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RESEARCH ARTICLE

Lactate and pH values in newborns with a history of acute fetal distress

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Abstract

Background: *Acute fetal distress (AFD) is a condition that requires timely diagnosis because it generates hypoxia, acidosis, and even intrauterine death. This study aimed to determine lactate and pH values in the umbilical cord in full-term newborns (NBs) with a history of AFD.* **Methods:** *We conducted a cross-sectional study in full-term NBs of mothers with at least one perinatal, neonatal, or gasometric AFD antecedent. Neonatal morbidity was considered: if 1-min Apgar ≤ 6, or advanced neonatal maneuvers, or neonatal intensive care unit (NICU) admissions were necessary. The cutoff points were lactate > 4mmol/L and pH < 7.2.* **Results:** *Of 66 NBs, 33.3% of mothers presented at least one antecedent for developing AFD; 22.7% presented hypertensive pregnancy disease, 13.6% oligohydramnios, and 63.6% other factors. Perinatally, 28.7% required advanced neonatal resuscitation maneuvers and 7.5% admission to the NICU. In the gasometry, the lactate and pH values for the neonatal morbidity of the NBs' group were 4.726 ± 1.401 and 7.293 ± 0.056, respectively, versus 2.240 ± 0.318 and 7.359 ± 0.022 (p < 0.05) for the group without associated neonatal morbidity.* **Conclusions:** *Lactate values in the umbilical cord increased by 25%, and pH decreased by one percent in NBs with a history of AFD and associated morbidity.*

Keywords: *Neonatal. Umbilical cord. Lactate. pH. Morbidity. Fetal distress.*

Valores de lactato y pH en recién nacidos con antecedente de sufrimiento fetal agudo

Resumen

Introducción: *El sufrimiento fetal agudo (SFA) es una condición que amerita un diagnóstico oportuno debido a que genera hipoxia, acidosis e incluso la muerte intrauterina. El objetivo de este estudio fue determinar los valores de lactato y pH en cordón umbilical en recién nacidos de término con antecedente SFA.* **Métodos:** *Se llevó a cabo un estudio transversal, en recién nacidos a término, de madres que tuvieron al menos un antecedente para SFA de tipo perinatal, neonatal o gasométrico. Se consideró morbilidad neonatal cuando presentaron Apgar al minuto ≤ 6, o requirieron maniobras avanzadas de reanimación neonatal, o ingreso a Unidad de Cuidados Intensivos Neonatales (UCIN). El punto de corte fue > 4 mmol/L para los valores de lactato y pH < 7.2.* **Resultados:** *De un total de 66 recién nacidos, el 33.3% de las madres presentaron al menos un antecedente para desarrollar SFA; el 22.7% presentó enfermedad hipertensiva del embarazo, el 13.6%, oligohi-*

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dramnios, y el 63.6%, otros factores. El 28.7% requirieron maniobras avanzadas de la reanimación neonatal y el 7.5%, el ingreso a la UCIN. En la gasometría, el valor de lactato y pH para el grupo de recién nacidos con morbilidad neonatal fue de 4.726 ± 1.401 y 7.293 ± 0.056 respectivamente, versus 2.240 ± 0.318 y 7.359 ± 0.022 (p < 0.05) para el grupo sin morbilidad neonatal asociada. **Conclusiones:** *Se observó un incremento del 25% de los valores de lactato en cordón umbilical y una disminución del 1% del pH en los recién nacidos con antecedente de SFA y morbilidad asociada.*

Palabras clave: *Neonatal. Cordón umbilical. Lactato. pH. Morbilidad. Sufrimiento fetal.*

Introduction

Acute fetal distress (AFD) deserves a timely diagnosis since it is a metabolic alteration that leads to the development of hypoxia, hypercapnia, and acidosis, generating neurological alterations, multiple organ failure, and even intrauterine death. This condition is manifested by altered fetal heart rate, meconium amniotic fluid expulsion, sustained hypomotility, and intrauterine overactivity[1-5]. Monitoring of patients with previous conditions, such as labor or prolonged expulsive disorders or labor induced with oxytocin or prostaglandins is essential, as they may be precipitating factors of AFD[6], which is an indication for pregnancy resolution[7,8].

