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Assessment of the Cardiotocogram and Perinatal Outcomes in Oxytocin-induced Labor

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ABSTRACT

Objective : To evaluate the correlation between the pattern of uterine contractions and fetal heart rate abnormalities and perinatal outcomes in oxytocin-induced labor in comparison with those in spontaneous labor.

Methods : In 2010 and 2011, 140 cases of oxytocin induction were investigated regarding uterine contractions, the frequency and types of fetal heart rate abnormalities, and the fetal prognosis and compared with 140 cases of spontaneous labor.

Results : In oxytocin-induced labor, cycle of labor pains tended to be short. In the first stage of labor, both variable decelerations and cardiotocographic abnormalities were more common in oxytocin-induced labor. The rate of cesarean sections was higher in the oxytocin-induced labor, but the rate of cesarean section due to non-reassuring fetal status did not differ between oxytocin-induced labor and spontaneous labor. Furthermore, no difference was observed in the Apgar score or the umbilical cord blood pH.

Conclusion : These results suggest that fetal heart rate abnormalities are more common in oxytocin-induced labor but that the rate of cesarean section due to non-reassuring fetal status and the prognosis of infants are the same as in spontaneous labor. (Jikeikai Med J 2011 ; 58 : 109-15)

Key words : oxytocin, cardiotocogram, fetal heart rate monitoring, uterine activity, perinatal outcome

INTRODUCTION

The rate of labor induction has recently increased with the number of elective inductions[1]. Safety becomes an issue with induced labor, but, in general, the rate of cesarean section is believed to be higher with induced labor than with spontaneous labor, which is prominent in nulliparas with an unfavorable cervix[2-4]. Moreover, several studies have found that oxytocin use is correlated with acidemia at birth and non-reassuring fetal status (NRFS)[5,6] and that selecting cesarean section upon the diagnosis of NRFS is more common with induced labor than with spontaneous labor. However, the rate of cesarean section may decrease with appropriate monitoring of the fetal heart rate (FHR) and with evaluation and comparison of the findings with uterine contractions. The purpose of the present study was to investigate the relationship between the patterns of uterine contractions and FHR abnormalities and perinatal outcomes in oxytocin-induced labor in comparison with those in spontaneous labor.

METHODS

This was a retrospective cohort study of 140 women

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with labors induced with oxytocin and 140 women with spontaneous labor, all without identified medical or obstetric indications for induction at The Jikei University Hospital from January 2010 through July 2011. Because we wanted to examine the effects of induction in a healthy, low-risk population, we limited our study to women with singleton fetuses in cephalic presentation who gave birth from 37 through 41 weeks' gestation. We excluded women who had any of the following conditions : premature rupture of membranes, chorioamnionitis, pregnancy-associated hypertension, Rh sensitization, diabetes, renal disease, lung disease, cardiac disease, fetal distress before onset of labor, intrauterine growth restriction, chronic hypertension, polyhydramnios, oligohydramnios, fetal abnormalities, previous cesarean delivery, and fetal death.

