VALUE OF DOPPLER ULTRASOUND IN DECISION MAKING FOR CESAREAN SECTION

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Doppler ultrasound scanning of fetal circulation has already become a current method for the assessment of prebirth fetal condition. Our paper aims to determine whether in some cases such an examination is sufficient to decide whether a cesarean section is indicated. The answer to this question is yes, and intrauterine growth restriction (IUGR) is the best application for this method.

History. Christian Andreas Doppler (1803-1853), an Austrian mathematician and physicist, discovered the wavelength alteration phenomenon depending on the relative speed between the source and the receptor. The piezoelectric effect was discovered by Pierre and Jacques Curie, in 1880.

The Doppler Effect started to be used for medical purposes towards the end of the 1950’s. The pulsatile Doppler dates back to 1966 (1).

Umbilical artery (UA) velocimetry. Vasoconstriction of the tertiary villi is considered responsible for the velocimetric alterations in the umbilical artery blood flow, consisting in a decrease in diastolic velocities and an increase in the resistance and impedance indices. Evidence of any histological placental alterations due to
absent or reversed diastolic flow is still lacking. Currently it is believed that reversed blood flow is the last stage of the spectrum of placental insufficiency, with a high risk of perinatal death. It seems that over 50% of the placental vessels have to be obstructed before absent or reversed diastolic flow in the umbilical artery to occur in (2).

Studies in which IUGR fetuses were longitudinally monitored showed that up to 80% of them had abnormal umbilical indices two weeks before the fetal acute deterioration. End-diastolic velocities are present approximately one week before acute deterioration. Up to 40% of the fetuses with acidosis have this abnormal umbilical flow pattern.

In severely compromised IUGR fetuses, this pattern may predict perinatal morbidity and mortality, with a relative risk of 4 and 10.6, respectively, in babies with absent or reversed end-diastolic blood flow. These babies also have a higher risk of long-term abnormal neurological development (2).

According to the Growth Restriction Intervention Trial (GRIT), an emergency cesarean section performed on account of reversed end-diastolic blood flow does not significantly improve immediate and late prognosis and supports the need for a 24-48 hour interval to allow corticosteroid administration (2).

In a high risk population, the use of Doppler ultrasound scanning of the umbilical artery reduces perinatal morbidity and mortality. Umbilical artery Doppler should be the first-line choice for monitoring the SGA (small-for-gestational-age) fetus. If the umbilical artery Doppler is normal, the pregnancy may be monitored every two weeks (3).

When the values of umbilical artery Doppler velocimetry are abnormal and the delivery is not indicated, the fetus should be monitored twice a week to check the diastolic blood flow. Fetuses with absent or reversed end-diastolic blood flow should be examined daily (4).

The delivery of a premature SGA fetus with absent or reversed umbilical artery blood flow is recommended before 32 gestational weeks if pulsations in the umbilical vein are detected, the fetus is considered viable and steroids were administered (4).

If the SGA diagnosis was made after 32 weeks gestation and UA abnormalities were detected, the delivery should occur not later than at 37 weeks gestation.

Delivery through cesarean section is recommended for SGA fetuses with absent or reversed diastolic blood flow. SGA fetuses with normal UA blood flow or abnormal UA blood flow and present diastolic blood flow may be delivered naturally, yet the rate of emergency cesarean section is high in these fetuses (4).

SGA fetuses with abnormal umbilical artery Doppler are smaller. There is a significant amount of data supporting the assumption that SGA fetuses with low umbilical artery blood flow are at higher risk of adverse perinatal outcome than normal blood flow fetuses (2).

There is a significant association between abnormal umbilical artery blood flow and perinatal outcome. Moreover, perinatal death is very rare if the umbilical blood flow is normal. Consequently, umbilical artery Doppler may be considered a tool allowing risk level differentiation in fetuses with low birth weight. Fetuses with normal Doppler ultrasound should be monitored more rarely. They may be considered normal SGA fetuses, and represent the lowest spectrum of healthy fetuses. Their
monitoring should be done accordingly (2). There are few studies conducted during birth which compare the efficacy of CTG (cardiotocography) and Doppler, as a method able to reveal fetal distress.

