Impact of Gestational Age at Delivery on Fetal Heart Rate Monitoring During the Second Stage of Labor

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Abstract: *Objective:* To clarify whether gestational age at delivery affects the interpretation level of fetal heart rate (FHR) tracings in the second stage of labor in primiparous and singleton pregnancies.

Methods: The database at one tertiary hospital in Japan was retrospectively reviewed for women with singleton fetuses in cephalic presentation and vaginal labor at ≥37+0 gestational weeks between June 1, 2011, and March 31, 2013. Continuous FHR tracings in the second stage of labor were subdivided into 10-minute intervals, each of which we called a window, from the beginning through delivery, and were assessed according to the five-tier classification proposed by the Japan Society of Obstetrics and Gynecology, in which level 1 is normal, level 2 is subnormal, and levels 3-5 are abnormal patterns. Subjects were divided into two groups, including early term (37 0/7 to 38 6/7 weeks) and full term (39 0/7 to 41 6/7 weeks), according to the delivery age.

Results: In total, 914 parturient women were eligible for the study protocol, including 228 and 686 women in early and full term, respectively. Vacuum extraction was more often observed in full term than in early term (P=0.007). Although the maximal level, number of level-5 windows, number of level-4 windows, and number of level-3 and level-4 windows were similar between the groups, the summation of level-4 windows ≥3 was significantly higher in full term than in early term (P=0.004).

Conclusion: Full term delivery has a higher risk than does early term delivery from the standpoint of FHR monitoring.

Keywords: Fetal heart rate tracing, Five-tier classification, Gestational age at delivery, Second stage of labor.

INTRODUCTION

Continuous intrapartum electronic fetal heart rate (FHR) monitoring was introduced in the 1960s and has been used worldwide. The classification system went through changes from 2-tier system as either “reassuring” or “nonreassuring” [1] to 3-tier system [2], and agreement on its use was reached because of the system’s simplicity and ease of teaching [3]. However, the intermediate tier covers too broad of an area to develop a clear management policy for obstetricians, midwives, and nurses. Then, a five-tier classification system was proposed by Parer and Ikeda [4] to resolve the matter, followed by the guidelines for intrapartum management based on FHR tracing interpretation proposed by the Japan Society of Obstetrics and Gynecology (JSOG) in 2009 [5]. This five-tier coding system is based on the baseline rate, type of deceleration, and quantity of variability, and its usefulness has been recently reported [6, 7].

Many fetal and maternal complications of pregnancy have been extensively examined in post term pregnancy, defined as a pregnancy that has reached or extended beyond 42 0/7 weeks of gestation. Post term pregnancies have been associated with increased fetal and neonatal mortality and morbidity as well as maternal morbidity [8]. Although term pregnancies have been thought to be relatively safe, the incidence of complications associated with post term pregnancy also increases prior to 42 weeks of gestation. For example, the rates of meconium, macrosomia, operative vaginal delivery, chorioamnionitis, endomyometritis, intrauterine fetal death, and cesarean delivery all increased before 42 weeks of gestation [9]. Additionally, the umbilical artery pH <7.0, base excess (BE) <-12 mmol/L, and 5-minute Apgar score <7 all increased before 42 weeks of gestation [10]. Term birth has previously been considered a homogeneous group when the risks associated with preterm (less than 37 weeks of gestation) and post term births are compared. However, there is a growing body of data indicating that neonatal morbidity decreases with delivery at later gestational age of term pregnancy and that infants delivered at 37 and 38 weeks of gestation are at increased risk for morbidity compared with infants delivered at 39 weeks [11-14]. Therefore, Fleischmen *et al*. [15] subcategorized term pregnancies into early term, from 37 0/7 to 38 6/7 weeks of gestation, and full term, from 39 0/7 to 41 6/7 weeks of gestation to pay attention to early term delivery, which has a higher risk of neonatal complications.

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In contrast, unexplained stillbirth apparently increases as gestation advances beyond 40 weeks [16], suggesting the senescence of placenta. Therefore, earlier delivery might be better for fetal well-being. Our literature search on PubMed found few investigations that focused on the association between gestational age at delivery and FHR monitoring. Because most deliveries are watched by FHR monitoring in clinical practice, it is important to verify the difference between early term and full term considering the assessment levels by FHR monitoring to manage pregnancies in each category.

The aim of this study was to clarify whether gestational age at delivery affects the interpretation level of FHR tracings in the second stage of labor in primiparous and singleton pregnancies.

