RESEARCH
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PREDICTIVE POTENTIAL OF YOLK SAC DIAMETER IN PREGNANCY A COMPREHENSIVE EVALUATION OF FETAL WELL-BEING

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Abstract
Introduction: An essential technique in obstetrics, ultrasound makes non-invasive early pregnancy assessment easier. In terms of nutrition exchange, the yolk sac reaches its maximum size by the twelfth week. Pregnancy outcomes can be predicted with the help of transvaginal ultrasound early detection, which allows for prompt intervention and individualised treatment for expectant women.
Related Work: The importance of yolk sac measures in forecasting first-trimester pregnancy outcomes has been highlighted by a number of research. The results show a correlation between aberrant yolk sac parameters (diameter and shape) and poor outcomes.
Aim and Objective: The study aims to quantify yolk sac diameter at a certain gestational age, classify these measurements, and examine the relationship between these measurements and the course of the pregnancy. Through the pursuit of these goals, the study hopes to make a significant contribution to our understanding of the predictive function of yolk sac diameter, which may have an effect on early pregnancy screenings and therapies.
Method: The study, which concentrated on expecting moms between the ages of 6 and 10 weeks gestation. Strict inclusion and exclusion standards guaranteed a representative sample. The yolk sac diameter was assessed using transvaginal ultrasonography (TVS), and accurate results were obtained through careful data collection and ethical concerns.
Result: The yolk sac's size grows as gestational age increases, and diagnostic accuracy tables demonstrate how well yolk sac diameter and shape measurements predict outcomes. These results offer important new information for improving prenatal care.
Discussion: The study examined the predictive significance of yolk sac diameter in 150 pregnant women and found that aberrant yolk sac diameter was associated with greater odds of unfavourable outcomes.
Conclusion: Larger yolk sac diameters have been linked to unfavourable pregnancy outcomes, according to the study, which highlights the significance of routine yolk sac biometry in early pregnancy examinations for improved prognostic insights.
Keywords: Yolk sac diameter, Early pregnancy assessment, Transvaginal ultrasound, Pregnancy outcomes, Gestational age, Prenatal care

I. INTRODUCTION

With benefits including ease of use, mobility, speed, and accuracy, ultrasound is a crucial non-invasive diagnostic technique in obstetrics. The yolk sac, the earliest extraembryonic structure, is apparent at the end of the sixth week and serves as a crucial pathway for the exchange of nutrients prior to the establishment of placental circulation. By the twelfth week, its diameter has peaked and is receding. Results are predicted using ultrasound markers such as a slow heart rate in the embryo, an abnormal gestational sac or yolk sac, and a poor decidual reaction. Peak functional activity occurs in the yolk sac between the fourth and seventh week, when it becomes detectable on transabdominal sonography around week seven. Unlike biochemical markers that are particular to a given scenario, TVUS is a typical baseline procedure.

The yolk sac, which resembles an egg sac surrounded with membranes, gives the developing embryo early nutrients and a rudimentary circulatory system. It is normally gone by the 12th week and actively participates in immune development, metabolic activity, and the collecting of foetal waste. Nine weeks into the pregnancy, Doppler tests show decreased vascularity, and there is a 62% chance of a normal pregnancy with a normal yolk sac. Predicting results is difficult because of a variety of contributing factors, especially since 80% of pregnancy losses happen in the first trimester. To enable appropriate intervention and psychological preparation for expectant moms, a dependable early assessment tool is essential

to customised management strategies. A proactive approach to potential difficulties is made easier with early detection, providing better informed and supportive prenatal care.

II. RELATED WORK

A study on 46 instances at five weeks pregnant was carried out at the Gynaecology department of the 6th October Hospital between February and August 2020. A statistically significant difference in mean yolk sac diameter (YSD) was found between terminated and continuing pregnancies, and abnormal yolk sac shape at 6 weeks was linked to worse pregnancy outcomes. At six weeks, a cutoff threshold of 2.8 was found. Nonetheless, there was no discernible variation in YSD at 9 and 12 weeks between the two cohorts, underscoring the prognostic significance of preliminary assessments. 52 first-trimester pregnant women participated in a different prospective cohort study conducted by [4], which linked yolk sac diameter (YSD) to unfavourable pregnancy outcomes. When it came to miscarriage prediction, YSD showed excellent specificity (100%) and sensitivity (97.8%). The significance of embryonic heartbeat rate (EHR) as a major predictor of first-trimester pregnancy outcomes was further emphasised by the study.

