

*Full Length Research Paper*

## **Variables that may affect the traditional signs of perinatal asphyxia**

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Received 24 May, 2021; Accepted 15 October, 2021

**The objective of this study was to prove if certain variables related to labour affect the traditional signs of perinatal asphyxia (cardiotocography records, Apgar score and the umbilical artery pH). This is an observational, multicentric, longitudinal, analytical, cohort study in pregnant women at term admitted to the delivery room of Hospital Infanta Cristina, Hospital de Fuenlabrada and Hospital Puerta de Hierro Majadahonda. Of all the variables under scrutiny, the onset of labour, parity, clamping the umbilical cord, gestational age, type of delivery, newborn weight and neonatal resuscitation have a significant relationship with the three signs of perinatal asphyxia. This study showed a relationship between the three signs and some of the studied variables, therefore recommending assessing them in the perinatal asphyxia diagnosis.**

**Key words:** Cardiotocography records, umbilical pH, Apgar score, perinatal asphyxia.

### **INTRODUCTION**

Perinatal asphyxia has a multifactorial origin, which may be produced both during pregnancy or labour. It is defined as a gas exchange detrimental to the foetus, where the level of oxygen in the blood decreases and the levels of CO<sub>2</sub> increase. If the situation is maintained over time, it results in hypoxemia and, consequently, acidosis, which in the most severe cases might cause irreversible damage to the foetus (Vargas-Vaca at al. 2019; Coronilla 2004 and Rivera et al. 2018).

There is not an agreement on the definition of perinatal asphyxia. Some of the criteria selected by different authors when defining it are (Vargas-Vaca at al. 2019): low Apgar scores, acidosis in umbilical cord gas, pathological cardiotocography (CTG) records, delay in spontaneous breathing, clinical signs of brain damage, etc. The most accepted definition is the one suggested by the American College of Obstetricians and Gynecologists (ACOG), the American Academy of Pediatrics (AAP) and

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the Committees on Maternal - Fetal Medicine and Fetus and Newborn which determined the 4 criteria that must occur so that the perinatal asphyxia can be considered the cause of neurological deficit (all of the following items must appear) (Coronilla, 2004; Cullen and Salgado, 2009; Lombardía and Fernández 2001; García et al., 2008) intense metabolic or mixed acidaemia (pH < 7.00), persistence of an Apgar score 0-3 over 5 min, immediate neonatal neurological sequelae and multi-organ system dysfunction in the immediate neonatal period.

As it has already been mentioned, the neonatal and obstetric indicators, such as the Apgar score, the umbilical artery pH and the foetal monitoring or cardiotocography are essential when diagnosing neonatal asphyxia. Their results may be affected by certain variables, such as gestational age, parity, newborn weight, using epidural analgesia, the type of labour, how the labour begins, the type of neonatal resuscitation, and cord clamping.

The maternal age might modify the results of the perinatal asphyxia signs since it has been proven that pregnant women over 35 have further perinatal and obstetric complications (Chamy et al., 2009). The same thing happens with the gestational age at the moment of birth, when pathological CTGs tend to be more frequent in advancing gestational age, and the Apgar scores lower in preterm labour (Chamy et al., 2009; González 2008 and Martínez 2008).

The onset of labour might be spontaneous or induced, following medical advice, when the benefits of terminating pregnancy for the mother and the foetus outweigh the potential benefits of continuing it. It leads to two different situations that might result in variations on the type of CTG as well as in the outcome of the other two tests.

Using epidural analgesia has been related to foetal head malposition, temperature increase, prolonged labour, more frequent use of oxytocin, an increasing number of instrumental deliveries, higher pH values in the umbilical cord, a growing need of neonatal resuscitation and non-reassuring foetal heart rate patterns, which shows its influence in the signs of perinatal asphyxia (Aguilar et al., 2008).

Parity refers to the number of pregnancies a woman had that have resulted in the birth of an infant weighing over 500 g after 20 weeks of gestation. During the second stage of labour, the Spanish Society of Obstetrics and Gynaecology (SEGO, 2008) reports that the standard duration in nulliparous women is up to 3 h, and 2 h in the case of multiparous. With epidural analgesia, these limits increase up to 4 h for nulliparous and 3 h for multiparous. By this token, parity might modify the types of CTG and the perinatal results, since the labour duration is usually different based on the number of previous pregnancies.

One of the variables most likely to influence the

perinatal results is the type of labour, because, depending on how the labour develops, newborns adapt better or worse to extrauterine life. Regarding the type of cardiotocography record, it would determine the type of labour, bearing in mind that non-reassuring records involve more instrumental deliveries and caesarean births.

