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Original Article

Relationship between fetal heart rate patterns and a time course for evaluation of fetal well-being: “the 30 minutes rule” for decision of mechanical delivery

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ABSTRACT

Objective: To predict acidosis in fetus showing deceleration associated with non-reassuring fetal status during delivery, we examined the relationship between duration of the deceleration and umbilical arterial pH.

Materials and methods: A total of 19,907 deliveries in eight facilities of the Juntendo Perinatal Care Group, 895 cases of vaginal deliveries with level 3 decelerations were selected for the subjects of this study. The cut-off point of time when the umbilical arterial pH fell below 7.20 in all cases of level 3 and for each deceleration type were examined. The explanatory variables were the pH and pO_2 of umbilical arterial gas and the time from onset of the level 3 pattern to delivery. From receiver operating characteristic (ROC) analysis using these variables, the critical point indicating low Apgar score was set at an umbilical arterial pH < 7.20.

Results: The cut-off point of time when the umbilical arterial pH fell below 7.2 was 33.5 min for all cases of level 3, and 604 cases of severe variable decelerations with normal baseline variability and normal baseline heart rates, the cut-off point was 33.5 min as well. For 108 cases of late decelerations, there was no significant cut-off point for either the mild or severe cases. Mild prolonged deceleration showed the cut-off point of 34.5 min.

Conclusions: We confirmed the time indices for predicting and preventing acidosis in fetuses showing decelerations. To prevent fetal acidosis, the decision related to proper timing for performing assisted delivery by considering the time course is important.

Introduction

Currently, fetal well-being is assessed primarily through cardiotocography (CTG) and umbilical arterial gas analysis at birth. CTG is the only method for evaluating fetal well-being during delivery, and abnormal heart rate patterns that may indicate a threat to fetal well-being and a heart rate pattern classification system for the diagnosis of non-reassuring fetal status have been described [1]. In recent years, wide acceptance of obstetrical practice according to the recommendation of the Guideline for Obstetrical Practice in Japan has contributed to the standardization. In addition, the analysis of data obtained through the Japan Obstetric Compensation System for Cerebral Palsy has contributed to the accumulation of evidence regarding cerebral palsy causation [2]. Given this situation, obstetricians and midwives are increasingly expected to provide high-quality management of labor and delivery. In 2011, that guideline introduced a 5-stage fetal heart rate pattern classification system with the aim to provide a guide for preserving fetal well-being for a safe delivery.

However, there is no consensus regarding appropriate action for abnormal heart rate patterns; that is, the guideline says no recommendation for treatment concerning fetuses with abnormal heart rate pattern along with the axis of time. Perhaps as a result, there are a few reported cases of cerebral palsy that might be related to a delay in performing cesarean delivery or the prolongation of time for forced delivery due to multiple vacuum extractions [3]. It is reasonable to repeat evaluations of the fetal condition and well-being based on the knowledge of fetal physiology when decelerations occur; however, it should be noted that CTG monitoring cannot predict the appropriate delivery time-point.

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In 1983, Mukubo et al. showed that variable decelerations correlated with umbilical arterial pH and Apgar score; they reported that the time from the onset of variable deceleration to the time at which an umbilical arterial pH fell to ≤7.2 was 105.1 min [4]. In 1986, Horiguchi et al. reported that the time interval from onset of severe variable deceleration to delivery that produced an umbilical arterial pH < 7.2 was 30.7 min, and that of late decelerations was 28.7 min [5]. Although these studies are excellent, their findings have not been used as criteria in clinical practice because of their small sample sizes.

To predict acidosis in fetus showing deceleration associated with non-reassuring fetal status during delivery, the relationship between duration of the deceleration and umbilical arterial pH were examined in the present study.

