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ORIGINAL ARTICLE

Prospect for vaginal delivery of growth restricted fetuses with abnormal umbilical artery blood flow

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Background. The best mode of delivery in cases of intrauterine growth restriction (IUGR) with umbilical artery blood flow changes is not well elucidated.
Objective. To evaluate outcome in IUGR with umbilical artery blood flow changes planned for vaginal delivery after a negative oxytocin challenge test (OCT).
Methods. In 84 term singleton pregnancies with suspected IUGR and no unanimous indication for abdominal delivery, Doppler velocimetry and OCT were performed. Positive OCT cases were delivered by cesarean section, negative OCT cases planned for vaginal delivery.
Results. Umbilical artery Doppler velocimetry was normal in 51 cases (normal group) and abnormal in 33 cases (increased pulsatility index with maintained forward diastolic flow). Gestational age at delivery was shorter ($p = 0.008$), positive OCT more common (33% vs. 16%; $p = 0.06$), and vaginal delivery less common (40% vs. 63%; $p = 0.04$) in the abnormal blood flow group compared with the normal flow group. When in labor, 68% in the abnormal flow group and 76% in the normal flow group delivered vaginally ($p = 0.6$). One baby had a lethal malformation and another suffered meconium aspiration and pneumothorax, but was discharged home healthy.
Conclusions. The vaginal delivery rate was significantly lower in the abnormal flow group compared with the normal flow group, but in cases finally destined for a trial of labor the vaginal delivery rates were similar. There was no indication that any fetus was exposed to detrimental hypoxia or distress.

Key words: Doppler; flow resistance; IUGR; oxytocin; pregnancy

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Suspected intrauterine growth restriction (IUGR) with absent or reversed end-diastolic (ARED) blood flow velocity in the umbilical artery (UA) indicates a fetus at a particular high risk of suffering death or morbidity (1–3). The choice of prompt abdominal delivery is then usually not controversial (4–7). In contrast, there is no general consensus on when and how to deliver IUGR fetuses having only a slightly or moderately increased UA vascular flow resistance, with forward diastolic flow maintained. Skinner et al. (8) found in a series of pregnancies complicated by increased UA vascular flow resistance that 90% of cases allowed a trial of labor delivered vaginally. However, IUGR was an indication for elective cesarean section (CS).

Abbreviations:
AGA: appropriate-for-gestational age; ARED: absent or reversed end-diastolic; BFC: blood flow class; CI: confidence interval; CS: cesarean section; IUGR: intrauterine growth restriction; LGA: large-for-gestational age; NICU: neonatal intensive care unit; NVD: normal vaginal delivery; OCT: oxytocin challenge test; ODFD: operative delivery for fetal distress; OR: odds ratio; PI: pulsatility index; SD: standard deviation; SGA: small-for-gestational age; UA: umbilical artery; WD: weight deviation.

The question addressing the best mode of delivery in IUGR fetuses with no other serious complication but increased UA vascular flow resistance is still unanswered.

When deciding on mode of delivery in cases of IUGR, the ultimate goal is to avoid unnecessary fetal exposure to hypoxia and distress. A trial of vaginal delivery should therefore be allowed only in cases assessed to run a minimal risk of developing distress in labor. More than three decades ago, the oxytocin challenge test (OCT) was introduced by Hammacher (9), Kubli et al. (10) and Pose et al. (11) for the assessment of the placental reserve capacity in cases of IUGR. The value of the OCT as a tool to detect placental insufficiency was reported by several investigators during the 1970s (12–15). However, with the advent of new methods for fetal surveillance the OCT became outmoded.

Alternative methods of antenatal fetal surveillance in IUGR, such as the nonstress test, biophysical profile and UA Doppler velocimetry, have proved to be of limited value in predicting the risk of developing fetal distress in labor (16–18). This is also true for more sophisticated Doppler velocimetry studies, such as recording of flow in the fetal middle cerebral artery (19,20) or renal artery (20). In order to determine the appropriate time and method of delivery for IUGR fetuses at term, we have therefore continued to use the OCT as a selection method in cases without any concomitant complication necessitating abdominal delivery.

