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1 **CHANGES IN THE ST-INTERVAL SEGMENT OF THE FETAL**
2 **ELECTROCARDIOGRAM**
3 **IN RELATION TO ACID-BASE STATUS AT BIRTH**

4
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24 Running title: Fetal ECG changes and acidaemia

25 **ABSTRACT**

26 **Objective:** To assess the occurrence of ST-interval segment changes of the fetal electro-
27 cardiogram (ECG) and cardiotocographic (CTG) abnormalities preceding acidaemia at birth.

28 **Design:** Case-control study.

29 **Setting:** University hospital labour ward.

30 **Sample:** Newborns with severe cord artery metabolic acidaemia (pH <7.00 and lactate \geq 10
31 mmol/l, n=24), moderate metabolic acidaemia (pH 7.00-7.09 and lactate \geq 10; n=48),
32 acidaemia (pH 7.00-7.09; n=52), pre-acidaemia (pH 7.10-7.19; n=265), and controls (pH
33 \geq 7.20; n=117).

34 **Methods:** Monitoring traces were assessed blinded to outcome.

35 **Main outcome measures:** CTG- and ST-changes.

36 **Results:** Any ST-event occurred significantly more often among cases with severe (79%) and
37 moderate (75%) metabolic acidaemia than among controls (50%). The difference was
38 restricted to baseline T/QRS-rises, and to the second stage of labour, during which any event
39 only occurred significantly more often among cases with severe metabolic acidaemia (62%)
40 than among controls (38%). ST-events coincided with abnormal CTG patterns in 67%, 44%,
41 40%, and 28% of cases with severe and moderate metabolic acidaemia, acidaemia and
42 preacidaemia, and in 12% of controls. ST-events with intermediary CTG were similarly
43 frequent in the case groups (0-6%) and controls (4%). The ST-guidelines stated intervention
44 in 96%, 62%, 73% and 49% in these case groups, and 23% of controls.

45 **Conclusions:** Only two of three cases with severe and less than half of cases with moderate
46 metabolic acidaemia were preceded by ST-events coinciding with CTG abnormalities. It is

47 therefore important to intervene for long lasting, rapidly deteriorating, or marked
48 (preterminal) CTG abnormalities, also in the absence of ST-events.

49

50 **Keywords:** fetal monitoring, ECG, ST-analysis, cardiotocography, acidaemia

Introduction

Analysis of the ST waveform in the fetal electrocardiogram (ECG) has been introduced as a complement to cardiotocography (CTG), aiming to reduce unnecessary interventions and the incidence of asphyxia, by increasing the specificity in identifying hypoxia.^{1,2} The STAN S21 fetal heart monitor (Neoventa Medical, Gothenburg, Sweden) uses computerized ECG analysis to detect ST-interval changes that may reflect myocardial hypoxia: continuous or episodic rises in T/QRS amplitude ratio, or ST segment depressions (“biphasic ST”).¹ The current system has been evaluated in three randomized trials, comparing monitoring with CTG and ST-analysis to CTG monitoring alone.²⁻⁴ The largest trial, from Sweden, showed lower rates of metabolic acidaemia and operative deliveries for fetal distress in the CTG and ST group.² The second study from Finland showed a higher rate of acidaemia (pH <7.05) in the CTG and ST group,³ whereas a smaller French study showed no differences.⁴

If ST-analysis should help us to prevent metabolic acidaemia, warning signs would be expected to appear *before* this degree of acidaemia is reached. Kwee *et al.* reported that, among cases monitored with a good signal quality until delivery, ST changes occurred together with abnormal CTG patterns in all five cases with pH < 7.00 and base deficit >12, but only in six of 13 cases with pH 7.00–7.04 and base deficit >12.⁵ At the same time, ST events are frequent also in cases with normal CTG patterns,⁶ and in cases without acidaemia.⁷ There is still limited information about frequency of different electrocardiographic changes at various degrees of acidaemia. Furthermore, the association between the occurrence of ST-events and acidaemia might differ between the first and second stages of labour, since in a recent study, ST-events were only associated with abnormal CTG patterns during the second stage.⁶

The aim of the present study was to assess how often acidaemia at birth was preceded by different ST events and CTG changes. Specifically, we wanted to assess at which severity of

acidaemia such changes occurred more often than among controls with a normal pH at birth.
We also intended to evaluate these associations for the first and second stages of labour.

