

# Relationship of Small-for-Dates Sac Size to Crown-Rump Length and Spontaneous Abortion in Patients With a Known Date of Ovulation

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Spontaneous abortion after established sonographic viability is rare. This study prospectively evaluated 39 late first-trimester abortions after fetal viability was established by ultrasound. The average crown-rump length measurement and mean sac diameter in this group were determined and compared with predicted values based on known conception dates, and the discrepancy between actual and predicted measurements was noted. The same calculations were then made on 39 prospectively matched non-aborting controls. We also determined the difference between sac size and crown-rump length in both groups. Significant differences were found for all three measures. Small-for-dates sac size and small-for-dates crown-rump length were defined as having a discrepancy score greater than 1 standard deviation (SD) above normal. Small-for-dates sac/crown-rump length was defined as having a discrepancy score less than 1 SD below normal. A high percentage of aborters was correctly predicted by a mean sac diameter (82%) or crown-rump length (77%) that was greater than +1 SD, with few false positives (12.8 and 5.1%, respectively). The cutoff for differences of sac minus crown-rump length measurements (10.1 mm) was less sensitive (56%), but just as specific (82%). When both the mean sac diameter and crown-rump length were smaller than expected (according to known date of ovulation), the ability to predict abortion was 71% with few false positives (3.5%). (*Obstet Gynecol* 78:369, 1991)

Once fetal viability has been demonstrated at 8-10 weeks of gestation, subsequent spontaneous abortion is infrequent, occurring in less than 5% of pregnancies.<sup>1</sup> Theoretically, a defect in the embryo or gesta-

tional sac might account for these fetal deaths, and a small-for-dates crown-rump length or sac size might be predictive of such an occurrence.

In 1975, Robinson<sup>2</sup> presented data on the diagnosis of early pregnancy failure by sonography. He described six patients who he categorized as "early level abortions in which fetal heart movements were demonstrated by sonar prior to spontaneous abortion." He found that while the crown-rump lengths were all equal to or above the mean, the gestational sac volumes were all at or below the second standard deviation (SD) of normality.

Recently, Bromley et al<sup>3</sup> confirmed that a small sac size in the first trimester is a predictor of poor fetal outcome. Their study included a larger series than Robinson's<sup>2</sup> and found that when the mean sac size minus crown-rump length was less than 5 mm, 15 of 16 (94%) aborted despite previously demonstrating viability.

However, neither study included or acknowledged the precise date of conception; both addressed primarily the issue of the difference between sac size and crown-rump length. The study by Bromley et al<sup>3</sup> prospectively identified patients with a mean sac size smaller than crown-rump length and with viable fetuses, determined the subsequent abortion rate in that group, and then compared that rate with 53 consecutive first-trimester pregnancies.

In contrast to Bromley et al,<sup>3</sup> we prospectively evaluated all first-trimester spontaneous abortions occurring despite previous substantiation of fetal viability by sonography to determine whether small-for-dates sac sizes are prevalent in this group. Furthermore, in contrast to the studies of Robinson<sup>2</sup> and Bromley et al, the present study set out to determine, based on

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known actual date of conception, whether small-for-dates crown-rump length would also predict spontaneous abortion. Finally, the study was designed to compare the sensitivity and specificity of small-for-dates crown-rump length versus small-for-dates sac size and the difference between sac size and crown-rump length in order to determine which measurement if any, alone or in combination, is most predictive of abortion.

### *Materials and Methods*

All patients in the study initially presented with infertility. All pregnancies in our practice between January 1987 and December 1988 were included if the exact date of conception was known and a late first-trimester spontaneous abortion occurred after the demonstration of fetal cardiac activity by ultrasound at 8 weeks of gestation ( $N = 39$ ). The number of pregnancies examined during the study period was 1286, with the aborters representing only 3.03% of the total pregnancies.

The best control was considered to be the patient herself, so that any subsequent successful pregnancy in a woman with a previous "early live abortion" was included as a control ( $N = 15$ ) as long as the pregnancy occurred during the study. In order to include 39 matched controls in the study, we selected 24 additional pregnancies as controls.

When a patient was found with an early live abortion, she was matched with the next patient with a single live gestation at 8 weeks regardless of sac size or crown-rump length. If the aborting patient had a subsequent successful pregnancy, the latter replaced the selected control. Further requirements to be selected as a control included: 1) age within 2 years of that of the aborter, 2) 1.5 years' duration of infertility, 3) same number of previous abortions as the aborter, and 4) same type of infertility problem (ie, anovulation, including drug used; donor insemination, intrauterine insemination, male factor, or endometriosis). Patients with intrauterine hematomas or uterine fibroids were excluded (no early live aborters had to be excluded).

The date of conception in all cases was determined by pelvic sonography<sup>4</sup> and by assessment of functional follicular maturity through measurement of serum estradiol (E2) and progesterone.<sup>5</sup> Ovulation was presumed to occur 24 hours after the peak serum E2 was reached, and was confirmed by demonstrating the collapse by at least 5 mm of a previous mature-size follicle of an average of 18–24 mm in diameter.