The main aim of the present prospective study was to investigate the success rate of planned vaginal delivery in IUGR cases with UA blood flow changes compared to cases with normal blood flow. The second aim was to investigate neonatal outcome relative to OCT result and decided mode of delivery, being aware of the possibility that performing an OCT and allowing a trial of labor could jeopardize the well-being of such already compromised fetuses (21).

Materials and methods

In this prospective study, 84 women with singleton pregnancies at term and with a suspicion of IUGR were examined with UA Doppler velocimetry and OCT. The indication for OCT was to make a decision on the time and mode of delivery. OCT negative cases were planned for a trial of vaginal delivery. Although false positive OCTs occur, it is a policy at our department to deliver women with a positive OCT by the abdominal route.

The OCT was performed in cases of a gestational age of $\geq$36 completed weeks and with no complementary indication for delivery necessitating an elective CS. Maternal complications were found in 16 cases of mild preeclampsia or gestational hypertension and in three cases of gestational diabetes.

All pregnancies at our department are dated at an early second trimester ultrasound examination (22), and a second routine ultrasound scan is performed at 32–33 weeks to detect IUGR. All cases with an estimated weight deviation (WD) from the mean of -5% to -21% were scheduled for a third scan 3–4 weeks later. Suspected IUGR was defined as an estimated fetal weight below the gestational age-corrected mean value minus 2 standard deviations (SD), corresponding to a WD of $\geq -22\%$ according to the reference weight curve (23). A fall of $>10\%$ WD between two ultrasound fetometries was also defined as suspected IUGR. After delivery, the true gestational age-corrected WD was calculated and the birthweight classified as appropriate-for-gestational age (AGA = mean $\pm$ 2 SD), small-for-gestational age (SGA = below mean minus 2 SD), or large-for-gestational age (LGA = above mean plus 2 SD). Severe IUGR was defined as a birthweight below mean minus 3 SD, corresponding to the 0.15th percentile.

According to the IUGR management protocol, UA Doppler velocimetry was performed in a free-floating loop of the umbilical cord during fetal quiescence. Three consecutive velocity waveforms were recorded to calculate the pulsatility index (PI) (24). A PI of mean $\pm$ 2 SD was considered normal (25). Only cases with maintained forward diastolic flow were included in the study: ARED blood flow at term is at our department an indication for a CS. PI values between $+2$ and $+3$ SD were classified as blood flow class (BFC) I, and BFC II when more than $+3$ SD.

UA PI is linearly and negatively correlated to gestational age during the last trimester (25). To enable statistical comparisons of PI in cases at different gestational ages, all PI values were adjusted to a fictitious gestational age of 280 days according to the equation: adjusted PI = measured PI + [(gestational age in days $-$ 280)/7] $\times$ 0.027 (26).

Both the Doppler velocimetry and the OCT were performed with the woman in a semirecumbent position, tilted slightly to the left. The Doppler velocimetry was performed immediately before the OCT was started. The OCT was preceded by 30 min of basal electronic fetal heart rate monitoring with a standard cardiotocograph, externally recording fetal heart rate and uterine contractions at a paper speed of 1 cm/min. Oxytocin stimulation begun at an intravenous

infusion rate of 6 mL/h (5 units of oxytocin in 500 mL 5.5% glucose, or saline in diabetic cases). The infusion rate was doubled every 10 min until three consecutive uterine contractions per 10-min window occurred repeatedly, and then maintained for at least 30 min, or until repetitive late decelerations occurred in OCT positive cases. The maximal infusion rate was set at 96 mL/h. The OCT was classified as negative or positive according to Freeman (13).

The main outcome parameters were, apart from mode of delivery: operative delivery for fetal distress (ODFD) when occurring in labor or after a negative OCT; Apgar scores; umbilical cord arterial and venous blood pH and base deficit in extracellular fluid (BD_{ecf}) (27); and transfer to the neonatal intensive care unit (NICU). An Apgar score of <7 at 1, 5 or 10 min, a cord arterial pH of <7.10 at birth, and a venous pH of <7.15, arterial BD_{ecf} of >10.0 mmol/L and venous >9.0 mmol/L were defined abnormal. Hospital discharge diagnoses were noted for both mother and child.

