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Is there a role for 3 dimensional power Doppler placental ultrasound and computerised assessment of calcification in post-term pregnancies?

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ABSTRACT

Purpose: To assess if three dimensional power Doppler (3DPD) placental ultrasound, evaluating volume, vascularisation, and blood flow in post-term pregnancies differs from normal pre-term third trimester pregnancies and to examine whether computer analysis identifies the continual increase in calcification in post-term pregnancies.

Materials and methods: A prospective cohort study of 50 women with post-term pregnancies (40 + 0 to 41 + 6 weeks) and 58 controls (36–40 weeks). 3DPD ultrasound was used to evaluate placental volume, vascularisation index (VI), flow index (FI) and vascularisation-flow index (VFI). Calcification percentage was calculated, by computer analysis. Results were compared with previously determined normal values and correlated with uterine, middle cerebral and umbilical artery Doppler values and placental histology.

Results: Placental volume, VI, FI and VFI are not influenced by GA beyond 40 weeks gestation and are similar between post-term and normal pregnancies (36–40 weeks). Placental volume decreased as the mean uterine artery pulsatility index (UtA PI) increased; $p = 0.047$. FI was reduced where chorangiosis was found at histology ($p = 0.033$). Computer analysis of placental calcification identified the increased calcification expected after 40 weeks, and showed that calcification continues to increase between 40 and 42 weeks ($p = 0.029$).

Conclusion: Although the sample size limits the generalisability of the findings, we found that calcification of the placenta continues to increase between 40 and 42 weeks gestation, that there is an association between an increasing UtA PI and a decreasing placental volume and that FI measurement may be useful in the identification of chorangiosis in post-term pregnancies.

Introduction

It has long been acknowledged that the risk of stillbirth and neonatal death increases as pregnancy is prolonged beyond 41 weeks.[1] A large study in 2004, involving 45,673 women who delivered after 37 weeks gestation, found that there was an increase in the risks for moderate or thick meconium stained liquor, an Apgar score of less than 7 at 5 min, admission to the neonatal intensive care unit, fetal macrosomia, chorioamnionitis and instrumental vaginal delivery in those pregnancies where delivery was after 40 weeks gestation.[2] It was additionally shown that resultant endomyometritis and caesarean section also increased when the pregnancy was prolonged beyond 41 weeks; and most importantly, that the risk of intrauterine fetal death was 2.5 times greater than before 40 weeks.[2]

Due to the risks associated with post-term pregnancy increased antenatal surveillance is required at this stage. A policy of induction of labour at 41 weeks of pregnancy or later is known to greatly reduce the risk of perinatal death and meconium aspiration syndrome.[3] Hospitals and clinicians differ in relation to the gestation at which they arrange an ultrasound scan to assess fetal wellbeing when a pregnancy is post-term. It is the policy at the hospital at which this study is carried out for all women who have not delivered to have an ultrasound scan at 41 weeks and five days gestation. At this scan the fetal presentation is checked, placental site confirmed and a biophysical profile is performed to assess fetal

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wellbeing.[4] As per hospital policy all women are reviewed by a member of the medical team following the scan. If the scan findings are normal induction is arranged for 42 weeks gestation (with patients consent); if there is any concern regarding the scan findings delivery may be arranged sooner, depending on the individual situation.

There have been a number of studies to date investigating three dimensional (3D) ultrasound assessment of the placenta, calculating volume, vascularisation and blood-flow. Placental volume is known to increase as gestational age increases in normal low-risk pregnancies.[5] Results of first trimester ultrasound assessment of placental volume are promising, with a strong correlation seen between the volume of the placenta and crown rump length (CRL) measurement in healthy pregnancies studied between 7 and 10 + 6 weeks.[6] Placental volume/CRL (termed as placental quotient or PQ), calculated at 12 weeks gestation has similar sensitivities for predicting pre-eclampsia and fetal growth restriction as Uterine artery Doppler at 22 weeks gestation.[7] Initial research into 3D power Doppler assessment of placental vessels shows a progressive increase observed in the number of intraplacental vessels and the number of vascular branches observed as gestation advances.[8] Normative indices have been defined for all the flow indices (vascularisation index (VI), flow index (FI) and vascularisation-flow index (VFI)) which have been shown to significantly increase over time with advancing gestation.[9,10] The FI, which identifies the most severe cases of placental impairment, has the lowest intraplacental variability of the three indices.[11] Further larger studies are recommended however before its accuracy in clinical diagnosis can be verified.[11] A study of 208 normal fetuses between 12 and 40 weeks and 13 with growth restriction (22–39 weeks) showed that, after 32 weeks, all the indices were significantly lower in 10 of the growth restricted pregnancies.[12]