Poor perinatal outcome is unusual in fetuses with IUGR and normal UA Doppler. Usually, associated diseases are present. Generally, IUGR and normal UA Doppler is a benign combination. A UA Doppler ultrasound of IUGR fetuses reduces the incidence of such obstetrical procedures as cesarean section and perinatal mortality. These fetuses are born at older gestational age and have higher average birth weight than fetuses with abnormal UA Doppler.

According to the 2014 Irish practical guidelines, IUGR fetuses with normal UA Doppler ultrasound should be monitored every two weeks and delivered between the 37 and 40 weeks gestation. These guidelines show that abnormal UA Doppler fetuses run a higher risk of adverse perinatal outcomes (5).

**Middle cerebral artery (MCA) velocimetry.** In a premature SGA fetus, the MCA Doppler has limited accuracy for predicting acidemia and adverse outcome and should not be used to determine the time of delivery. In a term SGA fetus with normal UA Doppler, if the MCA PI value does not exceed the 5th percentile, the predictive value is moderate, but it may be considered when determining the time of fetus delivery (3).

If the MCA Doppler is abnormal, the delivery is recommended not later than 37 weeks of gestation (4).

The umbilical and cerebral flow relationship is thought to be more sensitive tool when it comes to discriminating between constitutional SGA and IUGR fetuses. Animal studies showed that this rate is rather related to the degree of hypoxia than to individual components (2).

For the IUGR fetuses, the most important decision is whether their extraction from a hostile uterine environment is more beneficial than the risks brought about by prematurity. Fetal well-being tests can be classified as chronic or acute. The former tests become progressively abnormal as hypoxia increases, and the latter are related to the acute changes that occur in the advanced stages of fetal compromise and usually precede fetal death by a few days. The test results should be correlated.

The value of cerebral Doppler for predicting adverse outcome in a general population of SGA fetuses is limited and has low sensitivity (2).

It has been suggested that near term MCA Doppler may be useful in the prediction of adverse outcome independent of UA Doppler (2).

The abnormal cerebroplacental ratio in IUGR fetuses is a useful marker able to predict severe preeclampsia and increased cesarean section rate. In late-onset IUGR this ratio is even more efficient. Both vascular tests need to be conducted in the umbilical and middle cerebral arteries (6).

The Doppler velocimetric parameters for MCA assessment are not an independent factor. Prematurity and placental insufficiency play a major role in newborn survival prognosis. The degree of cerebral circulation vasodilation does not influence survival, which seems dependent on the degree of impairment of fetoplacental circulation. Placental insufficiency is a complication involving high neonatal mortality rates, especially if the fetus is premature.

The degree of placental circulation impairment, analyzed by UA PI, influences prognosis on an independent basis. Doppler velocimetry of cerebral vascularization is
also associated with neonatal mortality. Of all the multivariate tests, prematurity and the degree of impairment of placental circulation are independent factors of the final outcome, in placental insufficiency pregnancies (7).

**Uterine artery (UtA) velocimetry.** According to some protocols, uterine artery Doppler may be an independent IUGR criterion unlike other Doppler tests. Further research seems to be necessary before its inclusion in routine medical practice (2). We suggest performing UtA Doppler velocimetry in addition to basic ultrasonography during the 30 – 32 weeks gestation, in order to identify newborns with severe SGA (8).

**Umbilical vein (UV) velocimetry.** A decrease in umbilical vein blood flow was also detected in an asymptomatic stage of the disease related to a decrease in placental volume (2).

**Ductus venosus (DV) velocimetry.** Ductus venosus Doppler has moderate predictive value for acidemia and adverse outcome. It should be used to monitor premature SGA fetuses with umbilical artery abnormalities and to determine the time of delivery (4).

