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Diagnostic Accuracy of Doppler Ultrasound in Ectopic Pregnancy

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ABSTRACT

Objective: To evaluate the diagnostic accuracy of Doppler ultrasound in the detection of ectopic pregnancy.

Methodology: This prospective observational study was conducted at PESSI Hospital, I-12, Islamabad, in collaboration with different hospitals for data collection. The study was carried out over a period of one year from October 2021 to September 2022. All pregnant women aged >17 years presenting with symptoms of ectopic pregnancy, regardless of parity, were included. All patients underwent color Doppler ultrasound using a dedicated machine. Subsequently, the patients were followed until they underwent surgical management, and the operative findings were meticulously recorded. Data were collected using a pre-designed proforma and analyzed with SPSS version 20.

Results: The mean age of the participants was 31.53 years, and the average gestational age was 6.03 weeks. 35.0% of the participants had a positive family history. According to color Doppler ultrasound findings, the majority of cases (96.7%) were identified as positive for ectopic pregnancy, while surgical findings confirmed ectopic pregnancy in 93.3% of cases. The sensitivity of color Doppler ultrasound was 100%, specificity was 60%. The positive predictive value (PPV) was 94% and negative predictive value (NPV) was 100%, suggesting that it was 100% accurate in ruling out ectopic pregnancy.

Conclusion: Color Doppler ultrasound was found to be a highly sensitive, reliable, and noninvasive tool in diagnosing ectopic pregnancy. However, the findings cannot be definitively applied due to limitations, particularly the small sample size. Further large-scale studies are strongly recommended for validation and confirmation of the findings.

Keywords: Ectopic pregnancy, Doppler ultrasound, Sensitivity, Specificity.

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Introduction

Ectopic pregnancy is a medical condition in which a fertilized egg implants and grows outside of the uterus, most commonly within the fallopian tubes. This condition is a significant concern in obstetrics due to its potential to cause life-threatening complications, such as rupture and severe bleeding. Given its seriousness, the accurate and timely diagnosis of ectopic pregnancy is crucial in the field of obstetrics and gynecology. Doppler ultrasound has emerged as a valuable diagnostic tool for assessing ectopic pregnancies. This non-invasive imaging technique utilizes sound waves to visualize blood flow within the reproductive organs, facilitating the detection of abnormal pregnancies.

Ectopic pregnancy (EP) is a commonly encountered medical condition that poses a significant risk of maternal morbidity. Timely identification is crucial to enable prompt intervention.[1] It occurs when a fertilized egg implants itself outside the usual location within the uterus. In the United States, approximately 1% to 2% of pregnancies are ectopic, and around 2.7% of maternal deaths related to pregnancy result from ruptured ectopic pregnancies.[2] Various factors increase the risk of ectopic pregnancy, including a history of pelvic inflammatory disease, smoking, previous surgery on the fallopian tubes,

prior ectopic pregnancy, and infertility. 2 Of particular significance is the initial occurrence of ectopic pregnancy, as 50-80% of patients can regain reproductive function after undergoing surgical treatment.[3]

Additionally, there is a 7-17% likelihood of experiencing recurrent ectopic pregnancies.[3-5] It represents the cause of 75% of maternal fatalities during the early stages of pregnancy, making ectopic pregnancy one of the prevalent reasons for maternal deaths in the first trimester in many developing nations, including Uganda.[6] In Pakistan, there is a lack of precise data concerning the prevalence of ectopic pregnancies. However, a few studies conducted in Pakistan have reported figures ranging from 0.6% to 1.15%.[7,8] It can lead to the rupture of the fallopian tube, cervix, or abdominal area where the fertilized egg has implanted itself.[6,9] A minimum of 90% of all ectopic pregnancies occur in the fallopian tube, with 80% of them specifically in the ampullary segment of the tube.[6,9] Over the past few years, its occurrence has risen, primarily because of the higher prevalence of pelvic inflammatory diseases and the raised utilization of supported reproductive technologies.[9,10] Timely identification can also enable non-surgical treatment alternatives, such as attentive waiting or medical intervention. The diagnosis of ectopic pregnancy relies on a combination of factors, including the patient's clinical symptoms, serum human chorionic gonadotrophin (hCG) levels, and the findings of ultrasound scan of the pelvis.[11]

The rarity of certain variants of ectopic pregnancy increases the likelihood of clinical misdiagnosis, leading some patients to experience uncontrolled vaginal bleeding necessitating hysterectomy for life-saving measures.[12] This can result in fertility loss, and in rare instances, may lead to hemorrhagic shock or mortality due to excessive blood loss.[12]

Ultrasound (US) is the preferred imaging method for symptomatic women in the early stages of pregnancy presenting to the Emergency Department. The optimal approach for these patients involves pelvic ultrasound encompassing both transabdominal and transvaginal assessments.[13] Previous research has indicated a limited number of studies investigating the impact of Doppler ultrasound in diagnosing ectopic pregnancy. A study conducted in 1991 examined the utility of color Doppler ultrasound in this context. Therefore, the current study aims to address this research gap and incorporate the latest discoveries regarding the use of Doppler ultrasound by collecting data from various hospitals.

