

Predictable Ultrasonographic Findings of Early Abortion

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Early fetal growth delay and early oligohydramnios have been suspected as signs of embryonal jeopardy. However, little information is available for the prediction of early abortion. Sonographic examination of 111 early pregnancies between the sixth and ninth gestational week with regular, 28 day menstrual cycles was performed to investigate predictable sonographic findings of early abortion. Sonographic measurements of the gestational sac (G-SAC), crown-rump length (CRL) and fetal heart rate (FHR) were performed using a linear array real time transducer with Doppler. All measurements of 17 early abortions were compared to those of 94 normal pregnancies to investigate the objective rules for the screening of early abortion. Most of the early aborted pregnancies were classified correctly by discriminant analysis with G-SAC and CRL ($G-SAC = 0.5222 CRL + 14.6673 \approx 0.5 CRL + 15$, sensitivity 76.5% specificity 96.8%). With the addition of FHR, 94.1% of early abortions could be predicted. In conclusion, sonographic findings of early intrauterine growth retardation, early oligohydramnios and bradycardia can be predictable signs for the poor prognosis of early pregnancies.

Key Words: Sonography, Early abortion, Early oligohydramnios Intrauterine growth retardation, Fetal bradycardia

INTRODUCTION

With the development of sonographic scanning, the early detection of the fetal heart beat has been considered to be reassuring evidence of a viable pregnancy. Demonstration of cardiac motion confirms fetal life and predicts a normal clinical outcome in 88-90% of cases, whereas, the unequivocal absence of fetal heart beat verifies a pregnancy failure (Wilson et al, 1986). Moreover, Mantoni found that in cases of threatened abortion smaller fetuses have a poorer chance of a successful outcome of pregnancy than normal sized fetuses.

To distinguish abnormal pregnancies from normal, follow up sonograms are often recommended to evaluate growth and development. However, sonographic

criteria in these matters have not been thoroughly studied. Moreover, the literature is sparse regarding the sonographic features that can be used to discriminate abnormal pregnancies from normal in a single examination.

The purposes of the present study were to identify predictable sonographic findings of early abortion and to investigate the objective rules which are pathognomonic of pregnancy failure in those patients with a live fetus.

MATERIAL AND METHODS

During a 6-month period between January and June 1990, a total of 111 patients with regular, 28-day menstrual cycles between the sixth and ninth week of pregnancy were consecutively studied. All sonographic scans were done by the primary author using an Aloka SSD 650 with a 3.5 MHz transabdominal linear transducer with pulsed Doppler. In each case, one or more follow-up sonograms were performed. Only a

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single pair of sonograms for each pregnancy was used in the data analysis.

Biometric measurements including mean gestational sac size (G-SAC), crown-rump length (CRL) and fetal heart rate (FHR) were performed in each case. The mean gestational sac size was calculated by averaging the longitudinal, anterior-posterior, and transverse sac dimensions, measured between the inner sac walls. Gestational age was calculated from the first day of the last menstrual period.

Clinical outcome was determined by a review of medical records and subsequent sonographic examination. The clinical outcome was considered normal if a pregnancy terminated in term delivery. The clinical outcome was considered abnormal if there was an absence of fetal heart beat, or if spontaneous abortion occurred.

To determine which features were most reliable for diagnosing an abnormal clinical outcome, the individual sonographic measurements were independently compared with the subsequent clinical outcome. Moreover, the relationships between each determinant were analyzed.

For statistical analysis, t-test, simple linear regression and canonical discriminant analysis were performed with the use of the SPSS (statistical package for social science).

RESULTS

Of the 111 patients included in this study, 94 (84.7%) had a normal clinical outcome. Demographic data of the study population are shown in Table I. There were no differences in maternal age or clinical symptoms between patients able to continue to delivery and those who aborted. However, vaginal bleeding episodes occurred more frequently in the abnormal outcome group (p=0.0024).