The need for advanced neonatal resuscitation maneuvers is assessed at birth. At 1 and 5 min after birth, the Apgar test assesses the newborn (NB) and reports the adaptive response to the extrauterine environment[9]. There is an inverse relationship between the Apgar score and neonatal mortality: the lower the Apgar value with longer duration, the higher the probability of admission to the neonatal intensive care unit (NICU) and even death[10]. The Apgar score is fundamental for the initial clinical evaluation; however, its accuracy depends on the evaluator's skill and experience. Some NBs with hypoxia or acidemia may be overlooked with a normal Apgar score and suffer adverse consequences. Therefore, we should rely on gasometric values, especially lactate and pH, to establish the diagnosis, prognosis, and therapy[11].

Lactate and umbilical cord pH in NBs with a history of AFD contribute to predicting morbidity[12]. Lactate is the product of anaerobic metabolism, its accumulation in the brain is associated with the presence of hypoxia, edema, and tissue necrosis[13]. The mean of lactate levels in healthy term NBs are 3.600 ± 1.833 mmol/L, in contrast to term NBs with hypoxia, with mean levels of 6.423 ± 2.335 mmol/L[14]. NBs that clinically progress to AFD show mean lactate levles of 7.05 ± 4.03 mmol/L[15]. Currently, umbilical artery lactate levels are known to be a more informative measure of term NB morbidity than pH[13].

The pH is the result of acid-base balance[16]. Fetal acidemia in the umbilical cord has an umbilical artery pH cutoff value < 7.20 regardless of gestational age[17,18]. However, the American College of Obstetricians and Gynecologists and the National Institute for Health and Clinical Excellence recommend using arterial pH values < 7.00, which are clinically useful for identifying morbidity and mortality risk[19,20]. Fetal acidemia is associated with NICU admission, hypoxic-ischemic encephalopathy (HIE), and respiratory distress syndrome[21].

The measurement of lactate and pH may change according to the clamping time of the umbilical cord since it is stable for only 60 min after clamping to determine pH and gases[22,23]. Similarly, the umbilical cord is useful if kept in a heparinized syringe for the same time; after this period, the values tend to change[24]. For this reason, this study aimed to determine lactate and pH values by umbilical cord arterial blood gasometry in NBs with a history of AFD at a secondary level of medical care in patients with or without neonatal morbidity.

Methods

We conducted a cross-sectional, descriptive, prospective, and homodemic study in a secondary-level hospital. We included term NBs (≥ 37-41 weeks of gestation), products of a single pregnancy, with perinatal risk factors for AFD such as hemorrhage in the third trimester, infections, hypertensive states of pregnancy, anemia, collagenopathies, drug intoxication, or obstetric comorbidity; uteroplacental factors such as cord abnormalities, placental abnormalities, altered uterine contractility, anatomical uterine abnormalities; and obstetric factors including amniotic fluid with meconium, cephalopelvic incompatibility, use of medications (oxytocin), abnormal fetal presentation, prolonged or accelerated labor, instrumental delivery or cesarean section, premature rupture of membranes, oligohydramnios or polyhydramnios, alterations in fetal heart rate (tachycardia > 180/bradycardia < 120), decreased maternal perception of fetal movements, intrauterine

growth retardation, with a prenatal diagnosis of fetal distress[25]. Pre-term or post-term NBs, multiple pregnancies, and those with congenital malformations were excluded from the study.

Before delivery and after birth, the neonatal care protocols were followed, which included the five basic measures of neonatal resuscitation, determination of Apgar at 1 min and 5 min, with double clamping of the umbilical cord. With a previously signed informed consent form by the mother, a sample was taken from the umbilical artery proximal to the NB and the gasometric analysis was performed within the first 30 min of obtaining the sample.