Methodology

This prospective observational study was conducted at PESSI Hospital, I-12, Islamabad. The study was carried out over a period of one year from October 2021 to September 2022. All pregnant women aged over 17 years presenting with symptoms of ectopic pregnancy, regardless of parity, were included. Patients managed using different medical procedures to treat ectopic pregnancy, those suffering from severe mental or physical disabilities, and those not incorporated in the present study were excluded. The study was conducted after obtaining approval from the university's ethical research committee. Formal permissions were subsequently secured from the selected hospitals. Informed consent was obtained from all participating patients, and their demographic information was collected. The consent form explicitly stated the commitment to maintaining strict confidentiality and anonymity throughout the study, and participants were informed of their right to withdraw at any stage. Additionally, measures were taken to minimize harm to the participants.

All patients underwent color Doppler ultrasound using a dedicated machine. Subsequently, the patients were followed until they underwent surgical management, and the operative findings were meticulously recorded. Data were collected using a pre-designed proforma and analyzed with SPSS version 20. For categorical variables, we calculated the frequency and percentage, while numerical data were summarized using the mean and standard deviation. To determine the sensitivity (SE), specificity (SP), positive predictive value (PPV), negative predictive value (NPV), and accuracy of "Color Doppler ultrasound" compared to surgical findings as the gold standard, we used a 2x2 table.

Results

The mean age of the participants was 31.53 years, with a standard deviation of 5.45 years. The average gestational age was 6.03 weeks. Regarding family history, 35.0% of the participants had a positive family history. Parity distribution among the participants was as follows: parity II (36.7%), parity III (28.3%), nulliparous (15.0%), parity I (8.3%), and parity IV (11.7%). Regarding signs and symptoms, a significant portion of the sample experienced pain (93.3%), and PV bleeding (78.3%).

In terms of Color Doppler ultrasound findings, the majority of cases (96.7% of the sample) were identified as positive for ectopic pregnancy, with only 3.3% of cases

showing negative ultrasound findings. Moving on to surgical findings, 93.3% of the cases confirmed the presence of ectopic pregnancy through surgical exploration, while 6.7% of cases revealed negative surgical findings.

Based on these values, the sensitivity of color Doppler ultrasound was 100%, while the specificity was 60%. The positive predictive value (PPV) was 94%, indicating that when the ultrasound is positive, there is a 94% chance that it is correct. The negative predictive value (NPV) was 100%, suggesting that there was a 100% chance that it was accurate in ruling out ectopic pregnancy.

Table I: Descriptive statistics of demographic characteristics. (n=60)

Variables		Statistics
Age (Mean ± SD)		31.53 ± 5.45 years
Gestational age		6.03±0.78 days
Family history	Positive	21(35.0%)
	Negative	39(65.0%)
Parity	Nulliparous	9(15.0%)
	I	5(8.3%)
	II	22(36.7%)
	III	17(28.3%)
	IV	7(11.7%)
Sign/symptoms	Pain	56(93.3%)
	PV bleeding	47(78.3%)

Table II: Frequency of ectopic pregnancy to ultrasound and surgical findings. (n=60)

Variables	N	%
Color Doppler ultrasound findings		
Positive	58	96.7%
Negative	2	03.3%
Surgical findings		
Positive	56	93.3%
Negative	4	06.7%

Table III: Diagnostic accuracy of colour Doppler ultrasound by taking surgical findings as gold standard. (n=60)

Colour Doppler ultrasound findings	Surgical findings		Total
	Positive	Negative	
Positive	55 TP	3 FP	58
Negative	0 FN	2 TN	2
Total	55	5	60

Discussion

Ectopic pregnancies pose a significant threat to the health and well-being of women, demanding early and precise diagnosis for effective management. We investigate into the key findings of our study, which evaluated the diagnostic accuracy of Doppler ultrasound in ectopic pregnancy, and consider their implications for clinical practice. A total of 60 women were enrolled with an average age of 31.53 years and average gestational age is 6.03 weeks. Comparatively Verma ML et al[14] reported that the patients average age was 28.67 years and average gestational age was 7 weeks with ectopic pregnancy, furthermore we found the majority of the participants fall into parity II (36.7%), followed by parity III (28.3%), nulliparous (15.0%), parity I (8.3%), and parity IV (11.7%). Our findings were also supported by the Mohapatra I et al[15] as the average of women with ectopic pregnancy was 30.31 years and average gestational age was 8.6±2.2 week. Consistently a 10 years review from Ghana also stated that the overall mean age of patients with ectopic pregnancy was 27.61 ± 5.56 years and mean gestational age slightly higher compared to our findings 10.3 weeks.[17] Our findings were also closely supported by few national studies.[17-19] The gestational age around 6-9 weeks in most of the studies may because of the most ectopic pregnancies become symptomatic between 6 to 8 weeks of gestation. As the embryo grows, it causes pressure and stretching within the fallopian tube, which can lead to symptoms such as abdominal pain and vaginal bleeding. This is often when patients seek medical attention, and diagnosis occurs.