The moment of umbilical cord clamping after birth is important because this technique is not done uniformly by all the professionals. It can be done in two different ways: early clamping, immediately after birth; or delayed clamping, when the cord has stopped beating or 2 to 3 min after birth. Either technique might affect the pH values, since, in the case of delayed clamping, the umbilical circulation keeps on providing oxygen, which both expands the blood volume and corrects the pH. That is why, this variable should be taken into account (Tomé et al., 2016; Rabe et al., 2019; Rodríguez et al., 2016; Juanes and Toledo, 2013; Rincón et al., 2014).

The new born weight at the moment of birth is considered normal between 2500 and 4000 g for term pregnancies. Foetuses with intrauterine growth restrictions might experience complications during the neonatal period, such as breathing difficulties, polycythemia, perinatal asphyxia, etc. Likewise, macrosomic foetuses are more likely to suffer obstetric trauma and intrapartum asphyxia (Cleberson et al., 2014).

Neonatal resuscitation is a set of therapeutic measures aimed at restoring and monitoring human vital signs. This variable would be the one closer to the three signs studied in here, because, depending on the neonatal results, newborns will require one type of resuscitation or another one in order to adapt to extrauterine life (Dominguez, 2016; Cardiopulmonary Resuscitation Group of the Spanish Society of Neonatology, 2004).

The objective of this study is to document how the aforementioned variables can affect the results of the traditional perinatal asphyxia signs, so that, if their relationship is confirmed, they are taken into account in the diagnosis, since perinatal asphyxia is one of the most worrying problems for professionals specialising in obstetrics, paediatricians and society in general.

## METHODOLOGY

An observational, multicentric, longitudinal, analytical, cohort study was conducted. Every cohort comprises a fraction of the population under study which has one of the registry types according to the record classification guidelines suggested by SEGO that take place in the second stage of labour to assess the results of the aforementioned variables.

Each cohort consists of one of the types of recordings that take place during the delivery period to assess the results of the Apgar test, the umbilical artery pH and the neonatal resuscitation required by the newborn at the time of birth. The interpretation of the RCTG was performed in each hospital by a volunteer midwife with at least

5 years' experience in the delivery area of that hospital under the instructions provided by the principal investigator, and test periods were carried out to check that the collection and interpretation conformed to the study methodology according to the SEGO classification, recording the results on the data collection sheet designed specifically for this study, where the rest of the variables studied were also recorded.

It is a multicentric study carried out in three hospitals of the Community of Madrid. According to their activity, number of beds, technology, human resources, cases dealt with and portfolio of services, they are classified into low, medium or high complexity. Therefore, one hospital within each complexity range was selected: the *Hospital Puerta de Hierro* has high complexity; the *Hospital de Fuenlabrada*, medium complexity; and the *Hospital Infanta Cristina*, low complexity, because the authors of the study work in these hospitals.

The study population comprises pregnant women admitted to the delivery room of the three hospitals and who met the following inclusion criteria: pregnant women at term (>37 weeks until 42 weeks) with a minimum CTG period of 20 min during the second stage of labour. Women with one of the following conditions were not considered as candidates: records below 20 min of CTG, out-of-hospital deliveries, multiple pregnancies, preterm labours (<37 weeks), death before birth and pregnancies where data loss hampers comparison with the rest of the sample.

The sample size was worked out based on the total number of deliveries in every hospital in 2014, as well as the pH of umbilical cord in newborns, with a 95% confidence level for a maximum permissible error of 0.8%, using Epidat version 4.2. Hence, it was considered that every hospital needed the following records:

- (1) Hospital Infanta Cristina with a total of 1814 deliveries: 110 records.
- (2) Hospital de Fuenlabrada with a total of 2297 deliveries: 139 records.
- (3) Hospital Puerta de Hierro with a total of 3351 deliveries: 203 records.

Convenience sampling was carried out to complete the required number of records in each hospital from January 2014 to October 2014, following approval by the ethics and research committees of the three hospitals.

The variables under study were collected the following way:

- (1) Type of CTG (normal, suspicious and pathological, according to the classification by SEGO)
- (2) Maternal age
- (3) Type of delivery (eutocic, instrumental and non-elective caesarean)
- (4) Newborn weight
- (5) Apgar score
- (6) Type of neonatal resuscitation (0 or no resuscitation, I or removing secretions, II or applying indirect oxygen, III or providing intermittent positive pressure, IV or intubation, and V or administering medication)
- (7) Spontaneous or induced onset of labour
- (8) Parity
- (9) Arterial pH of the umbilical cord
- (10) Weeks of gestation at the moment of birth
- (11) Use or lack of use of epidural analgesia
- (12) Umbilical cord clamping
- (13) Type of hospital.

