Ultrasonographic Evaluation of Gestational Sac, Yolk Sac, Embryonic Heart Rate and Crown Rump Length as Prognostic Factors for First Trimester Pregnancy Outcomes

**Ayman El Sayed Solyman, Hamed Elsayed Ellakwa, Adel Gaber Allam,
Hasnaa Samir Aboumosalam Mousa*, Eman Said Badr**

Department of Obstetrics and Gynecology, Faculty of Medicine, Menoufia University, Egypt

*Corresponding author: Hasnaa Samir Aboumosalam Mousa, **Mobile:** (+20) 01014939630, **E-mail:** hasna2samir@gmail.com

ABSTRACT

Background: According to estimates, between 30% and 40% of implanted pregnancies end in spontaneous abortion in the first trimester, with the majority happening fairly early on.

Objectives: To evaluate gestational sac (GS) diameter and shape, yolk sac (YS) diameter and shape, embryonic heart rate (EHR) and crown rump length (CRL) during the first trimester as prognostic factors of first trimester pregnancy outcome.

Patients and Methods: This prospective observational cohort study was carried out on 118 patients in Shebin Elkom Teaching Hospital and Menoufia University Hospital in uncomplicated singleton pregnancy from (20-35) years old women.

Results: 109 cases (92.4%) resulted in an ongoing pregnancy and entered the 2nd trimester successfully, while 9 cases (7.6%) resulted in miscarriage. There was a highly statistically significant decrease in GS diameter, CRL, fetal heart rate but increase in YS diameter in fetal loss group more than ongoing pregnancy at 6, 9 and 12 weeks.

Conclusion: The best indicator of the prognosis for first trimester pregnancy outcomes was YS diameter measurement. Fetal heart rate, GS diameter, and CRL diameter were the next best predictors, and an increase in YS diameter beyond what is expected for any gestational age (GA) and a decrease in any of these factors are indicators of poor pregnancy outcomes during the first 12 weeks of pregnancy.

Keywords: CRL, Prognostic factors, EHR, Ultrasound, GS, YS.

INTRODUCTION

According to estimates, between 30% and 40% of implanted pregnancies end in spontaneous abortion in the first trimester, with the majority happening fairly early on [1]. A significant number of losses mostly happen relatively early in the gestation period; however, the risk of spontaneous abortion steadily drops to 2–5% after fetal cardiac activity develops [2].

On sonography, the intrauterine GS appears first, then the YS and the fetal pole with heart activity. When the mean GS diameter is between 5 and 6 mm, transvaginal sonography can readily identify a YS. It is well acknowledged that when a GS is larger than 8 mm, the YS should be examined [3].

Indeed, from the start of the fifth gestational week to the conclusion of the tenth, the size of the YS gradually grows. The size of the YS then steadily reduces [2].

After the completion of the 10th or 11th week of gestation, the YS shrinks quickly and finally vanishes[4].

When the embryo is at least 5 mm in size, cardiac activity should be seen. Additionally, heart activity should be visible to a doctor at 7 weeks of GA. From 100 beats per minute at 6 weeks to 170 beats per minute at 8 weeks, heart rates fluctuate with GA. With a transvaginal ultrasound, we can precisely show the EHR and determine if a fetus with bradycardia (less than 100 bpm) would have a successful pregnancy. Prenatal ultrasonography often detects the fetal heartbeat in M-mode by 6 weeks of gestation [5].

This study aimed to evaluate gestational sac (GS) diameter and shape, yolk sac (YS) diameter and shape, embryonic heart rate (EHR) and crown rump length (CRL) during the first trimester as prognostic factors of first trimester pregnancy outcome.

PATIENTS AND METHODS

This prospective observational cohort study was carried out on 118 patients in Shebin Elkom teaching Hospital and Menoufia University Hospital, outpatient clinic and Obstetrics and Gynecology Department in uncomplicated singleton pregnancy from (20-35) years old women from October 2022 to October 2023.