MATERIALS AND METHODS

A review of labor and delivery records from June 1, 2011, to March 31, 2013, was conducted at the Japanese Red Cross Nagoya Daiichi Hospital. The hospital is a tertiary referral center with approximately 1,500 deliveries per year. Primiparous women in active labor at ≥37 gestational weeks with singleton fetuses in cephalic presentation were included in the study. Cases with neonatal karyotype abnormality, malformations, or body weight at birth less than 2,000 g were excluded. Cases were also excluded when sampling for umbilical artery blood gas and acid-base balance analyses were not performed or when cesarean section (CS) was performed. Subjects were divided into two groups, including early term (37 0/7 to 38 6/7 weeks) and full term (39 0/7 to 41 6/7 weeks), according to the age at delivery. This study has been approved by the Institutional Ethics Committee of the Japanese Red Cross Nagoya Daiichi Hospital.

The FHR tracings in the second stage of labor were obtained by means of either an external ultrasonographic signal sensor or an internal intrauterine scalp electrode. Continuous monitoring by cardiotocography during labor is a routine procedure in our unit. Two observers, including an expert obstetrician with more than 30 years of clinical experience in obstetrics and a specialist trainee, reviewed the guidelines proposed by the JSOG. They then assessed the entire tracing of each subject without foreknowledge of the neonatal outcome. The second stage of labor was subdivided into 10-minute intervals from the beginning through delivery, and each interval of the FHR tracings was called a window. The levels were assessed in each window by using 5-tier classification system because the finer classification is suitable for comparison of fetal well-being. In the case of the appearance of multiple patterns in a window, the highest level was selected. The definitions of baseline, variability, and deceleration were similar to those shown in the ACOG Practice Bulletin in 2010 [17]. The five-tier coded system proposed by the JSOG has been previously reported [5] and is summarized in Table **1**. According to the JSOG guidelines, levels 1 and 2 are normal and benign variant patterns, respectively. Abnormal patterns are categorized into level 3 (mild variant pattern), level 4 (moderate variant pattern), and level 5 (severe variant pattern), with the risks of fetal acidemia and hypoxia. The umbilical cord was clamped immediately after birth, and an umbilical artery blood sample was obtained from a clamped segment for

Table 1: Levels of 5-Tier FHR Monitoring in Cases of Normal Baseline Variability

	Decelerations							
			VD		LD		PD	
	None	ED	Mild	Severe	Mild	Severe	Mild	Severe
Baseline								
Normal	1 (2)	2 (3)	2 (3)	3 (4)	3 (3)	3 (4)	3 (4)	4 (5)
Tachycardia (>160 bpm)	2 (3)	2 (3)	3 (4)	3 (4)	3 (4)	4 (5)	3 (4)	4 (5)
Bradycardia (80≤ <110 bpm)	3 (4)	3 (4)	3 (4)	4 (5)	4 (5)	4 (5)	4 (5)	4 (5)
Bradycardia (<80 bpm)	4 (5)	4 (5)		4 (5)	4 (5)	4 (5)		

FHR, fetal heart rate.
When variability is minimal, the levels are shown in parentheses. In cases of absent variability with or without deceleration, the levels are 5 or 4, respectively. When variability is marked, the levels correspond to those of tachycardia.
ED, early deceleration; VD, variable deceleration; LD, late deceleration; PD, prolonged deceleration.
Adapted from Okai *et al.* [5].

blood gas and acid-base assessments. Severe acidosis was defined as an umbilical artery pH <7.0 or a BE <-12 mmol/L. These values were chosen because the risk of morbidity or mortality does not increase until the pH is below 7.0 [18, 19] or the BE is below -12 mmol/L [19, 20], and the ACOG regarded them as one of the criteria sufficient to cause cerebral palsy [21]. The summation of level-4 windows ≥3, and the summation of the level-3 and level-4 windows ≥6 were included as evaluation items because they were strongly related with severe acidosis [7].

Statistical computations were performed using a commercially available statistical analysis package (StatMate III, Atoms, Tokyo, Japan). Comparisons of group means were performed using Student's *t*-test. The Mann-Whitney U test was used to compare non-normal continuous variables. Comparisons of proportions were performed using the chi-square test. Statistical tests were considered significant when the *P*-value was less than 0.05.

RESULTS

During the study period, a total of 2,685 parturient women were admitted to the labor ward. First, we excluded cases who were <37 gestational weeks, multiparous women, multiple births, intrauterine fetal death, and/or CS (*n*=1,723). Among the other 962 women, body weight at birth <2,000 g (*n*=7), no or insufficient FHR tracings (*n*=30), and uncollected umbilical blood (*n*=11) were also excluded. The remaining 914 were classified as eligible for the study protocol. There were 80 cases of vacuum extraction but no forceps delivery. No women received regional anesthesia during labor. The obstetric characteristics of the study population are shown in Table **2**. Vacuum extraction was more often observed in full term than in early term (*P*=0.007).