Methods

Materials

This study was conducted as multicenter retrospective cohort study, and was approved by the ethics committee of our hospital. A total of 19,907 deliveries were performed in eight facilities of the Juntendo Perinatal Care Group between January 1, 2012, and December 31, 2014. After excluding preterm, post-term and cesarean deliveries, the remaining 14,686 were full-term vaginal deliveries. Among them, 1052 had CTG data continuously recorded for the last 120 min before delivery and also had normal baseline variability and normal baseline heart rate. Of those 1052 deliveries, 895 cases of vaginal deliveries with level 3 decelerations (observed in 50% or more of contractions) were selected for the subjects of this study (Fig. 1), after excluding cases showing clinical chorioamnionitis at 120 min before delivery. Clinical chorioamnionitis was diagnosed in the presence of a maternal temperature of ≥38.0 °C and ≥2 of the following criteria [1]: uterine tenderness [2]; malodorous vaginal discharge [3]; maternal leukocytosis (white blood cell count of ≥15,000/μL); and [4] maternal tachycardia (≥100/min) [1].

The subjects were retrospectively studied according to the following protocols. There were 263 (29.4%) vaginal operative deliveries (i.e. vacuum extraction and forceps delivery) among 895 cases.

Definition of decelerations

Our 5-stage classification (Fig. 2) is based on the classification of The American College of Obstetricians & Gynecologists put out a Practice Bulletin in 2010 accepting the 3 categories, and appeared to rationalize Category II by describing 3 groups within it, primarily based on different types of FHR patterns [6].

Variable deceleration was defined as deceleration (≥15 bpm) with sudden decrease in fetal heart rate, which is lasting ≥15 s but <2 min from onset to return to baseline. Severe variable deceleration was defined as deceleration that is lasting ≥30 s with bottom of <70 bpm, or ≥60 s with bottom of 70–80 bpm.

Late deceleration was defined as deceleration (≥15 bpm) with slow decrease in fetal heart rate which bottom is behind a nadir of the uterine contraction, which is lasting ≥15 s but <2 min. Severe late deceleration was defined when the difference with the baseline more than 15 bpm.

Prolonged deceleration was defined as deceleration is ≥15 bpm, lasting ≥2 min but <10 min. Severe prolonged deceleration was defined as deceleration which bottom is <80 bpm.

Analysis

First, the cut-off point of time when the umbilical arterial pH fell below 7.20 in all cases of level 3 and for each deceleration type were examined.

If a case had prolonged deceleration first and additionally developed variable deceleration, it was classified into prolonged