Sample size estimation:

Based on review of past literature who found that the cut off value of gestational sac diameter at 6 weeks was 1.92,below this value the loss of pregnancy was 85.0% the more than this value the complete of pregnancy was 78.0% (AUC=.888). At 9 weeks, the cut off value was 3.11, the sensitivity was 90.0%, specificity was 93.0% and the accuracy was 91.0% (AUC=.917). The sample size is calculated using statistics and sample size pro program version 6 the sample size is 118. The power of study is 80% and confidence level is 95% [2]**.**

Pregnant women were divided into groups as follow:

- **Group (1):** women who were examined during (6-7 weeks + 6 days).
- **Group (2):** women who were examined during (8-9 weeks + 6 days).
- **Group (3):** women who were examined during (10-12 weeks).

- **Group (4):** women with first trimester spontaneous miscarriage.

Inclusion criteria: All patients in first trimester between 6-12 weeks, the patient knew exactly when her singleton pregnancies were due. Age range: 20 to 35 years.

Exclusion criteria: Patient declined transvaginal sonography, refusing follow-up care. Any fibroid disease or septal abnormality in the uterus. Individuals suffering from conditions such as severe anemia, thyroid dysfunction, diabetes mellitus, persistent hypertension. A pregnant patient with a molar. Inconsistent menstrual cycles or an unclear date of the last menstrual period.

Scanning technique:
Every pregnant woman gave their informed permission before a transvaginal scan was performed. The device we utilised for our investigation was a GE Healthcare logic V5 equipped with a 7–12 MHz TVS probe. America has had enough of empty bladders. Both the coronal and sagittal planes were scanned. TVS was performed using a holistic method. The uterus was scanned first, followed by the adnexa and the cul-de-sac. Both the YS and the GS were recognised. Callipers were placed at the inner edge of the YS to measure its inner diameter. It was determined that the typical diameter ranged from 2 to 5 mm. A YS was classified as large if its diameter was greater than 5 mm and as little if it is less than 2 mm.

The embryo was detected, and the intrauterine mean GS diameter was assessed. Afterwards, the EHR was measured following confirmation of embryo viability. The limbs and YS were not included in the measurement of the baby's centimeter-long limb (CRL), which was measured from the top of the baby's head (crown) to the bottom of their buttocks (rump) at 13 weeks of pregnancy, when it reached approximately 7 cm. if sub chorionic Hge. is present, its detection. At 9–12 weeks, nuchal translucency was assessed. If the pregnancy lasted until 13 weeks, it was deemed normal; if it ended in an abortion, it was deemed abnormal.

Follow up of cases:
Following a 12-week gestation period, the status of every pregnancy was monitored using a follow-up ultrasound exam. One of the negative consequences was an unplanned miscarriage that happened either before or at 12 weeks of pregnancy.

Ethical approval:
Menoufia Medical Ethics Committee of the Menoufia Faculty of Medicine gave its approval to this study. All participants gave written consent to participate in the study after receiving all information. The Helsinki Declaration was followed throughout the study's conduct.

Statistical analysis
Using an IBM-compatible personal computer running SPSS version 26.0, data were gathered, tallied, and statistically evaluated. Quantitative data were reported as mean±SD and range and were compared by Mann-Whitney's test (U). ROC curves were used to calculate the diagnostic performance of GS and YS diameters, CRL, and fetal heart rate. P <0.05 was considered significant.

RESULTS
Table (1) shows that mean age of studied females was 26.98±4.26, 38.1% were below 25 years and 61.9% above 25 years old. 14.4% were primigravida, 27.1% G2, 23.7% G3, 16.9% G4, 13.6% G5 and 4.2% were G6. 50% of studied females had history of CS and 11% did D&C.

Table (1): Demographic data of the studied cases (n=118).

		No.	%
Age	Mean ± SD	26.98 ± 4.26	
	Range (Minimum – Maximum)	20-35	
	<25 years	45	38.1
	≥25years	73	61.9
Gravidity	**PG**	17	14.4
	2	32	27.1
	3	28	23.7
	4	20	16.9
	5	16	13.6
	6	5	4.2
Surgical history	**Cesarian section**	59	50.0
	D&C	13	11.0

There was a highly statistically significant decrease in GS diameter, CRL, and fetal heart rate in fetal loss group more than ongoing pregnancy at 6, 9 and 12 weeks but increase in YS diameter (Table 2).

