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Circadian variation in the circumstances of delivery in a population at low obstetric risk

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While circadian variations in birth and perinatal mortality rates have previously been described in the literature, the reasons behind these observed rhythms remain unclear. The principal hypothetical causes include variations in obstetric practices and an association between the time of birth and biological parameters. In order to explore this issue we analysed the distribution patterns for time and day of birth, as well as circadian variations in maternal characteristics, obstetric practices and neonatal risk in a population at low obstetric risk. The study population included 685 low-risk pregnant women consecutively admitted at an early stage of labour to six maternity units. The results showed hourly variations in the birth rate and circadian variations in obstetric practices that might explain the hourly pattern observed for the birth rate. By contrast, the frequency of a positive neonatal risk indicator was uniform across all time categories in this population at low obstetric risk.

Key words: birth rate, circadian rhythm, low obstetric risk, obstetric practices

Circadian variations in perinatal mortality rates have been described in the literature since 1978[1–5] and include reports from Switzerland.[4,6,7] Paccaud et al. highlighted an increase in perinatal mortality associated with newborns delivered between 16.00 and 02.00 h, with a peak incidence at 23.00 h.[7] A heterogeneous distribution of high-risk deliveries during the day, with a shift of such deliveries towards the end of the afternoon, is one possible but untested explanation for the observed variations in perinatal mortality.

In parallel with these variations in perinatal mortality rates, hourly variations in the number of births have been described,[6–8] and these appear to be affected by biological circadian rhythms[1,7,8] or by the activity of hospital teams.[1,7] Other studies have suggested that such variations might reflect the scheduled rotas for obstetric procedures.[4,6,8–12]

We studied the relationship between selected characteristics of delivery that are potentially associated with perinatal mortality and the time of birth in a population of pregnant women at low obstetric risk, admitted to maternity services in an early stage of labour.

MATERIAL AND METHODS

Population

Our hypotheses were explored based on a secondary analysis of a multicentre prospective study designed to evaluate the effect of jaccuzzi baths on the first stage of labour and the pain felt by the women. All women admitted for delivery in five regional non-profit hospitals and in one private clinic in the canton of Vaud, Switzerland between 15 November 1991 and 30 April 1992 were screened for eligibility according to criteria designed essentially to select a low-risk population, i.e. for whom a jaccuzzi bath would not be risky or a barrier to close monitoring in an early stage of labour (cervical dilatation ≤2 cm). The use of a jaccuzzi bath was not found to be associated with the variable under study.

Definition of variables

- Time of birth

Births were categorized into three dichotomous variables.

i) The first was defined according to the shifts of the obstetric teams, labelled as 'day' (full medical and paramedical teams, from 07.30 to 17.59 h) and 'night' (reduced teams, from 18.00 to 07.29 h).

ii) The second was defined according to the study by Paccaud et al.[6] showing a difference in perinatal mortality rates between 'diurnal' (from 02.00 to 15.59 h) and 'nocturnal' (from 16.00 to 01.59 h) periods.

iii) The third was for deliveries during a 'weekday' (from Monday 00.00 to Friday 23.59 h) or at a 'weekend' (from Saturday 00.00 to Sunday 23.59 h).

- Other variables

We explored the relationship between the time of birth and the following.

i) Maternal characteristics: age (continuous), parity (primiparae versus multiparae) and previous Caesarean birth (dichotomous).

ii) Obstetric procedures: delivery induction, labour stimulation, epidural analgesia and analgesics (dichotomous variables).

iii) Characteristics of labour: duration of the first stage (2 cm to full cervical dilatation, continuous), duration of the second stage (between full cervical dilatation and birth,

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continuous), instrumental births (either Caesarean section, forceps or vacuum, dichotomous) and foetal monitoring scores. The score in the first stage of labour, in accordance with Hammacher's[13] method, was dichotomized into ≤4 or >4 (pre-pathological or pathological) and in the second stage of labour, according to Melchior,[14] dichotomized into ≤2 and 3–4 (bradycardia with episodes of acceleration during expulsion efforts, respectively stable foetal cardiac rhythm and subsequent decrease in rhythm resulting in bradycardia at the end of the expulsion stage). All the patients were monitored with an abdominal captor or a foetal scalp electrode except during the jaccuzzi baths.
iv) Neonatal risk which was considered to be present when at least one of the following conditions was fulfilled: an umbilical cord pH of less than 7.15 (arterial or, failing this, venous measurement), an Apgar score (at 1, 5 or 10 min) of less than 7 or newborn's transfer to a neonatal intensive care unit during the first week of life.