Uterine contractions, FHR monitoring, and neonatal outcomes were investigated. Uterine contractions were evaluated with external tocometry, wherein the uterine contraction time and labor pain cycle in the active phase (when cervical dilation is 5 to 6 cm) is evaluated. The contraction time was measured from the start of 1 contraction to the end of that same contraction, and the cycle of labor pains was measured from the peak of 1 contraction to the peak of the next contraction. The monitoring of FHR (MT-540 actocardiograph, Toitu Co., Ltd., Tokyo) was delimited every 20 minutes, and an investigation was conducted into the rate of overall normal monitoring, in which FHR abnormalities are not observed for 20 minutes (rate of normal interval) ; the incidence of FHR abnormalities and uterine contractions, when FHR abnormalities occurred at the first stage of labor ; the incidence of FHR abnormalities and the rate of forced delivery in the second stage of labor. The FHR abnormalities were classified into variable decelerations (VDs), late decelerations (LDs), and prolonged decelerations (PDs), according to the 2008 guidelines of the National Institute of Child Health & Development[7]. The LDs were subclassified into occasional LDs (oLDs), for those that were sporadic, and recurrent LDs (rLDs), for those that were recurrent. The VDs were classified, on the basis of the Kubli classification[8], into mild VDs (miVDs), for those with a duration of less than 30 seconds and with a level not less than 70 to 80 beats per minute (bpm) ; moderate VDs (moVDs), for those with a level of less than 70 bpm and duration of less than 30 to 60 seconds, or those that do not become less than 70 to 80 bpm even when the duration exceeds 60 seconds ; and severe VDs (sVDs), for those with a level of less than 70 bpm and a duration of more than 60 seconds. Oxytocin was administered as an infusion by means of a pump that allowed precise control of the flow rate and accurate minute-to-minute control. The dose of oxytocin was initially 2 mU/minute and was increased by 2 mU/minute at 40-minute intervals up to a maximum dose of 20 mIU/minute. The administration of oxytocin was discontinued when sVDs, rLDs, or PDs occurred in the first stage of labor, and oxytocin was readministered 30 minutes following the FHR pattern's return to normal. As prognostic indexes of the neonatal outcome, Apgar scores and the umbilical cord blood pH at birth were noted.

To determine whether differences were significant, Student's t-test was used when all groups were normally distributed and equally varied and if the amount of data was sufficient. The Mann-Whitney U test was used when groups were not normally distributed. Moreover, to compare data within groups, the χ^2 test and Fisher's exact probability test were used when appropriate. In all tests, differences were considered significant if the p-value was less than 0.05.

RESULTS

There were 312 cases of induced labor from January 2010 through July 2011 at The Jikei University Hospital. The criteria for inclusion were met by 140 women in whom labor was induced and by 140 women in whom labor was spontaneous and directly followed deliveries from women in whom labor was induced. The subjects with oxytocin-induced labor did not differ significantly from subjects with spontaneous labor in terms of maternal age, parity, body-mass index, or infant birth weight (Table 1). Because labor induction was scheduled after the condition of the cervix had been confirmed to have become favorable, the gestational age was higher in subjects with oxytocin-induced labor.

The uterine contraction time in the active phase (when cervical dilation is 5 to 6 cm) did not differ significantly between oxytocin-induced labor (65.3±13.8 seconds) and spontaneous labor (64.3±17.0 seconds), but the cycle of labor pains was significantly shorter with oxytocin-induced labor (166.3±38.8 seconds, $p<0.001$) than with spontane-

ous labor (220.6±84.7 seconds).

The rates of moVDs and sVDs in the first stage of labor were significantly higher with oxytocin-induced labor (21.4% and 13.6%, respectively) than with spontaneous labor (10.7% [$p<0.01$%] and 2.9% [$p<0.005$], respectively) (Table 2). The percentage of cases without cardiotocographic (CTG) abnormalities was significantly lower with oxytocin-induced labor (39.3%, $p<0.005$) than with spontaneous labor (56.4%).

The evaluation of uterine contractions according to the type of FHR abnormalities in oxytocin-induced labor (Table 3) showed that uterine contraction time was significantly longer in patients with PDs (81.8±25.2 seconds, $p<0.05$) and in patients with sVDs (73.9±15.8 seconds, $p<0.01$) than in patients without CTG abnormalities (64.2±11.3 second) and that the cycle of labor pains was significantly shorter in patients with PDs (140.9±48.1 seconds, $p<0.01$) than in patients without CTG abnormalities (170.7± 41.8 seconds). Regarding other FHR abnormalities, a tendency for the cycle of labor pains to be shorter was observed in all types of FHR abnormalities in oxytocin-induced labor, but no significant difference was observed. In patients with spontaneous labor, contractions times did not differ between patients with or without CTG abnormalities, and the cycle of labor pains was significantly shorter only in patients with PDs (137±31.1 seconds, $p<0.001$) than in patients without CTG abnormalities (214±66.3 seconds).