Table (2): Gestational sac diameter, yolk sac diameter, CRL and fetal heart rate at different gestational age period and its relation to the outcome of pregnancy.

Variable	Abortion (n=9) Mean ± SD Range	Ongoing pregnancy (n=109) Mean ± SD Range	U-Test	P value
GS diameter				
6-8 weeks	11.67±5.788 16-33	22.43±3.78 16-33	4.287	<0.001**
8-10 weeks	22.89±12.30 15-48	45.71±8.84 26-59	4.057	<0.001**
10-12 weeks	41.44±24.75 20-85	86.97±8.13 65 – 115	4.325	<0.001**
YS diameter				
6-8 weeks	4.51±1 3 – 5.8	2.57±0.4 1.8 – 3.5	5.875	<0.001**
8-10 weeks	5.49±1.55 2-7.2	4.54±0.42 3.5 – 5.2	3.274	<0.001**
10-12 weeks	6.1±1.1 4-7.3	2.85±0.87 1 – 5	10.527	<0.001**
CRL				
6-8 weeks	3.833±2.2 2 - 8	12.28±3.26 6- 19	4.869	<0.001**
8-10 weeks	11.56±5.7 7-22	26.41±2.64 19 - 33	4.894	<0.001**
10-12 weeks	21.33±12.69 13 - 45	43.97±4.53 32 - 51	4.116	<0.001**
Fetal heart rate				
6-8 weeks	88.89±19.95 70 - 120	129.63±9.995 110 - 155	6.065	<0.001**
8-10 weeks	100.33±18.25 76 - 135	146.02±9.46 125 - 165	7.429	<0.001**
10-12 weeks	87.33±15.297 74 - 115	136.08±8.895 118 - 155	9.430	<0.001**

U-Test: Mann-Whitney test, **: Highly significant

The cutoff value of gestational sac diameter at 6, 9 and 12 weeks to predict the outcome of pregnancy. It was 15 at 6 weeks, the sensitivity was 77.8%, specificity was 100% and the accuracy was 86%. At 9 weeks, the cutoff value was 27, sensitivity was 77.8%, specificity was 99.1% and the accuracy was 86%. At 12 weeks, the cutoff value was 57.5, sensitivity was 77.8%, specificity was 100% and the accuracy was 86% (figure 1).
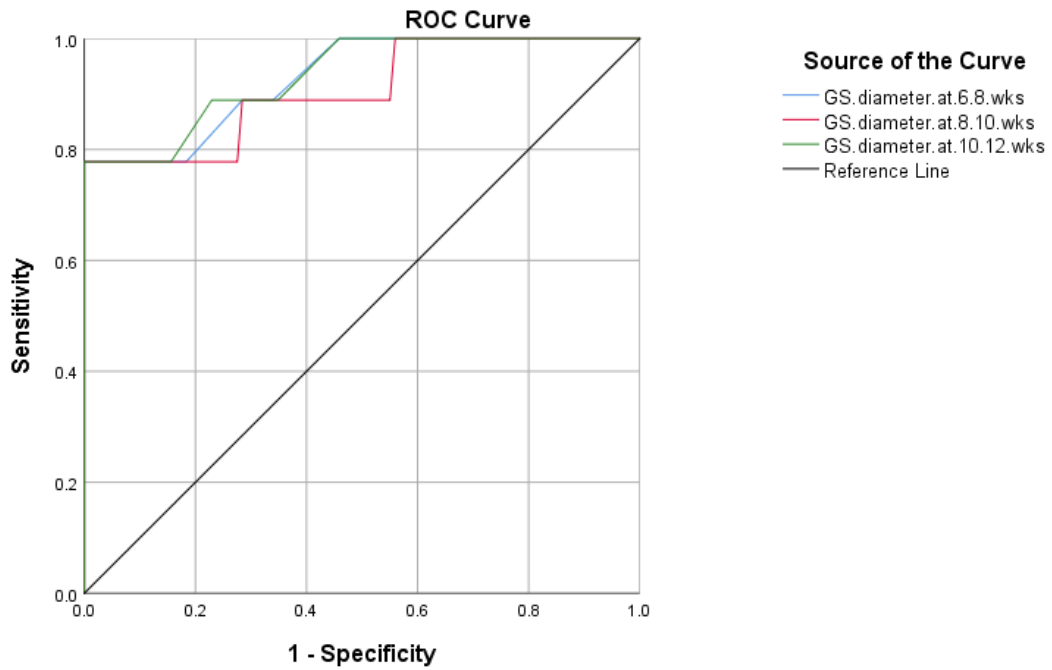
Figure (1): ROC curve study of the appropriate cutoff point for GS diameter at various GA.