The data obtained was stored in the electronic database Microsoft Excel 2010 and it was analysed later using the statistical package SPSS (Statistical Package for Social Sciences, version 22.0 for

Windows) (Statistical Package for Social Sciences 2010). In all cases, it was analysed beforehand if the relationships existing among the variables depended on the type of hospital. A p-value equal to or less than 5% ( $p \leq 0.05$ ) was considered significant.

In relation to descriptive statistics, qualitative variables were expressed as percentages and numerical quantification, while quantitative variables were expressed as mean and standard deviation (SD).

In the multivariate analysis, to study the relationship between a quantitative variable and one or more qualitative variables, an analysis of variance was performed and when a relationship was obtained between both variables, it was analysed using the Bonferroni multiple comparisons method. To study the relationship between a non-normal quantitative variable and a qualitative variable, non-parametric tests were used (Mann-Whitney test, Kruskal-wallis test, Spearman correlation test).

In the case of two qualitative variables, the Chi-Square test, Fisher's test and logistic regression were used.

Finally, for the analysis of two quantitative variables, linear regression was used.

In all cases it was previously analysed whether the relationships found between the variables depended on the type of hospital by means of regression models (linear regression, logistic regression and analysis of variance) with hospital interactions or by means of the Cochran-Mantel-Haenzel test.

Regarding the ethical considerations, the study complied with the International Legislation on Data Protection and the current Spanish legislation (Organic Law 3/2018, of 5th December, on the Protection of Personal Data and guarantee of digital rights, Official Gazette of the Spanish State 294 of 06/12/2018) (Protection of Personal Data and guarantee of digital rights 2018). It was also approved by the Ethics and Research Committees of the three hospitals where it was implemented.

## RESULTS

The descriptive analysis of the sample provided us with a total of 452 CTGs, being 54.5% of them normal, 31.4%, suspicious, and 14.2%, pathological. The average maternal age was 31.3 (SD 5.5.) and the average weeks of gestation were 39.2 (SD 1.2). Parity was 54.4% nulliparous, 35.6% primiparous, 6.9% secondiparous, 2.2% with three deliveries and 0.9% with four.

Regarding the type of delivery, 69% were eutocic, 16.2%, instrumental; and 14.8%, caesarean. The umbilical cord was clamped early in 74.6% of the deliveries and was delayed in 25.4% of the cases. The onset of labour was spontaneous in 53.3% of women and induced in 46.7%. Pregnant women who opted for epidural analgesia were 90.5%, whereas 9.5% used another type of analgesia or no analgesia at all.

As far as the newborns are concerned, their mean weight was 3260.7 g (SD 447.4). 81.2% did not require any resuscitation manoeuvres; 11.7% needed resuscitation type I; 5.5% resuscitation type II; 0.9% resuscitation type III; and 0.7% resuscitation type IV. The average umbilical artery pH was 7.26 (SD 0.09), the Kolmogorov-Smirnov test was performed to check for normal distribution, and the Apgar scores at 1 min after

**Table 1.** Maternal and gestational age in the three hospitals studied.

<b>Maternal age and gestational age in the three hospitals</b>		<b>Maternal age</b>	<b>Gestational age</b>
Infanta Cristina Hospital	N	110	110
	Media	30.6	39.2
	Minimum	15	37
	Maximum	39	41
	Standard deviation	4.332	1.252
	I.C. at 95%	29.8-31.4	38.9-39.4
Fuenlabrada Hospital	N	139	139
	Media	31.8	39.4
	Minimum	18	37
	Maximum	42	41
	Standard deviation	4.618	1.087
	I.C. at 95%	30.9-32.6	39.2-39.6
Puerta Hierro Hospital	N	203	203
	Media	31.4	39.2
	Minimum	17	37
	Maximum	41	41
	Standard deviation	6.371	1.237
	I.C. at 95%	30.6-32.3	38.9-39.3

birth stated that 96.2% of newborns did not have neonatal depression at the moment of birth; 3.1% had moderate depression and 0.7% a severe one. At 5 min after birth, 99.6% of the newborns did not have neonatal depression and only 0.4% had moderate depression.

When analysing the results of the three hospitals with respect to the type of GTCR, the most frequent were normal registrations at both the Hospital de Fuenlabrada and the Hospital Puerta de Hierro, while at the Hospital Infanta Cristina the most frequent were suspicious registrations.

The maternal and gestational age of the study participants is shown in Table 1, with the largest group in the three hospitals being nulliparous followed by primiparous women.

