

ORIGINAL RESEARCH ARTICLE



Intrapartum fetal heart rate between 150 and 160 bpm at or after 40 weeks and labor outcome

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Abstract

Introduction: A baseline fetal heart rate between 110 and 160 bpm is considered normal. However, among normal fetuses the average baseline heart rate has been shown to diminish progressively and the 90th centile of the fetal heart rate at 40 weeks of gestation has been consistently found at around 150 bpm. The aim of our study was to assess the labor and neonatal outcome of fetuses at 40 gestational weeks or beyond, whose intrapartum baseline fetal heart rate was between 150 and 160 bpm.

Material and methods: Retrospective cohort study including singleton pregnancies with spontaneous onset of labor, gestational age between 40⁺⁰ and 42⁺⁰ weeks, category I CTG trace according to the FIGO guidelines 2015 with baseline fetal heart rate between 110 and 160 bpm during the first 60 minutes of active labor. Exclusion criteria were maternal hyperpyrexia at admission, fetal arrhythmias, maternal tachycardia (>110 bpm) and uterine tachysystole (>5 contractions/10 minutes). The following outcomes were compared between fetuses with a baseline ranging between 110 and 149 bpm and those with a baseline ranging between 150 and 160 bpm: incidence of meconium-stained amniotic fluid, intrapartum hyperpyrexia, mode of delivery, Apgar at 5 minutes <7, arterial pH <7.1 and Neonatal Intensive Care Unit admission, incidence of a composite adverse neonatal outcome.

Results: In all, 1004 CTG traces were included in the analysis, 860 in Group 110-149 bpm and 144 in Group 150-160 bpm. Group 150-160 bpm had a significantly higher incidence of meconium-stained amniotic fluid (odds ratio [OR] 2.6; 95% CI 1.8-3.8), maternal intrapartum hyperpyrexia (OR 4.7; 95% CI 1.1-14.6), urgent/emergent cesarean section for suspected fetal distress (OR 13.4; 95% CI 3.3-54.3), Apgar <7 at 5th min (OR 9.13; 95% CI 1.5-55.1) and neonatal acidemia (OR 3.5; 95% CI 1.5-55.1). Logistic regression including adjusting for potential confounders showed that fetal heart rate between 150 and 160 bpm is an independent predictor of meconium-stained amniotic fluid (adjusted odds ratio [aOR] 2.2; 95% CI 1.5-3.3), cesarean section during labor for fetal distress (aOR 10.7; 95% CI 2.9-44.6), neonatal acidemia

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval; CS, cesarean section; CTG, cardiotocography; FHR, fetal heart rate; FIGO, International Federation of Gynecology and Obstetrics; OR, odds ratio.

(aOR 2.6; 95% CI 1.1-6.7) and adverse composite neonatal outcome (aOR 2.6; 95% CI 1.2-5.6).

Conclusions: In fetuses at 40 weeks or beyond, an intrapartum fetal heart rate baseline ranging between 150 and 160 bpm seems associated with a higher incidence of labor complications.

KEYWORDS

cardiotocography, chorioamnionitis, chronic hypoxia, fetal heart rate, neonatal acidosis

1 | INTRODUCTION

The use of cardiotocography (CTG) for continuous fetal heart rate (FHR) monitoring during labor is the most widely adopted method to identify the occurrence of intrapartum hypoxia.¹ A baseline FHR between 110 and 160 bpm irrespective of gestational age is considered in the normal range, and appears associated with low probability of fetal acidosis and good neonatal outcome. On the contrary, baseline FHR recordings above (or below) the normal range have been shown to herald the presence of fetal compromise. Based on this premise, according to most guidelines on fetal intrapartum surveillance produced by the main scientific societies, an expectant management is recommended whenever the FHR is within this normal band, while an obstetric intervention is warranted due to a suspicious or abnormal trace in the case of fetal tachycardia or bradycardia, respectively, defined as >160 or <110 bpm.²⁻⁴ The baseline FHR is finely tuned by the parasympathetic and sympathetic components of the autonomic nervous system, which are known to exert a depressive and an excitatory effect on the cardiac frequency, respectively. Since the maturation of the parasympathetic component is physiologically delayed in fetal life, the inhibitory effect of the vagal tone on fetal heart is expected to become increasingly stronger at term gestation.^{5,6} In accordance with this hypothesis, among normal fetuses, the average baseline heart rate has been shown to diminish progressively from 145 bpm at around 36 weeks to 135 bpm at 41 weeks of gestation.^{7,8} In a few large studies conducted by means of antepartum computerized CTG, the 90th centile of the FHR at 40 weeks of gestation has been consistently found at around 150 bpm.^{9,10}