For our study population, neonatal morbidity was defined if the NB presented at least one of the following conditions: Apgar at 1-min ≤ 6, need for advanced neonatal resuscitation measures (bag-mask ventilation or chest compressions), or admission to the NICU[26-30].

Data were analyzed with the statistical software (IBM SPSS Statistics v 20). Descriptive statistics were used for the general data of the mothers and NBs. Categorical variables were described as percentages, and quantitative variables were described as means and standard deviation; Student's t-test was used to compare the means of lactate and pH between NBs with or without morbidities.

Results

Sixty-six patients were recruited according to the inclusion criteria described; the perinatal characteristics are shown in table 1. The mean of maternal age remained within the optimal age group for gestation; most women have had multiple pregnancies. About half of the women were in the active labor phase, and 48.4% of the patients were in the latent labor phase induced with oxytocin. Approximately one third of the mothers showed at least one risk factor for developing AFD, with hypertensive disease of pregnancy being the most prevalent condition, followed by oligohydramnios.

Table 1 shows the neonatal characteristics starting with the mean weight and length, which were within the appropriate percentiles for the gestational age. Most of the NBs were female; 28.7% required advanced neonatal resuscitation maneuvers, with ventilatory assistance being more frequent than chest compressions; 27.2% obtained Apgar at 1-min ≤ 6; at 5 min, the vast majority recovered. Admission to the NICU was about one-eighth of the population. No NB mortality was observed in the study. However, 28.7% of the NBs presented morbidities, and 10.6% had direct risk factors for developing AFD, which determined the timing of their birth: 3% with the umbilical cord around the neck, 3% with dystocia at birth, 3% with intrauterine growth retardation, and 1.5% with macrosomia.

Table 2 shows the frequency of clinical signs used for prenatal diagnosis of AFD, such as bradycardia, tachycardia, and meconium in the amniotic fluid. The signs are listed in order of frequency, alone or simultaneously.

Table 1. Perinatal and neonatal characteristics

Perinatal	
Variable	
Gestational age in weeks, mean ± SD	27.1 ± 5.2
Pregnancies	
Primigravida, n (%)	27 (40.9)
Multigravida, n (%)	39 (59.1)
Labor	
Active phase, n (%)	34 (51.5)
Latent phase, n (%)	32 (48.4)
Onset of labor	
Spontaneous, n (%)	44 (66.6)
Induced (oxytocin-conducted), n (%)	22 (33.3)
Labor resolution	
Natural, n (%)	1 (1.5)
Cesarean section, n (%)	65 (98.4)
Obstetric factor leading to the development of AFD	
HDP, n (%)	5 (22.7)
Oligohydramnios, n (%)	3 (13.6)
Other, n (%)	14 (63.3)
Neonatal	
Weight in g, mean ± SD	3176.6 ± 367.8
Height in cm, mean ± SD	49.3 ± 1.9
Sex	
Female, n (%)	38 (57.5)
Male, n (%)	28 (42.2)
Morbidity	
APGAR ≤ 6 points at 1 min, n (%)	18 (27.2)
APGAR ≤ 6 points at 5 min, n (%)	2 (3)
Neonatal factor for developing AFD	
Umbilical cord around the neck, n (%)	2 (3)
Dystocia at birth, n (%)	2 (3)
IUGR, n (%)	2 (3)
Macrosomia, n (%)	1 (1.5)
Advanced reanimation maneuvers	
Bag-mask ventilation n (%)	18 (27.2)
Chest compressions n (%)	1 (1.5)
Admission to NICU	
n (%)	5 (7.5)

AFD: acute fetal distress; HDP: hypertensive disease of pregnancy; IUGR: intrauterine growth restriction; SD: standard deviation.

