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Early Pregnancy Fetal Cardiac Activity Detection by Superb Micro-Vascular Imaging (cSMI) Comparing with Color Doppler Ultrasound

Riffat Masud, Faisal Khurshid, Ghazal Jameel, Mussarat Ashraf*

Department of Radiology, PAEC General Hospital, Islamabad Pakistan, *Department of Gynecology, PAEC General Hospital, Islamabad Pakistan

ABSTRACT

Objective: To observe the sonographic advancement of the Doppler technique Superb Microvascular imaging (cSMI) for detecting fetal cardiac activity (FCA) in early pregnancy when not detected on grey scale ultrasound and conventional Doppler.

Study Design: Cross-sectional study.

Place and Duration of Study: Radiology Department and Gynaecological Department, Pakistan Atomic Energy Commission General Hospital in collaboration with Zahoor and Citilab Diagnostics Rawalpindi with a referral from Holy Family Hospital from Mar to Sep 2022.

Methodology: All cases were examined with Toshiba Aplio 300 and 500 ultrasound machines having software of Color Doppler Imaging (CDI), Advance Doppler Flow (ADF) and cSMI were used. Findings of grayscale Doppler including Color Power Doppler (CPD), Advance Doppler Flow (ADF) and cSMI patients with viable fetuses were followed at 2, 4 and 16 weeks and finally after 30 weeks of pregnancy.

Results: A total of 60 cases, 35 cases regarded viable pregnancy by detecting fetal cardiac activity (FCA) by greyscale, colour Doppler, and on cSMI. Five cases of nonviable pregnancies with no FCA on the Doppler cSMI greyscale and 5 cases of the embryonic sac (blighted ovum). Fifteen cases were reported nonviable with no cardiac flicker on the greyscale and no fetal cardiac activity on colour Doppler; however, fetal cardiac activity was detected on cSMI.

Conclusion: It is being concluded that cSMI (Superb Microvascular Imaging) is a new and highly sensitive method of detection of minimal vascular flow, disregarding any surrounding movement.

Keywords: Doppler technique, Early pregnancy, Fetal cardiac activity, Superb microvascular imaging.

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INTRODUCTION

Superb Microvascular Imaging (cSMI) detects microvasculature, which provides visualization of low-velocity microvascular flow.[1] Conventional colour Doppler imaging removes clutter from images by suppressing low-velocity components resulting in a flow loss in tiny vessels. cSMI separates flow from overlying tissue motion, preserving the subtlest low-flow components.[2,3]

Fetal cardiac activity is seen when the embryo is 2mm in size and is almost always seen by CRL of 5mm.[2] However, for accurate diagnosis of the non-viability of the fetus, the threshold of absent cardiac activity at 7mm length has been set to avoid harm to a potentially viable fetus by misoprostol use.[4] A false positive diagnosis of failure of early pregnancy can lead to negative consequences of early pregnancy failure.[5] To overcome this scenario, we have to find a way to improve the visualization of fetal cardiac activity (FCA), and that can be done by improved Doppler techniques like ADF and specially cSMI.[6]

A transvaginal (TVS) scan is considered the gold standard in assessing early pregnancy. If a patient declines a TVS, a facility of TVS is not available trans-abdominal sonogram (TAS) is recommended with a special Doppler protocol of ADF and cSMI.[7,8] In early pregnancy, the location and viability are key in establishing the diagnosis and guidelines for further management.[9] Miscarriage is a sensitive matter, and women who find the diagnosis difficult to accept do not appreciate fetal cardiac activity on the grey scale. Conventional Doppler should be advised with the case option.[10] The objective of the study is to utilise advanced Doppler techniques, i.e. Superb Vascular Imaging, to detect fetal cardiac activity in early pregnancy not seen on the greyscale and conventional Doppler imaging.