Umbilical blood tests are considered the gold standard for the assessment of newborn condition. The acid-base balance at delivery is more accurate than the Apgar score for the detection of intrapartum asphyxiation. There are undeniable connections between acidosis at birth and venous Doppler alterations, which account for the use of this method when making decisions to induce labor.

In conclusion, abnormal DV velocimetry is more common in high risk pregnancies than UA or MCA velocimetry. DV RI seems to be a better perinatal outcome predictor than the MCA S/D ratio (9).

**Umbilical venous blood flow** could be considered a more direct and physiological measurement of placental vascular function than that of umbilical artery Doppler indices because it indirectly reflects the amount of oxygen and nutrients reaching the fetus. Intrapartum UA Doppler is a poor predictor of the obstetrical outcome.

In normal circumstances, 20-30% of the umbilical vein blood passes the liver and is shunted through the ductus venosus to supply blood to the fetal heart and brain. In cases of chronic hypoxia, the ductus venosus is dilated and the amount of shunted blood increases to maintain adequate vital organ oxygenation. Consequently, diastolic blood flow velocimetry in the ductus venosus is the first parameter to be impaired by fetal hypoxia, followed by pulsations in the intra-abdominal part of the umbilical vein.

In conclusion, intrapartum CTG and UV Doppler monitoring may provide additional information in high risk pregnancies about the fetal condition and any suspected intra-partum fetal hypoxia (10).

Fetuses delivered through emergency cesarean section for suspected fetal distress had the lowest umbilical venous blood flow rates. If this blood flow is diminished, the cesarean section rate is higher and the relative risk is 2.83 times higher than in those with normal flows. Poorer outcome is also noted after birth. Measuring the umbilical venous flow may contribute to a hierarchical classification of pregnancy risk before delivery. The flow is calculated by multiplying blood velocity with vein diameter (11).

**Biophysical score (BPS).** Doppler abnormalities occurring in several vessels before 34 weeks gestation foresee an abnormal biophysical score and, hence, intra-
uterine death. After 34 weeks gestation death after abnormal MCA occurs faster than death predicted by the biophysical score. Fetal compromise progresses from placental to cerebral abnormalities, then to venous circulation abnormalities and only later to an abnormal biophysical score (12).

The median interval between a low MCA PI and death is 5 days. Fetus follow-up two times a week seems reasonable. The BPS becomes abnormal too late and it is not useful for indicating follow-up intervals. The BPS is slightly more useful before 34 weeks gestation for determining the follow-up intervals in SGA fetuses in order to prevent fetal death. After 34 weeks gestation, MCA Doppler is the only parameter employed to set the fetal follow-up intervals (12).

**Obstetric management.** Unless other problems occur, normal SGA fetuses, the average umbilical and cerebral artery Doppler values of whom are normal, may be delivered naturally, under surveillance, yet before 40 weeks gestation.

Normal IUGR fetuses with abnormal cerebroplacental ratio (CPR) but without uterine artery Doppler changes are recommended a Doppler ultrasound two times a week and natural delivery after 37/38 weeks gestation.

The obstetric management in the IUGR fetuses with abnormal cerebroplacental ratio or abnormal uterine artery Doppler and absent end-diastolic blood flow in the umbilical artery depends on their gestational age.

After 34 weeks gestation they may be delivered naturally, but in case of absent diastolic flow by cesarean section. Between 32 and 34 gestational weeks, reversed end-diastolic flow – corticosteroids and cesarean section within 24-48 hours; absent end-diastolic flow, steroids, daily Doppler ultrasound and delivery after 34 weeks gestation. Before 32 weeks – steroids and daily Doppler ultrasound until 34 weeks (2).

The IUGR fetuses with abnormal cerebroplacental ratio or uterine artery Doppler flow, with persistent ductus venous pulsatility and abnormal biophysical profile: beyond 32 weeks – cesarean section, below 32 weeks – steroids, admission, daily Doppler ultrasound until 32 weeks.

The IUGR fetuses with abnormal cerebral and uterine Doppler ultrasounds and decompensation – cesarean section at a tertiary care center. In those under 28 weeks, each case should be assessed by a multidisciplinary team. The family has also to be consulted (2).