The cutoff value of YS diameter to predict the outcome of pregnancy was 3.75 mm at 6 weeks, at 9 weeks, the cutoff value was 5.25 mm, at 12 weeks, the cutoff value was 4.75 mm. The cutoff value of CRL to predict the outcome of pregnancy was 8.5 mm at 6 weeks, 14.5 mm at 9 weeks, and at 12 weeks, it was 33 mm. Finally, the cutoff value of fetal heart rate to predict the outcome of pregnancy was 104 bpm at 6 weeks, 126 bpm at 9 weeks, and at 12 weeks, the cutoff value was 117 bpm (Figures 1-3).
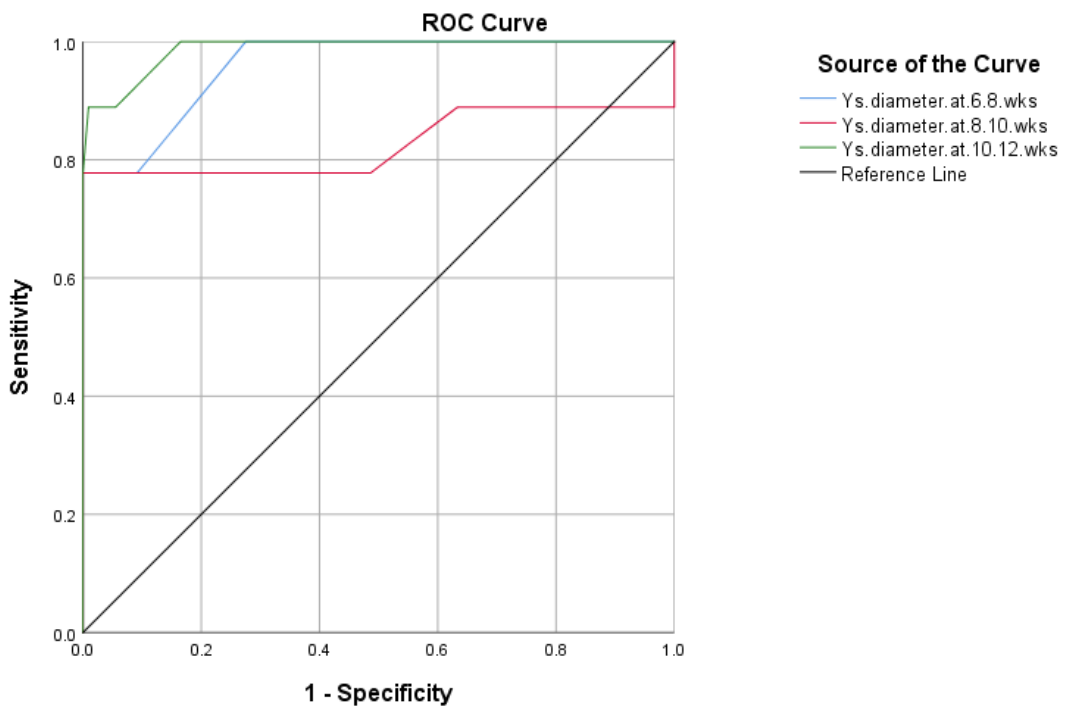

