Foetal Morbidity Depending on the Day and Time of Delivery

Fetale Morbidität abhängig von Tag und Uhrzeit der Entbindung

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Authors
Julia von Ehr, Nina Wiebking, Sudip Kundu, Constantin von Kaisenberg, Peter Hillemanns, Philipp Soergel

Affiliation
Klinik für Frauenheilkunde und Geburtshilfe, Medizinische Hochschule Hannover, Hannover, Germany

Correspondence
Julia von Ehr
Klinik für Frauenheilkunde und Geburtshilfe,
Medizinische Hochschule Hannover
Carl-Neuberg-Straße 1, 30625 Hannover, Germany
vonehr.julia@mh-hannover.de

Deutsche Version unter:
https://doi.org/10.1055/a-0637-9400

ABSTRACT

Introduction It is known that perinatal mortality is increased with births at night and at the weekend. The aim of the study was to investigate whether there is also an association between the time of delivery (weekday, night, weekend) and perinatal morbidity.

Material and Methods All births at Hannover Medical College between 2000 and 2014 were included in a retrospective data analysis. Multiple births, primary sections, severe foetal malformations and intrauterine deaths were not included. A 5-minute Apgar score ≤ 5 and cord arterial pH < 7.10 were defined as perinatal morbidity. Besides the time of delivery, different variables that are regarded as risk factors for increased perinatal morbidity were studied. Univariate logistical regression analysis was performed, followed by multivariate analysis.

Results 18 394 deliveries were included in the study. Pathological prepartum Doppler, medical induction of labour and delivery at night and/or at the weekend significantly increased the probability of an Apgar score ≤ 5 after 5 minutes. The probability that a child will have cord arterial pH < 7.1 post partum is significantly increased with a BMI > 25 before pregnancy, primiparity, medical induction of labour, peripartum administration of oxytocic agents, when the delivery took place at night and weekend combined, but also when the delivery took place at night or at the weekend/on a public holiday. Multivariate regression analysis showed that a time of delivery at night and/or at the weekend or on a public holiday is not a prognostic factor for a 5-minute Apgar score ≤ 5 (p = 0.2377) but is a prognostic factor for cord arterial pH < 7.1 (p = 0.0252).

Conclusion The time of delivery at night or at the weekend/on a public holiday increases the risk for cord arterial pH < 7.1 by ~ 30 % compared with delivery on a weekday. However, the time of delivery at night or at the weekend/on a public holiday does not increase the risk for the baby of having a 5-minute Apgar score ≤ 5.

ZUSAMMENFASSUNG

Einleitung Es ist bekannt, dass bei Geburten nachts und am Wochenende eine erhöhte perinatale Mortalität vorliegt. Ziel der Studie war es zu untersuchen, ob es auch einen Zusammenhang gibt zwischen dem Zeitpunkt der Entbindung (Werktag, nachts, Wochenende) und der perinatalen Morbidität.

Material und Methoden In eine retrospektive Datenanalyse wurden sämtliche Geburten an der Medizinischen Hochschule Hannover zwischen 2000 bis 2014 eingeschlossen. Mehrlingsgeburten, primäre Sectiones, schwere fetale Fehlbildungen und intrauterine Fruchttode wurden nicht berücksichtigt. Als perinatale Morbidität wurde ein 5-Minuten-Apgar-Wert ≤ 5 sowie ein Nabelarterien-pH-Wert < 7,10 definiert. Neben dem Entbindungszeitpunkt wurden verschiedene Einflussvariablen untersucht, die als Risikofaktoren für erhöhte peri-

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natale Morbidität gelten. Es erfolgte eine univariate logistische Regression und anschließend eine multivariate Analyse.
Ergebnisse Es wurden insgesamt 18 394 Geburten in die Studie eingeschlossen. Ein pathologischer Doppler präpartal, eine medikamentöse Geburtseinleitung und eine Entbindung nachts und/oder am Wochenende/Feiertag erhöhten die Wahrscheinlichkeit für einen Apgar-Wert ≤ 5 nach 5 Minuten signifikant. Die Wahrscheinlichkeit für ein Kind, postpartal einen Nabelarterien-pH-Wert < 7,1 zu haben, ist signifikant erhöht bei einem BMI > 25 vor der Schwangerschaft, bei Primiparität, bei medikamentöser Geburtseinleitung, bei der Gabe von Wehenmittel peripartal, wenn die Entbindung nachts am Wochenende als Kombination, aber auch wenn die Entbin-