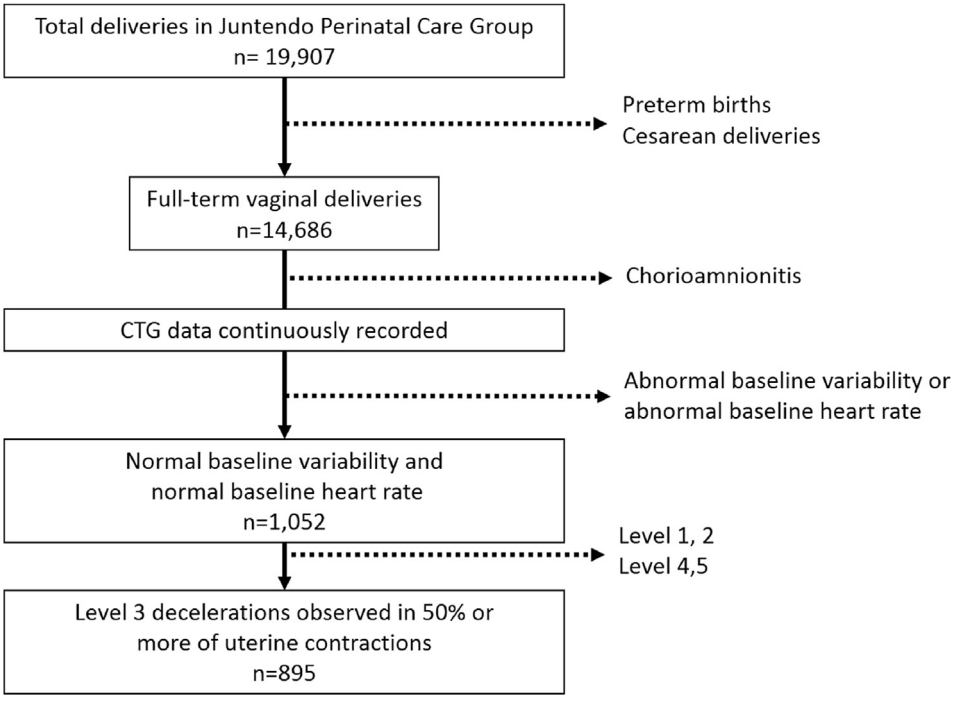


Fig. 1. Subjects. After excluding preterm and cesarean deliveries, the remaining 14,686 of 19,907 were full-term vaginal deliveries. Among them, 1052 had CTG data continuously recorded for the last 120 min before delivery and also had normal baseline variability and normal baseline heart rate. Of those 1052 deliveries, 895 cases of vaginal deliveries with level 3 decelerations.

