[3] The maximum colon diameter reported by Zalel et al[3] of 18 mm is in accordance with the findings of Nyberg et al.[1] The data in Table 18-3 do not provide the confidence intervals for the menstrual age groups evaluated. The largest diameter obtained of 28 mm may, therefore, be an outlier.

The small bowel diameter increases from 1 mm at 13 weeks' menstrual age to 4.4 mm in post-term fetuses[4]; the diameter of the jejunum is greater than the diameter of the ileum during the fetal period ($p < 0.05$).[5] The maximum diameter of fetal small bowel has been reported as between 6[1] and 8[3] mm (Figs. 18-3 and 18-4; see Table 18-3). The only sonographic data on small bowel diameter throughout gestation is in Table 18-3. Unfortunately, this study is methodologically flawed because it does not provide either the standard deviation or confidence intervals for each 5-week interval. A recent autopsy study obtained the outer-to-outer small bowel diameters in Table 18-4. The postmortem measurement of a flaccid loop of bowel may be significantly different from the diameter of a dynamic loop of bowel in a normal fetus. However, the different diameters of small bowel obtained in the autopsy and sonographic studies after the first trimester are in marked contrast to the comparable large bowel diameters throughout gestation (see Table 18-2). Because the same authors measured the small and large bowel in the autopsy series, the limited sonographic data on small bowel diameter may be inaccurate.

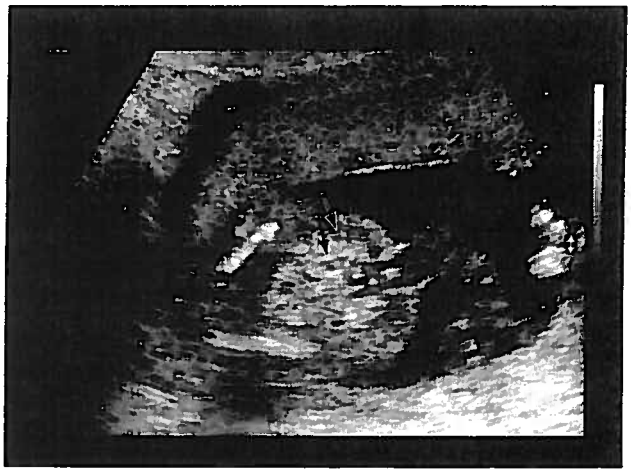

Figure 18-3
Normal small bowel diameter (*arrows*).

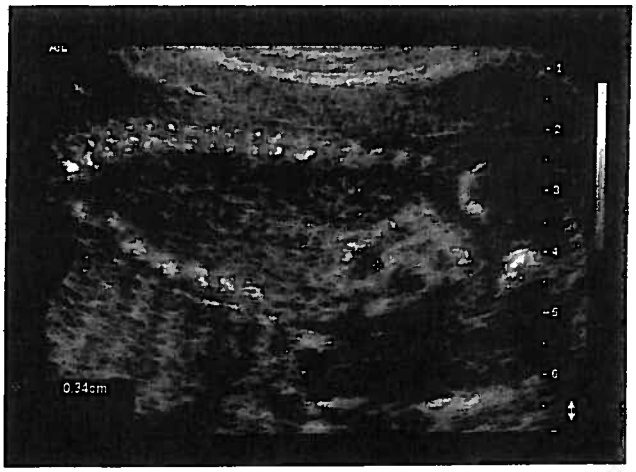

Figure 18-4
Dilated loop of small bowel (0.34cm) at 22 weeks' menstrual age.

Table 18-3 Lumen diameters (mm) of small bowel and colon at various menstrual ages

		Small bowel lumen size (mm)		Colon lumen size (mm)	
Menstrual Age (wks)	***N***	**Average**	**Largest**	**Average**	**Largest**
>40	9	4.4	6	18.7	28
35-40	44	3.7	8	16.8	26
30-35	36	2.9	6	11.4	16
25-30	44	1.8	3	8.0	13
20-25	44	1.4	2	4.4	6
15-20	34	1.2	2	3.6	5
10-15	32	1.0	1	1.5	2

From Parulekar SG: Sonography of normal fetal bowel. J Ultrasound Med 1991;10:211-220.

Table 18-4 Small bowel diameter (mm) at various menstrual ages

		Small bowel diameter (mm)	
Menstrual Age (wks)	***N***	**Jejunum**	**Ileum**
10-12	10	1.431 ± 0.317	1.000 ± 0.311
13-25	63	2.997 ± 0.996	2.392 ± 0.832
26-37	43	5.472 ± 1.808	4.883 ± 1.803
38-40	15	7.379 ± 2.301	6.356 ± 1.743

From Malas MA, Aslankoç R, Üngör B, et al: The development of jejunum and ileum during the fetal period. Early Hum Dev 2003;74: 109-124.