The numbers of women with delivery ages of 37, 38, 39, 40, and 41 weeks were 63, 165, 292, 273, and 121, respectively. Fetal and neonatal outcomes are shown in Table **3**. There were no differences in Apgar score at both 1 and 5 minutes, and the number of Apgar score at 5-minute less than 7 between early term and full term. Similarly, no difference was observed in umbilical pH and BE or the number of pH <7.0 or BE <-12 mmol/L, which indicated severe fetal acidosis. The maximal level, number of level-5 windows, number of level-4 windows, and number of level-3 and level-4 windows were similar between early term and full term. Notably, summation of level-4 windows ≥3 was significantly higher in full-term women than in early-term women (*P*=0.004). There was no significant difference in the summation of level-3 and level-4 windows ≥6 between early term and full term. Because the summation of level-4 windows ≥3 and the summation of the level-3 and level-4 windows ≥6 are the pivotal information for considering intervention [7], they were more precisely investigated according to the gestational age at delivery (Table **4**). We found an increasing trend of both summation of level-4 window ≥3 and summation of level-3 and level-4 windows ≥6 by week of gestation, although there was no significant difference. Table **5** shows the frequency of severe fetal acidosis and FHR monitoring levels according to the presence or absence of vacuum extraction in full term

Table 2: Obstetric Characteristics of the Study Population

	Early term	Full term	
	(*n*=228)	(*n*=686)	*P*
Maternal age (years)[a]	30.7±5.0	31.1±5.0	0.31
Induction or augmentation of labor[b]	85 (37.3)	297 (43.3)	0.11
Vacuum extraction[b]	10 (4.4)	70 (10.2)	0.007
Birth weight (g)[a]	2,802±334	3,092±346	<0.001
Sex[b]			0.13
Male	122 (53.5)	327 (47.7)	
Female	106 (47.5)	359 (52.3)	
Duration of 2nd stage (min)[a]	82±72	86±63	0.40
Duration of 2nd stage >120 min[b]	51 (22.4)	155 (22.6)	0.94

[a] Values are presented as the mean ± SD.
[b] Values are presented as *n* (%).

Table 3: Fetal and Neonatal Outcome in Early and Full Term Deliveries

	Early Term	Full Term	
	(*n*=228)	(*n*=686)	*P*
Apgar (1 min)[a]	9 (1-10)	9 (3-10)	0.72
Apgar (5 min)[a]	9 (5-10)	9 (6-10)	0.31
Apgar (5 min) <7[b]	2 (0.9)	5 (0.7)	0.82
Umbilical artery			
pH[c]	7.25±0.08	7.25±0.08	0.15
base excess (mmol/L)[c]	-6.33±3.34	-6.38±3.30	0.82
pH <7.0 or base excess <-12[b]	13 (5.7)	41 (6.0)	0.87
FHR monitoring			
Max level[a]	3 (1-5)	3 (2-5)	0.86
Windows of level 5[a]	0 (0-2)	0 (0-1)	0.73
Windows of level 4[a]	0 (0-5)	0 (0-9)	0.93
Windows of level 3[a]	2 (0-14)	2 (0-14)	0.09
Windows of level 3 or 4[a]	3 (0-17)	3 (0-16)	0.05
Summation of level-4 window ≥3[b]	3 (1.3)	41 (6.0)	0.004
Summation of level-3 and level-4 windows ≥6[b]	40 (17.5)	145 (21.1)	0.24

FHR, fetal heart rate.
[a] Values are presented as median (range).
[b] Values are presented as *n* (%).
[c] Values are presented as the mean ± SD.

Table 4: Abnormal FHR Tracing Levels According to Delivery Weeks

	Weeks of Gestation at Delivery					
	37	38	39	40	41	
	(n=63)	(n=165)	(n=292)	(n=273)	(n=121)	*P*[*]
Summation of level-5 window ≥1	1 (1.6)	1 (0.6)	3 (1.0)	4 (1.5)	1 (0.8)	0.92
Summation of level-4 window ≥3	0 (0)	3 (1.8)	16 (5.5)	17 (6.2)	8 (6.6)	0.07
Summation of level-3 and level-4 windows ≥6	8 (12.7)	32 (19.4)	56 (19.2)	58 (21.2)	31 (25.6)	0.30

FHR, fetal heart rate.
Values are presented as *n* (%).
[*] overall differences by chi-square test.

deliveries. The maximal level and number of level-4 windows were significantly higher in women with vacuum extraction compared with those without intervention, although the frequencies of severe fetal acidosis, the summation of level-4 windows ≥3, and the summation of the level-3 and level-4 windows ≥6 were not different between the groups.