Eighty pregnant women between seven and ten weeks gestation participated in a prospective observational research [5]. They found that gestational age and yolk sac diameter were positively correlated, and that abnormal YSD had a 92.95% sensitivity and 66.66% specificity in predicting bad pregnancy outcomes. It was determined that pregnant women would benefit from knowing this information while discussing the potential for poor outcomes and the need for follow-up ultrasonography. In contrast, [6]'s prospective study from January 2015 to February 2016 with 254 pregnant women between 6 and 10 weeks and 6 days of gestation demonstrated the value of evaluating the secondary yolk sac width as a helpful tool in predicting pregnancy outcomes.

It [7] was to ascertain whether variations in the size of the yolk sac were linked to unfavourable pregnancy outcomes. The researchers observed a rapid increase in yolk sac diameter and volume prior to pregnancy loss, highlighting the continued necessity of assessing the yolk sac during first-trimester ultrasound evaluations, even if they did not find a statistically significant difference between 2D and 3D measurements. All [8] things considered, these studies support the importance of yolk sac measurements, especially those related to diameter and shape, as useful indicators of first-trimester pregnancy outcomes. Through their insights, they aid in the improvement of early assessment procedures and provide guidance for counselling and follow-up protocols for pregnant women.

III. AIM AND OBJECTIVE

Aim:

The study's objective is to evaluate the yolk sac diameter's predictive utility in predicting pregnancy outcomes. The goals are outlined in order to accomplish a thorough comprehension of this goal.

Objective:

- The main goal is to measure the yolk sac's diameter during the crucial six to ten-week period of pregnancy.
- This classification is crucial for comprehending variations in yolk sac size, which forms the basis for evaluating potential correlations with the progression of pregnancy.
- Through statistical research, we hope to determine the nature of the correlation between the size of the yolk sac at the start of gestation and the outcome of the pregnancy.

IV. METHOD

These included removing pregnant women with ectopic or molar pregnancies, those with multiple gestations, congenital uterine malformations, foetal anomalies, known endocrine illnesses, and those who were unwilling to participate. Data was gathered according to a methodical process. A thorough history and examination were performed on each participant, and pregnant women within the designated gestational period were selected from the outpatient department. Transvaginal Ultrasonography (TVS) cases were only included once informed consent was obtained, emphasising the ethical significance of patient consent. During the TVS technique, the patient was positioned dorsally and a sterile, lubricated transducer was introduced into the vagina, about 6 to 8 cm deep.

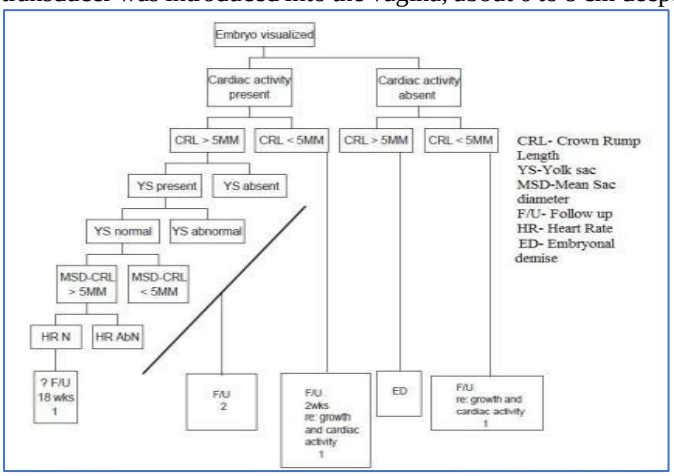

Figure 1: Representation of Early Prenatal (First trimester) Ultrasonography

After that, the patients were tracked until 20 weeks of gestation, at which point the results were classified as abnormal if the pregnancy ended in an abortion and as normal if it persisted above 20 weeks. The study's robustness and adherence to ethical and scientific standards are ensured by this meticulous and standardised data collection process, which also offers insightful information on the connection between yolk sac measurements and pregnancy outcomes.