Methods

This was a retrospective study including singleton fetuses in cephalic presentation delivered after 36 completed weeks at Lund University Hospital during April 1st 2002 – September 31st 2007, monitored with STAN S21 fetal heart monitor (Neoventa Medical, Gothenburg, Sweden). Indications for STAN monitoring were term high risk labour or CTG abnormalities, but sometimes the monitor was used merely because it was available in the delivery room.

It was a case-control study, with a control group of fetuses with cord artery pH ≥ 7.20 , and four case groups. The first and second study groups included newborns with metabolic acidaemia, defined as cord artery pH below 7.10 (population mean -2 standard deviations (SD)) together with a cord artery lactate ≥ 10 mmol/l (population mean +2SD), sub-grouped into severe (pH <7.00) and moderate (pH 7.00-7.09) metabolic acidaemia. The third group included newborns with non-metabolic acidaemia (pH <7.10, lactate <10 mmol/l), and the fourth newborns with pre-acidaemia (pH 7.10-7.19, representing 1-2 SD below population mean). There were two reasons for using lactate instead of base deficit to define the metabolic component of acidaemia. Firstly, lactate is a directly measured end product of anaerobic metabolism, in contrast to base deficit which is calculated from pH and pCO₂ (with different algorithms resulting in different results). Secondly, a recent study at our University showed that lactate had a higher association with poor 5 minute Apgar scores than base deficit (unpublished data).

The labour staff had used the STAN monitor since the Swedish RCT, with principally the same protocol for intervention.^{2,8} According to this protocol, intervention was recommended when any ST-event (except solitary biphasic events) appeared together with an abnormal CTG: baseline T/QRS rise >0.05 , episodic T/QRS rise >0.10 or 2 repeated or continuous biphasic ST-events. Intervention was also recommended when more pronounced ST-events appeared together with an intermediary CTG: baseline T/QRS-rise >0.10 , episodic T/QRS-rise >0.15 , or 3 repeated or continuous biphasic ST-events. Furthermore, intervention was recommended if the CTG was considered persistently abnormal for 60 minutes, or preterminal (defined as variability below 2 beats per minute), regardless of the presence of any ST-events. When the protocol stated intervention, the clinician in charge decided which intervention to undertake (delivery, fetal scalp blood sampling (FBS), or removal of a possible cause of fetal distress), depending on the clinical circumstances.

Acid base status in cord artery and cord vein blood was routinely assessed by puncture of the vessels immediately after birth. For the analysis, including assessment of the lactate level, ABL 735 (Radiometer, Copenhagen) was used. A complete acid-base status from artery and vein was obtained for 78% of all newborns during the study period. Acid-base values were validated according to the criteria suggested by Westgate et al.⁹

From computerized records we identified singleton fetuses with cephalic presentation delivered after 36 completed weeks who had been monitored with STAN and had available acid-base data. Of these, all infants with cord artery pH < 7.10 were included. We also randomly selected 200 infants with cord artery pH 7.10-7.14, 200 with pH 7.15-7.19, and 200 controls with pH >7.20 . To avoid too many comparisons, it was later decided to group all infants with pre-acidaemia (pH 7.10-7.19) together.

In order to evaluate the duration of CTG abnormalities and to assess the ST-analysis during a reasonable period of time we only included those cases monitored for at least 60 minutes. We also excluded cases with a gap between the end of monitoring and birth exceeding 20 minutes as the association between monitoring and acid-base status would be difficult to evaluate.

One author (MM) assessed the electronically stored traces using the STAN-Viewer® program (Neoventa Medical, Gothenburg, Sweden). All ST events registered in the ST log were recorded, as well as monitoring time, and time with insufficient signal quality. Cases with low signal quality were not excluded, since periods with low signal quality might be regarded as a limitation of the method (as well as due to the user), but a sub-analysis of the occurrence of ST events and CTG abnormalities was made for cases with metabolic acidaemia and good signal quality during the last hour of monitoring.

Each monitoring trace was then assessed by another two independent observers (of whom one was an experienced obstetrician) blinded to acid-base status at birth and other clinical data. The CTG traces were classified as normal, intermediary, abnormal, or preterminal, using the ST guidelines,⁸ with the amendment of combined decelerations as a criterion for abnormal CTG, since such a pattern has been associated with excessive oxytocin administration and low scalp blood pH values.¹⁰ The definition of a preterminal pattern was absent variability (< 2 beats per minute). The continuous duration of abnormal and preterminal CTG patterns before birth were assessed. The examiners also classified the CTG in association with ST-events, and if and when indications to intervene had occurred according to the guidelines. If the two observers categorized a pattern, or indication to intervene, differently, the trace was finally classified in consensus by the group.