One may raise the hypothesis that an intrapartum baseline FHR between 150 and 160 bpm at 40 weeks or beyond, despite being within the range indicate by the guidelines on CTG interpretation, might be considered an abnormal finding for the given individual fetus. Using a physiologic approach, even as an isolated finding, a higher than expected intrapartum baseline FHR may be judged as a clue to an underlying fetal disorder such as subclinical inflammation or chronic hypoxia, leading respectively to a dysregulated autonomic response or to an abnormally increased sympathetic activity.^{7,8,11,12}

The aim of our study was to assess the labor and neonatal outcome of fetuses at 40 gestational weeks or beyond, whose

Key message

Although normal, a fetal heart rate between 150 and 160 bpm at or after 40 weeks should be considered above the upper limits for the gestational age and, even as an isolated finding, seems to warrant strict fetal surveillance due to association with adverse labor outcome.

intrapartum baseline FHR during the first 60 minutes of active labor was between 150 and 160 bpm.

2 | MATERIAL AND METHODS

2.1 | Study design and study population

This is a retrospective cohort study conducted at the tertiary referral Hospital of Parma, between May 2018 and January 2020, and included a consecutive series of unselected pregnant women at term gestation or beyond in the active phase of the first stage of labor.

Inclusion criteria were singleton pregnancy, cephalic presentation, spontaneous onset of labor, gestational age between 40⁺0 and 41⁺3 weeks, normal CTG trace (Category I or 'normal' according to the International Federation of Gynecology and Obstetrics [FIGO] guidelines 2015)⁴ with a baseline FHR ranging between 110 and 160 bpm during the first 60 minutes of the active phase of first stage. Active labor was defined by a fully effaced, ≥6 cm dilated cervix coupled with >3 contractions in 10 minutes recorded at tocography.¹³

Maternal hyperpyrexia was defined as temperature (oral or auricular) ≥39.0°C (102.2°F) on any one occasion or a temperature between 38.0°C (100.4°F) and 39.0°C (102.0°F), confirmed by two measurements within 30 minutes.¹⁴

Exclusion criteria were: gestational age ≤39⁺6 weeks, rupture of membranes ≥12 hours or ≥6 hours when associated with documented Group B Streptococcus (GBS) infection, maternal hyperpyrexia at admission, suspicious or pathologic CTG trace during the first hour of active labor monitoring (category II or III or 'suspicious' or 'pathologic' according to FIGO guidelines 2015),⁴ uterine tachysystole (>5

contractions/10 minutes), suspected or documented fetal arrhythmias, qualitatively poor CTG signal, admission in the second stage of labor, maternal tachycardia (>110 bpm), use of antibiotics or drugs which can interfere with maternal or FHR (beta blockers, thyroid blockers) at labor onset, postnatal evidence of congenital anomalies.

Gestational age was calculated from crown-rump length measure at 11⁺⁰-13⁺⁶ weeks of gestation.¹⁵

In the eligible cases, a continuous CTG trace was obtained by a Doppler ultrasound system (Philips AVALON FM20 fetal monitor, Philips Medical System, The Netherlands) from the beginning of active labor to delivery. Maternal temperature, blood pressure (ERKA Perfect Aneroid 56 manual sphygmomanometer, Germany) and heart rate were recorded at labor admission and after 60 minutes of fetal monitoring. Lack of these latter data or of a continuous CTG recording was also considered an exclusion criterion.