In all three hospitals the most frequent type of delivery was eutheological. In the Puerta de Hierro and Fuenlabrada hospitals there were practically equal proportions of instrumental deliveries and caesarean sections, while in the Infanta Cristina Hospital the percentage of caesarean sections was lower than that of instrumental deliveries. Early umbilical cord clamping was most frequent in all hospitals.

The onset of labour was mostly spontaneous in all three hospitals, although the difference was minimal with

respect to induction, the difference being somewhat more marked in Hospital Puerta de Hierro. With respect to the use of epidural analgesia versus other types of analgesia or no analgesia, the Hospital Infanta Cristina was the hospital where the least epidural analgesia was administered.

The mean umbilical artery pH was very similar in the three hospitals shown in Table 2.

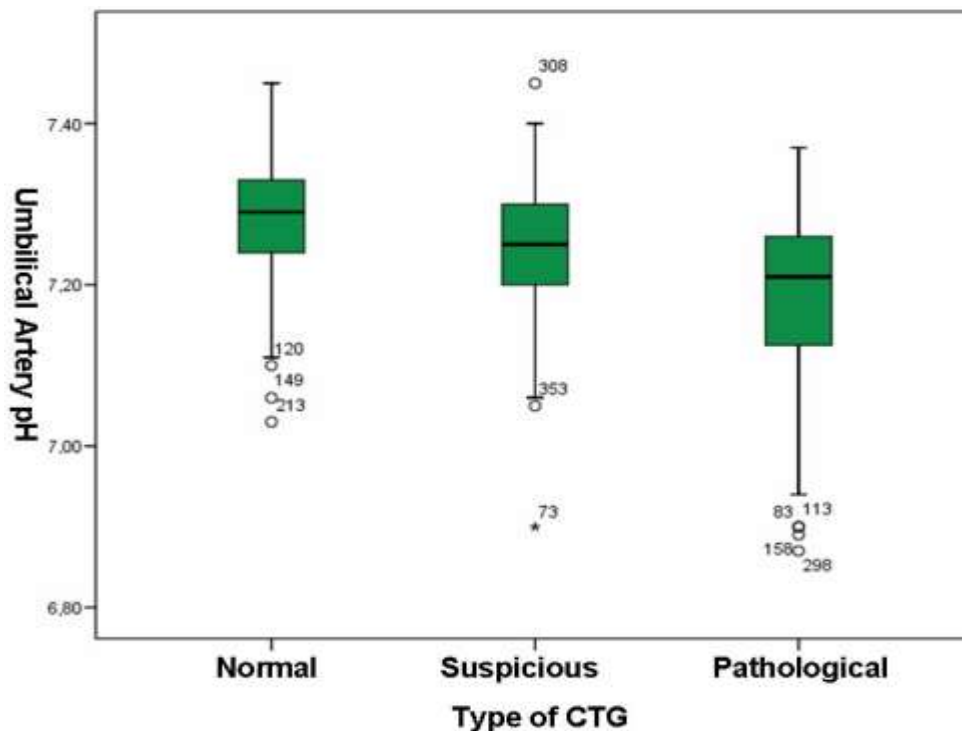
Regarding the variables studied in the newborn, the mean weight was very similar and few resuscitation manoeuvres were required in all hospitals. Most of the newborns presented absence of neonatal depression with scores above 8 in the Apgar test performed at one minute of life, indicating a good prenatal evolution in all three hospitals.

The multivariate analysis revealed that maternal age and epidural analgesia do not have a statistically significant relationship with any of the three signs under study. However, the onset of labour is related to the CTG type, regardless of the type of hospital, showing that pregnant women with a normal CTG are 2.1 times more likely to start labour spontaneously, in contrast to pregnant women with a pathological CTG.

The differences between the parity and cardiotocography records are significant, so for every

**Table 2.** Umbilical artery pH in the three hospitals studied.

Umbilical artery pH in the three hospitals	Infanta Cristina Hospital	Fuenlabrada Hospital	Puerta de Hierro Hospital
N	110	139	203
Media	7.23	7.25	7.28
Minimum	6.90	6.89	6.87
Maximum	7.45	7.42	7.45
Standard deviation	0.09397	0.08771	0.08140
I.C. at 95%	7.21-7.24	7.23-7.26	7.27-7.30



**Figure 1.** Type of CTG-umbilical artery pH.

additional delivery, it is 1.6 times more likely to have a normal CTG than a pathological or suspicious one, regardless of the hospital. The existing relationship between the type of umbilical cord clamping and the umbilical artery pH was also verified. It was noted that the average umbilical artery pH is higher in early clamping than in the delayed one, regardless of the type of hospital. However, the cord clamping and the type of CTG are related differently depending on the hospital, since the staff in the *Hospital Puerta de Hierro*, according to the protocol, only clamps the cord early, whereas in the *Hospital Infanta Cristina* and *Hospital de Fuenlabrada* it differs. In both places, pregnant women with suspicious

or pathological CTGs frequently require early clamping, while those with a normal CTG usually undergo delayed clamping in *Hospital Infanta Cristina*, but the type of clamping is similar in the *Hospital de Fuenlabrada*.