Figure (2): ROC curve study of the appropriate cutoff point for YS diameter at various GA.
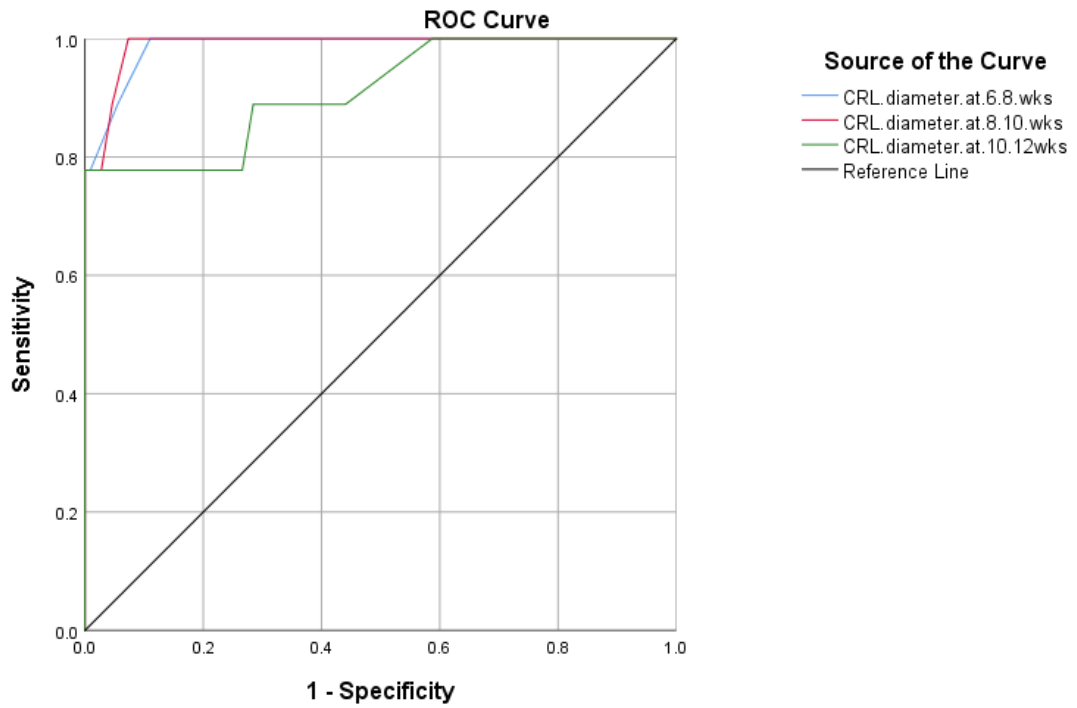
Figure (3): ROC curve study of the best cutoff threshold for CRL diameter at various GA.
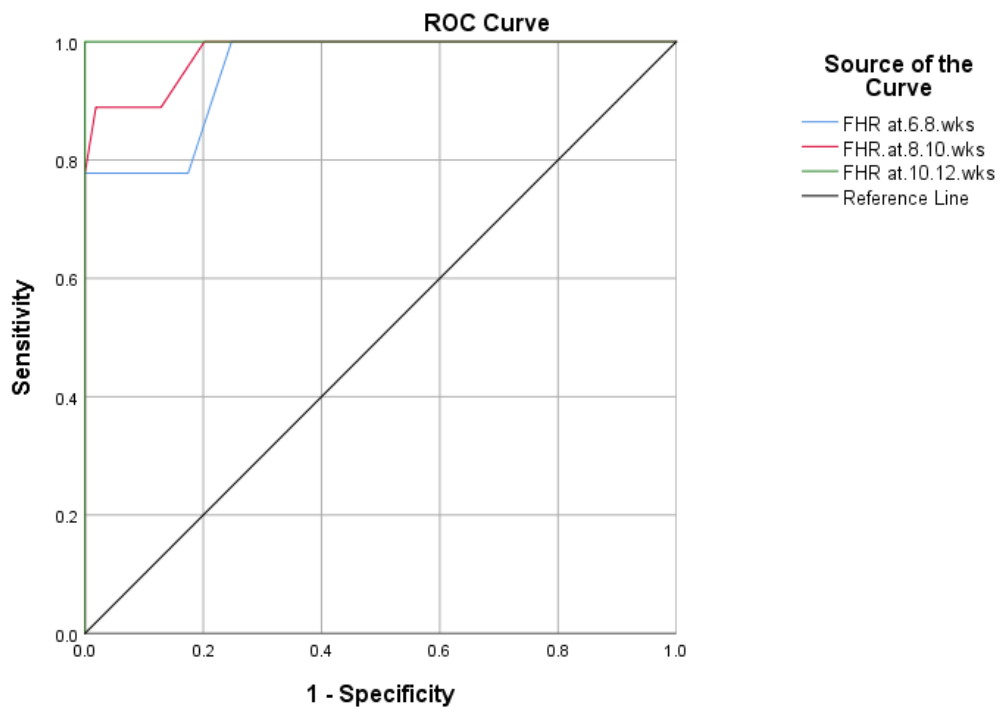

