ULTRASOUND EXAMINATION OF THE PLACENTAL BLOOD CIRCULATION LIMITS AND PERSPECTIVES

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Keywords: placental vascularization, fetal growth restriction, 3D ultrasound, angiography, histogram **Abstract:** Placenta, this organ with a particular vascular structure, by the functional integrity of which depends the birth of a new life, was the subject of numerous researches over time. Conventional twodimensional (2D) ultrasound, color/power and pulsed Doppler have been widely used for the structural and functional evaluation of the placenta during pregnancy. 3D ultrasound through modern techniques of power Doppler (3DPD) such as angiography and histogram analysis makes possible the qualitative and quantitative assessment of vascularization, flow and placental perfusion. 3D ultrasound may be important in the evaluation of feto-placental insufficiency in clinical practice, and in the prediction of fetal growth restriction and pre-eclampsia, although some limitations regarding the assessment of the placenta using 3D ultrasound still remain unresolved.

Cuvintecheie:vascularizațiaplacentei,restricțiacreșteriifetale,ecografia3D,angiografie,histogramă

Rezumat: Placenta, acest organ cu o structură vasculară particulară, de a cărei integritate funcțională depinde nașterea unei vieți noi, a constituit subiectul a numeroase cercetări de-a lungul timpului. Ecografia convențională bidimensională (2D), Doppler-ul color/power și pulsat au fost larg folosite pentru evaluarea structurală și funcțională a placentei în timpul sarcinii. Ecografia tridimensională (3D) prin tehnicile moderne power Doppler (3DPD) ca angiografia și analiza prin histogramă face posibilă evaluarea calitativă și cantitativă a vascularizației, fluxului și perfuziei placentei. Ecografia tridimensională fore poderne în evaluarea insuficienței feto-placentare în practica clinică și în predicția restricției de creștere fetală și preeclampsiei, deși unele limitări privind evaluarea placentei folsind ultrasunete ecografia 3D rămân încă nerezolvate.

INTRODUCTION

Placenta, this organ with a particular vascular structure, by the functional integrity of which depends the birth of a new life, was the subject of numerous researches over time.

The notion of placental circulation dates from Antiquity. At the end of the first century, Soranus described the chorion, amnion and the cord, containing 4 vessels. For many years, until the XVI th century maternal and fetal circulations were considered continuous. Over the ensuing years, arguments continued regarding the purely fetal versus shared origin of the placenta and the timing of the connection between the two systems. The question of exactly when is the actual uteroplacental circulation established, posed by Ramsey or how penetration of the maternal blood is in intervillous space after theories issued by Borrell, Panigel or Ramsey are still debated today.(1)

Multiple imaging techniques used in the past 50 years have culminated in ultrasound, which allows detailed and as far as is known, in the safety the examination of the placenta both structural and functional.(1)

Thorough examination of the placenta by conventional two-dimensional (2D) ultrasound occupies an important place in assessing normal and the pathological pregnancies. This allows the observation of location and thickness of the placenta, implantation, the morphology and its anomalies, and also detect changes in the cord insertion or particular aspects in the basal plate and/or chorionic.(2) While physical characteristics may furnish some informations on placental function, Doppler (color and spectral) ultrasound is the ideal clinical tool to assess placental performance in healthy and more particularly, in high-risk pregnancies. It also has value in predicting evolution of pregnancies and for some perinatal complications. All three circulations (fetal, placental and maternal) may be explored by Doppler technology.(3-6)

At the moment, the most practical method and with predicting value for some maternal-fetal complications in the third trimester such as: intrauterine fetal growth restriction (FGR), preeclampsia (PE), eclampsia, retro-placental hematoma, intrauterine fetal demise or premature birth, is by measuring resistance to flow in the uterine arteries to identify failure of trophoblast invasion of the spiral arteries.(3-7) Conversely, evaluation of fetal well-being can be made by estimating flow impedance (in particular, by identifying absent or reversed enddiastolic flow) in the umbilical artery, and this will detect severe restriction of flow in the villous circulation.(3,5-7) Although clinically very useful, examination of these two vessels for evaluation of placental function raises two issues. First, not all cases of placental insufficiency are associated with inadequate invasion of the maternal spiral arteries. Second, it has been estimated from animal studies that over 60-80% of placental vascularity has to be obliterated before any effect on umbilical artery resistance is demonstrated.(5-7)

These considerations have imposed a direct

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examination of the placenta by ultrasound Doppler. Applying color Doppler ultrasound and power Doppler (2D-PDI) in normal pregnancies in the third trimester, it may reveal subchorial vessels branching and intraplacentar vascular flow, from the chorionic to the basal plate being able to identify most cases 3-5 arteries. In pregnancies complicated by fetal growth restriction and fetal distress, intraplacentar vascular flow is weak or no highlight.(5) Velocimetric indices values of the detectable intraplacental arteries (lower than umbilical artery) may be normal in FGR even when recording abnormal velocity indices in the umbilical artery, suggesting uneven distribution of the phenomenon of vascular occlusion in placental vilous arteries.(5)