The gestational age has a statistically significant relationship with the umbilical artery pH, regardless of the type of hospital, so that, for every week over the gestational age, the average umbilical artery pH of the newborn decreases 0.1 units. The same thing happens with the type of CTG, representing this relationship in Figure 1.

The three indicators under study have a statistically significant relationship with the type of labour, regardless

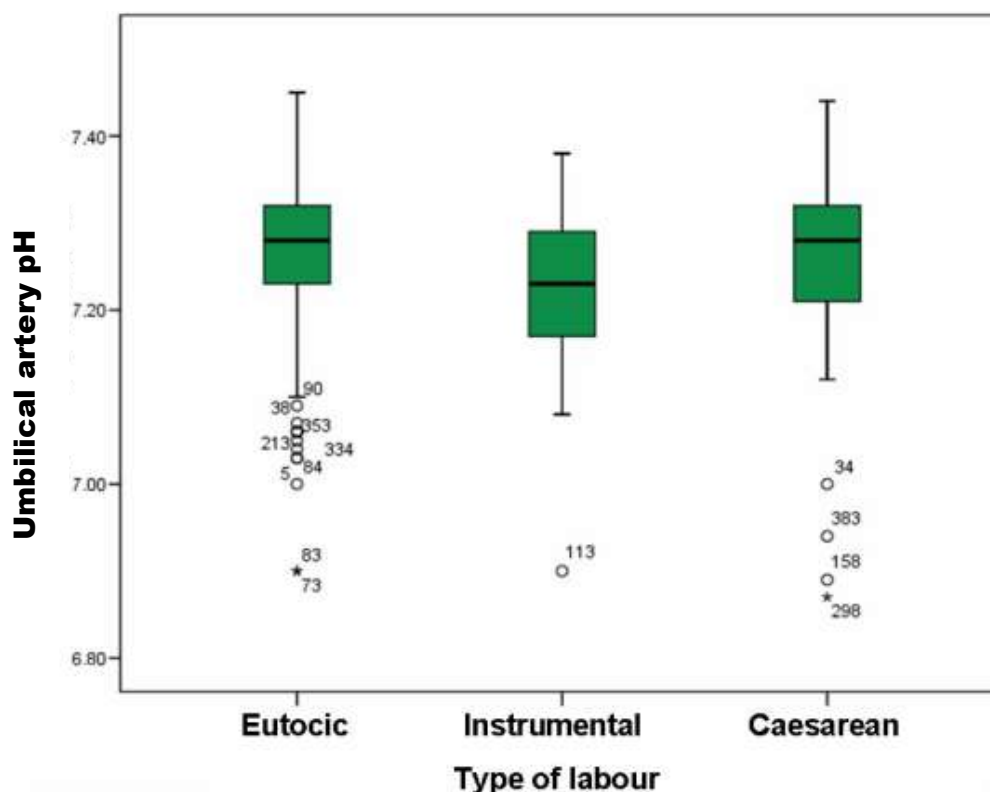


Figure 2. Type of labour-umbilical artery pH.

of the hospital. Regarding the CTG, pregnant women with eutocic deliveries are 2.9 times more likely to show normal CTGs compared to those with caesarean births; however, no significant differences have been found between instrumental and caesarean deliveries. Likewise, the umbilical artery pH (Figure 2) and the Apgar test at 1 (Figure 3) and 5 min after birth (Figure 4) show a significant relationship.

Significant differences were only found between the newborn weight and the type of CTG, regardless of the hospital. The average weight of children born of women with a normal CTG is higher than that of children born of women with a suspicious CTG. Among pregnant women with a pathological CTG, there were no differences regarding the other two types of cardiotocography records.

Finally, there were statistically significant differences between neonatal resuscitation and the three signs of perinatal asphyxia, regardless of the hospital. As far as the umbilical artery pH is concerned, when advanced resuscitation manoeuvres are required, the average value of the umbilical cord pH decreases. In the Apgar test at 1 and 5 min after birth, the lower the score, the higher the type of neonatal resuscitation needed. The

same applies to the types of CTG, declaring that among pregnant women with a suspicious CTG, it is 4.5 times more likely to need neonatal resuscitation in newborns, contrary to women with a normal CTG; and the offspring of women with pathological CTG are 5.3 times more likely to need neonatal resuscitation manoeuvres than those of pregnant women with a normal CTG.