Table 2. Gasometric and morbidity characteristics

AFD	n = 66 (100%)	APGAR ≤ 6 at 1 min	Advanced reanimation maneuvers	Admission to NICU	Lactate > 4 mmol/L	pH < 7.2
Bradycardia	25 (37.8)	10 (15.1)	10 (15.1)	2 (3)	5 (7.5)	0 (0)
Tachycardia	18 (27.2)	2 (3)	3 (4.5)	0 (0)	2 (3)	1 (1.5)
Meconium	14 (21.2)	3 (4.5)	1 (1.5)	1 (1.5)	1 (1.5)	1 (1.5)
Meconium/tachycardia	6 (9)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Mechonium/bradycardia	3 (4.5)	3 (4.5)	4 (6)	2 (3)	3 (4.5)	1 (1.5)
Neonatal morbidity	Morbidity rate: 2.8 per 10 NB (19/66 = 0.287 × 10)					
					Mean ± SD mmol/L	Mean ± SD
NB with morbidity	19 (28.8)	18 (11.8)	19 (12.5)	5 (7.5)	4.726 ± 1.401	7.293 ± 0.056
NB without morbidity	47 (71.2)	0 (0)	0 (0)	0 (0)	2.240 ± 0.318	7.359 ± 0.022

AFD: acute fetal distress; NB: newborn; NICU: neonatal intensive care unit; SD: standard deviation.

Regarding gas levels in the umbilical cord, the NBs who experienced neonatal morbidity showed higher lactate levels and lower pH levels, with values of 4.726 ± 1.401 and 7.293 ± 0.056, respectively. Conversely, the group with no associated neonatal health issues showed lower lactate levels of 2.240 ± 0.318 and slightly higher pH levels of 7.359 ± 0.022 ($p < 0.05$). The umbilical arterial lactate levels were higher and the pH levels were lower in NBs with no morbidities, as shown in table 3.

Discussion

AFD is a term used to determine abnormal variations in fetal cardiac patterns, decreased fetal movements, and the presence of meconium fluid that leads to progressive fetal hypoxia or acidemia secondary to poor fetal oxygenation[31]. In this study, NBs with prenatal history of AFD presented isolated bradycardia and meconium fluid as the most frequent clinical sign. These data were followed by tachycardia with or without meconium and, finally, the presence of meconium alone. The results were similar to those reported by Yaipén et al.[7], where the diagnosis of most of their patients was established by fetal heart rate alterations, followed by the presence of meconium. These clinical signs occur in response to hypoxia, which triggers fetal compensatory mechanisms: a decrease in heart rate; a reduction in oxygen consumption secondary to the cessation of non-essential functions, such as gross body movements; redistribution of cardiac output to perfuse essential organs, such as heart, brain, and adrenal glands; and predominance of anaerobic metabolism[6,32]. All of these mechanisms affect umbilical gases, and the effects of AFD can lead to increased perinatal morbidity and mortality, highlighting complications such as encephalopathy, seizures, cerebral palsy, neurodevelopmental delay, and death[19,33].

As for the perinatal characteristics, of our study, more than half of the mothers had already had other pregnancies. Zhang et al.[34]. found that the duration of labor in primigravidae was longer than in multigravidae, which is explained by the slower cervical dilatation of 4 to 6 cm, increasing the state of hypoxia in the uterus. One-third of our patients required induction - conduction of labor with oxytocin due to lack of progression. Einikyte et al. reported oxytocin as one of the maternal and pregnancy resolution factors influencing blood gas status in NBs, as oxytocin itself increases arterial lactate values[14].

One or more maternal factors accompanied the AFD. One-third of our population showed hypertensive disease of pregnancy, with the highest incidence, followed by oligohydramnios, fetal hypomotility, intrauterine growth restriction, premature rupture of membranes, prolonged delivery, polysystole, presentation dystocia, umbilical cord around the neck and fetal macrosomia, consistent with the studies of Sabol and Caughey and Ulloa-Ricardez et al., respectively[35,36].