**Babies' outcome.** The fetoplacental relationship is most strongly impaired during the intrapartum period. Uterine contractions may reduce by up to 60% the blood flow in the uterine arteries, and reduced placental perfusion may cause fetal distress. About 14.5% of the cases of neonatal cerebral palsy and encephalopathy are associated with intrapartum hypoxia. In developed countries, hypoxic-ischemic encephalopathy occurs in 2-3 out of 1000 live newborns, whereas in developing countries, the incidence is 10 times higher. Up to 63% of intrapartum hypoxia cases occur in pregnancies with no antenatal risk factors. The cerebroplacental (C/U) ratio analysis in term babies from low risk pregnancies before active delivery may predict a diagnosis of intrapartum fetal distress and the need for emergency cesarean section (13).

**Correlations.** In a study conducted in Ireland and published in AJOG in 2014, 76% of the 1200 IUGR pregnancies required active decision making regarding the mode and timing of delivery. Forty
percent required pre-labor cesarean section and 11% of them had abnormal Doppler velocimetry as delivery indication (14).

The cesarean section rate for suspected fetal distress was higher in normal weight and low cerebroplacental ratio fetuses than in SGA and normal CPR fetuses, which proves that CPR is more commonly associated with fetal distress than birth weight. Only SGA fetuses with abnormal CPR were admitted to a neonatal emergency unit (NNU) more frequently. Neonatologists are more prone to admit babies to NNU if they are younger (15).

Stratification of birth outcomes is more accurate using Doppler indices than newborn weight. The study supports the assumption according to which normal weight babies may also be compromised due to placental insufficiency and recommends Doppler ultrasounds in all of them. Most national guidelines recommend Doppler ultrasound only in complicated SGA pregnancies and not in normal weight babies (15).

The C/U ratio was often used in SGA studies. It seems it was the first time when it was used in normal weight and term babies. All those in the 90th percentile had no problems at birth and did not require emergency cesarean section.

The effect is independent of parity, gestation, birthweight and mother BMI. The technique should be generalized in order to classify pregnancies before delivery (13).

**CONCLUSIONS**

In our obstetrical experience, Doppler follow-up of IUGR babies is a good indicator of their health and may help the decision making for a caesarian section.

According to a particular protocol this method slightly reduces the cesarean section rate and decreases premature birth frequency (16): the absent or reversed blood flow in the umbilical artery is the most efficient cesarean section indicator; the MCA flow is more reliable in near-term pregnancy; the biophysical score is more reliable at younger gestational ages; ductus venosus examination often helps; some authors suggest that umbilical vein blood flow should be measured in all pregnancies; sometimes, uterine artery velocimetry is also necessary; measurements of various vascular systems should be correlated and an overall integrative score should be developed.

**REFERENCES**


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**IMPACT OF BACTERIAL CELLS AND SECRETOMES ON WOUND HEALING**

According to Brothers KM *et al.*, bacterial cells and secretomes from *Serratia marcescens* (95%), *Pseudomonas aeruginosa* (71%) and *Staphylococcus aureus* (29%) strains inhibit human corneal epithelial cell migration *in vitro* and *ex vivo*, thus affecting the process of wound healing. Lipopolysaccharide (LPS) seems to be a key factor in this inhibitory mechanism, since LPS core biosynthetic genes are required to inhibit corneal epithelial cell migration. Purified LPS from *S. marcescens* inhibits epithelial cell migration *in vitro* and wound healing *ex vivo*, while after LPS depletion of *S. marcescens* secretomes, migration of epithelial cells was no longer inhibited, suggesting that *S. marcescens* LPS is sufficient for inhibition of epithelial wound healing (Brothers KM, Stella NA, Hunt KM, Romanowski EG, Liu X, Klarlund JK, et al. Putting on the brakes: Bacterial impediment of wound healing. Sci Rep. 2015;5:14003. doi: 10.1038/srep14003).

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