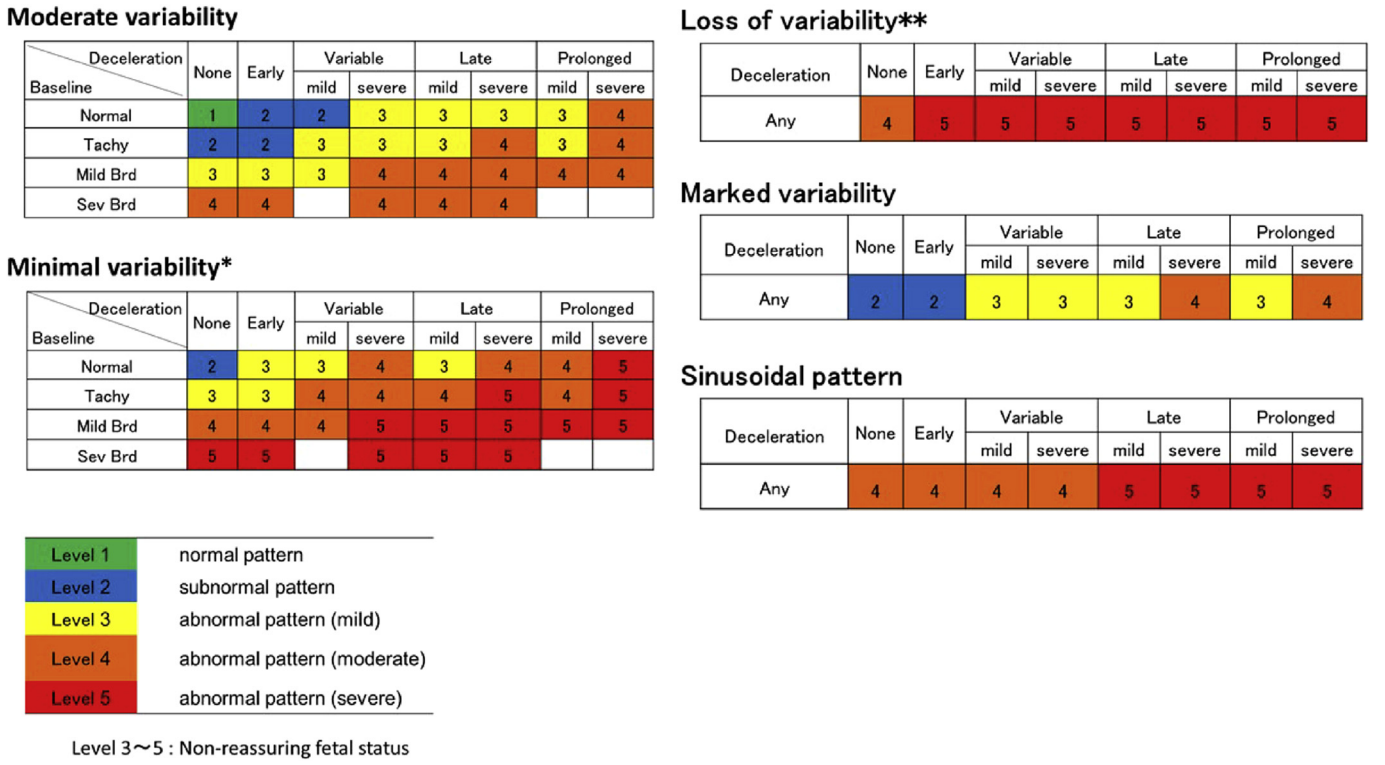


Fig. 2. 5-stage fetal heart rate pattern classification. Deceleration are classified into 1–5 stage based on type of deceleration, baseline, and fetal heart rate variability. *Minimal variability is defined as variability is detectable but ≤5 bpm. **Loss of variability is defined as variability is undetectable. Sev: Severe.

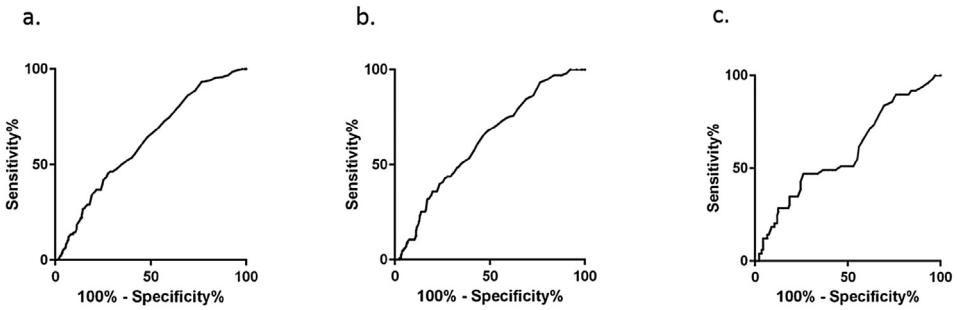
deceleration. If a case showed a level 4 deceleration during delivery, the time point of change was recorded. The variables were further examined by logistic regression analysis. The explanatory variables were the pH and pO_2 of umbilical arterial gas and the time from onset of the level 3 pattern to delivery. From receiver operating characteristic (ROC) analysis using these variables, the critical point indicating low Apgar score was set at an umbilical arterial pH < 7.20. Second, the cut-off point of time when the umbilical arterial pH fell below 7.25, 7.20, 7.15, 7.10, or 7.05 in cases of severe variable decelerations and evaluated changes along the temporal axis were calculated. Cases of late decelerations and prolonged decelerations were excluded from the analysis. Third, the cases of variable decelerations and late decelerations were divided into two groups, respectively, according to the presence/absence of reduction of baseline variability during the time from onset of the level 3 tracing to delivery, and the umbilical arterial gas values were compared between the two groups. Cases of prolonged decelerations were excluded from the analysis. The CTG data were read by maternal–fetal physicians certified by the Japanese Society of Perinatal and Neonatal Medicine, obstetric and gynecologic specialists, and senior residents in obstetrics and gynecology. In principle, instrument-assisted vaginal delivery was achieved using forceps. Extraction was attempted twice at maximum. The cut-off point was determined by ROC analysis and Youden's index. Comparisons of groups were performed using the χ^2 test and unpaired t-test or Mann–Whitney U test, depending on the distribution. Statistical significance was set at $p < 0.05$.

Results

The cut-off point of time when the umbilical arterial pH fell below 7.2 was 33.5 min for all cases of level 3 (the sensitivity, specificity, and positive and negative predictive values were 43.2%, 73.4%, 33.3%, and 81.1%, respectively) (Fig. 3a). For 604 cases of severe variable decelerations with normal baseline variability and normal baseline heart rates, the cut-off point was 33.5 min as well (the sensitivity, specificity, and positive and negative predictive values were 40.8%, 74.9%, 25.0%, and 86.0%, respectively). For 108 cases of late decelerations, there was no significant cut-off point for either the mild or severe cases. For 183 cases of mild prolonged deceleration, the cut-off point was 34.5 min (the sensitivity, specificity, and positive and negative predictive values were 42.9%, 75.4%, 38.9%, and 78.3%, respectively) (Fig. 3b and c).