It is normal for placental calcification to increase as the fetus approaches term and extensive calcification is common after 40 weeks.[13] A significant association has been shown between delayed placental maturation and pre-gestational and gestational diabetes, Rhesus incompatibility and antenatal or intrapartum death.[14] The only current ultrasound assessment of placental calcification is Grannum grading,[15] with a Grade 111 placenta at term associated with the absence of subsequent neonatal respiratory distress.[16,17] However a study in 2004 suggested that placental grading may lack objectivity, precision and reproducibility.[18] The authors found that while intra-observer agreement in grading placentas was generally good, agreement between observers was only fair for grades of 0–11, and poor for grade 111. A later review of routine late pregnancy ultrasound in 2008 questioned the reproducibility of reported placental grading results. The review concluded with a recommendation that future research of late pregnancy ultrasound should include evaluation of placental textural assessment.[19] A new software tool (the placentometer) which has been developed for assessing placental calcification. A previous study using this tool suggested that it may be an alternative method of assessing calcification to the more subjective method of Grannum grading.[20,21]

Placental volume and blood flow usually increase with gestational age; however there is no information about what happens to these features of the placenta beyond 40 weeks gestation. Evaluation of placental calcification and placental 3DPD are not included in post-term ultrasound examinations and it may be that these could offer some valuable additional information to aid clinical management. With this in mind this study aims to assess if three dimensional power Doppler (3DPD) of the placenta, evaluating placental volume, vascularisation, and blood flow in post-term pregnancies differs from normal-term pregnancy. It also investigates the ability of the placentometer to identify the increased calcification expected in the placenta in post-term pregnancies, providing further information to the clinician.

Materials and methods

This was a prospective cohort study comparing 2 groups; post-term pregnancies with normal pregnancies (control group). Fifty eight women were included in the control group, with scans performed between 36 and 40 weeks. Normative values were defined for all the study parameters.[7] The only differentiating factor between both groups was gestational age, which had been confirmed by scan at booking (10–14 weeks gestation). Otherwise recruitment, selection criteria and data collection was the same for both groups. Ethical approval for the study was granted by the Ethics Research Committee of the National Maternity Hospital, Dublin. For comparisons with the control group fifty women attending for a post-term ultrasound assessment, were recruited, following informed, written consent being obtained. As with the control group criteria for normality were a history of an uncomplicated pregnancy and a normally formed fetus, to control as many variables as possible and improve the rigour of the study.[22] In line with the study hospital's general guidelines for research studies exclusion criteria were multiple pregnancy, a diagnosis of fetal anomaly, if the woman was unable to understand the study or give informed consent or if they were aged less than 16 years.[23]

All scans were performed transabdominally using a Voluson 730 Expert ultrasound machine (GE Medical Systems, Austria), equipped with curved linear array transducers. A 2–7 MHz transducer was used to acquire all two dimensional (2D) images, and a 4–8 MHz transducer was used to acquire the three dimensional (3D) images. Spectral Doppler ultrasound, supported by colour flow imaging, was used to record blood velocity waveforms of the uterine, umbilical and middle cerebral arteries. Each patient in the post-term cohort had one scan performed as per departmental policy with additional 3DPD images recorded and saved. Gestational age at the time of the scan ranged from 40 + 1 to 41 + 6 weeks.

3DPD ultrasound was used to calculate placental volume, vascularisation index (VI), flow index (FI) and vascularisation-flow index (VFI). This was done using the Virtual Organ Computer-aided Analysis (VOCAL™) software, employing a previously described method (Fig. 1).[24] The percentage of calcification was also calculated by computer analysis (Fig. 2A and B), using a software-assisted grading tool (placentometer). This involved initial delineation of the placental outline to define the region of interest (ROI), which included the basal, body and surface areas of the placenta. Next the intensity threshold was adjusted to enable identification of all calcification within the ROI.[7]

The study parameters (placental volume, blood flow and percentage of calcification) were analysed for both changes with gestational age within the post-term group and for comparisons with normal cohort.[7] They were also correlated with the Doppler waveforms in the post-term group as follows: the mean uterine artery Doppler pulsatility index (UtA PI), which if above the 95th centile is associated with both IUGR and pre-eclampsia[25]; umbilical artery (UA) PI which is also abnormal if above the 95th centile[26] and middle cerebral artery (MCA) PI (if below 95th centile) known to be associated with poorer perinatal outcome and an increased risk of abnormal neurobehaviour at birth and at 2 years of age.[27] The study parameters for the post-term group were also correlated with placental histology which was performed to detect placental disease.

Statistical analysis was performed using PASW statistics, Version 18 (SPSS Inc., Chicago, IL, USA). Following assessment for normal distribution linear regression analysis was conducted to