CYCLICAL PATTERN OF NON-NUTRITIVE SUCKING IN NORMAL AND HIGH-RISK NEONATES

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ABSTRACT

This study determined patterns of suction cycles by recording sucking pressure in full-term infants, normal pre-term infants and newborns with pathology (hypoxia at birth). Associations between these patterns and some clinical parameters were established in order to evaluate feeding capacity for the purpose of guiding specific stimulation and aiding hospital discharge in better health conditions. Seventy-five infants of both sexes were assessed after informed consent, grouped by their status at birth. Body weight and Apgar score were determined. Sucking pressure was evaluated with an ad-hoc device. Maximum and minimum pressure scores and the number of suction cycles were measured. Data were analyzed statistically at a significance level of p< 0.05. Maximum sucking pressure values varied between study groups. Full-term infants showed the highest pressure values and number of suction cycles. In pre-term infants, lower pressure values and fewer suction cycles were observed. Those with hypoxia showed great variability in both parameters. This study found a cyclical pattern of non-nutritive sucking in normal and high-risk newborns. Normal and preterm infants showed a significant direct correlation between suction cycles and Apgar scores at 5 minutes, but the infants with pathology due to hypoxia group did not show the same association. These findings are an important tool that will contribute to improving newborn maternal nutrition and optimizing the quality of life for high-risk newborns in our environment.

Keywords: *suction, neonates*

PATRÓN CÍCLICO DE LA SUCCIÓN NO NUTRITIVA EN NEONATOS NORMALES Y DE ALTO RIESGO

RESUMEN

En este trabajo se determinaron patrones de ciclos de succión mediante registros de la presión de succión en recién nacidos a término, prematuro normal y recién nacido con patología (hipoxia al nacer). Además, se establecieron asociaciones entre estos patrones y algunos parámetros clínicos, con el propósito de valorar la capacidad de alimentación, para orientar la estimulación específica y favorecer el alta de internación en mejores condiciones de salud. Se evaluó a 75 neonatos de ambos sexos con consentimiento firmado, agrupados según su condición al nacer. Se determinó el peso corporal y el score de Apgar. Se obtuvieron los registros de valores máximos y mínimos de presión utilizando un aparato "ad-hoc" (de presión-succión) que permitió medir el número de ciclos de succión. Los datos fueron analizados estadísticamente con un nivel de significación p< 0.05. Los valores máximos de presión-succión presentaron variaciones entre los grupos analizados. Los valores más altos de presión y el mayor número de ciclos de succión se observó en nacidos a término. Los prematuros mostraron valores de presión más bajos y menor cantidad de ciclos de succión, lo que posibilitó establecer un patrón específico para estos grupos. Los hipoxiados exhibieron una gran variabilidad en ambos parámetros. En los neonatos normales y pretérmino hubo una correlación directa y significativa entre los ciclos de succión y los valores de Apgar a los cinco minutos. El grupo de recién nacidos con patología debido a hipoxia no mostró la misma asociación. Estos resultados constituyen una importante herramienta que contribuirá a mejorar la nutrición materna neonatal y optimizar la calidad de vida de los recién nacidos de alto riesgo en nuestro medio.

Palabras clave: *succión, neonatos*

INTRODUCTION

Sucking is routinely evaluated at Neonatal Intensive Care Units (NICUs) through qualitative clinical observation of formula feeding or breastfeeding, and reported by nurses as good, fair or poor according to intake volume and time. It is used as an indicator of behavior and the success of oral feeding[1], as well as being a diagnostic tool for detecting future developmental problems[2]. Sucking involves rhythmical coordinated movements of neuromuscular and osteoarticular components[3]. Clinical assessments identify abnormal sucking and are of vital importance for managing dysphagia (with uncoordinated or weak sucking patterns), where the subject is unable to obtain an adequate volume of food within a given time, particularly premature newborns, whose proper coordination of sucking, swallowing and breathing reflexes needs to be assessed[4,5]. Lack of suck-swallow coordination due to immaturity or injury to neurological centers occurs in pre-term and small-for-gestational-age infants[6]. Evaluation of sucking in newborns is a useful rehabilitation strategy for starting oral stimulation programs to organize sucking components and improve feeding[7].