Sonographic determinants of fetal growth and de-

velopment at each gestational week are presented in Table II. Growth and development, as determined by mean gestational sac size (G-SAC), crown-rump length (CRL) and fetal heart rate (FHR) were significantly delayed between the seventh and ninth week in the aborted group compared to the normal outcome group (Fig I, II, III). Among 94 patients of the normal outcome group, each determinant of growth and development and the following relationship with gestational days are calculated by linear regression.

$$G-SAC_i = 0.8273 \times \text{Gestational Days} - 15.3437$$

$$(R^2 = 0.636, P < 0.001)$$

$$CRL_i = 0.7664 \times \text{Gestational Days} - 29.4213$$

$$(R^2 = 0.766, P < 0.001)$$

$$FHR_i = 2.4408 \times \text{Gestational Days} + 14.5203$$

$$(R^2 = 0.586, P < 0.001)$$

(i: given gestational day)

Canonical discriminant analysis was used for multivariate analysis, and the stepwise method was applied to select the most predictable ultrasonographic determinants. Mean gestational sac size and crown-rump length were chosen as the discriminant criteria for predicting pregnancy outcome.

The discriminant function and cutting score were as follows:

$$\text{Discriminant score (D)} = 0.09938 \text{ CRL} + 0.1903 \text{ G-SAC} - 3.9587$$

$$\text{Cutting score} = \frac{n_2 C_1 + n_1 C_2}{n_1 + n_2} = 1.1675$$

(n: group size, C: group centroid)

The discriminant function is shown in Fig IV.

Classification results are presented in Table III. With this discriminant function, the percentage of correct classification was 93.7%. Sensitivity, specificity, positive predictive value and negative predictive value were 75.5%, 96.8%, 81.3% and 95.8%, respectively. As a result, the discriminant function could be modified to the practical equation.

Table 1. Clinical Characteristics of 111 Patients

	Normal Pregnancy (n=94)	Early Abortion (n=17)
Maternal Age (years)	29.15 ± 4.15	29.86 ± 4.71
Vaginal Bleeding	19 (20.2%)	10 (58.8%)
Lower Abdominal Pain	5 (5.3%)	1 (5.8%)
Previous Spontaneous Abortion	28 (29.8%)	6 (35.3%)
Outcome	51 Deliveries	17 Abortions
	43 On-going pregnancies	

Table 2. Comparison of Early Abortion with Normal Pregnancies

G.A.	No. of Cases		G-SAC (mm)		CRL (mm)		FHR (bpm)	
	Normal Preg.	Early Ab.	Normal Preg.*	Early Ab.*	Normal Preg.*	Early Ab.*	Normal Preg.*	Early Ab.*
6 Weeks	33	3	21.5±5.0	17.7±4.7	5.1±3.3	2.7±0.6	121±15	118±25
7 Weeks**	38	7	27.4±5.0	18.4±6.5	9.8±3.6	3.4±1.5	142±15	94±9
8 Weeks**	12	5	34.2±5.4	14.1±6.2	15.2±4.1	7.4±4.4	162±11	127±16
9 Weeks**	11	2	38.2±5.6	16.0±2.8	21.3±3.4	9.0±4.2	173±12	135±21

G.A.: Gestational Age

*Mean±S.D.