The monitoring of FHR before the development of serious FHR abnormalities (sVDs, rLDs, and PDs) in patients with oxytocin-induced labor (Table 4) showed that the rates of miVDs and moVDs in patients with sVDs, rLDs, or PDs did not differ significantly from those in all patients. However, the normal interval rate for all patients with oxytocin-induced labor (84.0%±14.9%) was significantly higher than that for patients with sVDs (67.9%±22.0%, $p<0.01$), rLDs (70.5%±15.0%, $p<0.05$), or PDs (73.5±16.2%, $p<0.05$).

Table 1. Patient characteristics

	Oxytocin-induced labor (n=140)	Spontaneous labor (n=140)	p-value
Age (years)	32.2±5.3	31.1±5.0	NS*
Parity			NS
0	52.1% (n=73)	49.3% (n=69)	
1-2	47.1% (n=66)	50.0% (n=70)	
≥3	0.7% (n=1)	0.7% (n=1)	
BMI**	25.0±2.8	24.5±3.3	NS
Gestational age (weeks)	39.6±1.2	39.0±0.9	$p<0.001$
Birth weight (g)	3,171±336	3,093±335	NS

*NS : not significant, **BMI : body-mass index

Table 2. Rate of FHR abnormalities in the first stage of labor

	miVDs (%)	moVDs (%)	sVDs (%)	rLDs (%)	PDs (%)	No CTG*** abnormalities	Normal interval rate (%)
Spontaneous labor	32.9	10.7	2.9	5.0	5.7	56.4	80.6±17.6
Oxytocin-induced labor	35.0	21.4*	13.6**	7.9	7.9	39.3**	84.0±14.9

*$p<0.01$, **$p<0.005$, ***CTG : cardiotocographic

Table 3. Correlation between FHR abnormalities and uterine contractions at in the first stage of labor

	Oxytocin-induced labor		Spontaneous labor	
	Contraction time (seconds)	Cycle of labor pains (seconds)	Contraction time (seconds)	Cycle of labor pains (seconds)
miVDs	66.7±15.5	159.2±54.3	64.2±13.6	230.0±96.1
moVDs	68.6±20.5	152.1±48.9	69.3±16.2	211.3±93.0
sVDs	73.9±15.8**	159.7±34.1	62.5±15.0	215.0±61.9
rLDs	70.9±21.7	157.3±83.9	65.7±14.0	175.7±72.3
PDs	81.8±25.2*	140.9±48.1**	72.5±14.9	137.5±31.1***
No CTG abnormalities	64.2±11.3	170.7±41.8	64.3±17.1	214.7±66.3

*$p<0.05$, **$p<0.01$, ***$p<0.001$, compared with no CTG abnormality

Table 4. FHR patterns before the development of severe FHR abnormalities in oxytocin-induced labor

	miVDs (%)	moVDs (%)	sVDs (%)	rLDs (%)	PDs (%)	Normal interval rate (%)
All oxytocin groups	35.0 (n=49)	21.4 (n=30)	13.6 (n=19)	7.9 (n=11)	7.9 (n=11)	84.0±14.9
sVDs (n=19)	26.3 (n=5)	26.3 (n=5)	–	0	15.8 (n=3)	67.9±22.0**
rLDs (n=11)	54.5 (n=6)	27.2 (n=3)	27.2 (n=3)	–	0	70.5±15.0*
PDs (n=11)	45.4 (n=5)	18.2 (n=2)	9.1 (n=1)	9.1 (n=1)	–	73.5±16.2*

*p<0.05, **p<0.01, compared to with all oxytocin groups

Table 5. Rates of FHR abnormalities in the second stage of labor

	miVDs + moVDs (%)	sVDs (%)	rLDs (%)	PDs (%)	No CTG abnormalities
Spontaneous labor	67.1	28.6	2.1	7.9*	20.0
Oxytocin-induced labor	56.4	26.4	5.0	15.7*	13.6

*p<0.05

Table 6. FHR patterns in the second stage and the fetal outcomes in oxytocin-induced labor