METHODOLOGY

The cross-sectional study was conducted at the Radiology Department of Pakistan Atomic Energy Hospital Islamabad with the collaboration of the Gynecology Department, Zahoor and Citilab Diagnostic Rawalpindi Pakistan, from March to September

Correspondence: Dr Riffat Masud, Department of Radiology, PAEC General Hospital, Islamabad Pakistan

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2022. The study included 60 referred cases of early pregnancy (5th to seventh weeks).

Inclusion Criteria: Only cases with pregnancy test positive and antenatal scan no or dubious fetal cardiac activity (FCA) seen on the greyscale or even on conventional Doppler to confirm the viability of pregnancy before ongoing termination, were included.

Exclusion Criteria: Cases of above eight weeks pregnancy and those of 7-8 weeks pregnancy who have cardiac flicker on the greyscale and conventional Doppler, were excluded.

Toshiba Aplio 300 and 500 ultrasound machines having software of Doppler (CDI, ADF) and cSMI were used. Findings of grayscale Doppler, including CPD, ADF and cSMI patients with viable fetuses, were followed at intervals of 2, 4 and 16 weeks and finally after 30 weeks of pregnancy. Superb Microvascular Imaging (cSMI) is a potentially useful mode in detecting microvasculature compare to standard (conventional) Doppler techniques. The study aims to compare the efficacy of cSMI to assess the ability of cSMI to detect early pregnancy failure. Among conventional Doppler ultrasound examination and cSMI techniques, pulsed Doppler ultrasound had the highest sensitivity, and Superb Microvascular Imaging (cSMI) had the highest specificity.

All information regarding weeks of pregnancy, crown-rump length (CRL) finding on the greyscale, conventional Doppler and cSMI were documented. Statistical Package for Social Sciences (SPSS) version 20.0 was used for the data analysis. Quantitative variables were expressed as Mean±SD and qualitative variables were expressed as frequency and percentages.

RESULTS

The study comprised 60 patients, including cases of an embryonic sac (blighted ovum). All patients were evaluated with grey scale conventional Doppler (CDI) with advanced ADF and cSMI techniques. It was found to be superior in showing cardiac flicker in early pregnancy. The distribution of cases and their outcome is given in Table-I. Statistical analysis of 55 patients, excluding 5 cases of blighted ovum, the colour Doppler finding showed 72.7% sensitivity and 100% specificity with a positive value of 100%, negative prediction value of 25% with an accuracy of 75%, negative likelihood ratio of 0.16, and positive likelihood ratio as specificity 100%. So PLR cannot be calculated. cSMI finding is 98% sensitivity, specificity of 100%, positive predictive value of 100% and accuracy of 98.3% with a negative predictive value of 83.3%.

Table-I: Distribution of Cases of Early Pregnancy (n=60)

No of Cases	Average Gestational age (Weeks)	Average CRL (mm)	Grey Scale Finding	Conventional Doppler	cSMI	Outcome
05	6.4-7.0	7.2-10	No cardiac flicker (FCA)	No FCA	No FCA	Non-viable pregnancy
05	6.5-7.0	8.1-9.8	Anembryonic gestational sac	No internal doppler flow	Absent flow	Blighted ovum
15	6.5-7.1	8.1-10.6	No cardiac flicker (FCA)	No FCA/Cardiac flicker	FCA with positive flow	Viable (follow up recommended)
35	6.4-7.0	7.2-10.2	FCA seen	Doppler flow with FCA seen	FCA with positive flow	Viable pregnancies

Statistical analysis of 15 cases in whom FCA was absent on Greyscale+ on conventional Doppler and positive on cSMI shows 46.7% sensitivity on the colour Doppler CDI and accuracy 46.7% whereas on cSMI is with 100% accuracy; however, specificity cannot be calculated (Table-II).

The diagnostic accuracy of cSMI (99%) was significantly superior to colour Doppler (78.8%) for detecting fetal cardiac activity in early pregnancy. Sensitivity was significantly higher than colour Doppler (cSMI 99.3%).