In cases where both intermediary and abnormal CTG and ST-abnormalities existed at different times the latter was registered as the indication to intervene. When no other

intervention criteria were present, we recorded the presence of a “rapidly deteriorating CTG trace”, suggested as a reason to consider intervention in the absence of ST-events.⁸

Abnormalities occurring during the last 10 minutes before birth were considered separately, since this was considered too late to allow intervention.

Obstetrical data were retrieved from computerized obstetric records. The results were analyzed with the Stat-View[®] software program. The chi-square test or Fisher’s exact test (if any expected number was below 5) were used for discrete variables, and Mann-Whitney test for continuous variables.

Results

During the study period there were 17 445 deliveries, about 20% monitored by STAN S21. The computerised search identified 787 cases and controls. Of these, 66 were excluded as they had incorrectly been registered as monitored by STAN, 117 as the recordings were less than 60 minutes, 34 since the time interval between the end of monitoring and delivery exceeded 20 minutes, 32 due to missing CTG and ST traces, and one where the breech mode was used incorrectly. In addition, 31 cases and controls with missing venous samples or too small differences in pH or pCO₂ between arterial and venous sample were excluded. After all exclusions, 506 cases were left for analysis: 24 with severe metabolic acidemia; 48 with metabolic acidemia; 52 with acidemia, 265 with pre-acidemia, and 117 controls.

Background obstetrical and neonatal characteristics are presented in Table 1. The case groups had longer duration of labour and higher rates of instrumental delivery than controls. Monitoring time varied between 1 and 18 hours for individual fetuses, and the median monitoring time was higher in the case groups (3.6-4.3 h) than in controls (median 3.2 h)

(Table 2). Periods of low signal quality were common; 40-50% of cases and 36% of controls had a period of insufficient signal quality of more than 15 minutes.

Half of the controls had at least one ST-event during monitoring (Table 3). Events occurred more often in cases with severe (79%), and moderate (75%) metabolic acidaemia than in controls, and this difference remained significant after excluding events the last 10 minutes before delivery. During the first stage, the occurrence of ST-events was not higher in any study group than among controls, but cases with severe metabolic acidaemia had higher rates of ST events (62%) during the second stage than controls (38%).

The most common event, baseline rises of the T/QRS-ratio, was the only type occurring significantly more often in cases with metabolic acidaemia than among controls. A rise of the T/QRS-ratio above 0.10 was more frequent in cases with severe metabolic acidaemia (42%) than among controls (15%). Ten of 72 cases with metabolic acidaemia had episodic T/QRS rises; eight also had baseline rises. In one of the two the remaining cases the episodic rise appeared at the time of spontaneous delivery. Only three cases with metabolic acidaemia (and only two controls) had repeated biphasic ST events.

The combined analysis of CTG and fetal ECG is presented in Table 4. The simultaneous occurrence of abnormal CTG and ST-events, being an indication to intervene, was 12% in controls and highest among cases with severe (67%) and moderate (44%) metabolic acidaemia. For traces with good signal quality during the last hour of monitoring, the rates were 12 of 16 (75%) and 14 of 33 (42%) in these groups (not shown in table). Indication to intervene for intermediary CTG patterns and ST-events did not appear significantly more often in any study group than in controls. Any indication to intervene according to the guidelines occurred in 23% of controls, and more often in all case groups (in 96% and 62% of cases with severe and moderate metabolic acidaemia).

In the absence of other intervention criteria, a rapidly deteriorating CTG trace was present only in one case of metabolic acidaemia, and in seven cases of pre-acidaemia (but in none of the controls; not shown in table).

Three neonates delivered in the first stage by caesarean section had pH <7.10. Two of them had ST-events, and in all three there were preterminal patterns >10 minutes.

Discussion

The present material, including a relatively large number of cases with metabolic acidaemia, provided the opportunity to evaluate the relation between different ST-events and CTG-abnormalities and acid-base status at birth. Cases and controls constituted a relatively high risk group, since the STAN method was preferably used for high risk cases. The study groups had longer median duration of labour, and 12-34% longer median monitoring time than controls. This difference might have biased the results towards a higher rate of ST-events among the cases, but the higher rates in cases with metabolic acidaemia remained when calculating the number of events per monitored hour.