A. Statistical Method:

The study's data analysis included a combination of descriptive and inferential statistical approaches to enable a comprehensive understanding of the research findings. Descriptive statistics, such as mean (average) and standard deviation (SD) with range (Min-Max), were used to present the results for continuous measures. For categorical measurements in the presentation, frequency and percentage were employed. The significance of the research parameters was assessed on a continuous scale between two groups using the Student t-test (two-tailed, independent) (intergroup analysis). This statistical method helps determine whether there is a significant difference between the means of the two groups. To analyse categorical scales between two or more groups, the Fisher Exact test or Chi-square test were

applied. These tests are suitable for examining the relationship and determining whether there is a significant relationship between categorical variables. Several criteria were used to assess how well yolk sac shape (regular/irregular) and yolk sac diameter (normal/abnormal) predicted outcomes (excellent outcome/missed abortion). The following formulas were used to determine the following metrics: sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV):
Sensitivity: The test's capacity to accurately identify the condition's carriers.

$$\text{Sensitivity} = \frac{\text{True Positive (TP)}}{\text{False Negative (FN)} + \text{True Positive (TP)} \times 100}$$

Specificity: The test's capacity to accurately identify those who do not have the illness.
Specificity is equal to True Negative (TN) + False Positive (FP) times 100.

$$\text{Specificity} = \frac{\text{True Negative(TN)}}{\text{False Positive(FP)} + \text{True Negative (TN)} \times 100}$$

Positive Predictive Value (PPV): The likelihood that individuals who test positive for the ailment actually have it.

$$Positive\ predictive\ value\ (PPV) = \left[\frac{TP}{TP + FP}\right] \times 100$$

Negative Predictive Value (NPV): The likelihood that individuals who test negative for the condition actually do not have it.

$$\text{Negative predictive value (NPV)} = \left[\frac{\text{TN}}{\text{FN} + \text{TN}}\right] \times 100.$$

Taking into account both positive and negative cases, these metrics offer a thorough evaluation of the diagnostic accuracy of yolk sac characteristics in predicting pregnancy outcomes. With a 95% level of significance, strong statistical inference was guaranteed. The normal distribution of dependent variables, random selection from the population, and the independence of cases in the samples were among the presumptions for statistical analysis.

B. Ethical Issues:

The study's ethical conduct was closely monitored by a series of strong guidelines and protocols. First, in a language appropriate for their comprehension, potential volunteers received a concise and understandable description of the nature and goal of the study. Before any patient could participate, a properly completed informed consent form a critical component of ethical research practices was obtained from them. Confidentiality and anonymity were maintained as the study's guiding principles. At every stage of data collection, analysis, and reporting, participant names were protected to guarantee the privacy and confidentiality of their information. Crucially, their choice to opt out did not jeopardise their entitlement to proper care and treatment, underscoring the moral precept of voluntary involvement. Careful attention was paid to financial issues in order to minimise any unnecessary hardship for the participants. No participant paid any more costs just for the study's objectives, and the investigator was in charge of any additional costs spent.
Additionally, before the study started, the "Institutional Ethics Committee" approved the protocol, providing ethical monitoring. Although no such cases occurred during the trial, a pledge to swiftly notify the ethics committee of any planned changes in the study protocol or design was upheld.

V. RESULT

The tables that are displayed give a thorough summary of the features of the yolk sac and how well they predict the outcomes of early pregnancy. Based on gestational age (GA) at enrollment, Table 1 presents the yolk sac circumference and shows a consistent increase in mean circumference from 6 to 9 weeks. The observed data show that yolk sac growth is dynamic in the early stages of pregnancy, ranging from 2.8 to 8.1 mm. Table 2 displays the distribution of favourable and poor outcomes throughout various weeks according on the gestational age at enrollment.