Based on this background, this study determined suction cycle patterns by recording sucking pressure in full-term infants, normal pre-term infants and infants born with pathology (hypoxia at birth). In addition, associations were established between those patterns and some clinical parameters, in order to assess feeding capacity to guide specific stimulation, aiding hospital discharge in better health conditions.

METHOD

Study design

This is a descriptive, observational, quantitative study of sucking pressure in normal full-term infants, pre-term infants and infants with hypoxia.

Participants

Sucking pressure was measured in 75 newborns of both sexes, grouped as: 1) full-term infants (controls: FTI, n=34), 2) pre-term infants (PTI; n=32) and 3) infants with pathology due to hypoxia (IPH; n=9) born at the Hospital Universitario Maternidad y Neonatología (Córdoba National University – UNC), Argentina. The population was proportional to the number of births at this hospital over the same years (2004-2009).

This study was approved by the Bioethics Committee of the School of Medical Science at Córdoba National University in office at the time the study was begun, and follows the standards set forth in the Treaty of Helsinki. Newborns receiving care at the Neonatology Service through office visits or NICU were included with authorization from their parents (informed consent). All study groups were clinically stable (without respiratory assistance, hemodynamic compensation or generalized infections). The study procedure was safe and non-invasive. Infants were weighed on a digital pediatric scale and their Apgar score was determined. The 1 to 10 Apgar scale measures breathing effort, heart rate, muscle tone, reflexes and skin color. The higher the score, the better will be the infant's progress, while a score of less than 5 at five minutes after birth indicates probable perinatal hypoxia.

Non-nutritive sucking pressures were measured using an *ad-hoc* recording device (*intellectual property No. 336022* registered at Argentina's National Intellectual Property Office [*Dirección Nacional de Derecho de Autor*]). The system consists of a pressure sensor with a piezoresistive silicon device and a transducer that transforms variations in pressure into electric current. It measures the pressure applied at one of its inputs compared to the reference pressure (pressure of a water column expressed in millimeters) which was used to calibrate the displacement of an air column in the device at different pressures. Another input is connected to a pacifier by means of a 50 cm length of latex tubing, both sterilized by autoclaving. The pressure recorded by the device is transferred to a computer and stored in an Excel® database, which allows them to be viewed graphically. We determined the number of suction cycles per minute and established a profile of maximum values for sucking pressure expressed in millimeters of water column. The device was calibrated at three degrees of resistance (low, medium and high) and adapted according to sucking capacity. Low-resistance sensors were used for pre-term infants to prevent them from wasting energy, which might affect body weight gain. We made efforts to control the risk of any potential bias in this study by establishing commitment criteria such as clinical stability and the last feeding time at the time sucking pressure was recorded.

Statistical analysis

Data were entered into a database for statistical analysis and subject to descriptive statistics, two-way non-parametric tests to compare means (Mann Whitney's U-test and Kruskal Wallis) and linear correlation coefficient analysis (Spearman's test) using the software Infostat® [8]. The significance level was set at $p \leq 0.05$.

RESULTS

Non-nutritive sucking pressure recorded for one minute showed moments of maximum pressure values followed by brief pauses. Minimum sucking pressure values expressed the passive return of the water column after the pressure applied. Maximum and minimum pressures formed sucking cycles, appearing as positive pressures greater than zero separated from each other by an interval of time (Figs. 1 and 2).

In FTI, sucking pressure was low for the first few seconds while the infant adapted to the teat, followed by normal sucking up to 60 seconds, approximately (Fig. 1). Maximum sucking pressure values ranged from 16 to 20 mm water column using the high-resistance sensor.

In PTI, sucking pressure during the first 35 seconds was too low to be recorded, after which it increased and became more regular (Fig. 2). Maximum sucking pressure values ranged from 14 to 18 mm water column using the low-resistance sensor.