**p<0.01 in G-SAC, CRL, FHR

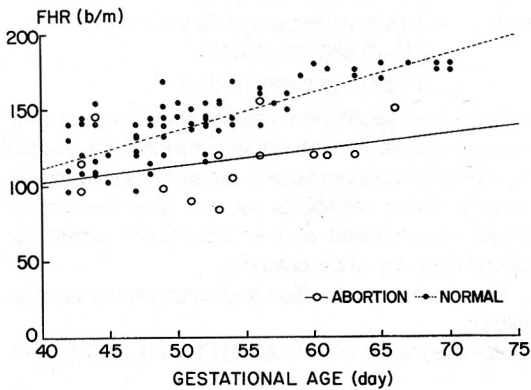


Fig. 1. GA vs. FHR

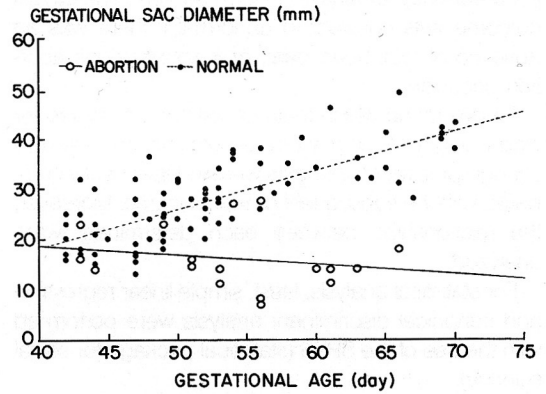


Fig. 3. GA vs. GSAC

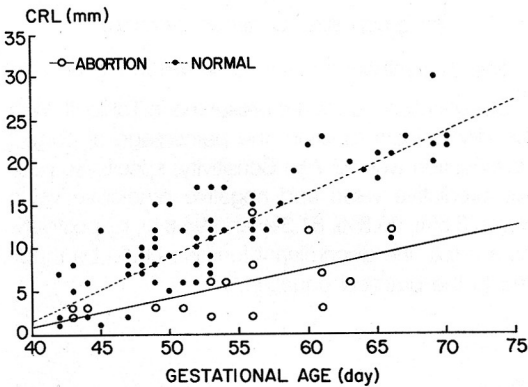


Fig. 2. GA vs. CRL

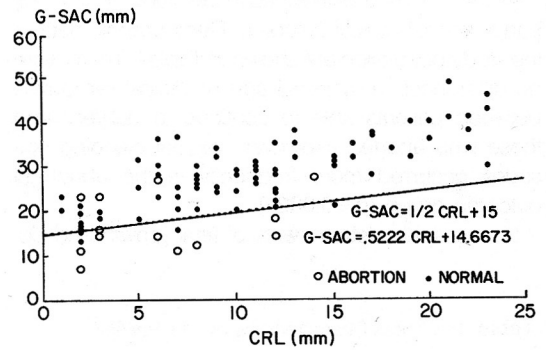


Fig. 4. G-SAC vs. CRL

$$G-SAC = 0.5222 CRL + 14.6673 \approx 0.5 CRL + 15$$

Thereafter, attempts were made to test 4 rules which can predict clinical outcome. The four rules were as follows:

- Rule I : $G-SAC_i < 0.5 CRL_i + 15$
- Rule II : $G-SAC_i < G-SAC_{i-14}$ (days)
- Rule III : $CRL_i < CRL_{i-14}$ (days)

Rule IV : $FHR_i < FHR_{i-14}$ (days)

(i = gestational days)

Rule I presents a discriminant equation which indicates relatively early oligohydramnios. Rules II, III and IV show delayed fetal growth and development similar to a gestational age of more than 14 days younger.

Table 3. Classification Results

	Early Ab.	Normal Preg.	Total
$D \leq$ cutting score	13	3	16
$D >$ cutting score	4	91	95
Total	17	94	111

D: Discriminant Function

% of Correct Classification = 93.7%

Sensitivity = 76.5% Positive Predictive Value = 81.3%

Specificity = 96.8% Negative Predictive Value = 95.8%

When Rules I or II or III were satisfied (Table IV), classification results were similar to the results obtained with the discriminant equation (Table III), and while sensitivity was same, the specificity was lower (91.5% vs 96.8%). Therefore, neither Rule II nor III provide further information in the prediction of clinical outcome.

On the contrary, when Rules I or IV were satisfied, that is to say if FHR was included, sensitivity was higher (94.1%) without a significant change of specificity (Table V). Among the 4 cases which were not predicted by Rule I alone (Table III), 3 of these cases could be predicted when Rule IV involving FHR was added to the screening procedure.

