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Evaluation of umbilical cord pulsatility after vaginal delivery in singleton pregnancies at term

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ABSTRACT

Objectives: To define the duration of umbilical cord pulsatility (UCP) after vaginal delivery and to evaluate its possible association with maternal characteristics and obstetric and neonatal variables.
Study design: Prospective observational study on women with a singleton pregnancy at term who had a vaginal delivery and cord clamping at the cessation of pulsations. The collection of UCP duration was performed through a stopwatch and by manual palpation of the umbilical cord. Maternal (age, BMI, parity, antepartum hemoglobin), obstetric (pregnancy characteristics, gestational age at delivery, induction of labor, duration of the first, the second and the third stage of labor, post-partum blood loss, umbilical cord length) and neonatal (birthweight, Apgar score, hematocrit, hemoglobin) variables were then compared between two groups: long-term vs. short-term UCP.
Results: A total of 102 women were identified. The median duration of UCP after birth was 213 s (IQR 120, 420), corresponding to 3 min and 33 s. The long-term UCP group (n = 51) had a significantly longer duration of third stage of labor (median 12 vs. 8 min, $p < 0.001$) and a significantly higher birthweight (median 3530 g vs. 3250 g, $p = 0.005$) compared with the short-term UCP group (n = 51). No differences in the other variables were found between groups.
Conclusion: For the first time we have reported the duration of UCP after vaginal delivery. An increased duration of UCP is associated with a prolonged duration of third stage of labor and a higher birthweight.

Introduction

Until recently, umbilical cord clamping was performed immediately after delivery; this practice was part of the active management of the third stage of labor, where the aim was the prevention of post-partum hemorrhage [1]. However, there was no evidence supporting this hypothesis. Conversely, a delayed cord clamping with the newborn placed on the maternal abdomen was proved to improve the neonatal hematologic asset, reducing the risk of anemia and facilitating cardiovascular and respiratory adaptation [2]. Placenta-fetal transfusion has many positive effects, both short- and long-term. Immediately after birth, the additional blood volume provides an adequate preload to the left ventricle, helping the transition from the uterus to the external world, and this is a reason to keep the cord intact at least until the beginning of respiration in newborns delivered vaginally at term [3,4]. A delayed umbilical cord clamping is also associated with increased ferritin and hematocrit levels, thus reducing the risk of neonatal anemia and favouring a more effective response to the oxidative stress of delivery [2]. Placental transfusion also allows considerable stem cells transfer to the newborn [5]. When it is not possible to wait until the end of the placental transfusion, cord milking is a valid alternative [6].

Defining the optimal time interval for cord clamping is still controversial [7]. A peculiarity of umbilical cord is its own pulsatility, detectable with simple manual palpation, that was often used to determine the best time for delayed clamping. Until now, pulsatility has not been studied regarding its duration and physiological range. Its determinants and the influence of its duration on neonatal outcome are unknown. We clearly need to extend our knowledge regarding this point. Knowledge of umbilical cord pulsatility (UCP) duration can also provide additional information to give to women who request to delay cord clamping until the end of pulsation.

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The first goal of the study was to measure the duration of UCP from birth to the complete end of pulsations, defining median time values and range in singleton neonates delivered vaginally at term. The second aim was to assess possible associations between this temporal parameter and maternal, obstetric and neonatal variables.

Materials and methods

This is an observational study on women admitted to Careggi University Hospital (Florence, Italy) between February and September 2016, with a singleton pregnancy at term, who had an uncomplicated vaginal delivery. Cord clamping was performed after the cessation of pulsations. This practice is not routinely performed at our Center, but it was performed for the study. Exclusion criteria were: multiple gestation, gestational age (GA) at delivery <37 weeks, cesarean delivery, operative delivery, umbilical cord milking. Newborns with pathological fetal heart rate at the intrapartum cardiotocography or those needing neonatal reanimation after delivery were also excluded from the study. The collection of UCP duration was performed by the same operator using a stopwatch and by manual palpation of the umbilical cord. The population was divided into two groups: the group with longer UCP duration (long-term UCP group) and the group with shorter UCP duration (short-term UCP group), using the median duration of UCP as cut off to determine the groups. The two groups were compared for the maternal variables (maternal age, body mass index, parity, antepartum hemoglobin), obstetric variables (pregnancy characteristics, GA at delivery, induction of labor, administration of antibiotics and analgesia, duration of the first, second and third stage of labor, post-partum blood loss, umbilical cord length) and neonatal variables (birthweight, Apgar score, hematocrit, and hemoglobin values). Neonatal weight was registered within 2 h after birth. Statistical analysis was performed using the Student's t-tests or Mann-Whitney test for continuous variables, and the Chi-square test or Fisher exact test for categorical variables, where appropriate. The distribution of continuous variables was tested using the Shapiro-Wilk test. A correlation analysis was performed using the Spearman's correlation coefficient. Statistical analysis was performed using SPSS v 23.0 (SPSS Inc, Chicago, IL) and a p-value < .05 was considered significant.