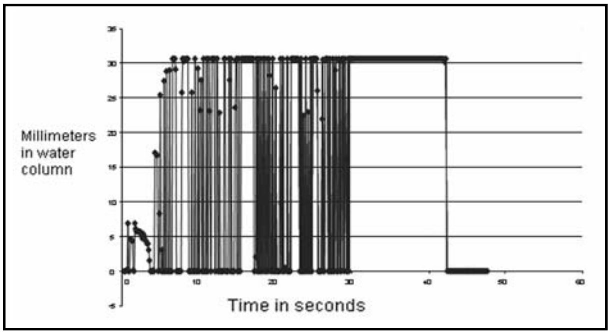

Fig. 1: Maximum and minimum sucking pressure values in a full-term infant, expressed in millimeters of water column, in one minute.

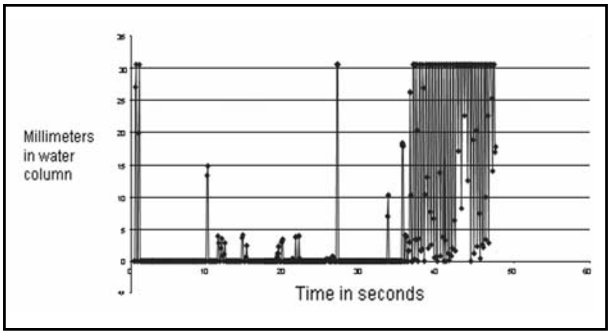

Fig. 2: Maximum and minimum sucking pressure values in a normal pre-term infant, expressed in millimeters of water column, in one minute.

In IPH, regular suction cycles were not observed. Most IPH showed maximum sucking pressure values ranging from 13 to 16 mm water column; the rest showed sucking pressure values either lower (33%) or higher (22%) than those, upon applying orofacial stimulation techniques.

In groups FTI and PTI, there was no significant difference in maximum sucking pressure values with relation to sex, although there was a significant correlation between maximum sucking pressure values and body weight ($R = 0.33$, $p<0.05$).

FTI performed more sucking cycles per minute than the other groups (Table 1).

Apgar scores (FTI: 8.85 ± 0.44; PTI: 8.75 ± 0.62, IPH: 7.22 ± 1.48) differed significantly among groups ($p<0.0005$), with the lowest values for IPH.

In FTI and PTI there was a direct significant correlation between sucking cycles and Apgar scores at 5 minutes ($R = 0.41$, $p<0.02$). This association was not found for IPH.

DISCUSSION

Nutritive sucking involves lips, mandible, tongue, and hard and soft palate. The synchronous movement of tongue and jaw causes the liquid to flow, facilitated by the pressure seal of the lips. These coordinated actions generate the strong negative intraoral pressure that characterizes sucking. Nutritive sucking requires significant forces generated by the mandible and tongue in cycles of approximately 1 Hz, whereas in non-nutritive sucking, the cycles are 1 to 2 Hz [9].

Analysis of sucking is a sensitivity indicator used clinically in the evaluation of normal neurodevelopment based on sucking patterns[10], knowledge of the biomechanics of the anatomical-histological and functional structures involved in sucking and the sucking times of newborns[11].

Table 1: Suction cycles in full-term infants, pre-term infants and infants with pathology.

Suction cycles	n	Mean values ± SD	p<
Full-term Infants	34	5.00 ± 2.06	
Pre-term Infants	32	3.41 ±1.01	0.0028*
Infants with pathology	9	3.67 ±1.80	

*Mean values ± standard deviation (SD) differ between groups

Breathing, chewing and swallowing have cyclical motor behavior patterns, with a pattern of muscle activation and deactivation in each cycle. Behavior during sucking cycles may be similar. These activities may be controlled by a neuron network located in the brain stem and spinal cord, which regulates muscle activity for motor behavior[12].

The system used for recording sucking in this study enabled measurement of sucking capacity, charting of sucking cycles and comparison of clinical appraisals to graphic records in full-term infants, pre-term infants and infants with pathologies. Sucking is a complex combination of muscular, joint and neurological activities, which requires systematized evaluation that will minimize any possible subjective appraisals of the force applied during sucking. The recording system used in this study clearly provides advantages over the usual method for evaluating suction by quantitative clinical observation.

Quantitative determination of sucking pressure applied in one minute by full-term infants, pre-term infants and infants with pathology revealed sucking patterns with different numbers of cycles according to the characteristics of each group.