The χ^2-test and Fisher's exact test were used to compare categorical observations, the Mann–Whitney *U*-test for quantitative observations, and simple linear regression analysis for associations between variables. Odds ratio (OR) with 95% confidence interval (CI) was calculated for risk estimation. A two-tailed p of <0.05 was considered statistically significant.

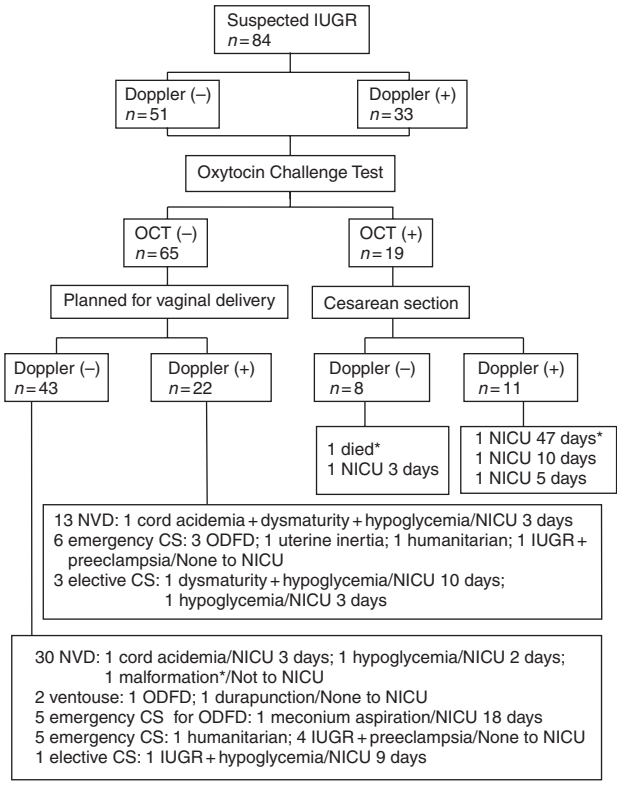

Fig. 1. Flow chart displaying selection criteria and neonatal outcome relative to Doppler velocimetry and oxytocin challenge test (OCT). (–) denotes normal or negative; (+) denotes abnormal or positive; (*) denotes congenital malformation. CS, cesarean section; IUGR, intrauterine growth restriction; NICU, neonatal intensive care unit; NVD, normal vaginal delivery; ODFD, operative delivery for fetal distress.

Results

UA blood flow was abnormal in 33 cases (25 BFC I and 8 BFC II) and normal in 51 cases. (In the following text, figures in the abnormal flow group are mentioned ahead of figures in the normal flow group.) There were no differences between the groups regarding maternal age or parity, or delay from OCT to delivery (median 2 vs. 1 day, range 0–11 and 0–19, respectively). In Fig. 1, a flow chart displays the selection and outcome pathways.

Demographic characteristics and outcome variables relative to UA Doppler velocimetry are shown in Table I. Mean gestational age at delivery was significantly lower in the abnormal UA blood flow group and vaginal delivery less common compared with the normal flow group. One neonate (normal flow group, positive OCT) still had an Apgar score of 1 after 10 min, and died after 30 min due to malformations with median cleft-face syndrome and skeletal dysplasia.

Altogether, OCT was positive in 19 cases (23%). In the abnormal blood flow group, the OR (95% CI) for a positive OCT was 2.69 (0.94–7.65), and for vaginal delivery 0.39 (0.16–0.95). There were no significant differences of gestational age-adjusted PI between OCT positive and OCT negative cases, and there was no difference with regard to BFC.

The ultrasonically estimated WD from the mean ± SD did not differ between the groups ($-29.4 \pm 9.7\%$ vs. $-28.6 \pm 8.8\%$; $p = 0.8$). A positive correlation was found between estimated and true WD ($r = 0.78$, $p < 0.0001$). No relationship between BFC and SGA was found ($p = 0.6$).