ST events coinciding with abnormal or intermediary CTG patterns were present in 67% of cases with severe and 48% of cases with moderate metabolic acidaemia (75% and 42% in cases with good signal quality). These figures are in agreement with previous reports in which CTG and ST-changes preceded metabolic acidaemia (pH <7.05 and base deficit >12) in 56-70%,^{7,11} and acidaemia (pH <7.05) in 77% of cases.^{12,13} With good signal quality, CTG and ST-abnormalities has previously been reported to precede severe and moderate metabolic acidaemia in 5/5 and 6/13 cases, respectively,⁵ and acidaemia in 89%.^{12,13}

In the present study, an intermediary CTG together with pronounced ST events did not occur more often in any study group than among controls. Possibly this intervention criterion is unnecessary. However, such a conclusion may only be applicable if the CTG classification strictly follows the guidelines. We are aware that many interpreters hesitate to categorise a pattern as abnormal, and two thirds of the traces that we classified as abnormal according to the criteria had been classified as intermediate by the midwives caring for the patients. An intermediary CTG with ST events is therefore a reason for careful CTG evaluation, and the midwife should discuss such cases with an obstetrician.

We found no association between ST-events during the first stage of labour and cord artery pH. In a previous study, no association was found between CTG abnormality and ST events during the first stage.⁶ Hence, it appears as if most events during the first stage accompany normal CTG patterns, and can be disregarded. However, there is no evidence that ST events coinciding with CTG abnormalities are less significant in the first stage than in the second. Our study only included three cases with pH below 7.10 after (caesarean) delivery in the first stage (two with ST-events and abnormal CTG, and all three with preterminal patterns), which were too few to evaluate the association between ST-events during the first stage and cord artery pH.

We found no association between episodic T/QRS-rises or biphasic ST events and cord artery pH. Episodic rises of the T wave are thought to reflect temporary hypoxia. It is conceivable that a hypoxic episode is not associated with acidaemia as long as it is transitory. The results may indicate that the relevance of episodic T/QRS rises is small. Biphasic ST events only occurred in three cases with metabolic acidosis (and in two controls), and the study was underpowered to evaluate the association between these events and acid-base status at birth. Biphasic ST-events have been suggested to reflect depleted fetal glycogen reserves, and have

been associated with fetal growth restriction in observational studies.¹ In the present study only one case with severe metabolic acidaemia, one with acidaemia, eight with pre-acidaemia and three controls were SGA at birth (Table 1). None of these showed repeated biphasic ST-events.

According to guidelines, an abnormal CTG of over 60 minutes and a preterminal pattern are indications to intervene. At least one of these criteria were present in 22 of 24 cases with severe, and in 22 of 48 with moderate metabolic acidaemia. Preterminal patterns were rare among controls (2%) and frequent (83%) in cases with severe metabolic acidaemia. However, only a third of cases with moderate metabolic acidaemia had preterminal patterns, indicating that this, as the word implies, is a late sign of hypoxia.

Abnormal CTG patterns lasting more than 60 minutes have been associated with adverse outcome in newborns with acidaemia.¹⁴ However, most acidaemic fetuses did not have abnormalities lasting for one hour, and waiting for 60 minutes is hazardous if the trace is deteriorating. An expert group recently recommended intervention for rapidly deteriorating patterns in the absence of ST events.⁸ A definition of rapid deterioration is lacking, and the criterion therefore difficult to evaluate. In our study, it was common that one examiner categorised a decelerative second stage pattern with minimal variability as “rapidly deteriorating” and the other as preterminal, supporting intervention for such patterns. If STAN users recognise that only half to two thirds of cases with metabolic acidaemia are associated with ST events, the importance to intervene in cases with long-lasting, rapidly deteriorating, or preterminal CTG patterns will be better understood.

According to the guidelines, intervention was indicated in 96% and 62% among cases with severe and moderate metabolic acidaemia, and in 73% of cases with acidaemia. Still, the rates of operative delivery for fetal distress were only 46%, 23% and 15% in these groups.

Although other interventions than operative delivery had sometimes been undertaken, we were worried the criteria that in some cases had been neglected.