The time point when the umbilical arterial pH fell below 7.25, 7.20, 7.15, 7.10, and 7.05 in cases of variable decelerations were determined by ROC analysis and Youden's index: they were 22.5, 33.5, 34.5, 43.5, and 44.5 min, respectively. The cut-off point of time became longer as the umbilical arterial pH value became lower, and there was a strong negative correlation between them ($R^2 = 0.9147$) (Fig. 4)

Comparison of the two groups with severe variable decelerations divided according to the presence or absence of a reduction in baseline variability for the last 120 min before delivery showed that there was no significant difference in the time from onset of the level 3 pattern to delivery, but the percentage of those with an umbilical arterial pH of <7.20 was significantly greater in the baseline variability reduction group, and the values of pH, pCO_2, and base excess (BE) were significantly lower in the baseline variability reduction group (Table 1). On the other hand, comparison between the two groups with late decelerations divided by the presence or absence of baseline variation reduction showed that the percentages of those with an umbilical arterial pH < 7.20 was significantly higher in the baseline variability reduction group (79.6%). An analysis of arterial blood gas also showed that the difference between the two groups with late decelerations was greater than that observed between the two groups with severe variable decelerations; in addition, there was also a significant difference in pO_2 (Table 2). Thus, respiratory and metabolic acidosis



	< 7.2	≥ 7.2
≥ 33.5min	92	184
< 33.5min	117	502

*p<0.05

	< 7.2	≥ 7.2
≥ 33.5min	42	126
< 33.5min	61	375

*p<0.05

	< 7.2	≥ 7.2
≥ 34.5min	21	33
< 34.5min	28	101

*p<0.05

Fig. 3. Cut-off point. a. All cases of level 3. b. Severe variable decelerations. c. Mild prolonged deceleration. The cut-off point of time when the umbilical arterial pH fell below 7.2 was 33.5 min for all cases of level 3. For 604 cases of severe variable decelerations, the cut-off point was 33.5 min as well. For 183 cases of mild prolonged deceleration, the cut-off point was 34.5 min.

a.

UmApH	Cut-off point (min)
< 7.25	22.5
< 7.20	33.5
< 7.15	34.5
< 7.10	43.5
< 7.05	44.5

b.

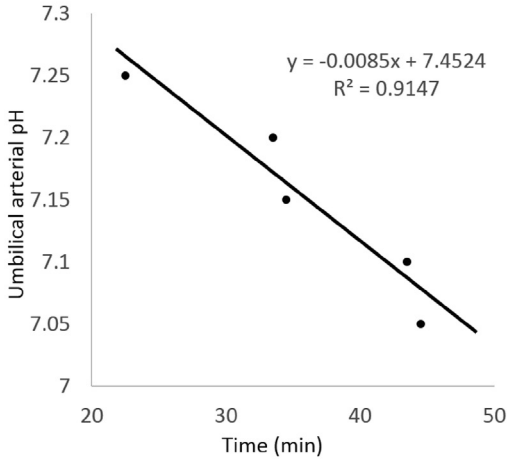


Fig. 4. Time point of variable decelerations. a. Time point of variable decelerations. The time point when the umbilical arterial pH fell below 7.25, 7.20, 7.15, 7.10, 7.05 in cases of variable decelerations were 22.5, 33.5, 34.5, 43.5, 44.5 min, respectively. b. Correlation between time point and umbilical arterial pH. There was a strong negative correlation between time point and umbilical arterial pH.

was more severe in the baseline variability reduction group, both in terms of cases of severe variable decelerations and of cases of late decelerations. In particular, the baseline variation reduction group with late decelerations showed significant hypoxia.