All CTG traces were retrospectively evaluated by three investigators with a specific training in CTG interpretation, and each determined the baseline heart rate in the first hour of active labor.

Baseline FHR was defined as the approximate mean FHR during at least 10 minutes of stable segments, excluding accelerations and decelerations.⁴ Cases were excluded if in the first hour of active labor the baseline appeared unstable and could not be clearly determined or if the CTG trace was characterized by one of the following aspects: baseline >160 or <110 bpm; reduced (<5 bpm) or increased (>25 bpm) variability, sinusoid pattern, presence of one or more decelerations, absence of accelerations, lack of cycling, received epidural analgesia during the first hour of active labor.^{16,17}

For all the included cases, labor characteristics and clinical outcomes were retrospectively collected from a dedicated electronic database.

2.2 | Outcome

The following labor and clinical characteristics of the cases with a baseline FHR of 110-149 vs 150-160 bpm during the first hour of active labor were compared: meconium-stained amniotic fluid, intrapartum hyperpyrexia (>38°C), mode of delivery, Apgar at 5 minutes <7, arterial umbilical cord pH <7.1 and Neonatal Intensive Care Unit admission. Cesarean section (CS) performed during labor was further categorized into CS for suspected fetal compromise and CS for labor arrest. The incidence of an adverse composite neonatal outcome defined as the presence of at least one of the following was also compared between the two groups: arterial pH <7.1, Apgar at 5 minutes <7, Neonatal Intensive Care Unit admission, neonatal resuscitation.

2.3 | Statistical analyses

Statistical analysis was performed using the Statistical Package for Social Science (SPSS), release 21.0 (IBM Corp., Armonk, NY, USA). The Kolmogorov-Smirnov test was used to assess the normality of

the distribution of the data. Categorical variables were compared using the Chi-square or Fisher Exact test, and comparison of continuous variables included t test for independent sample and two-tailed t tests. A binary logistic regression analysis was performed to assess the independent predictors of outcomes using all the variables that were significantly different between the two FHR groups at the univariate analysis. Data were expressed as odds ratio (OR) ± 95% confidence interval (CI). Multiple regression including significant variables was used to examine the adjusted OR (aOR) for each predictor.

2.4 | Ethical approval

The study project was approved by the local ethics committee on 5 April 2019 (number 14 976).

3 | RESULTS

A total of 4623 deliveries occurred during the study period; 2770 (59.9%) were excluded for gestational age <40 weeks and of the remaining 1853, 556 (30.0%) underwent induction of labor and 37 (2.0%) underwent elective CS. A total of 1260 deliveries were assessed for eligibility and 1004 CTG traces fulfilled the inclusion criteria; 860 (85.6%) of them presented a baseline FHR between 110 and 149 bpm, and 144 (14.4%) presented a baseline FHR between 150 and 160 bpm (Figure 1).

Maternal, labor and neonatal characteristics of the two FHR groups are presented in Table 1. At univariate analysis, a significantly higher rate of nulliparous women (59.0% vs 47.8%; $P = .01$) was noted in the group 150-160 bpm as well as a higher incidence of epidural analgesia (43.8% vs 27.8%; $P < .001$) and augmentation with oxytocin (39.6% vs 18.1%; $P < .001$). Furthermore, the group with 150-160 bpm FHR had a longer length of active labor (370.8 ± 229.6 vs 253.6 ± 182.9 ; $P < .001$).