In this study according to the Color Doppler ultrasound findings, 96.7% of the sample, were identified as positive ectopic pregnancy and 93.3% of the cases confirmed the presence of ectopic pregnancy through surgical exploration. Based on these values, the sensitivity of color Doppler ultrasound was 100%, the specificity was 60%. The positive predictive value (PPV) was 94%, indicating that when the ultrasound is positive, there is a 94% chance that it is correct. The negative predictive value (NPV) was 100%, suggesting that there was a 100% chance that it was accurate in ruling out ectopic pregnancy. In the comparison of this study Shobairi E et al[19] reported that the Doppler sonography diagnosis of ectopic pregnancy showed a sensitivity of 97.1%, a specificity of 94.3%, and PPV 94.4% and NPV as 97%. On the other hand, Malik and colleagues conducted research to evaluate the effectiveness of transabdominal and transvaginal sonography in diagnosing ectopic pregnancies. They found that when diagnosing suspected ectopic pregnancies using transabdominal scans, the sensitivity was 82.3%, specificity stood at 93.3%, the positive predictive value was 98.5%, and the negative predictive value was 48.2%.

The overall accuracy rate for these diagnostic methods was reported at 84%. Lin TY et al[21] observed that the traditional sonography continued to be the primary means

of diagnosing ectopic pregnancy, but 3D ultrasound played a vital role in accurately illustrating the exact location of the gestational sac. In the study by Chen X et al[22] observed that the contrast-enhanced ultrasound images offer distinctive attributes and diagnostic indicators for tubal ectopic pregnancy, such as identifying the gestational sac, the presence of a prominent ring-like structure, tubal enlargement, and tubal enlargement accompanied by a hematoma.[23] Despite extensive literature review, no further studies specifically addressing the diagnostic accuracy of color Doppler ultrasound in diagnosing ectopic pregnancy were found. Color Doppler ultrasound allows healthcare professionals to visualize blood flow within the pelvic region. Ectopic pregnancies often exhibit abnormal blood flow patterns in the fallopian tube or other sites outside the uterus. Through color Doppler imaging, areas with increased blood flow or vascular abnormalities indicative of ectopic pregnancy can be identified. However, robust evidence supporting the efficacy of this technique is limited in the literature, and our study also has several limitations. Ectopic pregnancy cases were rare, the sample size was relatively small, and ultrasound findings may vary depending on the operator's skill. Therefore, further large-scale studies are strongly recommended to validate these findings and ascertain their applicability in clinical practice.

Conclusion

In conclusion, this study has demonstrated that color Doppler ultrasound is an exceptionally sensitive, noninvasive, and reliable tool for diagnosing ectopic pregnancy. Despite its lower specificity, its high sensitivity and remarkable negative predictive value make it valuable in ruling out ectopic pregnancy. This capability could potentially decrease the necessity for invasive surgical interventions, particularly in cases where ultrasound results indicate a negative outcome. However, the applicability of these findings is limited due to various constraints, notably the small sample size. Therefore, further large-scale studies are strongly recommended to validate and reinforce these findings.