The overall results showed that both the time course and the reduction of baseline variability were useful for predicting fetal acidosis in cases of variable decelerations. For cases of late decelerations, the reduction of baseline variability (but not the temporal axis) was useful for predicting fetal acidosis. For cases of prolonged decelerations, the time course was useful for predicting fetal acidosis, as shown in the cut-off points in Result 1.

Discussion

This study examined the usefulness of the 5-stage fetal heart rate pattern classification system with the additional consideration of time course in predicting fetal acidosis. The guidelines of the Japanese Society of Obstetrics and Gynecology (the section on

Table 1
Comparison of umbilical arterial gas values in severe variable decelerations with normal and minimal baseline variability.

	Moderate variability n = 497	Minimal variability n = 107	p-Value
Level 3 ~ delivery (min)	19.4	22.2	0.12
pH < 7.20	12.3% (61cases)	39.3% (42cases)	<0.01
pH	7.29 ± 0.07	7.23 ± 0.08	<0.01
pO_2 (Torr)	22.8 ± 17.9	21.6 ± 18.1	0.84
pCO_2 (Torr)	48.5 ± 26.1	54.9 ± 11.2	0.01
HCO_3^- (mEq/L)	21.6 ± 3.8	22.1 ± 3.7	0.47
BE (mEq/L)	−4.58 ± 3.92	−6.58 ± 4.12	<0.01

(mean ± SD).

Table 2
Comparison of umbilical arterial gas values in late decelerations with normal and minimal baseline variability.

	Moderate variability n = 59	Minimal variability n = 49	p-Value
Level 3 ~ delivery (min)	26.8	30.9	0.28
pH < 7.20	30.5% (18cases)	79.6% (39cases)	<0.01
pH	7.25 ± 0.09	7.17 ± 0.06	<0.01
pO_2 (Torr)	29.8 ± 29.0	19.1 ± 5.9	0.02
pCO_2 (Torr)	50.0 ± 14.1	59.5 ± 12.7	<0.01
HCO_3^- (mEq/L)	21.4 ± 6.0	20.7 ± 4.6	0.54
BE (mEq/L)	−6.19 ± 5.88	−9.05 ± 5.31	0.01

(mean ± SD).

obstetrics) in 2014 noted a negative correlation between the duration of non-reassuring fetal status and fetal blood pH, suggesting the importance of time course in the assessment of fetuses showing heart rate patterns at level 3 or more.

The cut-off point of time when the umbilical arterial pH fell below 7.20 in cases of severe variable decelerations in this study was similar to that reported by Horiguchi et al.

Interestingly, although there was no significant cut-off point in cases of late decelerations, the values were similar between those with mild and severe cases, suggesting that the risks cannot be judged only from the depth of bradycardia in cases of late decelerations. As the cause that had difficulty in evaluation in time course in the late deceleration, fetal hypoxia may have already existed at the stage when the deceleration developed. Therefore, in the late deceleration, the etiology was originally different from severe variable deceleration which occurred in the pressure of the umbilical cord, so changes in umbilical arterial pH were hard to be relatively seen within 120 min.

Regarding the relationship between the time course and fetal acidosis, in 1982, Fleischer et al. reported that the number of cases with pH < 7.25 increased after 120 min, and they also reported that rapid cumulative acidosis was observed after a certain time period [7]. The cut-off point of time in our study was shorter than that reported by Fleischer et al., but this was probably due to the fact that our cut-off point of time, indicating an umbilical arterial pH < 7.20, was a relatively safe one (80% safe at a pH $\geq$ 7.20). In addition, they reported that linear deterioration was observed in severe variable decelerations, supporting our view that consideration of time course is useful in predicting fetal acidosis. Thus, it may be possible to manage the delivery considering its original characteristic that umbilical cord arterial blood pH turns worse linearly in case with severe variable decelerations.