Intervention was also indicated for 23% of controls. This figure may seem high, even in a high risk population. It should, however, be emphasized that “intervention” must not always be operative delivery. In doubtful cases, FBS for the analysis of pH or lactate may be useful. Actually, the STAN method with the current guidelines has only been evaluated with FBS as an option.²⁻⁴ In the Swedish RCT, FBS was performed at similar rates in the study arms (11% and 9%),² whereas in the study from Finland, twice as many samples were taken in the CTG arm (16%) as in the CTG+ST arm (7%).³ This might be one explanation for the lower rate of acidaemia in the CTG arm of that study. The rate of FBS also differed between the study arms in the French study, but were high in both the CTG (62%) and CTG+ST arm (27%).⁴

None of the RCTs indicated an increased rate of operative delivery with the use of STAN. It must be stressed that the occurrence of ST-events should not trigger interventions when CTG patterns are normal – otherwise the high rate of ST-events among non-hypoxic fetuses may lead to many unnecessary and potentially harmful procedures. Even worse is if STAN users become accustomed to the occurrence of ST-events and do not react when indicated, i.e. in the presence of an abnormal CTG. If the additional information provided by STAN is to be useful, as it was in the Swedish RCT,² accurate CTG interpretation is essential.

Conclusion

This study showed that although the presence of ST-events increases the probability of fetal acidaemia, events are frequent (50%) also among controls with normal cord blood gas values. ST-events together with abnormal CTG patterns, reflecting hypoxia, appear late in the hypoxic process, and are inconsistent, occurring in half of cases with moderate, and in two of

three cases with severe metabolic acidaemia. It is therefore important to act when CTG abnormalities are marked or long lasting, also in the absence of ST-events. This is in agreement with recently published recommendations.⁸

Disclosure of interests

None of the authors has any commercial or other conflicting interest in STAN or other methods of fetal monitoring.

Contribution to authorship

Malin Melin contributed in planning the study, assessed the ST-information from the monitoring traces, and contributed to manuscript writing and data analysis. Anna Bonnevier assessed fetal heart rate traces, and reviewed the manuscript. Monika Cardell assessed fetal heart rate traces, and contributed to manuscript writing. Linda Hogan assessed fetal heart rate traces, and reviewed the manuscript. Andreas Herbst planned and coordinated the study, assessed fetal heart rate traces, analysed the data, and wrote the final manuscript.

Details of ethics approval

Since this was a retrospective study of data from patients' files and monitoring traces from our unit, no ethics committee approval was needed.

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Table 1. Background obstetrical and neonatal characteristics. Figures are presented as numbers (%) if not stated otherwise. Statistically significant differences ($p<0.05$) between cases and controls are marked with an asterisk (*).

	Severe metabolic acidaemia ¹ N=24	Metabolic acidaemia ² N=48	Acidaemia ³ N=52	Preacidaemia ⁴ N=265	Controls ⁵ N=117
Nulliparous mother	16 (67)	38 (79)	39 (75)	201 (76)	77 (66)
Post term pregnancy ($\geq 42+0$ weeks)	5 (21)	6 (12)	7 (13)	23 (9)	13 (11)
Induction of labour	11 (46)*	8 (17)	10 (19)	36 (14)	24 (21)
Duration of 1 st stage ⁶ (h), median (range)	4.2 (0-8.7)	6.4 (0-16.5)*	5.1 (0-17.8)*	5.0 (0-29.0)*	3.5 (0-16.0)
Duration of 2 nd stage (h), median (range)	1.1 (0-3.1)	1.5 (0-5.8)*	1.2 (0-7.0) *	1.3 (0-6.2)*	0.9 (0-9.3)
Fetal scalp blood sampling	6 (25)	6 (12)	8 (15)	21 (8)	12 (10)
Instrumental delivery	8 (33)	14 (29)*	15 (29) *	61 (23)*	10 (9)
Caesarean section	4 (17)	3 (6)	0 (0)	10 (4)	7 (6)
Operative delivery for fetal distress	11 (46)*	11 (23)*	8 (15)*	46 (17)*	9 (8)
Male gender	15 (62)	27 (56)	25 (48)	147 (55)	59 (50)
Birth weight (kg), median (range)	3.6 (2.7-4.7)	3.8 (2.8-4.9)	3.6 (2.2-4.9)	3.7 (2.3-5.2)	3.7 (2.4-5.0)
Small for gestational age at birth ⁷	1 (4)	0	1 (2)	8 (3)	3 (3)
Cord artery pH, median (range)	6.96 (6.77-6.99)*	7.06 (7.00-7.09)*	7.07 (7.01-7.09)*	7.15 (7.10-7.19)*	7.25 (7.20-7.42)
Cord artery lactate, mmol/l, median (range)	13.2 (10.4-21.0)*	11.2 (10.0-18.0)*	8.7 (5.8-9.9)*	7.2 (3.4-13.3)*	4.6 (1.9-8.9)
5-min Apgar score <7	8 (33)*	3 (6)	6 (12)*	2 (1)	0 (0)
Admission to neonatal care unit	16 (67)*	11 (23)*	8 (16)*	19 (7)	5 (4)