Transvaginal fetal ultrasound was performed at 42–45 days post-conception by one experienced ultra-

sonographer using an ATL Ultramark 4 unit (Advanced Technology Laboratories, Bothell, WA) equipped with a 5-MHz endovaginal transducer. Mean sac diameter was calculated in millimeters from an average of the length, width, and height of the gestational sac, as measured from the inner wall. This measurement was then compared with the data of Hellman et al<sup>6</sup> for the same gestational age. Crown-rump length in millimeters was measured as the greatest length of the embryo, and the measurement was compared with the data of Robinson and Fleming.<sup>7</sup> Nomograms for both of these measurements can predict gestational age based on the first day of the last menstrual period preceding conception.

All patients had a repeat ultrasound examination at 12 weeks to confirm continued fetal viability, or sooner if clinically indicated to establish a diagnosis of spontaneous abortion.

The predicted gestational age was computed by adding 14 days to the interval from conception to the date of the ultrasound. The predicted age was then referred to the data of Hellman et al<sup>6</sup> to determine the predicted mean sac diameter, and to that of Robinson and Fleming<sup>7</sup> to determine the predicted crown-rump length. Mean sac diameter discrepancy was calculated by subtracting the actual sac diameter from the predicted value. The same procedure was carried out to determine the crown-rump length discrepancy. The actual crown-rump length was then subtracted from the actual mean sac diameter to determine sac/crown-rump length discrepancy.

Differences in the discrepancies between aborting and non-aborting patients were analyzed using a two-tailed, paired Student *t* test with  $P < .05$  needed to attain statistical significance. Data are expressed in mm  $\pm$  SD. Small-for-dates sac size was defined as a mean sac diameter discrepancy greater than 1 SD above normal. Similarly, small-for-dates crown-rump length was defined as a crown-rump length discrepancy greater than 1 SD above normal. Small-for-dates sac/crown-rump length was defined as a sac/crown-rump length discrepancy less than 1 SD below normal (normal was based on the mean value found for non-aborters). We calculated the sensitivity and specificity for small-for-dates sac size, small-for-dates crown-rump length, and small-for-dates sac/crown-rump length when considered individually and in various combinations.

### *Results*

Seventy-eight pregnancies in 63 patients were evaluated, 39 of which ended in a first-trimester spontaneous abortion and 39 of which did not. All non-aborters

**Table 1.** Comparison of Discrepancy Scores Between Aborters and Non-Aborters

Outcome	N	Mean sac diameter discrepancy (mm)	Crown-rump length discrepancy (mm)	Sac/crown-rump length discrepancy (mm)
Aborters	39	10.1 ± 6.1	5.7 ± 4.0	9.9 ± 4.5
Non-aborters	39	0.1 ± 4.0	0.4 ± 2.6	13.9 ± 3.8
P		<.001	<.001	<.001

had successful deliveries (as determined by telephone consultation).

Table 1 presents discrepancies between predicted and actual mean sac diameter and crown-rump length based on predicted gestational age, and the difference between mean sac diameter minus crown-rump length. For all three measures, the discrepancy in aborting pregnancies was significantly greater than that in non-aborters ( $P < .001$ ). Table 2 lists the distribution of aborters and non-aborters by sac size, crown-rump length, and sac/crown-rump length discrepancies.

The sensitivity and specificity in predicting subsequent abortion for a discrepancy of greater than 4.1 mm in mean sac size between that predicted by menstrual age and that observed were 82.1 and 87.2%, respectively. The sensitivity and specificity of a discrepancy of greater than 3.0 mm in crown-rump length between that predicted by menstrual age and that observed were 76.9 and 94.9%, respectively. When the difference between mean sac diameter and crown-rump length was 10.1 mm or less, sensitivity and specificity for subsequent abortion were 56.4 and 82.1%, respectively.

Table 3 demonstrates that the majority of aborters ( $N = 28$ ) had both a mean sac diameter and a crown-rump length more than 1 SD above the mean for non-aborters. Small sac or crown-rump length when considered alone was not as specific in predicting sponta-

**Table 2.** Distribution of Abortions by Sac Size, Crown-Rump Length, and Sac/Crown-Rump Length Discrepancy

Outcome	Sac size		Crown-rump length		Mean sac minus crown-rump length	
	Small for dates	Normal	Small for dates	Normal	Small for dates	Normal
	Aborters	32	7	30	9	22
Non-aborters	5	34	2	37	7	32
Total	37	41	32	46	29	49

**Table 3.** Distribution of Abortions by Combinations of Sac Size and Crown-Rump Length

Outcome	Small-for-dates sac size, normal crown-rump length	Normal sac size, small-for-dates crown-rump length	Small-for-dates sac size, small-for-dates crown-rump length	Normal sac size, normal crown-rump length
Aborters	4	2	28	5
Non-aborters	4	1	1	33

neous abortion as was the finding of both small sac and crown-rump length; ie, there were fewer false-positives if one used both criteria to evaluate the patient. There were only five aborters in whom both measures were normal. In contrast, in 33 of the 39 non-aborters, both of these measurements fell within normal limits.