dung nachts oder am Wochenende/Feiertag erfolgt ist. Die multivariate Regressionsanalyse ergab, dass ein Entbindungszeitpunkt nachts und/oder am Wochenende oder Feiertag kein prognostischer Faktor für einen 5-Minuten-Apgar-Wert ≤ 5 (p = 0,2377), jedoch für einen NapH-Wert < 7,1 (p = 0,0252) ist.
Schlussfolgerung Der Entbindungszeitpunkt nachts oder am Wochenende/Feiertag erhöht das Risiko für einen Nabelschnurarterien-pH < 7,1 um ~ 30 % im Vergleich zu einer Geburt an einem Werktag. Der Entbindungszeitpunkt nachts oder am Wochenende/Feiertag erhöht jedoch nicht das Risiko für das Kind, einen 5-Minuten-Apgar-Wert ≤ 5 zu bekommen.

Introduction

In the 1970s and early 1980s, several studies were published that described an association between delivery at the weekend and increased perinatal mortality [1–3]. Fortunately, there has been a marked fall in foetal perinatal mortality to 5.2–5.4 affected children per thousand births in the last 60 years. In routine obstetric practice, foetal perinatal mortality is therefore a rare event today. Apart from mortality, however, foetal perinatal morbidity is now a central concern, especially due to perinatal asphyxia.

Hypoxic ischaemic encephalopathy (HIE) as a result of perinatal asphyxia is regarded worldwide as one of the main reasons for foetal mortality and morbidity [4]. The reported incidence is 2–3 per 1000 live births in industrialised countries and up to 15 per 1000 live births in developing countries [5, 6]. It is assumed that 23 % of the 3.6 million peripartum deaths annually worldwide are a result of perinatal asphyxia [4, 7].

The majority of children who have suffered perinatal hypoxia recover rapidly and do not develop any neurological abnormalities. The proportion of children with HIE can develop neurological abnormalities of varying degree, which affect motor function, sensory function, cognition or behaviour [8]. There may be cerebral palsy, mental retardation, epilepsy, impaired hearing or only minimal behavioural abnormalities [9].

The standard procedure is to assess the newborn baby directly post partum using the Apgar score and exclude perinatal asphyxia by performing blood gas analysis on the placental artery and placental vein. The Apgar score awards 0–2 points for the following five criteria: colour, heart rate, reflexes, tone and breathing. The Apgar score is measured and recorded after one, five and ten minutes. The best possible score is 10 points and the worst is 0 points. An Apgar score of 7–10 is regarded as normal. A persistent Apgar score of 0–3 correlates with increased perinatal mortality [10, 11]. However, its predictive value as regards impaired cognitive function is controversial [12]. The Apgar score cannot provide evidence or exclusion of foetal hypoxia. This requires blood gas analysis from the umbilical cord artery as soon as possible post partum. Conclusions about the baby's metabolic status can then be drawn from the cord arterial pH and base excess. Measurement of the cord arterial pH is accepted as an objective criterion for assessing the newborn baby's condition [13]. Cord ar-

terial pH > 7.20 is normal. A level between 7.20 and 7.10 is described as mild acidosis, which does not lead to any subsequent neurological problems if corrected normally. Cord arterial pH between 7.10 and 7.00 is moderate and below 7.00 is severe acidosis. Cord arterial pH below 7.00 is regarded in many studies as the critical threshold where foetal mortality and morbidity increase sharply [14].

The aim of our study was to investigate whether there is an association between the time of delivery and perinatal morbidity in a university hospital.

Material and Methods

Study design

All deliveries in Hannover Medical College from 01.01.2000 to 31.08.2014 were included in this retrospective analysis. Births with the following criteria were excluded: primary sections, obviously faulty data, twin datasets, higher multiple births, delivery outside the hospital, severe foetal malformations, late abortions and intrauterine death. A 5-minute Apgar score ≤ 5 and cord arterial pH < 7.10 were defined as surrogate markers for perinatal morbidity.