	Forced delivery rate (%)	Apgar score at 1 minute	Apgar score at 5 minutes	Umbilical cord blood pH
miVDs + moVDs (n=79)	8.5	8.6±0.7	9.2±0.5	7.29±0.07
sVDs (n=37)	22.5*	8.4±0.6	9.1±0.5	7.27±0.07
rLDs (n=7)	42.9	8.4±0.5	8.9±0.4	7.23±0.09
PDs (n=22)	36.4	8.5±1.0	9.1±0.4	7.26±0.07
No CTG abnormality (n=19)	0	8.8±0.7	9.4±0.5*	7.29±0.08
All oxytocin groups	11.4	8.6±0.8	9.2±0.5	7.29±0.07

*p<0.05, compared with all oxytocin groups

In the second stage of labor, the rate of PDs was higher in patients with oxytocin-induced labor (15.7%, p<0.05) than in patients with spontaenous labor (7.9%), but significant differences were not observed for other FHR abnormalities (Table 5). The comparison of FHR patterns in the second stage of labor and fetal outcomes (Table 6) showed that the rate of forced delivery tended to be high in patients with serious FHR abnormalities (sVDs, rLDs, and PDs). However, no significant difference was observed regarding the Apgar score or the umbilical cord blood pH in any group.

The examination of the rate of FHR abnormalities in the second stage of labor according to the presence of FHR abnormalities (sVDs, rLDs, or PDs) in the first stage in patients with oxytocin-induced labor (Table 7) showed that in patients with sVDs in the first stage, the rates of VDs in the second stage tended to be higher than in all patients, and the rate of moVDs was significantly higher (52.6%, p< 0.05). When patients had rLDs in the first stage, the incidence of rLDs in the second stage tended to be higher (45.4%) than for all patients, and when patients had PDs in the first stage, the rate of PDs in the second stage tended to be higher (27.3%). All FHR abnormalities tended to have a higher recurrence rate.

The comparison of birth outcomes (Table 8) showed that the rates of instrumental delivery and cesarean section were significantly higher with oxytocin-induced labor (17.8%, p<0.05 and 10.7%, p<0.05) than with spontaneous labor (7.1% and 3.6%) ; however, NRFS was the reason for only 1 of 15 (6.7%) cesarean sections with oxytocin-induced labor but was the reason for 4 of 5 (80.0%) cesarean sections with spontaneous labor. Moreover, no significant dif-

Table 7. FHR abnormalities in the second stage according to FHR abnormalities in the first stage of oxytocin-induced labor

	miVDs (%)	moVDs (%)	sVDs (%)	rLDs (%)	PDs (%)
All oxytocin groups	33.6	22.9	26.4	5.0	15.7
sVDs group (n=19)	36.8	52.6*	47.3	5.3	21.1
rLDs group (n=11)	18.2	18.2	9.1	45.4	9.1
PDs group (n=11)	36.4	45.5	27.3	18.2	27.3

*p<0.05, compared with all oxytocin groups

Table 8. Outcomes of pregnancies and infants

	Oxytocin-induced labor	Spontaneous labor	p-value	Relative risk (95% confidence interval)
Mode of delivery				
Normal vaginal delivery	100 cases (71.4%)	125 cases (89.3%)	p<0.001	0.71≤0.80≤0.90
Vacuum extraction	24 cases (17.1%), due to NRFS* : 13 cases (9.3%)	10 cases (7.1%), due to NRFS : 7 cases (5.0%)	p<0.05 NS	1.19≤2.40≤4.83 0.76≤1.86≤4.52
Forceps delivery	1 cases (0.7%), due to NRFS : 0 cases	0 cases		
Cesarean section	15 cases (10.7%), due to NRFS : 1 case (0.7%)	5 cases (3.6%), due to NRFS : 4 cases (2.9%)	p<0.05 NS	1.12≤3.00≤8.03 0.03≤0.25≤2.21
Forced delivery due to NRFS	14 cases (10.0%)	11 cases (7.9%)	NS	0.60≤1.27≤2.71
Outcomes of the infants				
Apgar score at 1 minute	8.6±0.8	8.6±0.8	NS	
at 5 minutes	9.2±0.5	9.1±0.4	NS	
Umbilical cord blood pH	7.29±0.07	7.30±0.07	NS	

*NRFS : non-reassuring fetal status, **NS : not significant

ference was observed in the Apgar score or the umbilical cord blood pH.