Results

A total of 102 women with a singleton pregnancy and a vaginal delivery at term were enrolled. The median duration of UCP after birth was 213 s, corresponding to 3 min and 33 s, with an interquartile range (25th–75th percentile IQR) of 120–420 s. Using the median duration value (213 s) as cut off, we identified the long-term and the short-term UCP group. Fifty-one women (50%) were included in the long-term UCP group while 51 women (50%) were included in the short-term group. No statistically significant difference was found between the groups for maternal characteristics such as maternal age, body mass index (BMI), parity and ante-partum hemoglobin, or for the variables regarding the gestation (Table 1). The long-term UCP group had similar obstetric characteristics compared with the short-term UCP group, except for the duration of the third stage of labor, which was significantly longer in the long-term UCP group (median: 12 min vs. 8 min, $p < 0.001$) (Table 2). The infants in the long-term UCP group had a significantly higher birthweight compared with the infants in the short-term UCP group: median 3530 (IQR 3220, 3680) vs 3250 (IQR 3000, 3480) ($p = 0.005$). No differences in other neonatal characteristics were found (Table 3). The Spearman correlation analysis showed significant correlation of UCP duration with the duration of third stage ($p < 0.001$) and with birthweight (p=0.02) (Fig. 1), but not with the other continuous variables (gestational age, blood loss, cord length, apgar score, neonatal hemoglobin and hematocrit).

Discussion

Pulsatility is a peculiarity of the umbilical cord, which is often used to establish the timing of cord clamping. However, the physiological duration of UCP has not been reported in literature. Defining the optimal timing for cord clamping is an important goal and knowing the duration of UCP could be useful in providing this information. This study found that the median duration of UCP after birth was 213 s (IQR 120, 420), corresponding to 3 min and 33 s.

Boere et al. [8] showed that umbilical flow was independent of pulsatility and that it was not related to the duration of UCP, as the flow could end before or after the ceasing of the pulsations, and not even at the same time in arteries and the vein, with great variability in different cases. According to that study, there is the need to reconsider the use of umbilical cord pulsatility as a landmark of delayed umbilical cord clamping. However, that study did not report pulsatility duration, so this notion was still missing. The study by Law et al. [9] evaluated when blood ceases to flow in the umbilical cord after delivery. The author found that umbilical flow reached a plateau after only 140 s, as was observed by weighing the newborns immediately after birth with the cord intact and assessing that they stopped increasing their weight after such an interval.

In our study the two groups of short- and long-term UCP were compared for maternal, obstetrical and neonatal variables. We could not find any statistically significant difference between the two groups regarding maternal and gestational characteristics, suggesting that these parameters do not influence the duration of umbilical cord pulsatility. Regarding the delivery data, we found out that there was a statistically significant difference in the

Table 1
Maternal and pregnancy characteristics in the study group (n = 102).

	Long-term group (n = 51)	Short-term group (n = 51)	p value
Maternal age (years)	32.4 ± 5.4	32.2 ± 5.8	0.94
BMI (kg/m$^{2)}$	21.3 (19.6, 23.4)	21 (18.4, 23.8)	0.33
Pregnancies (n.)	2 (1, 2)	2 (1, 2)	0.57
antepartum Hb (g/dL)	11.9 ± 1.10	11.8 ± 1.12	0.62
IVF	2 (3.9%)	2 (3.9%)	0.69
Gestational Diabetes	7 (13.7%)	6 (11.8%)	0.50
TPB	0	2 (3.9%)	0.25
SGA	4 (7.8%)	3 (5.9%)	0.50
AF alterations (oligohydramnios, polyhydramnios)	5 (9.8%)	7 (13%)	0.36
Gestational hypothyroidism	6 (11.8%)	8 (15.7%)	0.39

BMI, Body Mass Index; Hb, hemoglobin; IVF, In Vitro Fertilization; TPB, Threatened Preterm Birth; SGA: small for gestational age; AF, Amniotic Fluid.
Data are given as n (%), mean ± SD or median (25^{th}-75^{th} percentile interquartile range).

Table 2
Delivery characteristics (n = 102).

	Long term group (n = 51)	Short term group (n = 51)	p value
Induction of labor (n.)	18 (35.3%)	17 (33.3%)	0.50
Analgesia (n.)	12 (23.5%)	16 (31.4%)	0.25
Antibiotics (n.)	13 (25.5%)	16 (31.4%)	0.33
GA at birth (wks)	39 (39, 40)	39 (39, 40)	0.92
Duration of first stage (min)	120 (75, 220)	170 (100, 255)	0.23
Duration of second stage (min)	43 (24, 73)	35 (16, 83)	0.59
Duration of third stage (min)	12 (10, 18)	8 (7, 10)	<0.001
Blood loss (mL)	200 (100, 400)	200 (100, 400)	0.39
Cord length (cm)	70 (65, 70)	70 (65, 70)	0.17

GA, Gestational Age, SD. Standard Deviation.
Data are given as n (%) or median (25^{th}-75^{th} percentile interquartile range).