## DISCUSSION

Authors that compare maternal age with changes in the cardiotocography records do not find a relationship between both variables (González, 2008; Milsom et al., 2002). That is also the case of our study, where we cannot prove a statistically significant relationship between the three types of record in the second stage of labour, the Apgar score and umbilical artery gases, and the maternal age at the moment of birth.

This study proves the relationship between the gestational age and the changes in CTGs: the higher the gestational age (in pregnant women at term), the more frequent to find pathological records as Chauhan et al. (2008) and Casellas and Cabrera (2007) state in their



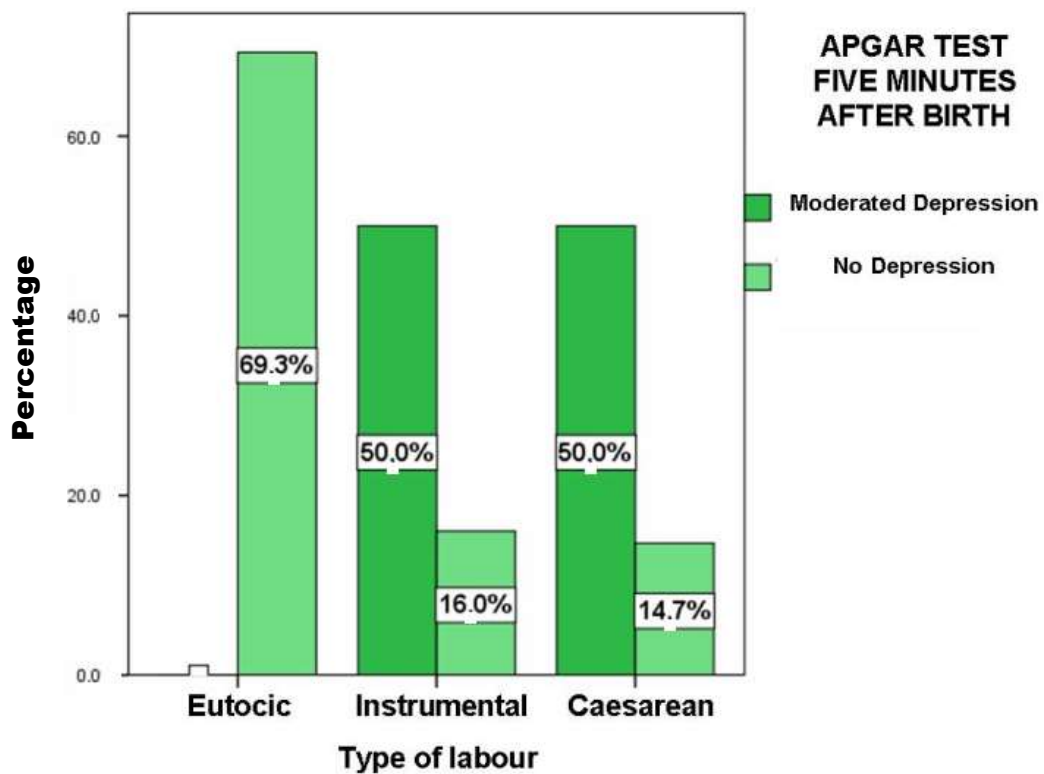


Figure 3. Apgar test 1 min alters birth-type of labour.