The primary outcome of the study is reported on Table 2. Compared with group 110-149 bpm, group 150-160 bpm had a higher incidence of meconium-stained amniotic fluid (OR 2.6; 95% CI 1.8-3.8), intrapartum maternal pyrexia (OR 4.7; 95% CI 1.1-14.6),

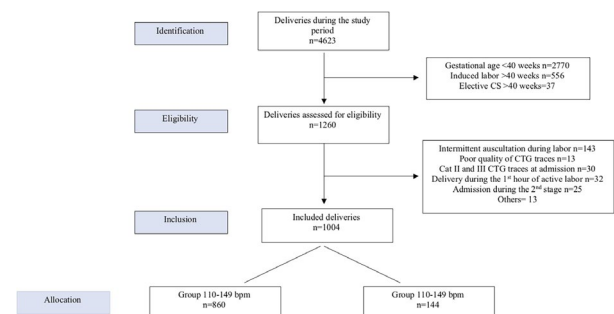


FIGURE 1 Flow chart of included cases [Color figure can be viewed at wileyonlinelibrary.com]

TABLE 1 Maternal and neonatal characteristics

	Group 110-149 bpm (n = 860)	Group 150-160 bpm (n = 144)	P value
Maternal age (Years)	32.0 [28.0-35.0]	32.0 [29.0-36.0]	.12
Caucasian	699 (81.3)	114 (79.1)	.55
Pre-pregnant BMI (Kg/m ²)	22.0 [20.0-25.0]	22.0 [20.0-25.0]	.73
Gestational weight gain (kg)	12.0 [10.0-14.0]	12.0 [10.0-14.0]	.33
Artificial reproductive techniques	17 (1.9)	2 (1.4)	.63
Nulliparous	411 (47.8)	85 (59.0)	.01
Baseline FHR at examination (bpm)	135.0 [130.0-140.0]	153.0 [151.0-155.0]	<.001
Gestational age at delivery (weeks)	40.6 [40.3-41.0]	40.6 [40.3-41.0]	.50
Birthweight (g)	3490.0 [3240.0-3751.0]	3530.0 [3255.0-3823.0]	.70
Birthweight percentile	54.0 [28.0-77.0]	56.0 [35.0-82.5]	.16
Birthweight <10th percentile	49 (5.7)	5 (3.4)	.27
ROM at admission	235 (27.3)	41 (28.4)	.77
Interval time from ROM to active labor (min)	318.0 ± 480.0	309.0 ± 391.0	.89
Genitourinary infections			
	620 (72.1)	107 (74.3)	
	17 (19.9)	31 (21.5)	.26
	69 (8.0)	6 (4.2)	
Epidural analgesia	238 (27.8)	63 (43.8)	<.001
Augmentation with oxytocin	156 (18.1)	57 (39.6)	<.001
Total length of active labor (min)	253.6 ± 182.9	370.8 ± 229.6	<.001

Abbreviations: BMI, body Mass Index; FHR, fetal Heart Rate; ROM, rupture of membranes; GBS, group B Streptococcus.

Data have been expressed as n (N, %), mean ± SD or median [IQR].

TABLE 2 Comparison of labor and neonatal outcome between women with baseline fetal heart rate (FHR) between 110 and 149 bpm and women with baseline FHR between 150 and 160 bpm during the first 60 minutes of active labor

	Group 110-149 bpm (n = 860)	Group 150-160 bpm (n = 144)	P value	Odds ratio	95% CI
Meconium-stained Amniotic fluid	180 (20.9)	59 (40.9)	<.001	2.6	1.8-3.8
Intrapartum hyperpyrexia	6 (0.7)	4 (2.8)	.02	4.7	1.1-14.6
Spontaneous vaginal delivery	777 (90.3)	116 (80.6)		Reference	Reference
Operative vaginal delivery	62 (7.2)	14 (9.7)		1.5	0.8-2.8
Overall Cesarean Section			<.001		
Cesarean Section for fetal distress	21 (2.5)	14 (9.7)		4.5	2.2-9.0
	3 (0.4)	6 (4.1)		13.4	3.3-54.3
Apgar <7 at 5 min	2 (0.2)	3 (2.1)	.004	9.1	1.51-55.1
Arterial pH <7.10	14/696 (2.0)	8/118 (6.8)	.003	3.5	1.5-8.6
NICU admission	8 (0.9)	3 (2.1)	.21	2.3	0.5-8.6
Composite neonatal outcome	22/696 (3.2)	12/117 (10.3)	<.001	3.5	1.7-7.3

Abbreviations: NICU, Neonatal Intensive Care Unit.