Statistical analyses

Bivariate relationships between the categorical variables were analysed by χ^2 tests and t-tests were used to compare the population means for the continuous variables, after logarithmic transformation where applicable (labour duration, stages 1 and 2). The level of statistical significance was fixed at $p<0.05$. The analyses were first performed on the whole set of observations and then repeated separately for spontaneous and induced labours (additional tables for the subgroup analyses are available on request to the first author).

RESULTS

Population

Overall, 1,392 women were registered in the six participating maternity units during the study period. Of these, 685 (49.2%) met the eligibility criteria. Most of the exclusions were attributed to a cervical dilatation >2 cm on admission (46.6%) and to specific procedures (epidural analgesia, Caesarean section and analgesia) planned prior to admission or used before 2 cm dilatation (34.9%). Other exclusions (22.9%) were for abnormal presentation, multiple pregnancy, intra-uterine growth retardation (P<10 according to the ultrasound), delivery before 37 weeks or after 42 weeks, hypertension, pre-eclampsia, gestational diabetes and diabetes mellitus, vaginal haemorrhage, polyhydramnios, chronic foetal distress, stillbirth, other high risk pregnancy not specified and 5.3% of the exclusions were for logistic problems (the absence of one study co-ordinator). More than one criterion can apply simultaneously. A previous Caesarean section alone was not considered as an exclusion criterion because it does not necessarily imply a Caesarean section in the current delivery. *Table 1* presents the study population, obstetric procedures and labour parameters of the 685 women included.

Birth distributions for time and day

Births were uniformly distributed over the days of the week and the frequency of births did not differ between weekdays and weekends, with 491 births registered during weekdays (71.7%; expected 71.4%). We observed a greater number of births between 11.00 and 17.00 h (45.7%; expected: 29.2%) and reduced numbers between 19.00 and 06.00 h (34,2%, expected 50.0%). However, no variations were observed in the frequency of births between day and night or in the hours defined as diurnal and nocturnal, except for an increased rate of birth following an induced labour during the day and diurnal phases.
We did not observe an association between maternal age or parity and the time of birth *(table 2)*, although a previous Caesarean section was more common among the day births (RR=1.92) and during weekends (RR=1.87). In spontaneous births, primiparity was associated with delivery during the day (RR=1.24), while a smaller proportion of primiparae delivered during the day in the induced labour group (RR=0.60).

Obstetric practices

Labour induction was found to be associated with a birth during daytime hours (RR=2.17). Where labour was not induced, we observed an association between intrapartum

Table 1 Characteristics of the included women (n=685)

		n	Missing values
Maternal characteristics			
Mean age (±2 SD) (years)	28.15 ± 0.33	684	1
Primigravidae (%)	41.2	282	0
More than 2 gravidae (%)	22.9	157	0
Primiparae (%)	47.2	323	0
Prior Caesarean section (%)	5.8	40	0
Obstetric practices			
Labour induction	21.9	149	34
Labour stimulation	41.6	271	34
Epidural analgesia	19.0	130	0
Use of analgesics	56.7	388	1
Delivery process			
Labour stage 1 duration (min)	223 ± 11	649	36
Labour stage 2 duration (min)	29 ± 3	642	43
Caesarean section, vacuum or forceps (%)	16.2	11	0
Hammacher score >4 (%)	7.2	45	57
Melchior score >2 (%)	15.7	80	176
Positive neonatal risk indicator (%)[a]	14.5	85	97

a: Positive when at least one of the following conditions was fulfilled: i) an umbilical cord pH of less than 7.15 (arterial or, failing this, venous measurement), ii) an Apgar score at 1, 5 or 10 min of less than 7 or iii) newborn's transfer to a neonatal intensive care unit during the first week of life

labour stimulation and daytime hours of birth (RR=1.29). Epidural analgesia was more frequently administered in the group of nocturnal births, in all births (RR=2.33) as well as in spontaneous labour (RR=2.01) and in induced labour (RR=3.36) subgroups. By contrast, no significant difference was found in respect of the analgesia received. The type of day was not related to the frequency of labour induction, labour stimulation or the use of epidural analgesia or analgesics.