Table 1: Yolk sac circumference based on gestational age at enrolment

GA (Completed Weeks at the time of enrolment)	Cases	Minimum (mm)	Maximum (mm)	Mean (mm)
Upto 6 weeks	Sixty six	2.8	6.8	4.933
Upto 7 weeks	Forty Three	2.9	7.0	5.147
Upto 8 weeks	Twenty Three	2.8	7.2	5.319
Upto 9 weeks	Thirteen	2.9	8.1	5.575
Total	**150**	**2.8**	**8.1**	**5.271**

Notably, as gestational age increases, the number of positive outcomes declines while the percentage of negative outcomes trends upward. This shows that the chance of unfavourable outcomes could be influenced by the gestational age at enrollment.

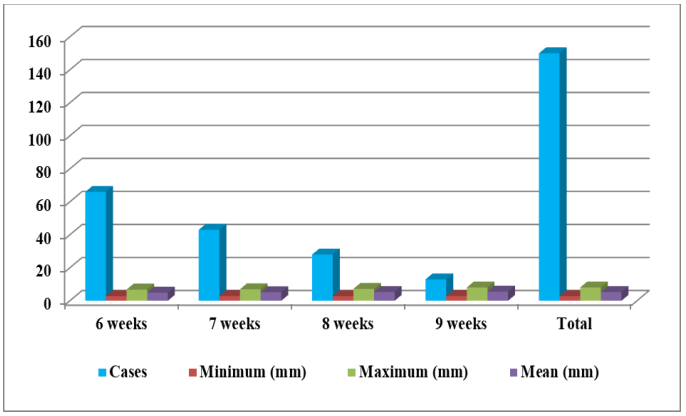

Figure 2: Representation of Yolk sac circumference based on gestational age at enrolment

Table 2: Outcome based on the gestational age at enrolment

GA (completed Weeks at the time of enrolment)	Positive result		Unsatisfactory Results	
	No of Cases	%	No of Cases	%
Upto 6 weeks	Fifty four	46.20	12	36.40
Upto 7 weeks	Thirty Five	29.90	8	24.20

Upto 8 weeks	Nineteen	16.20	9	27.30
Upto 9 weeks	Nine	7.70	4	12.10
Total	117	100.00	33	100.00

The diagnostic accuracy of irregular or regular yolk sac shape in predicting pregnancy outcomes is examined in Table 3. While the specificity of 87.88% indicates that the assessment of yolk sac shape is reliable in identifying cases with a missed abortion, the sensitivity of 86.32% implies that it is useful in identifying cases with a favourable result. While the negative predictive value of 64.44% indicates a moderate capacity to rule out missed abortions, the positive predictive value of 96.19% highlights the great possibility that a typical yolk sac shape corresponds to a positive outcome.

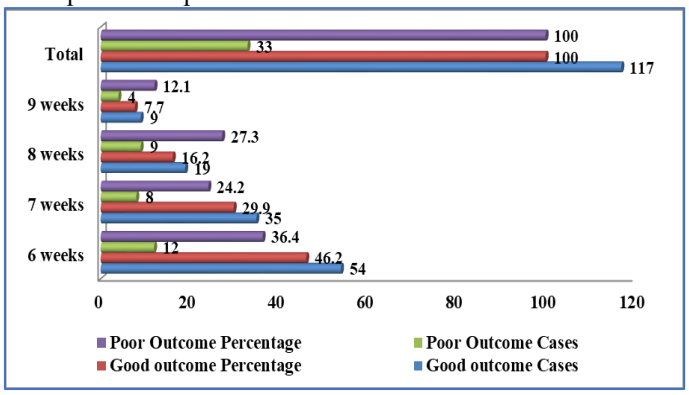

Figure 3: Representation of Outcome based on the gestational age at enrolment

The diagnostic accuracy of yolk sac diameter (normal/abnormal) in predicting pregnancy outcomes is the main topic of Table 4. The evaluation of yolk sac diameter is extremely good at identifying positive outcomes, as indicated by its high sensitivity of 91.45%, and its specificity of 87.88% indicates that it is good at identifying situations where an abortion was missed. A normal yolk sac width is associated with a favourable outcome, as indicated by the positive predictive value of 96.40%, while the negative predictive value of 74.36% indicates a reasonable ability to eliminate missed abortions.