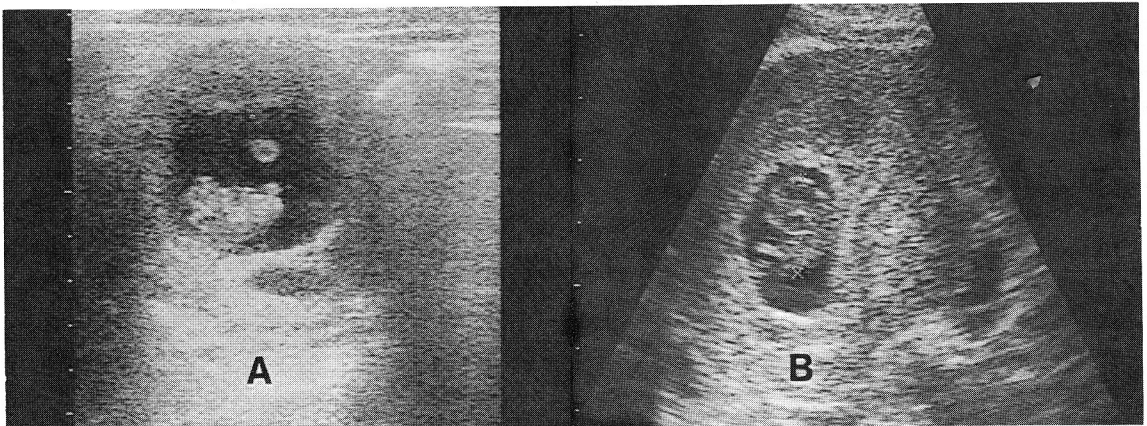


Fig. 5. A. Ultrasonographic findings of transverse section of the uterus, with normal pregnancy outcome. Fetal crown-rump length was 20mm and the mean gestational sac was 33mm. ($G-SAC > 0.5 CRL + 15$)
 B. Early oligohydramnios with 16mm fetus which progressed to spontaneous abortion 7 days later on follow-up sonography. The mean gestational sac size was 21mm. ($G-SAC < 0.5 CRL + 15$)

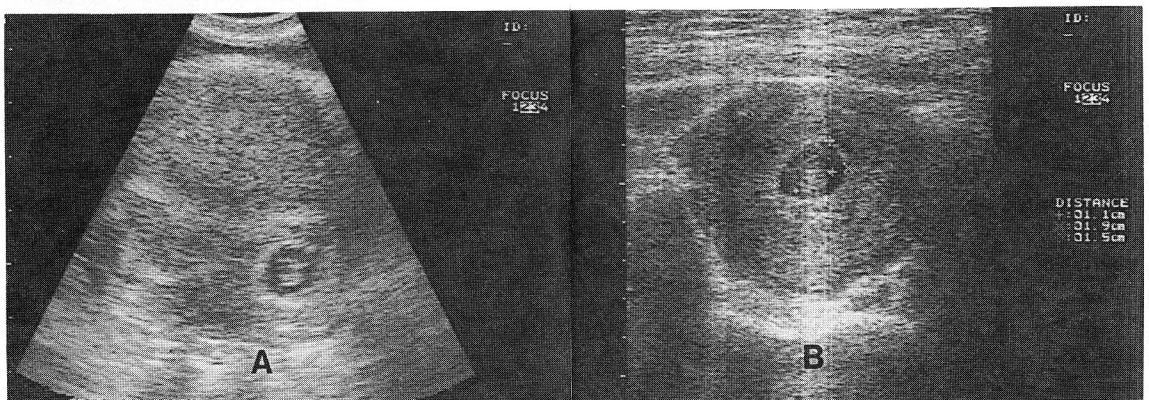


Fig. 6. Another two cases of early pregnancies with unsuccessful outcome.
 A. Without concern for the gestational age, oligohydramnios was noted as the sonographic finding. Mean gestational sac size 11mm and the 7mm crown-rump length, ($G-SAC < 0.5 CRL + 15$), which aborted a few days later.
 B. This pregnancy showed 17mm gestational sac size and 11mm fetal pole, ($G-SAC < 0.5 CRL + 15$). This indicated oligohydramnios and predicted a grave prognosis at outcome.