Data are expressed as n (%).

TABLE 3 Multivariate analysis of factors influencing labor and neonatal outcome

	FHR 150-160 bpm aOR (95% CI)	Nulliparous aOR (95% CI)	Analgesia aOR (95% CI)	Augmentation aOR (95% CI)	Labor length aOR (95% CI)
Meconium-stained amniotic fluid	2.2 (1.5-3.3)	1.3 (0.9-1.8)	1.8 (1.2-2.6)	1.3 (0.8-1.9)	1.0 (0.99-1.01)
Intrapartum hyperpyrexia	2.0 (0.5-7.6)	3.1 (0.3-26.7)	7.43 (0.8-66.9)	3.68 (0.5-20.7)	1.0 (0.98-1.01)
Overall cesarean section	2.5 (1.2-5.2)	1.5 (0.6-3.6)	1.3 (0.6-2.9)	2.4 (0.9-6.0)	1.0 (0.99-1.1)
Cesarean section for fetal distress	10.7 (2.9-44.6)	1.20 (0.2-5.8)	0.9 (0.2-3.8)	3.1 (0.5-17.8)	0.99 (0.99-1.01)
Apgar <7 at 5 min	5.03 (0.7-32.9)	1.40 (0.1-15.8)	0.9 (0.1-6.7)	8.2 (0.5-128.8)	1.0 (0.99-1.01)
pH <7.10	2.6 (1.1-6.7)	1.3 (0.5-3.7)	0.90 (0.3-2.6)	1.6 (0.5-5.0)	1.0 (0.99-1.01)
Composite neonatal outcome	2.6 (1.2-5.6)	0.8 (0.5-1.1)	1.3 (0.60-3.0)	1.1 (0.4-2.7)	1.0 (0.99-1.01)

CS during labor (OR 4.5; 95% CI 0.2-9.0), neonatal acidemia (OR 3.5; 95% CI 1.5-55.1) and adverse composite neonatal outcome (OR 3.5; 95% CI 1.7-7.3). The risk of low Apgar was also increased (OR 9.13; 95% CI 1.55-55.1); although this was registered only in five cases. No cases of stillbirth or neonatal death were reported.

The logistic regression with all the variables that appeared significantly different between the two FHR groups at univariate analysis is shown on Table 3. FHR between 150 and 160 bpm remained the only independent predictor of CS for suspected fetal distress (aOR 10.7; 95% CI 2.9-44.6), neonatal acidemia (aOR 2.6; 95% CI 1.1-6.7) and adverse composite neonatal outcome (aOR 2.6; 95% CI 1.2-5.6) and both FHR (aOR 2.2; 95% CI 1.5-3.3) and epidural analgesia (aOR 1.8; 95% CI 1.2-2.6) appeared significantly associated with meconium-stained amniotic fluid.

4 | DISCUSSION

Our study demonstrated that a baseline FHR between 150 and 160 bpm at or after 40 weeks during the first 60 minutes of spontaneous active labor is an independent risk factor for an adverse labor and neonatal outcome, and was associated with a higher incidence of meconium-stained amniotic fluid, intrapartum maternal pyrexia, emergency CS for suspected fetal compromise and neonatal acidemia.

Our findings are novel and difficult to explain. An intrapartum fetal baseline between 150 and 160 bpm at ≥ 40 weeks, despite being within the normal range proposed by most CTG guidelines, may indicate the effects of a dysregulated autonomic system on the fetal heart or of an unexpected prevalence of the sympathetic nervous system over vagal tone. A dysregulated autonomic response may be triggered by the early steps of an inflammatory process^{18,19} arising in the fetus or in the adnexa, whereas the abnormally exaggerated activity of the sympathetic nervous system may be due to an increased release of the catecholamines by the fetal adrenal glands, which could reflect an underlying condition of chronic hypoxia.²⁰⁻²² Both inflammation/infection or hypoxic pathways can act independently or synergistically during labor and are known to promote the occurrence of adverse outcomes, including acidemia, passage of meconium/meconium aspiration syndrome and fetal compromise.^{23,24}