According to some studies, analysis of the ratio between intraplacental and umbilical artery resistance indices in the second trimester may improve the diagnostic value of Doppler velocimetry in pregnancies at risk for later obstetric complications.(3)

A method of imaging the placental circulation (both fetal and maternal) in vivo is required as an important means of predicting FGR/PE and as the basis for evaluating therapeutic options for these conditions.(7)

Medical world has been "invaded" in the last 10-15 years by more advanced ultrasound equipment. Threedimensional ultrasound (3D) with more sophisticated programs allows today a fetal-placental assessment more depth.

The volume of the placenta can be measured using 3D ultrasound by rotational technique using VOCAL program (Virtual Organ Computer-Aided AnaLysis) (8,9) and the combination of 3D technology with color or power Doppler allow the amazing representation of placental vascular tree, a true angiography by 3D color Doppler method (3D-CDI) and 3D power Doppler angiography (3D- PDA), described for both normal and pathological pregnancy.(7,10-12)

3D color Doppler imaging of the placental circulation highlights the vessels running along the basal plate and chorionic plate with two-way flow in the villi. The maternal spiral arteries offers bright signals, indicating high velocity flow into the fetal cotyledon.(7)

3DPD ultrasound can depict intraplacental vessel characteristics such as the density of vessels, branching, caliber changes, and tortuosity; being superior to 2D power Doppler (2DPD) ultrasound for the detection of secondary and tertiary stem vessels in the placenta. Spiral arteries can be seen discharging blood into the intervillous space, and the dilated terminal ends (like a bud) of these vessels suggest normal trophoblastic invasion.(7,11,13,15)

Considerably reduced placental vascularity with impaired budding for the villous circulation are predictive for pregnancies with FGR not identified by uterine or umbilical artery velocimetry.(7) This should be relevant in clinical practice because incomplete placental development is generally associated with FGR.(7,15) However, ultrasound 3D-PDA is advisable to be done up to 28 weeks to provide a reliable image of the vascularity from both anterior and posterior placental sites.(7) The visualization earlier in pregnancy (at 12-14 weeks) of the villous circulation in the cotyledon and its relation to spiral arteries, may have predictive value for subsequent fetal growth and risk of pre-eclampsia. (7.15)

Assessing functional reserve of the placenta by an objective assessment of its vasculature in normal blood supply and especially in different pathological situations can be done by calculating vascular indices using histogram (3D power Doppler histogram). (13-15)

3DPD indices are calculated automatically by the device being displayed on screen. These indices which permit to

assess placental perfusion include: vascularization index-VI that means the proportion of color in the studied volume (placenta) providing information on vessels that can be detected in placenta, flow index-FI which provides a value of the amplitude of color signal thus providing information on transported blood cells at the time of 3D action (placental blood flow) on a scale of 1 to 100 and vascularization-flow index VFI that combines information on the presence of vascular and blood flow. (13-15) One of the problems of quantification of the power Doppler signal is the lack of information on which part of the placenta the signals are coming from.(13) The assessment of placental perfusion using 3DPD ultrasound is called 'placental vascular sonobiopsy' (PVS) (16) but also 'virtual placental biopsy' (17). Some authors have found a good correlation between indices of PVS and those from evaluation of the entire placenta considering PVS a valid alternative for evaluation of the placental vascular tree when visualization of the entire placenta is not feasible.(18) Other authors have questioned the reliability or reproducibility of 3DPD parameters (VI, FI or VFI) as a tool to quantify placental perfusion, despite their use in many publications.(19)

In pregnancies with FGR was found a reduction of the indices of vascularity, flow or their combination, the most reliable index being the flow index; this is not fully supported because even the evolution of the indices during normal pregnancy is considered differently in the literature. (13-16) One possible explanation for the difference placental vascular indices may be the different sampling method for volume acquisition in the placenta.(20)

Recently have been elaborated articles that provide fundamental concepts on 3D ultrasound with its variants, comparing the results obtained by different authors so far; these show the advantages of 3DPD technology but also the importance of correct examination and interpretation of placental circulation through the knowledge of methodology for a correct 3D examination and also the limits of method and the importance of eliminating artifacts and signal attenuation in depth or through other tissue interposition. (20.21)

Although some authors believe that most published studies are flawed making their interpretation difficult and the use of this technology in the field of obstetrics is still in early experimental phase (21), there is hope that this method may become a new method to assess the effectiveness of some treatments for feto-placental insufficiency before and after treatment (7,20) contributing thus to the reduction of perinatal morbidity and mortality

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