Among OCT negative cases there were 22 cases of abnormal blood flow and 43 cases of normal flow. No significant difference was found between the groups for any of the investigated parameters. The rates of CS (9/22 vs. 11/43), ODFD (3/22 vs. 6/43), and admission to the NICU (3/22 vs. 4/43) were not statistically different between the blood flow groups.

Among OCT negative cases, four cases were switched to elective CS for no other reasons but IUGR, maternal psychological stress, or emerging hypertension. Thus, only 19 and 42 cases, respectively, had a trail of vaginal delivery. The final

Table I. Umbilical artery Doppler blood flow results relative to demographic characteristics and perinatal outcome. Values are number of cases, or mean ± standard deviation. For statistical comparisons, the Mann–Whitney *U*-test, the χ^2-test and Fisher's exact test were used, and a two-tailed $p < 0.05$ regarded statistically significant

	Normal flow $n = 51$		Abnormal flow $n = 33$		Significance of difference (p)
Positive OCT	8	(16%)	11	(33%)	0.06
Vaginal delivery	32	(63%)	13	(40%)	0.04
Vaginal delivery*	32	(76%)	13	(68%)	0.5
ODFD*	6	(14%)	3	(16%)	1.0
Gestational age at delivery (days)	277.3 ± 11.3		270.6 ± 7.2		0.008
SGA	31	(61%)	21	(64%)	0.8
Birthweight deviation (%)	−22.5 ± 10.3		−24.9 ± 10.8		0.3
Apgar score <7					
1 min	4	(8%)	2	(6%)	1.0
5 min	2	(4%)	0	–	–
10 min	1	(2%)	0	–	–
Cord artery pH < 7.10	1	(2%)	1	(3%)	1.0
Cord vein pH < 7.15	1	(2%)	0	–	–
High cord blood BD_{ecf}†	1	(2%)	1	(3%)	1.0
Admission NICU	5	(10%)	6	(18%)	0.3

OCT, oxytocin challenge test; ODFD, operative delivery for fetal distress; SGA, small-for-gestational age; BD_{ecf}, base deficit in extracellular fluid; NICU, neonatal intensive care unit.

*Calculated on OCT negative cases and when elective cesarean section was excluded.

†Increased BD_{ecf}: arterial > 10.0 mmol/L, venous > 9.0 mmol/L.

vaginal delivery rate (13/19 vs. 32/42; $p = 0.6$) and transfer to the NICU (1/19 vs. 3/42; $p = 1.0$) were not different between the blood flow groups.

Among OCT negative cases with abnormal UA blood flow ($n = 22$) there was one case of cord acidemia (arterial pH 7.09, venous 7.17) but no case of low Apgar score (Fig. 1). Among OCT negative cases with normal UA blood flow ($n = 43$) there was one case of low Apgar scores (2^1, 3^5 and 7^{10}) and one case of cord acidemia (arterial pH 7.01, venous 7.05). The baby with low Apgar scores was postterm and suffered meconium aspiration and pneumothorax, but was healthy at discharge home.

According to our obstetric guidelines, all cases with a positive OCT were delivered by a CS the same day. Among OCT positive cases (11/33 vs. 8/51), one newborn had Apgar scores <7 (and died due to a lethal malformation) but cord acidemia occurred in none of the cases. Three of 11 cases in the abnormal flow group and 1/8 cases in the normal flow group were admitted to the NICU ($p = 0.6$). Taking death and NICU transfers together, there was no statistically significant difference between the groups ($p = 1.0$). The hospitalizations in the NICU were in the abnormal flow group for 5 days (hypoglycemia), 10 days (dysmaturity) and 47 days (atrial and ventricular septal heart defects), respectively; in the single case in the normal flow group the hospitalization lasted 3 days (neonatal respiratory distress).