A service model with a doctor on call for 24 h starting at 7.30 h was used in the gynaecology department of Hannover Medical College throughout the study period. Midwives worked in shifts throughout the study period. The time of delivery was classified as follows according to staffing schedules:

- Weekday delivery: from Monday 07.00 h to Friday 18.00 h
- Weekend delivery: from Friday 18.00 h to Monday 07.00 h
- Delivery during the day: from 07.00 h to 18.00 h
- Delivery at night: from 18.00 h to 07.00 h
- Public holidays were treated as weekend

In addition, the following variables, which are published risk factors for increased perinatal morbidity, were studied:

- BMI > 25 prior to pregnancy
- Weight gain > 20 kg during pregnancy
- Primiparity
- Medical induction of labour

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- Administration of oxytocic agents during the birth, usually oxytocin
- Prepartum maternal age > 35 years
- Prepartum pathological foetal Doppler

Statistical analysis

The data were analysed statistically using Microsoft Excel (Microsoft, Seattle, WA, USA) and Analyse-it for Microsoft Excel (Analyse-it Ltd., Leeds, GB). The analysis referred to two target variables: cord arterial pH post partum and Apgar score after 5 minutes. Univariate logistical regression analysis was performed with one independent variable and one dependent variable (pH or Apgar). In addition to the time of delivery (day vs. night, weekday vs. weekend/public holiday, weekday during the day vs. at night and weekend/public holiday) the variables listed above were studied.

This was followed by multivariate analysis using the parameters that have a significant influence on cord arterial pH < 7.1 or a 5-minute Apgar score ≤ 5.

Results

Of the 27 526 births that took place in the gynaecology department of Hannover Medical College from 01.01.2000 to 31.08.2014, 9132 were excluded because of the aforementioned criteria. This left 18 394 data sets.

## Number of births with pathological Apgar and/or cord arterial pH

The cord arterial pH was < 7.1 in 504 of the 18 394 deliveries studied. This is equivalent to 2.74%. In 179 deliveries, the 5-minute Apgar score was ≤ 5, equivalent to 0.97% of the deliveries. Both a cord arterial pH < 7.1 and a 5-minute Apgar score ≤ 5 were recorded in 21 births, equivalent to 0.11%.

Distribution of number of deliveries according to time

8815 babies were born during the day (47.92%). 66.17% of the births (n = 12 172) took place on a weekday. A further distinction was made between weekdays during the day versus weekend and weekdays at night. 6566 deliveries took place during the day on a weekday. This is equivalent to 35.70% of the deliveries. 30.48% (n = 5606) of the babies were born at night on a weekday, 12.22% (n = 2249) during the day at the weekend and 21.6% (n = 3973) at night during the weekend. The time of delivery had no significant influence on the rate of secondary section and operative vaginal delivery. The decision-to-delivery intervals (DDI) too did not show any significant difference between the different times of delivery.

Percentage distribution of deliveries with a cord arterial pH < 7.1 or 5-min Apgar score ≤ 5 depending on the day and time of delivery

2.3% of the babies (n = 151) with a cord arterial pH < 7.1 and 0.79% (n = 52) with a 5-minute Apgar score ≤ 5 were born on a weekday during the day. The numbers were: 3.09% (n = 173) of babies born on a weekday at night had cord arterial pH < 7.1 and 1.07% (n = 60) had a 5-minute Apgar score ≤ 5 while 2.89% (n = 180) of babies born at the weekend had cord arterial
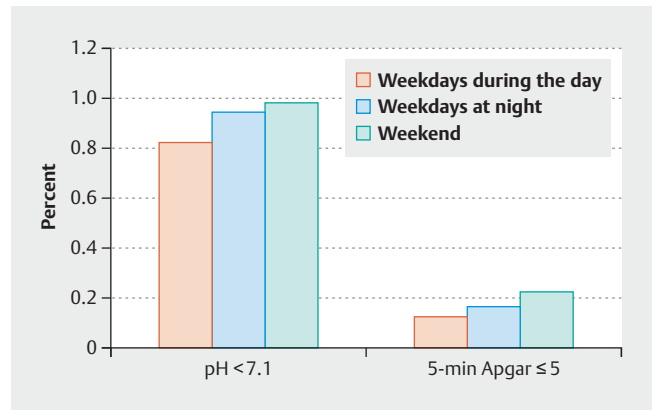
▶ **Fig. 1** Percentage distribution of deliveries with a cord arterial pH < 7.1 or 5-min Apgar score ≤ 5 depending on the time of delivery on weekdays during the day, weekdays at night and at the weekend.

pH < 7.1 and 1.08% (n = 67) had a 5-minute Apgar score ≤ 5 (▶ **Fig. 1**).