Regarding the characteristics of NBs with a history of AFD, most were within the appropriate percentiles

Table 3. Gasometric and morbidity characteristics

AFD	n = 66 (100%)	APGAR ≤ 6 at 1 min	Advanced reanimation maneuvers	Admission to NICU	Lactate > 4 mmol/L	pH < 7.2
Bradycardia	25 (37.8)	10 (15.1)	10 (15.1)	2 (3)	5 (7.5)	0 (0)
Tachycardia	18 (27.2)	2 (3)	3 (4.5)	0 (0)	2 (3)	1 (1.5)
Meconium	14 (21.2)	3 (4.5)	1 (1.5)	1 (1.5)	1 (1.5)	1 (1.5)
Meconium/tachycardia	6 (9)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Mechonium/bradycardia	3 (4.5)	3 (4.5)	4 (6)	2 (3)	3 (4.5)	1 (1.5)
Neonatal morbidity	Morbidity rate: 2.7 per 10 NB (18/66 = 0.272 × 10)					

AFD: acute fetal distress; NICU: neonatal intensive care unit.

for gestational age, weight, and length. In NBs with clinical signs compatible with the disease, in addition to an Apgar score ≤ 6 points, AFD diagnosis was corroborated by lactate and pH altered values. As in the study by Carpio and Romero the risk of obtaining a pH < 7.20 coupled with amniotic fluid with meconium or 1-min Apgar ≤ 6 points was higher compared to neonates with clear fluid at delivery, and in those who obtained 1-min Apgar ≥ 7 points[37].

Regarding the characteristics of the umbilical cord gases, we identified that the average lactate value was lower, and the pH value higher than those reported by other authors. This difference could be attributed to an early diagnosis and timely treatment of AFD in our population, thus reducing neonatal morbidity, despite the alteration of its gasometric values[13,15,38].

In our study, arterial lactate levels were higher in NBs with morbidity than those with no morbidity data despite having a history of AFD. This finding is similar to Natesan's findings, where higher lactate concentrations correlated with poor neonatal outcomes and prognosis[39].

In clinical practice, pH is more commonly used than lactate as an indicator of neonatal status. It is important to note that pH and base excess require more blood and more complex equipment than lactate measurement. Furthermore, lactate can be measured using a portable device, requiring less blood, which makes it more affordable and maintenance-friendly. Some authors have stated that the combined measurement of pH and lactate does not represent a better prediction of abnormal results than each method separately[40,41], generating an increase in the number of abnormal results. If combined tests are performed, a high lactate value indicates action, even if the pH is normal. Cases of severely depressed NBs have been reported with this combination of findings[42].

As these studies were not performed in the same population group, the combined evaluation of these measurements in a homodemic group is interesting. Therefore, the diagnosis of AFD should be corroborated by complementary methods, such as continuous fetal electrocardiogram recording or computer-assisted electronic fetal monitoring, fetal pulse oximetry, or fetal scalp sampling with immediate blood gas or lactate determination[43].

Among the limitations of our study were that no information was available on the remaining arterial blood gas parameters, no follow-up of gasometric changes was possible, NBs with HIE could not be identified, and no NBs were known to have died in the NICU.

Neonatal care requires highly technical and costly interventions; we believe that immediate gains in reducing neonatal morbidity will come mainly through implementing simple, practical, and proven interventions on a broader scale during the prenatal, intrapartum, and postpartum periods. By better understanding traditional practices that rely on scientific evidence communication strategies, we can change practices to improve neonatal care, particularly at birth. In events such as hypoxia, AFD, perinatal asphyxia, and infections, this understanding offers the most significant potential to improve the survival and health of future generations of infants and children.

In summary, an increase in umbilical cord lactate values of approximately 25% was observed in the group of term NBs with a history of AFD and associated neonatal morbidity. Besides pH decreased 1% without reaching acidemia levels. These findings contrasted

with the group of term NBs with a history of AFD but no associated neonatal morbidity.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this study.

Confidentiality of data. The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent. The authors have obtained the written informed consent of the patients or subjects mentioned in the article. The corresponding author has this document.

Conflicts of interest

The authors declare no conflicts of interest.

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