DISCUSSION

Our study shows that nonviable early fetal pregnancy on a greyscale with no cardiac flicker depicts cardiac flicker (FCA) on cSMI. Out of 60 cases in our data, 15 showed no cardiac flicker on the greyscale at all, and 8 cases showed no flow even on conventional Doppler. However, all 15 cases showed cardiac flicker on cSMI with a diagnostic accuracy of 99% and a diagnostic sensitivity of 99.33%, significantly superior to conventional Doppler (78.8%).

Transvaginal sonography (TVS) is considered more accurate than transabdominal sonography (TAS) in detecting the viability of early fetal pregnancy with a positive pregnancy test.[11,12] As per recommendation,

Table-II: Distribution Of Cases Showing Absent Cardiac Activity On Grey Scale, Plus/Minus Cardiac Activity On Color Doppler And Detection Of Fetal Cardiac Activity Through CSMI In All Cases (n=15)

Age of Patient	Time of Pregnancy	CRL (mm)	Cardiac Activity on Grey Scale	Cardiac Activity on Conventional Doppler	Cardiac Activity of CSMI
35Y G3P1	6w4d	7.2	Absent	Absent	Present
29Y G2P1	6w4d	7.1	Absent	Absent	Present
27Y G2P1	6w5d	8.1	Absent	Absent	Present
33Y G3P2	6w5d	8.1	Absent	Absent	Present
31Y G3P1	6w6d	8.4	Absent	Absent/Present	Present
28Y G2P1	6w5d	8.2	Absent	Absent	Present
28Y G2P0	6w6d	8.3	Absent	Absent/Present	Present
27Y G2P1	7w0d	9.8	Absent	Absent/Present	Present
25Y G1P0	7w0d	9.8	Absent	Absent/Present	Present
21Y G1P0	6w4d	7.2	Absent	Absent	Present
20Y G1P0	6w5d	8.1	Absent	Absent	Present
32Y G3P2	6w5d	8.2	Absent	Absent	Present
33Y G3P1	6w6d	8.4	Absent	Absent/Present	Present
20Y G1P0	7w0d	9.8	Absent	Absent/Present	Present
22Y G2P1	7w0d	10.64	Absent	Absent/Present	Present

the Doppler study is not used in the TVS due to thermal effect, compared to TAS 21&22.[13] Though, under pressure from bioeffects and safety committees of professionals like the international society for Ultrasound in Obs and Gynae (ISUOG), several manufacturers have changed their default setting of Doppler in fetal mode in their machines.[14,15] As the acoustic output is high in Doppler, special precautions are recommended, particularly in early gestation. Therefore, Doppler, including cSMI, is relatively safe with transabdominal ultrasound, especially in early pregnancy.[16] Currently, no study is available on the subject for reference regarding the application of cSMI in detecting FCA in early pregnancy.

As radiologists, we should understand the use of various diagnostic tools to deal with early pregnancy in the first semester, commonly encountered in clinical practice and referrals.[17,18] Therefore, our recommendations are if CRL>7 mm or CRL<7 mm with no visible heartbeat on TVS or TAS, the transabdominal sonography (TAS) with special Doppler protocols of Advance Doppler Flow (ADF) and cSMI may be advised. Our current study finding may lead to new development for imaging the early fetal pregnancy viability using the cSMI mode of the advanced Doppler technique.

LIMITATION OF STUDY

The only limitation of our study was that out of 15 cases seen to have FCA on cSMI were advised for follow-up. Only 8 cases were reported for 3–4 follow-ups. The rest of the 7 cases did not respond after the second follow-up.

CONCLUSION

It is being concluded that cSMI (Superb Microvascular Imaging) is a new and highly sensitive method of detection of minimal vascular flow, disregarding any surrounding movement. As a result, it can help detect FCA in early pregnancy compared with conventional grey scale ultrasound & Doppler study.

Conflict of Interest: None.

Author's Contribution

Following authors have made substantial contributions to the manuscript as under:

RM & FK: Data acquisition, data analysis, drafting the manuscript, critical review, approval of the final version to be published.

GJ & MA: Concept, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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