Distribution of the variables

The BMI of 6546 women was over 25 prior to pregnancy, corresponding to 35.59% of all cases. Weight gain of more than 20 kg during pregnancy was found in 2605 cases, equivalent to 14.16% of the births. 9267 of 18 394 births were to primigravidae (50.38%). Labour was induced medically in 30.23%, corresponding to 5560 deliveries. Oxytocic agents were given during 4949 births, corresponding to 26.90%. The mother's age at delivery was ≥ 35 years in 4301 cases (23.38% of all births). 161 foetuses had a prepartum pathological Doppler, corresponding to 0.88% of births.

▶ **Table 1** shows the distribution of the variables in the different times of delivery.

Variables influencing a 5-min Apgar score ≤ 5 in univariate analysis

Pathological Doppler pre partum and medical induction of labour significantly increased the probability of an Apgar score ≤ 5 after 5 minutes (p = 0.008; 95% CI 1.29–3.3 and p = 0.037; 95% CI 0.60–1.00 respectively). When the baby was born at night or at the weekend/on a public holiday, the probability of the baby having a postpartum Apgar score ≤ 5 after 5 minutes also increased significantly (p = 0.027; 95% CI 1.04–2.70). If the times of delivery at night (p = 0.29; 95% CI 0.91–1.38) and at the weekend/on a public holiday (p = 0.054; 95% CI 1.0–1.51) are considered separately, there was no significant probability. Maternal age over 35 years at delivery (p = 0.40; 95% CI 0.77–1.94), BMI over 25 prior to pregnancy (p = 0.11; 95% CI 1.0–1.07), weight gain of more than 20 kilograms during pregnancy (p = 0.052; 95% CI 0.43–1.05), primiparity (p = 0.63; 95% CI 0.78–1.17) and peripartum use of oxytocic agents (p = 0.36; 95% CI 0.70–1.14) had no influence on an Apgar score ≤ 5 after 5 minutes (▶ **Table 2**).

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▶ **Table 1** Distribution of the variables in the different times of delivery, weekdays during the day, weekdays at night and at the weekend.

Variable	Weekday day (n = 6566)	Weekday night (n = 6222)	Weekend (n = 5606)
BMI > 25 prior to pregnancy	36.32 % (n = 2385)	31.68 % (n = 1971)	39.06 % (n = 2190)
Primiparity	48.75 % (n = 3201)	45.72 % (n = 2845)	57.46 % (n = 3221)
Weight gain > 20 kg	14.03 % (n = 921)	13.1 % (n = 815)	15.5 % (n = 869)
Medical induction of labour	25.85 % (n = 1697)	31.85 % (n = 1982)	33.56 % (n = 1881)
Use of oxytocic agents	25.77 % (n = 1692)	24.73 % (n = 1539)	30.65 % (n = 1718)
Maternal age ≥ 35 years	36.43 % (n = 1567)	30.06 % (n = 1293)	33.5 % (n = 1441)
Pathological foetal Doppler	1.14 % (n = 75)	0.69 % (n = 43)	0.77 % (n = 43)

▶ **Table 2** Univariate analysis of the variables influencing a 5-min Apgar ≤ 5.

Variable	Odds ratio	95% CI	p
Age at delivery > 35 years	1.223	0.7718–1.939	0.3982
BMI > 25 prior to pregnancy	1.032	0.9945–1.071	0.1087
Weight gain > 20 kg during pregnancy	0.671	0.4268–1.054	0.0517
Pathological Doppler	2.061	1.290–3.295	0.0079
Primiparity	0.951	0.7748–1.168	0.6317
Medical induction of labour	0.774	0.6010–0.9966	0.0374
Peripartum use of oxytocic agents	0.895	0.7014–1.143	0.3648
Delivery at night	1.119	0.9096–1.377	0.2852
Delivery at night or at the weekend/ on public holidays	1.670	1.041–2.679	0.0271
Delivery at the weekend	1.228	0.9988–1.510	0.0542