Figure (4): ROC curve study of the appropriate cutoff point of fetal heart rate diameter at various GA.

DISCUSSION

The assessment of YS diameter, followed by fetal heart rate, GS diameter, and CRL, was found to be the most accurate predictor of first trimester pregnancy outcomes in our study.

The mean age of the females under investigation in our study was determined to be 26.98±4.26, which was in line with the findings of a previous study by **Patel et al.** [6], which revealed that the study population's mean age was 26.6 years.

The present study showed that 9 cases (7.6%) developed abortion and 109 cases (92.4%) continued their pregnancy after 12 weeks. This was comparable to previous study by **Hassan et al.** [7] who examined 136 expectant mothers; 9 (6.6%) of pregnancies ended early, and 127 (93.4%) of them carried on past the 12-week mark. But lower than **Detti et al.** [8] as they found that embryo loss occurs in 61 of 304 (20%) embryos.

The current study found that at 6, 9, and 12 weeks, the GS width was significantly smaller in the group of women who had fetal loss than in the group of women who continued to be pregnant. Similar to this, some research employed 3D ultrasonography to measure the trophoblast or GS volume in order to forecast miscarriages in the early stages of pregnancy [9–11].

According to **Abd Ellatif et al.** [2], the GS diameter at six weeks had a cutoff value of 1.92; a pregnancy was lost at a rate of 85.0% below this value and 78.0% full. After nine weeks, the accuracy was 91.0%, specificity was 93.0%, sensitivity was 90.0%, and the cutoff value was 3.11.

In terms of the relationship between the form of the GS and the outcome of the pregnancy, 109 (92.37%) of the cases had a round and normal GS. Two instances (22.2%) had an irregularly shaped GS, whereas nine cases (7.63%) had a failed pregnancy and seven cases (77.8%) had a normal form. The morphology of the GS and the outcome of the pregnancy were shown to be extremely significantly correlated (p<0.001).

According to **Wang et al.** [12], GA was not taken into consideration as an analytical parameter in the miscarriage prediction mode created by a convolutional neural network. Instead, the focus was on the morphologic features of the GS.

In terms of YS diameter, the current study revealed that at 6, 9, and 12 weeks, the fetal loss group had a significantly higher rise in YS diameter than the continued pregnancy group. **Wie et al.** [11] demonstrated that the larger YS was linked to 77.78 percent of the abortions in their research, which is consistent with our findings. Moreover, a statistically significant difference in YS width was observed by **Srivastava et al.** [13] between the groups that had miscarriage and those that continued their pregnancy. Furthermore, it has been determined that an enlarged YS is linked to miscarriage [4].

On the contrary, aberrant results were reported by **Burton and Jauniaux** [14] with normal YS size and shape. These results confirm that YSD within the normal range does not always result in favourable outcomes. Variations in YS morphology may not be the main reason for miscarriage; rather, they might indicate aberrant embryonic development or death. Another theory is that between weeks 8 and 10, the embryo's blood supply transitions from the YS to the placenta, and this may be the result of a defect in the transfer. This is indicated by the disappearance of arterial signals in the YS circulation and the concurrent increase in the umbilical placental blood flow. At this specific GA, more research is necessary as this might be the cause of miscarriage.