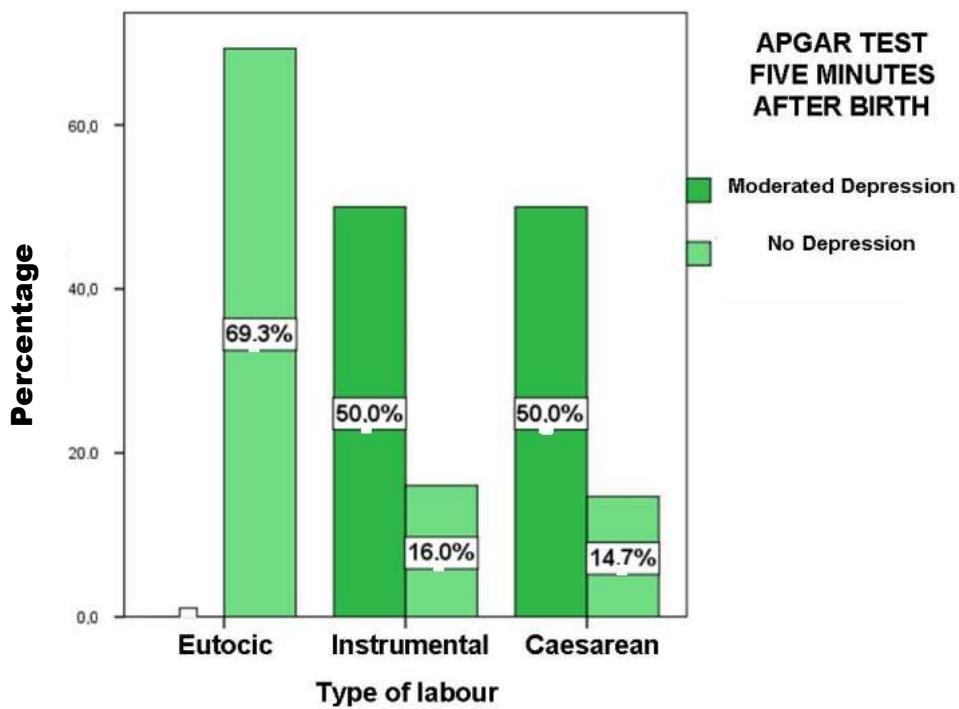


Figure 4. Apgar test 5 min alter birth-type of labour.

studies. On the contrary, there are other studies that find no correlation between these two variables (González, 2008; Galan and Battaglia (2010). Regarding the Apgar test, no significant differences were found based on the weeks of gestation. It might be due to the fact that in our sample we only gathered data on gestations at term. A decreasing Apgar score has been described only in preterm newborns, due to their immature central nervous system and musculoskeletal system, in accordance with Rüdiger et al. (2010) and Acero et al. (2019), as well as in postterm infants, as shown by Salvo et al. (2007). Unlike the reviewed studies (Galan and Battaglia, 2010; López, 2008) in here there is evidence of a relationship between the umbilical artery pH and the weeks of gestation, diminishing the average pH as the gestational age increases.

At the outset, we thought that inducing labour might influence the results, since labour is usually longer and it might affect both the gas results and the Apgar scores, but neither in our study nor in the one by López (2008) it has been observed. The opposite is true for the types of CTG, where pregnant women with a spontaneous onset of labour are more likely to have normal records, contrary to women who require induction. This result was predictable since induction requires an intervention in the natural labour process, which might lead to changes in the cardiotocography records.

Nowadays, epidural analgesia stands out among other methods for pain relief during labour, despite not being exempt of risks, as shown in this study, since in every hospital over 78% of the time they make use of the aforementioned analgesia. There are no significant differences in the use of epidural analgesia in relation to the three variables under study, as it is stated in the articles by Aguilar et al. (Aguilar, 2008) and Paternoster et al. (2001).

The results of this study show that the number of offspring does not affect neither the umbilical artery pH nor the Apgar score. This is a predictable data because the foetal compromise during labour does not depend on maternal parity. However, it has been proven that the higher the number of deliveries, the more frequent it is to have a normal CTG, which might be due to the fact that, as parity increases, deliveries are usually faster.

Other studies (Rivera et al., 2018; López (2008) prove that the average umbilical artery pH is higher in normal deliveries than in caesarean births, a predictable relationship since a large number of caesareans are carried out when suspecting a non-reassuring foetal status. However, in our study, this association is not observed, but there are statistically significant changes between the average pH in instrumental labours in contrast to caesareans, where it is lower. Regarding the types of CTG in the second stage of labour, normal CTGs are less common in instrumental and caesarean

deliveries than in the eutocic ones, an understandable result because the worse the changes in the foetal heart rate during the second stage of labour, the more necessary to receive obstetric intervention, in agreement with the studies by González (2008) and Liu and Liu (2002).

There is a lot of literature (Salvo et al., 2007; Baskett et al., 2006; Laffita et al., 2004) on the relationship between instrumental deliveries and low Apgar scores, since, many times, instrumentation takes place because of acute foetal distress, growth retardation, retroplacental hematomas and abnormal presentations among others, all of which are related to a low Apgar score at the moment of birth. This information is consistent with the results of the present study.

Regarding the umbilical cord clamping compared to the type of labour, it is necessary to reflect on the fact that in caesarean and instrumental deliveries there is more early clamping. In caesareans, it is always done that way to close the surgical wounds as soon as possible. In the case of instrumental deliveries, because they are done when complications arise during labour, newborns might show worse adaptation and need resuscitation manoeuvres immediately after birth. In agreement with the articles published by López (2008), Lievaart and Jong (1984) and Wilberg et al. (2008), our study proves that the average umbilical artery pH is higher with early clamping than with the delayed one, although other studies (Bernal, 2013; Rabe et al., 2019) do not show differences in the mean arterial pH concerning the two types of clamping.