Variables influencing cord arterial pH < 7.10 in univariate analysis

The probability of a baby having a cord arterial pH below 7.1 post partum was significantly increased if the mother had a BMI over 25 prior to pregnancy (p = 0.03; 95% CI 1.02–1.48), when it was the mother's first delivery (p < 0.0001; 95% CI 1.4–1.7), after medical induction of labour (p < 0.0001, 95% CI 1.10–1.32), with peripartum use of oxytocic agents (p < 0.0001; 95% CI 1.33–1.6), when the delivery was at night (p = 0.013; 95% CI 1.02–1.23), at the weekend (p = 0.043; 95% CI 0.91–1.25) and when the delivery was at night or at the weekend/on a public holiday (p = 0.0057; 95% CI 1.08–1.59). The variables maternal age over 35 years at delivery (p = 0.29; 95% CI 0.71–1.11), weight gain of more than 20 kilograms during pregnancy (p = 0.32; 95% CI 0.94–1.22) and pathological Doppler prepartum (p = 0.11; 95% CI 0.95–1.96) had no influence on cord arterial pH < 7.1 (▶ **Table 3**).

Multivariate analysis for a 5-min Apgar score ≤ 5

Multivariate regression analysis was performed with the variables described above (pathological foetal Doppler, medical induction of labour and time of delivery at night and/or at the weekend/on a public holiday) that significantly increased the probability for a 5-min Apgar score ≤ 5. This did not show any significant association (p = 0.238). The time of delivery at night and/or at the week-

end/on a public holiday is therefore not a prognostic factor for a 5-min Apgar score ≤ 5.

Multivariate analysis for cord arterial pH < 7.10

Multivariate regression analysis was performed with the variables (BMI over 25 prior to pregnancy, primiparity, medical induction of labour, peripartum use of oxytocic agents) that significantly increase the probability for cord arterial pH < 7.10. This showed that the time of delivery (at night and/or at the weekend/on a public holiday) is a prognostic factor for birth of a baby with cord arterial pH < 7.10 (p = 0.025).

Discussion

In this study we investigated whether foetal morbidity is dependent on the time of delivery in a German university hospital. The result we obtained was that the time of delivery at night or at the weekend/on a public holiday increases the risk for cord arterial pH < 7.10 by 30 % compared with delivery on a weekday. However, the time of delivery at night or at the weekend/on a public holiday does not increase the baby's risk for a 5-minute Apgar score ≤ 5.

This discrepancy, that the time of delivery at night or at the weekend/on a public holiday increases the risk for cord arterial pH < 7.10 but not for a 5-minute Apgar score ≤ 5, is consistent

► **Table 3** Univariate analysis of the variables influencing cord arterial pH < 7.1.

Variable	Odds ratio	95 % CI	p
Age at delivery > 35 years	0.8922	0.7129–1.107	0.2948
BMI > 25 prior to pregnancy	1.228	1.021–1.477	0.0300
Weight gain > 20 kg during pregnancy	1.069	0.9393–1.217	0.3195
Pathological Doppler	1.366	0.9536–1.957	0.1129
Primiparity	1.543	1.401–1.699	< 0.0001
Medical induction of labour	1.208	1.102–1.323	< 0.0001
Peripartum use of oxytocic agents	1.453	1.329–1.590	< 0.0001
Delivery at night	1.120	1.024–1.225	0.0125
Delivery at night or at the weekend/ on public holidays	1.308	1.078–1.586	0.0057
Delivery at the weekend	1.067	0.9078–1.253	0.0433

with various studies that have shown a low correlation between Apgar score and cord arterial pH [15 – 17].

There are a few studies that see an association between foetal outcome and time of delivery. In a large cohort study in the US, it was clear that the probability of a 5-minute Apgar score < 7 was 11 % higher on a quiet weekend and 29 % higher on a busy weekend than on a quiet weekday [18]. Moreover, the study showed that delivery at the weekend increases the probability of admission of the baby to a neonatal intensive care unit and the probability of longer hospitalisation of the mother; in addition, the risk for neonatal seizures increases with delivery on a busy weekend [18]. Palmer et al. studied over 1 million deliveries in the UK [19]. Here, too, an association was shown between the day of delivery (weekday vs. weekend) and foetal and maternal outcome (increased perinatal mortality, increased rate of puerperal infections and increased rate of neonatal injuries) [19]. There are also a few analyses, however, which did not find this "weekend effect" [20 – 22].