Table 3
Neonatal characteristics (n = 102).

	Long term group (n = 51)	Short term group (n = 51)	p value
Birthweight (g)	3,530 (3,220, 3,680)	3,250 (3,000, 3480)	0.005
Hematocrit (%)	50 (48, 53)	52 (48,55)	0.39
Hemoglobin (g/dL)	16.4 (15.7, 17.1)	16.6 (15.7, 17.5)	0.68
Apgar score at 1 min	9 (9, 10)	9 (9, 10)	0.92
Apgar score at 5 min	10 (10,10)	10 (10,10)	0.39

Data are given as median (25^{th}-75^{th} percentile interquartile range).

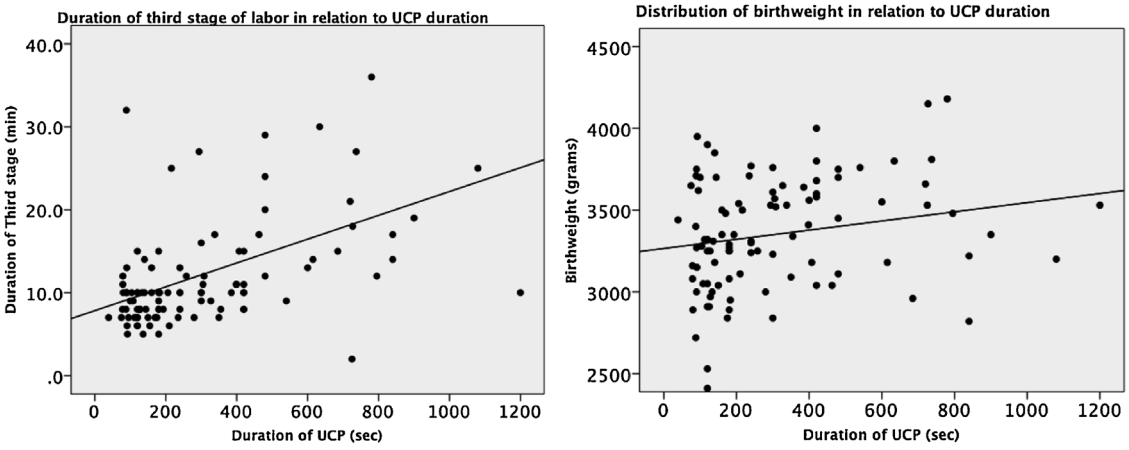

Fig. 1. Correlation between UCP duration and: duration of third stage of labor (left) and birthweight (right).

duration of placental delivery (third stage of labor): it was longer in the group with increased pulsatility, with three cases in which placental delivery happened before the ceasing of pulsatility. A study by Andersson et al. could not point out any difference of duration of the third stage of labor among groups with different timing of clamping [10]. The prolonged 3rd stage of labor in the long-term UCP group in our study may be explained by assimilating the effects of long-term UCP to the effects of umbilical cord drainage in the 3rd stage of labor. Taebi & coll. showed the duration of the 3rd stage of labor is longer in patients that have umbilical cord drainage [11]. However, the effect of umbilical cord drainage is a controversial issue and more research is needed in this area.

As far as regards newborns' variables, we observed that those with longer pulsatility duration weighed more than those with shorter pulsatility duration. This finding can reflect the different amount of placental transfusion in the two groups. It is assumed that when pulsatility lasts longer, a greater amount of placental blood goes to the neonate, affecting his/her weight. Similar findings emerged from a review of 15 trials investigating the effect of timing of umbilical cord clamping of term infants on maternal and neonatal outcomes: the authors found that the mean birthweight was significantly higher in the late, compared with the early, cord clamping group [1].

We acknowledge that this study has some limitations. One limitation is that birthweight was not measured prior to UCP cessation, and therefore it is not clear how much birthweight would change in the same neonate due to increased blood volume. In addition, we did not record data on placental weight and we have no data on pathology, as the placenta of the cases enrolled was not sent to the pathologist for analysis. Another limitation is that the difference of cord pH between the groups was not evaluated. This data is reliable only when the sampling is performed within 90 s from delivery, regardless of clamping [12]. As the exact timing of sampling was not recorded, comparison of cord pH was not included in this study.

In conclusion, for the first time we have been able to define the duration of UCP after a vaginal delivery in women with a singleton

pregnancy at term. A longer duration of UCP could be associated with a longer duration of the third stage of labor and a higher birthweight. These results can also help clinicians to better inform those women who ask to delay cord clamping until the end of pulsatility, as part of the requests on their birth plan. Additional studies are necessary to investigate the UCP in complicated pregnancies, especially when a preterm birth occurs, and to identify the potential determinants of UCP after birth in such population of patients.

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