Table 4. Screening Results When Rules I/II/III are Satisfied

	Early Ab.	Normal Preg.	Total
Predicted	13	8	21
Unpredicted	4	86	90
Total	17	94	111

% of Correct Classification = 89.2%

Sensitivity = 76.5% Positive Predictive Value = 61.9%

Specificity = 91.5% Negative Predictive Value = 93.5%

Table 5. Screening Results When Rules I/IV are Satisfied

	Early Ab.	Normal Preg.	Total
Predicted	16	7	23
Unpredicted	1	87	88
Total	17	94	111

% of Correct Classification = 92.8%

Sensitivity = 94.1% Positive Predictive Value = 69.6%

Specificity = 92.6% Negative Predictive Value = 98.9%

DISCUSSION

The pregnancy failure rate after the detection of fetal heart beat has been reported differently according to gestational age, such as 20-24% at intrauterine pregnancy (IUP) 5-6 weeks (Levi *et al.*, 1990), 10-12% at IUP 6-7 weeks and 2-2.3% at IUP 7-12 weeks (Nyberg *et al.* 1987). The rate of spontaneous abortion in our investigation was 15.7%.

However, it has been uniformly reported that patients with threatened abortion, in whom sonographic examination shows a live fetus, will have a successful pregnancy outcome in approximately 90% of cases. In any series of investigation, the challenge is to characterize the 10% of live pregnancies that result in an unfavorable outcome. It has been suggested that there is a significant association between small CRL and poor outcome of pregnancy, so-called 'early fetal growth delay'. In this investigation, early intrauterine growth retardation, as shown by small G-SAC, CRL and FHR had a significant impact on early abortion ($p < 0.001$). It is suggested that an exceptionally small G-SAC with a relatively normal CRL and FHR for a given gestational age is a more reliable impending sign of early abortion than an overall reduction of G-SAC, CRL and FHR. However, none of these findings have been found to have a sufficiently high positive predictive value to permit confident diagnosis of intrauterine growth retardation. Despite this phenomenon of intra-

uterine growth retardation, the biologic nature and implications are obscure. It is suggested that the fetus might be in stress in early life from placental insufficiency or a fetal defect.

As another biometric parameter, first trimester embryonic bradycardia has been previously as an indicator of impending fetal loss (Shenker *et al.*, 1986). However, a biometric parameter alone can not be an absolute predictor of outcome. In order to predict clinical outcome more efficiently and accurately, we attempted to test each biometric parameter individually and in combination. Surprisingly, it was found that early intrauterine growth retardation as expressed in our discriminant equation can predict clinical outcome more correctly.

While Levi *et al.* reported that a mean sac diameter less than the 95% confidence interval has a predictive value of 71% for abnormal outcome, our discriminant equation with the G-SAC and CRL showed a predictive value of 81% for abnormal outcome (Levi *et al.*, 1990). This discriminant equation allows accurate prediction of early pregnancy failure using only one or two sonographic parameters. Thus, not only early intrauterine growth retardation based on each biometric parameter but also early oligohydramnios, as shown in the relation of CRL to G-SAC ($G-SAC < 0.5222 CRL + 14.6673 = 0.5 CRL + 15$) can provide further information to predict early pregnancy outcome regardless of gestational age. Additional inclusion of FHR with discriminant equation ($G-SAC < 0.5 CRL + 15$) showed a higher sensitivity (94.1%) in the prediction of early pregnancy failure. It is proposed that most cases of early abortion are caused by oligohydramnios combined with intrauterine growth retardation, but in cases with normal fetal gestational sac size and crown-rump length, cardiac immaturity, *i.e.*, bradycardia seems to be the cause.

In conclusion, with the sonographic findings of early intrauterine growth retardation, early oligohydramnios and bradycardia can predict the poor prognosis of early pregnancies with adequate certainty at the time of fetal heart beat detection.

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