Induction of labor was decided in 44 cases of negative OCT whereas expectant management was decided in 21 cases. There was no difference between these groups regarding BFC, SGA or degree of growth restriction. In the expectant management group, 1/9 cases in the abnormal flow group delivery was by emergency CS due to fetal distress, and in 3/9 cases with elective CS; the corresponding figures in the normal flow group were 3/12 and 0/12. The three elective CS were, in combination with blood flow changes and suspected IUGR, performed because of relative prematurity (36 weeks + 2 days), emerging gestational hypertension, and for no other obvious reason but IUGR, respectively. In no case was the Apgar score <7 at 5 or 10 min; in one case the cord arterial (but not venous) pH was acidemic. In three cases the newborns were admitted to the NICU, all for benign problems (and all belonging to the abnormal flow group); their admissions lasted from 3 to 10 days.

Of 15 cases with severe IUGR, 6/9 with abnormal flow and 2/6 with normal flow had a positive OCT ($p = 0.3$). Of the seven cases subsequently allowed for a trial of vaginal delivery, 1/3 and 2/4, respectively, were successfully delivered vaginally. No baby with severe IUGR had cord blood acidemia, but one had low Apgar scores (lethal malformation). All three cases of malformations belonged to the severely growth restricted group. One baby died, as described above, and two babies were diagnosed to have atrial and ventricular septal heart defects. Both these two babies did well, one even without transfer to the NICU.

Results between women with and without other complications (hypertension, preeclampsia, gestational diabetes) were not different.

Discussion

This study showed a higher likelihood of a positive OCT and a lower vaginal delivery rate in IUGR cases with abnormal UA Doppler velocimetry compared with cases with normal Doppler flows. In cases with abnormal flow, that is a high UA vascular flow resistance but still maintained forward diastolic flow, vaginal delivery was achieved in 40% of cases as compared with 63% in cases with normal flows. However, of OCT negative cases planned for vaginal delivery and finally also destined for a trial of labor, 68% of those with an abnormal Doppler velocimetry and 76% of those with a normal flow were ultimately delivered by the vaginal route. This suggests that the OCT was just as good in the abnormal flow group as in the normal flow group at selecting suitable candidates for a trial of vaginal delivery.

It was of special concern that the risk of developing hypoxia or neonatal morbidity should not increase by performing the OCT. Because of the low proportion of newborns admitted to the special neonatal care unit (13%), we assert that no fetus in the series was exposed to detrimental hypoxia or unnecessary neonatal morbidity because of the management program. Indeed, among nonmalformed babies only one had more than just benign morbidity and this neonate was discharged home healthy. The prerequisite for this good outcome was that no OCT was performed in cases of ARED blood flow in the UA, as such fetuses are particularly vulnerable to superimposed hypoxia likely to occur during labor and delivery (1–3). An OCT could further jeopardize the health of an already compromised fetus (21). ARED blood flow is therefore an absolute indication for abdominal delivery at our department.

Severe growth restriction is commonly associated with poor perinatal outcome and neonatal morbidity (28–30). In fact, all cases of congenital malformation in the series were severely growth restricted. Of 15 women with severely growth restricted fetuses seven were allowed a trail of labor, but only three ultimately delivered vaginally. This number is inadequate for any conclusion, but the poor success rate raises the question of whether a primary CS should be generally recommended in cases of severe IUGR, irrespective of the Doppler velocimetry and OCT results. On the other hand, none of the nonmalformed neonates in this subgroup suffered low Apgar scores or cord blood acidemia at birth.

In summary, this prospective study was performed in a series of suspected IUGR pregnancies with or without UA blood flow changes, but with no concomitant indication unanimously necessitating abdominal delivery prior to the OCT. The OCT was positive twice as often in the group with abnormal UA Doppler velocimetries, as compared with the group with normal flows (OR 2.69; 95% CI 0.94–7.65). The vaginal delivery rate in the group with abnormal blood flow was therefore significantly lower than in the group with normal flow (OR 0.39; 95% CI 0.16–0.95). However, of cases finally destined for a trial of labor, vaginal delivery was achieved equally often in the groups. We found no indication that the OCT or trial of labor exposed any baby to detrimental hypoxia or distress.

Although the OCT has commonly been abandoned on behalf of more modern methods for fetal evaluation, we continue to use the OCT in selected cases as an appreciated tool to assess the well-being of growth restricted and other fetuses with mild to moderate UA blood flow changes.

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