Discussion

Our results support the hypothesis that the rate of cesarean section due to NRFS can be reduced by appropriately monitoring the FHR and by evaluating uterine contractions. We found that the rate of FHR abnormalities tended to increase when oxytocin was used to induce labor, but when appropriate procedures were taken, the rate of cesarean section due to NRFS was similar to that for spontaneous labor, and the prognosis of infants was good.

The cycle of labor pains in the active phase was significantly shorter with oxytocin-induced labor than with spontaneous labor. Moreover, the incidence of FHR abnormalities in the first stage of labor was higher with oxytocin induction. This result was evaluated by external monitoring, and labor intensity could not be compared quantitatively ; however, when labor was induced with oxytocin, the cycle of labor pains tended to be shorter than with spontaneous labor, indicating that the incidence of FHR abnormalities increased.

When uterine contractions in oxytocin-induced labor were evaluated according to FHR abnormalities, the cycle of labor pains tended to be shorter with all FHR abnormalities. When the cycle of labor pains becomes shorter, the incidence of FHR abnormalities can be reduced by appropriately reducing the oxytocin dosage. On the other hand, when FHR monitoring before the development of sVDs, rLDs, and PDs was investigated, the rate of miVDs or moVDs or both was not high, and predicting these abnormalities from the FHR pattern was difficult. Simpson et al.[9] hyperstimulated uterine contractions for 30 minutes us-

ing oxytocin in 56 nulliparous women admitted to the hospital for elective labor induction with oxytocin ; they used 2 definitions of hyperstimulation to identify periods of excessive uterine activity : 6 or more uterine contractions in 10 minutes and 5 or more but fewer than 6 uterine contractions in 10 minutes. They reported that when the oxygen concentration in fetal blood and the FHR pattern over 30 minutes were evaluated and compared with those of patients with a normal contraction pattern (5 times or less in 10 minutes), the oxygen concentration in the fetal blood was significantly lower in the 2 groups of patients with 5 or more uterine contractions, variability and accelerations were decreased, and rLDs occurred more frequently. Moreover, although changes in variability occurred 22 to 24 minutes following hyperstimulation, fetal blood oxygen concentration has been reported to decrease 5 minutes after hyperstimulation. The FHR abnormalities can be avoided by discontinuing the administration of oxytocin when hyperstimulation is observed. Three treatments have been used to treat hyperstimulation : 1) discontinuing oxytocin infusion, 2) discontinuing oxytocin infusion and giving a bolus injection of lactated Ringer's solution, and 3) discontinuing oxytocin infusion, giving a bolus injection of lactated Ringer's solution, and lateral positioning ; the fetal heart rate improved most quickly when all 3 treatments were performed (14.2 minutes, 9.8 minutes, and 6.1 minutes, respectively). Uterine contractions numbering 5 or more in 10 minutes can be said to be an index for hyperstimulation of the uterus, and if this index is used, labor can be induced more safely by reducing the oxytocin dosage before FHR abnormalities occur.

When we investigated the second stage of labor, we found that the rate of forced delivery owing to the development of serious FHR abnormalities tended to be higher. When sVDs occurred in the first stage of labor, the rate of FHR abnormalities, including sVDs, in the second stage was high. Moreover, rLDs recurred at a high rate in the second stage. When serious FHR abnormalities occur in the first stage, the high likelihood of forced delivery and recurrent FHR abnormalities in the second stage suggest that preparations should be made for forced delivery.