DISCUSSION

A survey of women who recently gave birth found that over half believed that full term was reached at 37-38 weeks of gestation and that most believed it was safe to deliver before 39 weeks of gestation when there are no other medical complications requiring early delivery [22]. Similarly, some obstetricians believe that placental senescence affects fetal well-being, despite a lack of evidence, and that delivery before the estimated date of delivery is thus preferable. However, no consensus has been so far achieved on the most appropriate age of delivery. This is the first report to examine the impact of gestational age at delivery based on the FHR monitoring levels using the five-tier classification system proposed by the JSOG.

Table 5: Severe Acidosis and FHR Monitoring Level in Full Term Delivery with and without Vacuum Extraction

	No Intervention	Vacuum Extraction	
	(*n*=616)	(*n*=70)	*P*
Umbilical artery			
pH <7.0 or base excess <-12[a]	34 (5.5)	7 (10.0)	0.13
FHR monitoring			
Max level[b]	3 (2-5)	4 (3-5)	<0.001
Windows of level 5[b]	0 (0-1)	0 (0-1)	0.96
Windows of level 4[b]	0 (0-9)	1 (0-7)	0.003
Windows of level 3[b]	2 (0-14)	2 (0-12)	0.65
Windows of level 3 or 4[b]	3 (0-16)	3 (1-12)	0.36
Summation of level-4 window ≥3[a]	36 (5.8)	5 (7.1)	0.66
Summation of level-3 and level-4 windows ≥6[a]	128 (20.8)	17 (24.2)	0.50

FHR, fetal heart rate.
[a] Values are presented as *n* (%).
[b] Values are presented as median (range).

A statistically significant negative linear association between gestational age and umbilical artery pH has been previously reported [23, 24], although the range was very narrow; the mean pHs were 7.26 at 37 weeks and 7.22 at 42 weeks [23]. Unexpectedly, in the present study, the mean umbilical artery pH level was 7.25 in both early term and full term, and there was no difference between the groups. This effect may be due to the smaller sample size examined. However, considering that the cutoff levels indicative of fetal acidemia and for clinical usefulness are 7.10 [23] or 7.00 [25], our results and the previous report indicated that gestational age at delivery did not have a controversial influence on umbilical artery pH within the 5-week period of term pregnancy. Otherwise, intensive surveillance by continuous FHR monitoring during the second stage of labor, timely identification of nonreassuring fetal status, and proper intervention might avoid leading to a lowering in pH levels.

In the present study, vacuum extraction was more often observed in full term deliveries than in early term deliveries. Because vacuum extraction can stimulate the fetal parasympathetic nervous system and induce fetal bradycardia, our findings that the maximal level and number of level 4-windows increased in vacuum deliveries compared with non-intervention deliveries may reflect the influence of vacuum extraction. Additionally, the higher prevalence of summation of level-4 windows ≥3 in full term deliveries might be due to the more frequent use of vacuum extraction. However, considering that the indications for vacuum extraction are nonreassuring fetal status in the first place or, in our hospital, a prolonged second stage of labor and that there was no difference of summation of level-4 windows ≥3 between the vacuum extraction group and no intervention group, it is likely that the higher prevalence of summation of level-4 windows ≥3 in full term deliveries is not the result of vacuum extraction but rather the reason for choosing vacuum extraction.

We previously assessed the FHR monitoring based on the numbers of abnormal level-windows and the maximal level and demonstrated that the duration and degree of the FHR tracing interpretation levels played a role in the occurrence of severe fetal acidosis [7]. The summation of abnormal windows is anticipated to increase with a longer second stage of labor. Therefore, this study was designed for only primiparous women who usually take a longer time until delivery. Because there was no difference in the duration of the second stage of labor between early and full term deliveries, the higher prevalence of summation of level-4 windows ≥3 in full term deliveries should be attributable not to the duration of the second stage but to different gestational age at delivery.

The accumulation of oxidative damage to proteins, lipids, and DNA induces a form of advanced aging that prevents the placenta from meeting the demands of the fetus, and as a consequence, the viability of the fetus is compromised [26]. Histological evidence is the appearance of syncytial knots which increase in

frequency with gestational age. The nuclei within the knots are transcriptionally inactive and display evidence of oxidative damage [27]. A well-known example is the relationship between oxidative stress in the human placenta and telomere length. Reduced telomerase activity [28] and decreased telomeres [29] with advanced gestation have been reported, and telomere-induced senescence may decrease the standby capacity of the placenta to cope with the metabolic demands of the fetus. The worse FHR monitoring levels in full term births shown in the present study may be attributable to the senescence of placenta.

CONCLUSION

Obstetricians should give consideration to both fetal well-being and infant morbidity. Although previous reports by other investigators [11-14] have shown that infants delivered at early term are at increased risk for morbidity compared with those at full term and, hence, that full term is preferable to early term, it should be kept in mind that full term delivery is not necessarily safer than early term delivery from the standpoint of FHR monitoring.

CONFLICT OF INTEREST

We declare that we have no conflict of interest.

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