An instrumental delivery (unplanned Caesarean section or the use of a vacuum or forceps) was more frequent among nocturnal births (RR=1.53), including in the spontaneous labour subgroup (RR=1.60), but not in the induced labour subgroup. Unfavourable Melchior scores were more frequent for diurnal births (RR=1.68). We found no correlation between the time of birth and the Hammacher score. The duration of the first and second stages of labour was not associated with the time of birth. Weekday and weekend births were similar with regard to instrumental delivery, cardiotocographic reports and labour duration.

Neonatal risk indicators

The analysis of the neonatal risk indicator did not reveal any differences associated with the various time of birth variables or with the type of day. At the α =0.05 level, an RR of 1.9 could have been detected for each variable with a power greater than 0.80.

DISCUSSION

Our data show that time-related variations in the delivery process are observed among women at low obstetric risk who were admitted at an early stage of labour.

We registered a circadian rhythm in the numbers of births, consistent with previous studies that have attributed the observed variations to the circadian character of obstetric practices (instrumental deliveries, labour induction and stimulation).[8] Our data suggest that obstetric practices might play an important role in the hourly variations of the birth rate. Firstly, we observed that births after labour induction or stimulation occurred more frequently during the daytime hours, while a full obstetric team is present. Secondly, the daytime hours were associated with an increased number of deliveries among women with a prior Caesarean section. Thirdly, higher rates of epidural analgesia were recorded during the nocturnal hours. These findings suggest that obstetric practices, e.g. labour induction and stimulation in the first part of the day, tend to favour a labour management resulting in births during the daytime hours. Births occurring during the hours characterized by a reduced team were less likely to result from an induced or stimulated labour, but were more likely to involve an instrumental delivery or the administration of epidural analgesia. In this low-risk population, possible indications for epidural analgesia include stagnant dilatation or presentation, an exacerbation of maternal pain or exhaustion on the part of the patient and/or the obstetric team.

Despite the observed variations in the delivery process, our data did not show parallel variations in the indicator of neonatal risk. More surprising was the more favourable cardiotocographic Melchior score during the nocturnal hours. This observation could be explained by the lack of sensitivity and specificity reported for this foetal evaluation technique.[15,16] The relationship between perinatal mortality or morbidity and the hourly variations in obstetric practices deserves further exploration in specifically designed studies.

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Table 2 Distribution of maternal characteristics, obstetric practice and delivery process variables by time and day of birth (all births, n=685)

	Time of birth		Time of birth		Day of birth	
	Day (7.30–17.59h)	Night (18.00–7.29h)	Diurnal (2.00–15.59h)	Nocturnal (16.00–1.59h)	Weekend (Saturday and Sunday)	Weekday (Monday to Friday)
Maternal characteristics						
Age (mean ± 2 SD) (years)	28.2 ± 0.4	28.1 ± 0.5	28.0 ± 0.4	28.4 ± 0.6	28.4 ± 0.7	28.1 ± 0.4
Parity 1 (%)	47.6	45.8	47.1	46.5	44.9	48.1
Prior Caesarean section (%)	7.3*	3.8*	6.2	5.3	8.8*	4.7*
Obstetric practice						
Induced labour (%)	29.3*	13.5*	23.5	22.2	18.7	24.6
Epidural analgesia (%)	17.2	21.4	12.8*	29.8*	19.1	19.0
Use of analgesics (%)	59.1	53.0	57.3	55.5	61.3	61.3
Delivery process						
Labour stage 1 (min)	223 ± 13	223 ± 18	215 ± 13	236 ± 19	222 ± 18	223 ± 13
Labour stage 2 (min)	28 ± 3	31 ± 5	27 ± 3	33 ± 5	28 ± 5	30 ± 3
Instrumental delivery[a] (%)	15.7	15.9	13.1*	20.1*	14.8	16.7
Hammacher score >4 (%)	7.7	6.2	7.5	6.2	6.7	7.4
Melchior score 3–4 (%)	16.6	14.2	18.2*	10.8*	16.4	15.8

* $p<0.05$

a: Caesarean section, vacuum or forceps

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Appendix a Exclusion criteria[a] (n=707)