Additionally, we demonstrated that the fate of a pregnancy could be predicted using the cutoff value of YS diameter at 6, 9, and 12 weeks. At six weeks, it was 3.75, with 77.8% sensitivity, 100% specificity, and 86% accuracy. After nine weeks, the accuracy was 86%, specificity was 100%, sensitivity was 77.8%, and the threshold value was 5.25. At 12 weeks, there was a very statistically significant difference with the threshold value being 4.75, sensitivity being 88.9%, specificity being 100%, and accuracy being 99%.

This was consistent with earlier research by **Kurjak et al.** [15], which provided the following criteria for subsequent first trimester death based on YS quality: 1-No YS; 2-Too large YS exceeding 6 mm (sensitivity 16%, specificity 97%); and 3-Too small YS below 3 mm (sensitivity 15%, specificity 95%).

According to **Hassan et al.** [7], the mean YS diameter in millimetres (mm) for the pregnancy loss group was 4.77± 0.81 at week nine and 3.24± 0 at week twelve. Likewise, **Sakr et al.** [16] demonstrated that 184 (92%) of the patients had a normal and circular YS morphology. Six instances (37.5%) had an irregular YS form, 10 cases (62.5%) had a standard YS shape, and 16 cases (8%) had a failed pregnancy. The form of the YS and the outcome of the pregnancy were shown to be significantly correlated (p<0.05).

In the current study, at 6, 9, and 12 weeks, the CRL diameter significantly decreased in the group with fetal losses compared to the continued pregnancy. This was consistent with other research because **DeVilbiss et al.** [17] discovered that small crown-rump length and low fetal heart rate were independent predictors of clinical pregnancy loss, with the highest risks noted for pregnancies with both traits. According to **Rashid et al.** [18], women who miscarried had a mean z-score of CRL that was considerably lower than those who remained to be in a viable pregnancy (-1.43 vs. -0.80, P = 0.030).

According to **Reljič** [19], miscarriage risk was higher for fetuses with a CRL of less than 18 mm at 13 weeks gestation. It's likely that a growth delay in the early stages of pregnancy results from improper development. When **Abdallah et al.** [20] performed first-trimester screening ultrasonography between 11 and 14 weeks, the false positive rate for miscarriage was 8.3% when using a CRL cutoff of 4 mm, and it was likewise

8.3% when using a CRL cutoff of 5 mm. Using a CRL cutoff of > 5.3 mm produced no false-positive findings.

It is known that the mean heart rate gradually rises from 6 weeks (120 to 140 bpm) to 9 weeks (145 to 170 bpm), after which it gradually stabilises to a lower heart rate for the remainder of the pregnancy. The EHR may be seen as early as 5 to 6 weeks of gestation. Research has shown that an embryo's heart rate of less than 100 beats per minute (bpm) is linked to an increased chance of miscarriage, and that when the rate is less than 80 bpm, the probability of embryonic death nearly reaches 100% [21].

More than continuous pregnancy, the fetal heart rate in the group experiencing fetal loss showed a statistically significant drop in the current study. The current study is consistent with several earlier studies that discovered that most individuals with EHRs less than 100 BPM had poor outcomes [22–24].

The results of **Adiga et al.'s study** [25] showed that the sensitivity, specificity, and accuracy for EHR (≥ 100 bpm) were 99.3%, 83.3%, and 98.5%, respectively. Furthermore, **Seungdamrong et al.** [26] found that in 78.3% (36/46) of singleton pregnancies, there was positive fetal heart activity at 6 weeks' gestation. The authors also showed that in terms of predicting an ongoing pregnancy, the presence of fetal heart activity at 6 weeks' gestation achieved 100% sensitivity, 100% specificity, 100% positive predictive values, and 100% negative predictive values.

Our study's key strength is that all of the ultrasounds were performed by a single researcher, which ensures low inter-observer variability and measurement consistency. The fact that every participant in the research had a precisely defined GA added to the precision of our findings.

CONCLUSION

Our research revealed that the greatest indicator of the prognosis for first trimester pregnancy outcomes was the assessment of the YS diameter, which was followed by the fetal heart rate, GS diameter, and CRL. Poor pregnancy outcomes within the first 12 weeks of pregnancy are predicted by decreased CRL diameter, fetal heart rate, GS diameter, and increased YS diameter compared to expectations at any GA.

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