Regarding the Apgar test at 1 and 5 min after birth, there is no correlation with the type of clamping, as it is the case in other studies Sánchez et al. (2006). This is a surprising fact, because, generally, when a newborn finds it difficult to adapt to extrauterine life, it is normal to clamp the umbilical cord early, so that neonatal resuscitation manoeuvres can start as soon as possible. As regards the type of umbilical cord clamping and the CTG type, there are differences depending on the type of hospital. In the *Hospital Puerta de Hierro*, they only clamp the cord early because they use active management of the third stage of labour, so the amount of blood and the blood pressure is considerably higher than the physiological one, consequently early clamping is obligatory. This relationship shows that pregnant women with suspicious and pathological CTG frequently have the cord clamped early, whereas in those with a normal CTG, delayed clamping is usually more common. This is an expected result since, after a normal CTG, newborns usually adapt well to extrauterine life, which allows professionals to delay clamping until a few minutes after birth.

In our study, the average weight of newborns was 3259 g, with no significant differences regarding the umbilical artery pH results. That is the expected outcome, since in



the bibliography (Salvo et al., 2007; Bon et al., 2007), there are only references concerning the newborns with growth retardation, where there is a higher rate of acidemia, hypoxemia and hypercapnia. The same thing happens with the Apgar score: there are no significant differences related to the weight of newborns, contrary to the findings of the literature, where children with low birth weight or exceptionally large are connected with lower Apgar scores (Salvo et al., 2007; Jolly et al., 2003; Bandera et al., 1980). Nonetheless, there are differences between the newborn weight and the CTG types in the second stage of labour, holding that the average weight of newborns whose mothers had a normal CTG is higher than those with a suspicious CTG, as stated by Romero et al. (2011) and Bruce et al. (1980) in their studies where fetuses with uterine growth retardation, due to their lower supplies, are more likely to develop modifications in CTGs.

Perinatal asphyxia is the situation that most frequently requires neonatal cardiopulmonary resuscitation at the moment of birth Arjona (2019). When analysing our results, we verify the relationship between neonatal resuscitation and CTGs. It is a logical result because in records with some changes in the foetal heart rate it is likely that newborns have difficulties adapting to extrauterine life and thus require resuscitation manoeuvres, contrary to López (2008) who reveal in their studies that there is not a relationship between changes in the Foetal Heart Rate and the need to do neonatal resuscitation. The same applies to the existing relationship between the neonatal resuscitation manoeuvres and the umbilical artery pH, a predictable result where the average pH decreases as more resuscitation manoeuvres are required. It is normal since newborns with a lower pH probably adapt worse to extrauterine life in their first minutes. Regarding the Apgar scores and the need for neonatal resuscitation, we were expected to find statistically significant differences in their relationship, because the value at 1 min after birth reflects the foetal adaptation to extrauterine life and the need of resuscitation manoeuvres, whereas at 5 min, the score shows how effective the aforementioned measures have been.

Among the limitations of the present study, there is the inter-observer variability when interpreting the cardiocography records, since every hospital has a different observer.

As stated by Villanueva and Grajeda (2012) and Schwartz and Young (2006), mean inter-observer agreement is between 20 and 30%, and lower when dealing with pathological or potentially pathological records, as well as when deciding whether a foetus requires intervention. The same applies to the average pH, which depends on the laboratory of each hospital, and the Apgar score, which depends on the person

performing it. Based on the delivery, it will be assessed by the nurse/midwife or paediatrician who carries out the neonatal resuscitation.

It is important to highlight the external validity of the study, thanks to the registration of a large number of cases and the fact that it is a multicentric study, although it has been proven that results do not depend on the centre.

In further research, it would be interesting to include variables such as prematurity, other types of analgesia, maternal pathology (pre-eclampsia, gestational diabetes, epilepsy, intrauterine growth retardation, oligohydramnios, etc.), maternal position in the second stage of labour, etc. in order to add further data to this line of investigation.

In conclusion, although there is no clear consensus on the indicators of perinatal asphyxia despite the passage of time, it seems that umbilical artery pH, cardiotocographic recording and the Apgar test are indispensable for its diagnosis, hence the importance of taking into account the variables studied in this research such as the onset of labour, parity, gestational age, type of delivery, weight of the newborn and the type of neonatal resuscitation where their relationship with these obstetric and neonatal indicators is demonstrated and which can therefore modify their results.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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