There have been various attempts to explain why both the foetal and the maternal outcome is poorer at night in many studies compared with deliveries during the day. A possible reason may be the hospital staff's sleep deficit. With regard to work performance, the sleep deficit can result in fatigue, impaired cognitive performance, delayed decision making, diminished psychomotor performance and worse mood, which is readily comprehensible for the reader and also well documented [23 – 25]. 24 hours without sleep lead to a reduction in cognitive performance comparable to a blood alcohol level of 100 mg/dl [26]. The data on the influence of doctors' sleep deficit and long working hours on clinical outcome is controversial. One retrospective cohort study investigated whether complication rates are increased in operations performed by surgeons or gynaecologists who had been on duty the previous night [27]. Increased complication rates were found for surgeons when the possibility of sleeping was less than six hours. Seen overall, however, an increased complication rate was not found [27]. This is consistent with a retrospective analysis of cardiac surgery procedures, some of which were performed by surgeons who had been on duty the night before and some by sur-

geons who had not had to work the previous night [28]. No difference in complication rates was found [28]. In a study published by Gawande et al. on operative complications, fatigue or strain was reported by surgeons as the third most frequent cause for mistakes [29]. Various studies about the performance of surgeons in laparoscopic simulation during and after a 24-hour shift arrived at different results. Some showed a deterioration in performance [30 – 34]. Two studies showed an improvement, however [35, 36], whereas no difference was found in three further studies [37 – 39].

The degree of reduction in performance as a result of fatigue and lack of sleep differs greatly individually [40 – 42]. The causes are considered to be specific personal sensitivity to sleep deficit, the individual degree of alertness, the individual quantity of sleep required to feel fully rested and the individual timing of the sleep-wake rhythm [43].

Reduced cognitive performance can also arise due to sleep inertia. Sleep inertia signifies the physiological status of reduced cognitive performance and sensorimotor performance directly after waking. This reduced performance can last between 3 and 10 minutes [44], and effects on performance were still found after two hours in one study [45]. Other studies are lacking, however, especially on the effects on routine clinical work, for example during 24-hour duty periods in which there was sleep.

Possibly, reinforced training (e.g., team training) and electronic systems (e.g., CTG monitoring equipment) are suitable to reduce these human limitations. There are no studies of this.

The "weekend effect" must be discussed in a further attempt to explain poorer foetal and maternal outcome at the weekend. There have been a few studies from different specialties and countries showing that patient mortality is increased when they are admitted to hospital at the weekend compared with admission on a weekday [46, 47]. It is suggested that the weekend effect is due particularly to poorer medical care. Fewer staff work at the weekend than on weekdays [48 – 50]. The staff on duty are often younger and less experienced [51, 52].

To put the validity of many of the aforementioned studies into perspective, it should be noted that many of them are retrospec-

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tive analyses, which obtained their data from the hospitals' coding systems [46, 47, 53, 54]. It is well known, however, that coding is often incorrect, especially with emergency admissions [55, 56].

Chronobiological mechanisms must also be considered as a further possible cause for a poorer foetal outcome at night. The physiological onset of labour is often between midnight and 2 a. m. Ruffieux et al. showed that this correlates with delivery in the course of the forenoon with a normal birth weight and good foetal outcome [57].

Other studies indicate that the duration of labour and mode of delivery are dependent on the mother's sleep quality and quantity before the birth. Mothers who had little sleep or frequent sleep interruptions had significantly longer labours and more frequent sections [58, 59].

Moreover, according to Lindow et al., the concentration of oxytocin in maternal blood is higher at night than during the day [60]. What effects this has on the course of labour is unknown, however. Caughey et al. discussed whether non-symptom-guided use of oxytocin at night might lead rather to uterine hyperstimulation with the risk of foetal asphyxia [20].

Conclusion for Practice

Even though the study showed that the time of delivery at night, at the weekend or on public holidays increases the risk for cord arterial pH < 7.10, the clinical relevance of this finding is not high. The reason is, on the one hand, that a low cord arterial pH per se is a rare event (2.74% of all births) and, on the other hand, that this is followed by increased perinatal morbidity only in very few cases. It is nevertheless important for the obstetric team to be aware of the risk for a possibly poorer foetal outcome at night, at the weekend or on public holidays so as to minimise any possible causal factors that can be influenced.

Conflict of Interest

The authors declare that they have no conflict of interest.

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