### Discussion

The data presented here confirm that small-for-dates sac size is predictive of late first-trimester spontaneous abortion even after sonographic demonstration of fetal viability. There are, however, differences in methodology and results of the three related studies mentioned above. Robinson<sup>2</sup> studied only six patients who aborted during the first trimester after viability was determined, and all six had normal crown-rump lengths but small sac sizes; the low sac ratio was found in less than 5% of pregnancies progressing normally. Robinson defined "small" as being beyond 2 SDs of normal. The present study used only 1 SD as the cutoff and, in so doing, still found that this level would have predicted 82% (32 of 39) of first-trimester abortions after viability, while only falsely diagnosing 12.8% (five of 39) of the non-aborters. Certainly, increasing the cutoff to 2 SDs would eliminate false negatives and positives, but would also fail to detect many of these late live aborters. Using the 5-mm cutoff established by Bromley et al<sup>3</sup> for actual mean sac diameter minus crown-rump length, we would have detected only four of 39 (10%) of the aborters.

The main purpose of performing ultrasound at 8 weeks is to provide information for anxious patients concerning whether they will have a successful outcome, as subsequent spontaneous abortion is usually rare after viability at this time. Many of these patients might have been treated with progesterone and could have a higher rate of missed abortions. Certainly, complications from retained products are more severe with these more advanced pregnancies.

However, with normal viability and sac and crown-

rump length measurements, just one ultrasound examination should suffice for the first trimester. An abnormal ultrasound despite viability would caution the treating physician to order a subsequent sonogram in a week to 10 days. Therefore, we believe that the less stringent cutoff value is more useful because too many abortions would be missed using stricter criteria.

Bromley et al<sup>3</sup> assumed that measurement of crown-rump length provided the true gestational age of the fetus and that sac size could then be compared with this norm. Nyberg et al<sup>8</sup> also demonstrated a reduced rate of sac growth in spontaneously aborting versus non-aborting patients. However, our data, which included exact conception dates, show that the majority of these subsequent aborters demonstrate abnormalities in both crown-rump length and sac size, with the latter even disproportionately smaller. Nevertheless, mean sac diameter discrepancy and crown-rump length discrepancy were both more sensitive than the sac/crown-rump length discrepancy in detecting subsequent abortion, as the subtraction of actual sizes may fail to detect a small sac volume if the crown-rump length is equally early. In fact, if only crown-rump length discrepancy were used, application of the 1-SD cutoff value would have identified 76.9% of aborters and would have been falsely positive in only 5.1% of non-aborters.

The advantage of merely subtracting crown-rump length from sac diameter is that knowledge of the exact conception date is not necessary. Hertz et al<sup>9</sup> estimated that the menstrual history was accurate in only 18% of cases. Variability in the duration of the follicular phase may lead to dating that appears early or late, despite a normal pregnancy. Sabbagha<sup>10</sup> reported that in 15% of normal pregnancies, there was a considerable difference between actual birth date and that predicted by ultrasound. Other authors have also provided data suggesting difficulties in dating gestational age by conventional ultrasound nomograms.<sup>11-13</sup> The original dating methods by Hellman et al<sup>6</sup> for sac size and by Robinson and Fleming<sup>7</sup> for crown-rump length were subject to the above problems because actual conception dates were not precisely known. Therefore, inaccuracies might occur from comparing actual measurements with these predicted measurements. Nevertheless, these long-established values appear to be fairly accurate based on our data, as there were almost no differences between our non-aborters' actual crown-rump lengths or sac diameters and those that were predicted based on the date of conception.

The women used for this study were all infertility patients; thus, these findings may not apply to the general population. However, because infertility pa-

tients or habitual aborters are the groups of women most in need of sonography at 8 weeks' gestation and because their conception dates are usually known with fair accuracy, our data support evaluating potential later abortion despite present viability. Such evaluation includes not merely calculating the actual difference in measurement of crown-rump length and sac size, but also measuring the difference between actual mean sac diameter and actual crown-rump length versus the standard predicted values based on gestational age to determine whether these measurements fall outside the cutoff range when there is a significant increased risk of spontaneous abortion.

Bromley et al<sup>3</sup> provided ultrasound data from 5.5-9 weeks. We have found that actual crown-rump length and mean sac size differences may not be constant throughout the first trimester but may actually increase with advancing gestation. All of the pelvic sonograms in our study were performed at 8 weeks, a time that we believe provides the most useful information to prevent false positives or negatives. Possibly the use of earlier ultrasound allowed Bromley et al to conclude that 5 mm was the most useful difference of the two values, but this would have detected only a small minority of the aborters in our study. The methodology of Bromley et al—prospectively isolating all those patients with small sacs and then determining the abortion rate—does not allow the reader to determine what percentage of late live aborters would have been missed by their more narrow criteria.

Based on our data, it seems appropriate to recommend that a woman with a viable gestation at 8 weeks but a small-for-dates crown-rump length or sac size should have a repeat sonogram later in the first trimester. Normal values would markedly reduce the cost-effectiveness of a repeat procedure.

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