Apgar scores and umbilical cord blood pH in the present study indicated that the prognosis of infants was generally good after oxytocin-induced labor or spontaneous labor and it was found that the prognosis of infants is not affected by induced labor using oxytocin. Prysak and Castronova[10] found no difference in the rate of admission to the neonatal intensive care unit (NICU) between 461 cases of elective induction (4.6%) and cases of spontaneous labor (3.9%) and concluded that elective induction is safe. Similar findings have been obtained in other studies[11,12]. On the other hand, Jonsson et al.[5] examined the obstetric characteristics 2 hours before delivery of infants with an umbilical cord blood pH of less than 7.05 at birth ; they found that 6 or more uterine contractions in 10 minutes (odds ratio : 4.94) and the use of oxytocin (odds ratio : 2.20) were correlated with infant acidosis and that oxytocin was used in 75% of cases with 6 or more uterine contractions in 10 minutes. However, Jonsson et al.[5] also found that in 11% of cases in which oxytocin was used, FHR monitoring had been inadequate and in 22% uterine activity had not been monitored. Such practices are clear deviation from labor ward departmental guidelines for oxytocin use. In contrast, when oxytocin is appropriately discontinued or reduced in dosage according to strict protocols, oxytocin-induced labor does not increase the risk of acidemia[13-16], and Jonsson et al.[5] mentioned that by appropriately using oxytocin and monitoring contraction frequency and FHR patterns, infant acidosis may be avoided ; they also mentioned that more attention be paid to uterine contractions and the fetal response to uterine activity. Moreover, Clark et al.[17] have established a checklist-based management protocol for oxytocin administration based on the maternal-fetal response to oxytocin rather than according to the infusion rate ; they reported that the rate of cesarean section decreased slightly without prolonged delivery time, with the 1-minute Apgar scores and the incidence of infant complications significantly improving.

In the present study, the rate of cesarean section and the rate of instrumental delivery were both high with oxytocin-induced labor, a finding obtained by several previous studies[2-4,10,12] ; however, the rate of cesarean section due to NRFS was 0.7%, which was lower than with spontaneous labor. Regarding the rate of cesarean section, Nielsen et al.[11] have reported that 116 patients with good Bishop scores who underwent elective induction had a rate of cesarean section (6.9%) that was similar to that of patients for whom management was expectant (7.3%). If the Bishop score is good and risk factors that indicate induction are excluded, labor can be induced with oxytocin without increas-

ing the rate of caesarean section due to NRFS.

In the present study we found that the cycle of labor pains tended to be shorter and the rate of FHR abnormalities tended to be higher with oxytocin-induced labor. We also found that FHR abnormalities were improved by adjusting the dosage of oxytocin and that the rate of cesarean section due to NRFS (0.7%) and the prognosis of infants with oxytocin-induced labor were similar to those with spontaneous labor. Abnormalities of FHR in the first stage of labor are difficult to predict on the basis of the FHR pattern but they tended to appear when the cycle of labor pains was short. Our findings suggest that as the cycle of labor pains becomes shorter, FHR abnormalities can be avoided by discontinuing oxytocin infusion. On the other hand, when sVDs and rLDs occur in the first stage of labor, similar FHR abnormalities are more likely to recur in the second stage, and the rate of forced delivery tends to be higher. The rate of instrumental delivery due to NRFS was higher with oxytocin-induced labor, and it indicated that when serious FHR abnormalities occur in the first stage of labor, preparations for a possible forced delivery should be made.

The number of cases in the present study was small, and the detailed evaluation of uterine contractions was limited because this result was evaluated by external monitoring and labor intensity could not be compared quantitatively ; however, labor induction with oxytocin was able to be safely performed when the FHR and uterine contractions were monitored and appropriately evaluated, and the dosage of oxytocin was adjusted. The rate of cesarean section due to NRFS and the prognosis of infants with oxytocin-induced labor were confirmed to be similar as with spontaneous labor.

The results of the present study suggest that to prove our hypothesis additional cases must be accumulated ; therefore, we plan to establish a strict protocol that appropriately evaluates uterine contraction, while appropriately adjusting the dosage of oxytocin.

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