Exclusion criteria	n	%
Cervical dilatation >2 cm on admission	328	46.6
Epidural analgesia planned before 2 cm dilatation	94	13.4
Planned Caesarean section	85	12.1
Analgesics, benzodiazepam and/or spasmolytics given before 2 cm dilatation	66	9.4
Delivery before 37 or after 42 completed weeks	35	5.0
Abnormal presentation	28	4.0
Maternal fever ≥ 38°C	25	3.6
IUGR (percentile <10 according to ultrasonography)	15	2.1
Multiple pregnancy	12	1.7
Hypertension of pregnancy, preeclampsia	11	1.6
Vaginal haemorrhage	10	1.4
Chronic foetal distress (non stress test + at <2 cm dilatation)	7	1.0
Gestational diabetes or diabetes mellitus	6	0.9
Other high risk pregnancy or contraindication to jaccuzzi bath, not specified	5	0.7
Polyhydramnios	4	0.6
Stillbirth diagnosed prior to or during admission	2	0.3
Logistic problems (study co-ordinator on vacation at one site)	37	5.3

a More than one criteria can apply simultaneously

Appendix b Distribution of maternal characteristics, obstetric practice and delivery process variables by time and day of birth (spontaneous labour, n=536)

	Time of birth		Time of birth		Day of birth	
	Day (7.30–17.59h)	Night (18.00–7.29h)	Diurnal (2.00–15.59h)	Nocturnal (16.00–1.59h)	Weekend (Saturday and Sunday)	Weekday (Monday to Friday)
Maternal characteristics						
Age (mean ± 2 SD) (years)	28.1 ± 0.5	28.1 ± 0.6	28.0 ± 0.5	28.2 ± 0.7	28.2 ± 0.7	28.0 ± 0.5
Parity 1 (%)	53.5*	43.2*	51.2	44.9	44.9	51.9
Prior Caesarean section (%)	3.5	3.2	5.3	4.9	7.9	4.0
Obstetric practice						
Induced labour (%)	60.1*	46.3*	55.0	52.0	52.1	54.7
Epidural analgesia (%)	20.0	18.7	14.2*	28.5*	19.7	19.4
Use of analgesics (%)	57.8	52.9	56.5	54.0	59.7	54.0
Delivery process						
Labour stage 1 (min)	235 ± 16	220 ± 19	224 ± 15	235 ± 23	226 ± 20	230 ± 16
Labour stage 2 (min)	31 ± 4	31 ± 5	30 ± 4	33 ± 6	28 ± 5	32 ± 4
Instrumental delivery[a] (%)	14.1	15.1	12.0*	19.2*	13.1	16.1
Hammacher score >4 (%)	6.6	5.5	7.5	3.6	7.2	5.9
Melchior score 3–4 (%)	16.9	14.6	18.6	10.7	15.7	16.0

* p<0.05
a: Caesarean section, vacuum or forceps

Appendix c Distribution of maternal characteristics, obstetric practice and delivery process variables by time and day of birth (induced labour, n=149)

	Time of birth		Time of birth		Day of birth	
	Day (7.30–17.59h)	Night (18.00–7.29h)	Diurnal (2.00–15.59h)	Nocturnal (16.00–1.59h)	Weekend (Saturday and Sunday)	Weekday (Monday to Friday)
Maternal characteristics						
Age (mean ± 2 SD) (years)	28.7 ± 0.8	28.2 ± 1.5	28.2 ± 0.8	29.1 ± 1.3	29.1 ± 1.6	28.4 ± 0.8
Parity 1 (%)	34.2*	57.1*	34.0	50.0	44.9	38.6
Prior Caesarean section (%)	8.8	8.6	9.3	7.7	11.4	7.9
Obstetric practice						
Induced labour (%)	76.5	23.5	65.1	34.9	23.5	76.5
Epidural analgesia (%)	12.3*	40.0*	10.3*	34.6*	13.4	20.0
Use of analgesics (%)	60.5	54.3	58.8	59.6	65.7	57.0
Delivery process						
Labour stage 1 (min)	178 ± 18	232 ± 51	171 ± 20	228 ± 36	198 ± 37	188 ± 22
Labour stage 2 (min)	22 ± 5	35 ± 16	20 ± 5	35 ± 12	28 ± 14	24 ± 6
Instrumental delivery[a] (%)	21.1	22.9	18.6	26.9	25.7	20.2
Hammacher score >4 (%)	10.5	12.1	7.9	16.3	5.9	12.5
Melchior score 3–4 (%)	15.2	7.7	16.2	8.1	21.4	10.4

* p<0,05
b: Caesarean section, vacuum or forceps