References

1. Dooley WM, Chaggar P, De Braud LV, Bottomley C, Jauniaux E, Jurkovic D. Effect of morphological type of extrauterine ectopic pregnancy on accuracy of preoperative ultrasound diagnosis. Ultrasound Obstet Gynecol. 2019;54(4):538-44. https://doi.org/10.1002/uog.20274
2. Hendriks E, Rosenberg R, Prine L. Ectopic pregnancy: diagnosis and management. American family physician. 2020 May 15;101(10):599-606.
3. Boychuk AV, Khlibovska OI, Yakymchuk YB. Ectopic pregnancy and its long-term results. Wiad Lek. 2020 Jan 1;73(1):139-44. https://doi.org/10.36740/WLek202001127
4. Boychuk A, Kurylo OU, Tolokova T. Prevention of Adhesions in The Preservation of Reproductive Health of Women with Endometryoid Cysts.Rec. J. Pharm., Biol. Chem. Sci. 2017; 8(3): 1447-54
5. Boychuk AV, Yakymchuk YB, Yakymchuk OM. Violation of homocysteine exchange in conservative treatment of ectopic pregnancy. Collection of scientific papers of the Association of Obstetricians-gynecologists of Ukraine. Polygraph plus: Kyiv, 2014. ISBN 978-966-8977-45-9
6. Obeagu EI, Faduma MH, Uzoma G. Ectopic Pregnancy: A Review. Int. J. Curr. Res. Chem. Pharm. Sci. 2023;10(4):40-4.
7. Begum B, Bhanbhro BA, Rehman M. Analysis of ectopic pregnancy among local population of Pakistan. INTERNATIONAL JOURNAL OF ADVANCED BIOTECHNOLOGY AND RESEARCH. 2019 Jan 1;10(1):452-6.
8. Bai M, Kulsoom O, Azra B, Atta J, Javaid S. Incidence, Predictability and Causes of Tubal Rupture IN Ectopic Pregnancy in a Pakistani Population: A Descriptive Cross-Sectional Study. **J. Res. Med. Dent. Sci**. 2022 Jan;10(1):110-5.
9. Zhang QI, Xing X, Liu S, Xie X, Liu X, Qian F, Liu Y. Intramural ectopic pregnancy following pelvic adhesion: case report and literature review. Archives of Gynecology and Obstetrics. 2019 Dec;300:1507-20. https://doi.org/10.1007/s00404-019-05379-3
10. Committee on Practice Bulletins-Gynecology. ACOG Practice Bulletin No. 191 summary: tubal ectopic pregnancy. Obstet Gynecol. 2018;131(2):409-11 https://doi.org/10.1097/AOG.0000000000002499
11. UK NG. Diagnostic accuracy of ultrasound features for tubal ectopic pregnancy. National Institute for Health and Care Excellence (NICE); 2019: https://www.ncbi.nlm.nih.gov/books/NBK576537/? report=reader
12. Feng H, Zheng Y, Ke Y. Ultrasound vs. histologic findings in 40 patients with special types of ectopic pregnancy. Am. J. Transl. Res. 2021;13(7):7829.
13. Lee R, Dupuis C, Chen B, Smith A, Kim YH. Diagnosing ectopic pregnancy in the emergency setting. Ultrasonography. 2018 Jan;37(1):78. https://doi.org/10.14366/usg.17044
14. Verma ML, Singh U, Solanki V, Sachan R, Sankhwar PL. Spectrum of ectopic pregnancies at a tertiary care center of northern india: a retrospective cross-sectional study. Gynecology and Minimally Invasive Therapy. 2022 Jan;11(1):36. https://doi.org/10.4103/GMIT.GMIT_1_21
15. Mohapatra I, Samantray SR, Samantaray SR. Scar ectopic pregnancy-an emerging challenge. Cureus. 2021 Jul 27;13(7). https://doi.org/10.7759/cureus.16673
16. Sefogah PE, Oduro NE, Swarray-Deen A, Nuamah HG, Takyi RB, Nuamah MA, Oppong SA. Factors Associated with

Ruptured Ectopic Pregnancy: A 10-Year Review at a District Hospital in Ghana. Obstetrics and Gynecology International. 2022 Mar 7;2022. https://doi.org/10.1155/2022/1491419

17. Khan M, Parveen F, Aijaz SA, Memon SA. Risk factors and presenting complaints of ectopic pregnancy at tertiary care Hospital. PJHS. 2021;15(3):1226-8.
18. Malik S, Nawaz S, Rasheed M, Nadeem I, Shah SA, Nigar F. Correlation of? CG Levels with Size of Gestational Sac in Patients of Ectopic Pregnancy Presenting to a Tertiary Care Health Facility. **Nat. J. Health Sci**. 2022 0;7(4):169-73. https://doi.org/10.21089/njhs.74.0169
19. Shobairi E, Jalilian N, Rezaie M, Behafarid S. Diagnostic index of doppler sonography in ectopic pregnancy. J Kermanshah Univ Med Sci. 2013;17(2):e77120
20. MALIK SA, MALIK S, MAQBOOL A. Comparison of Transabdominal and Transvaginal Sonography in the Diagnosis of Ectopic Pregnancy. P J M H S 2010;4;1;22-27
21. Lin TY, Chueh HY, Chang SD, Yang CY. Interstitial ectopic pregnancy: a more confident diagnosis with three-dimensional sonography. **Taiwan J Obstet Gynecol**. 2021 Jan 1;60(1):173-6. https://doi.org/10.1016/j.tjog.2020.11.028
22. Chen X, Wu Q, Wei N, An G, Yu H, Zhang Y, Wang N. Evaluation of Clinical Efficacy of Contrast-Enhanced Ultrasound in the Diagnosis of Ectopic Tubal Pregnancy. Alternative Therapies in Health and Medicine. 2023 Sep 29:AT9159.