¹ Cord artery pH <7.00 and lactate ≥ 10 mmol/l

⁵ Cord artery pH ≥ 7.20

² Cord artery pH 7.00-7.09 and lactate ≥ 10 mmol/l

⁶ From regular contractions and cervical dilation ≥ 4 cm

³ Cord artery pH 7.00-7.09, lactate < 10 mmol/l

⁷ Below -22% (2 SD) from expected weight at gestational age

⁴ Cord artery pH 7.10-7.19

Table 2. Background monitoring characteristics. Figures are presented as numbers (%) if not stated otherwise. Statistically significant differences ($p < 0.05$) compared with controls are marked with an asterisk (*).

	Severe metabolic acidaemia N=24	Metabolic acidaemia N=48	Acidaemia N=52	Preacemia N=265	Controls N=117
Duration of STAN monitoring (hours) ¹	4.1 (1.2-10.2)	4.3 (1.0-11.8)**	3.6 (1.0-13.8)*	4.2 (1.0-18.6)**	3.2 (1.0-12.0)
Disconnected >15 minutes	1 (4) *	17 (35)	14 (30)	79 (30)	29 (25)
Insufficient signal quality >15 minutes	12 (50)	21 (44)	26 (50)	107 (40)	42 (36)
STAN-monitoring started during the first stage of labour ²	23 (96)	43 (90)	48 (92)	237 (89)	103 (88)

1. Monitoring time minus disconnected time

2. Monitoring started at least 20 minutes before full cervical dilatation.

Table 3. Occurrence of different types of ST-events in relation to cord artery acid-base status. Figures are presented as numbers (%) if not stated otherwise. Each group is compared with controls (pH ≥ 7.20), and significant differences are marked with * (p < 0.05) or ** (p < 0.01).

	Severe metabolic acidaemia N=24	Metabolic acidaemia N=48	Acidaemia N=52	Preacidaemia N=265	Controls N=117
Number of ST-events, median (range)	3.5 (0-15)*	2 (0-14)*	1 (0-23)	1 (0-40)	1 (0-73)
Any baseline T/QRS rise (>0.06)	18 (75)*	33 (69)*	27 (52)	144 (54)	56 (49)
Baseline T/QRS rise >0.10	10 (42)*	8 (17)	9 (17)	42 (16)	17 (15)
Any episodic T/QRS rise (>0.10)	3 (12)	7 (15)	10 (19)	33 (12)	11 (9)
Episodic T/QRS rise >0.15	3 (12)	3 (6)	4 (8)	12 (5)	5 (4)
Repeated biphasic ST	1 (4)	2 (4)	4 (8)	13 (5)	2 (2)
Any ST-event ¹	19 (79)*	36 (75)**	31 (60)	151 (57)	58 (50)
Any ST-event ¹ , last 10 minutes before birth excluded	19 (79)**	32 (67)*	29 (56)	139 (52)	54 (46)
Monitoring started first stage²	N=23	N=43	N=48	N=237	N=103
Any event during first stage ¹	12 (52)	20 (47)	20 (42)	107 (45)	41 (40)
Monitored during second stage³	N=21	N=45	N=47	N=228	N=89
Any event during second stage ¹	13 (62)*	20 (44)	21 (45)	93 (41)	34 (38)
Any event during second stage, last 10 minutes before birth excluded ¹	13 (62)*	15 (33)	18 (38)	77 (34)	28 (31)

¹ Single biphasic events (occurring in 6 cases) were not included, since this is never indication to intervene according to guidelines.

² Only those with monitoring started at least 20 minutes before full cervical dilatation included.

³ Cesarean deliveries before full cervical dilatation and cases with second stage shorter than 20 minutes excluded.