Sameshima et al. performed continuous monitoring of late decelerations and baseline variability with CTG for the last 2 h before delivery and compared them to those in the normal baseline variability group in the absence of decelerations [8]. They reported that the baseline variability reduction (or disappearance) group showed significant deterioration in the umbilical arterial pH, pCO_2, and BE when there were recurrent decelerations, while such changes were not observed in pO_2. This result was largely consistent with our findings of the changes associated with baseline variability, with the exception of the association between the decrease in pO_2 and the reduction in baseline variability. Based on existing knowledge of fetal physiology, it is reasonable to think that fetal hypoxia is more advanced when baseline variability is reduced (or disappears) in the presence of late deceleration (an early sign of fetal hypoxia). The textbooks state that fetal hypoxia can be a cause of baseline variability reduction; however, few studies have examined the independent association between baseline variability reduction and fetal hypoxia. This study confirmed the importance of the assessment of baseline variability in fetuses showing late deceleration.

The limitations of this study are as follows: First, the subjects were restricted to cases of vaginal delivery; severe cases (level 4–5) and those requiring cesarean delivery were excluded. Second, an association between fetal acidosis and the frequency and intervals of late deceleration has been reported [9], and therefore further studies on this topic are required.

The results of this study were consistent with our clinical knowledge and experience in daily practice. We had been vaguely aware of the importance of considering the time course when using the 5-stage classification system. The results of this study confirmed that the 5-stage classification with the additional consideration of the time course could contribute to the safe management of delivery.

In this study, we confirmed the time indices for predicting and preventing acidosis in fetuses showing decelerations. The validity of the current target delivery time (i.e., approximately 30 min) for cases showing severe variable decelerations was confirmed. In cases of late decelerations, reduction of baseline variability was important for predicting acidosis. To prevent fetal acidosis, the decision related to proper timing for performing assisted delivery by considering the time course is important.

Conflicts of interest

None of the authors has any conflicts of interest to declare.

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Tajima A, Koizumi A, Tanaka T, Matsuoka S, Shimada N, Imai Y, Nishioka N, Nagano H, Yamada M, Yashiro R.

References

[1] Guideline for obstetrical practice in Japan 2011. Japan society of obstetrics and gynecology and Japan association of obstetricians and gynecologists.
[2] Hasegawa J, Toyokawa S, Ikenoue T, Asano Y, Satoh S, Ikeda T, et al. Relevant obstetric factors for cerebral palsy: from the nationwide obstetric compensation system in Japan. PLoS One 2016;28:11.
[3] Report of working group for fetal heart rate monitor. Jpn Counc Qual Health Care 2016:30–1.
[4] Mukubo M, Okai T, Sakamoto S, Hara K, Horiguchi S. Judgment of the fetal distress using the fetal heartrate pattern. Med Electron Bionics 1983;21:179 [in Japanese].
[5] Horiguchi S, Murata T, Yanai E, Kamei Y, Mukubo M. Severe variable deceleration and fetal distress. Parturition Anesth 1986;61 [in Japanese].
[6] American College of Obstetricians and Gynecologists. Practice bulletin no. 116: management of intrapartum fetal heart rate tracings. Obstet Gynecol 2010;116:1232–40.
[7] Fleischer A, Schulman H, Jagani N, Mitchell J, Randolph G. The development of fetal acidosis in the presence of an abnormal fetal heart rate tracing. I. The average for gestational age fetus. Am J Obstet Gynecol 1982;144:55–60.
[8] Sameshima H, Ikenoue T. Predictive value of late decelerations for fetal acidemia in unselective low-risk pregnancies. Am J Perinatol 2005;22:19–23.
[9] Kikuchi H, Noda S, Katsuragi S, Ikeda T, Horio H. Relationship between intrapartum FHR deceleration patterns and unbilical arterial blood gas values at delivery. J Jpn Soc Perinat Neonatal Med 2015;51:180–5.