In the case of subtle chronic hypoxia, the mechanism leading to a greater release of catecholamines is a subclinical placental insufficiency, which can primarily manifest during labor due to the presence of uterine contractions and which may, under these conditions, precipitate fetal acidemia.²⁰⁻²²

On the other hand, in the presence of fetoplacental infection or inflammation, the production of cytokines and other inflammatory mediators leads to an increase of the FHR baseline secondary to a dysregulation of the thermoregulatory center and to an increased metabolic rate.^{10,25}

This may explain why in our series, a baseline FHR in early active labor between 150 and 160 bpm was associated with the later occurrence of maternal fever, meconium staining of amniotic fluid and fetal acidemia. Indeed, independently of the concomitant chronic hypoxia, in the presence of intrauterine inflammation/infection there is an increased metabolic demand, leading to a higher oxygen consumption and to an accelerated fall in the fetal pH.²⁶⁻²⁸

To the best of our knowledge, this is the first study in which the clinical significance of a higher than expected baseline FHR for a given gestational age (but <160 bpm) has been investigated as isolated finding. Previous studies have demonstrated that FHR patterns change throughout the pregnancy due to the progressive maturation of the parasympathetic system. In normal fetuses a progressive decline of the baseline FHR throughout the last weeks of pregnancy has been consistently described by a large number of studies.¹⁰⁻¹²

To date, no difference has been reported in the baseline heart rate values at term according to parity, although in our large series, an incidence of 150-160 bpm was more likely among nulliparous women. The significance of this finding remains uncertain but it may explain why, in the higher FHR group at univariate analysis, the epidural rate, the use of oxytocin and the duration of labor were also significantly higher.

However, after adjustment for all variables at logistic regression, the baseline FHR turned out to be significantly associated with labor outcome and not the parity or the other baseline characteristics of the two FHR groups.

Based on our study, a higher than expected baseline FHR during active labor, even as an isolated finding, would appear to warrant

a strict fetal surveillance due to its association with adverse labor outcome. More specifically, continuous CTG from the early stages of labor and the assessment of inflammatory markers (eg maternal temperature, CPR and WBC count) are to be considered in these cases.

Although the intrapartum CTG findings associated with established chronic hypoxia or chorioamnionitis have been inconsistently described and include mostly tachycardia, reduced variability, no accelerations and lack of cycling, it seems likely that these two conditions may be anticipated by an isolated rise of the baseline towards the upper limits.²⁹

Whether a suspicion of subtle fetal hypoxia or inflammation at its subclinical early stages based on the observation of a higher than expected baseline FHR on the CTG trace, will positively impact on labor management, and ultimately on clinical outcome, remains to be proven. However, it seems likely that under these circumstances, some obstetric interventions such as early antibiotic or antipyretic administration and exercising caution in the use of oxytocin may be beneficial for both the mother and the fetus, slowing the progression of the process and reducing the occurrence of severe intrapartum complications.^{12,30}

The main strengths of our study are represented by its original design, by the large study population and by its consecutive enrollment. Additionally, given that all the CTG traces have been evaluated in consensus by three experts and that the baseline is considered the most reproducible parameter, such an evaluation is expected to be reliable.

The main limitations of our study include its retrospective design, and the lack of clinical and laboratory data related to a possible neonatal or maternal infection. Moreover, since the evaluation of placental histopathology has not been systematically performed, the association between the higher than expected baseline FHR and the pathology findings suggestive of chorioamnionitis or chronic hypoxia was not assessed.

5 | CONCLUSION

Our study has shown that as an isolated finding, a higher than expected baseline FHR for the given gestational age, even if it is within the normal stipulated range (110-160 bpm), appears to be associated with adverse labor and neonatal outcomes. Further larger prospective studies are needed to confirm our novel observation and to assess whether a tailored strategy of labor management may improve the clinical outcome of these cases.

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CONFLICT OF INTEREST

None.

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