Table 3: Accuracy of the yolk sac's form (regular or irregular) diagnostic forecasting the result (positive or missed abortion)

Parameter	Percentage	95% CI
Sensitivity	86.32	78.74% to 91.98%
Specificity	87.88	71.80% to 96.60%
PPV	96.19	90.95% to 98.45%
NPV	64.44	53.05% to 74.41%

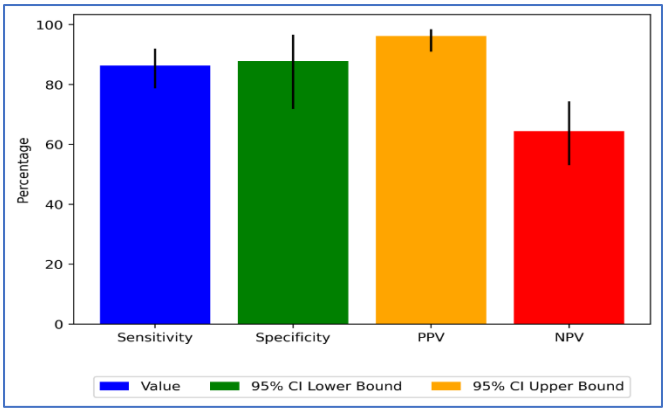

Figure 4: Representation of Accuracy of the yolk sac's form (regular or irregular) diagnostic forecasting the result (positive or missed abortion)

All of the data point to a relationship between early pregnancy outcomes and properties of the yolk sac. The yolk sac circumference increases with gestational age, which is consistent with the first trimester's typical growth patterns. Furthermore, the distribution of results across various gestational ages suggests that there may be a relationship between the chance of favourable or unfavourable outcomes and the date of the examination.

Table 4: Yolk sac diameter (normal/abnormal) diagnostic accuracy for forecasting the result (positive or missed abortion)

Parameter	Percentage	95% CI
Sensitivity	91.45	84.84% to 95.83%
Specificity	87.88	71.80% to 96.60%
PPV	96.40	91.42% to 98.53%
NPV	74.36	61.27% to 84.17%

The diagnostic accuracy tables demonstrate the predictive power of measurements of yolk sac diameter and shape. Both metrics are strong indications, as shown by the high sensitivity and specificity values; the sensitivity of yolk sac diameter is somewhat higher. Shape and diameter both have very high positive predictive values, highlighting their usefulness in predicting favourable results. Negative predictive scores, on the other hand, point to a moderate ability to rule out missed abortions, which emphasises the necessity of a thorough approach in early pregnancy evaluations.

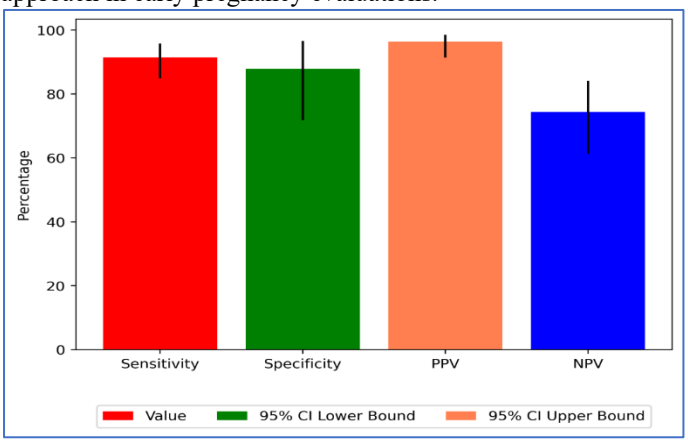

Figure 5: Representation of sac diameter (normal/abnormal) diagnostic accuracy for forecasting the result (positive or missed abortion)

The dynamic aspect of early pregnancy development is shown by the systematic increase in yolk sac circumference and the

differing percentages of excellent and bad outcomes at different gestational ages. The diagnostic accuracy tables demonstrate how well assessments of yolk sac shape and diameter work together to predict results, with each parameter providing a distinct set of information. By incorporating these findings into clinical practise, prenatal care could be enhanced and early pregnancy examinations could become more accurate.

VI. DISCUSSION

In order to shed light on possible associations between yolk sac features and gestational outcomes, the study examined the role of yolk sac diameter as a predictor of pregnancy outcomes in 150 pregnant women. Fifteen to twenty percent of pregnancies end in miscarriage, which is defined as the evacuation of a foetus or embryo from the uterus before 20 weeks of pregnancy or when it weighs less than 500 gm at birth. Chromosomal abnormalities, maternal age, uterine malformations, and other variables all play a role in spontaneous miscarriages; the first trimester is critical. Sonographic imaging reveals the yolk sac, a tissue that is essential for communication between the mother and the developing embryo. Women of all ages were enrolled in the study, but a sizable fraction were between the ages of 21 and 25. Cases of primigravida and multigravida were also included. Notably, the various stages of early pregnancy were reflected in the differences in gestational age upon enrollment. Measurements of the yolk sac diameter at 9 weeks revealed a mean of 5.575 mm, which is in line with other research. According to the data, a lesser fraction of cases had poor outcomes, while the majority of cases showed positive outcomes. Notably, a higher rate of unfavourable outcomes was linked to aberrant yolk sac diameter. Similarities in the trends of yolk sac width during gestation were seen when comparing this study to others, including Tawfik WM (2021) and Bhattarai A et al (2020). The study focused on the predictive usefulness of yolk sac diameter and examined the relationship between yolk sac features and pregnancy outcomes.

A variety of statistical techniques were used in the analysis to evaluate the diagnostic accuracy of yolk sac shape and diameter in terms of outcome prediction, including sensitivity, specificity, positive predictive value, and negative predictive value. High sensitivity and specificity were demonstrated by the data, highlighting the potential of yolk sac characteristics as trustworthy predictors. Informed permission, participant autonomy, confidentiality, and institutional ethics committee approval were all carefully taken into account when making decisions about ethics. The option to withdraw was given to participants without affecting their course of treatment, and they were not subjected to any further financial obligations. The research offers significant understanding into how yolk sac characteristics affect early pregnancy outcomes. The results highlight the importance of yolk sac diameter as a possible predictor of the health of the foetus. The study's sound methodological and ethical considerations improve the validity of its findings, laying the groundwork for more investigation into this important reproductive health topic.

VII. CONCLUSION

The study highlight a clear correlation between larger yolk sac diameter and worse pregnancy outcomes, with missed abortions being the most common unfavourable outcome in cases with larger yolk sac diameter. A statistically significant increase in the incidence of unfavourable outcomes was seen in the group with larger yolk sac diameters as compared to the normal group. Additionally, the study found a substantial correlation between aberrant yolk sac diameter and irregular yolk sac shape and unfavourable outcomes. Regular yolk sac shape and normal yolk sac diameter showed high sensitivity levels of 86.32% and 91.45%, respectively, in predicting successful pregnancy outcomes, according to the sensitivity analysis. The work is noteworthy because it shows that yolk sac diameter and shape are both reliable indicators of early pregnancy outcomes. This suggests that standard first-trimester evaluations should include yolk sac biometry. Although the study acknowledges the use of both measures as indicators, it shows that yolk sac shape may have a greater predictive capacity for unfavourable pregnancy outcomes. Given that yolk sac form has a better sensitivity and specificity than yolk sac diameter, evaluating the shape may offer a more sophisticated insight into the likelihood of unfavourable pregnancy outcomes. The premise that prompt treatments and enhanced prenatal care can result from early identification of anomalies in yolk sac features is supported by the study's recommendation to routinely incorporate yolk sac biometry in first-trimester examinations. When assessing the overall trajectory of pregnancy outcomes throughout the crucial early stages, a thorough assessment of the size and structure of the yolk sac becomes an invaluable tool for physicians. The study concludes by highlighting the significance of yolk sac biometry in early pregnancy outcome prediction, with a special emphasis on both shape and size. The study's practical prescription for routine evaluation and the nuanced prognostic capacity of yolk sac shape make it an important contribution to the advancement of prenatal care techniques and the understanding of early pregnancy diagnostics.

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