Full-term infants were able to apply greater pressure and perform more sucking cycles per minute than the other two groups [13]. Pre-term infants were unable to perform the muscle activity required for sucking. Pre-term infants develop age-appropriate sucking patterns later and some attain it by 40 weeks gestation. Breathing, salivation and swallowing are altered in these infants, causing apnea and choking due to lack of coordination, which improves with gestational age, in agreement with reports from other authors[5,13-15]. Some studies are consistent with our findings, highlighting the importance of knowledge of these different sucking development stages in order to design appropriate therapies[2, 10].

Other authors consider that proper neonatal sucking achieved at 40 weeks is a predictor of neurodevelopment[2] and a monitoring strategy for high-risk newborns (HRN)**.** Poorly coordinated sucking rate and swallowing may predict feeding and neurological problems, particularly in newborns with bronchopulmonary dysplasia[4].

In this study, the sucking capacity in newborns with hypoxia was altered and showed no association similar to those observed in the other groups, which may be the result of alterations caused by the hypoxia with particular affectation on each newborn. These newborns may be rapidly fatigued due to their pathology, and be unable to complete the sucking cycle, requiring immediate early stimulation programs.

Knowledge of the cyclical sucking pattern and its direct association with the Apgar score in normal and high-risk newborns is an important tool for assessing neonatal breastfeeding. This is a starting point for further studies on sucking which will aid hospital discharge in better health conditions and optimize quality of life of high-risk newborns in our environment.

ACKNOWLEDGMENTS

We thank Pedro R. Moya for his advice on project design and for facilitating access to the Neonatal Service, University Maternity and Neonatology Hospital (HUMN), National University of Cordoba, Córdoba, Argentina

This work was supporteded by a grant from the Secretaría de Ciencia y Tecnología (SECyT), Universidad Nacional de Córdoba. Resol Nº 214/2010, 26/2011.Argentina.

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REFERENCES

1. Mizuno K, Ueda A. The maturation and coordination of sucking, swallowing, and respiration in preterm infants. J Pediatr 2003;142:36-40.
2. Medoff-Cooper B, Shults J, Kaplan J. Sucking behavior of preterm neonates as a predictor of developmental outcomes. J Dev Behav Pediatr 2009;30:16-22.
3. Simbrón A., Carranza M, Giambartolomei L, Ferraris ME. Diagnóstico precoz de disfunción temporomandibular en niños prematuros. Estudio de dos casos clínicos. Rev Arch Argent Pediatr 2006;104:358-362.
4. Gewolb IH, Bosma JF, Taciak VL, Vice FL. Abnormal developmental patterns of suck and swallow during feeding in preterm infants with bronchopulmonary dysplasia. Dev Med Child Neurol 2001;43:454-459.
5. Lau C, Smith EO, Schanler RJ. Coordination of suck-swallow and swallow respiration in preterm infants. Acta Paediatr 2003;92:721-727.

6. da Costa SP, van der Schans CP, Zweens MJ, Boelema SR, van der Meij E, Boerman MA, Bos AF. The development of sucking patterns in preterm, small-for-gestational age infants. J Pediatr 2010;157:603-609.
7. Fucile S, Gisel EG, Lau C. Effect of an oral stimulation program on sucking skill maturation of preterm infants. Dev Med Child Neurol 2005;47:158-162.
8. Universidad Nacional de Córdoba. Infostat (Versión Profesional. Actualización octubre de 2008) Estadística y Diseño. Córdoba: Facultad de Ciencias Agropecuarias. URL: http://www.infostat.com.ar/
9. Erin M. Wilson, Jordan R. Green, Yana Yunusova, Christopher A. Moore, Task Specificity in Early Oral Motor Development. Semin Speech Lang 2008;4:257-266.
10. Medoff-Cooper B, Bilker W, Kaplan JM. Sucking patterns and behavioral state in 1- and 2-day-old full-term infants. J Obstet Gynecol Neonatal Nurs 2010;39: 519-524.
11. Carranza M, Simbrón A, Carda C and Ferraris M E. Morphology of the pterygoid lateral muscle associated to the mandibular condyle in the human prenatal stage. Acta Odontol Latinoam 2006;19:29-36.
12. Smith A. Speech motor development: Integrating muscles, movements, and linguistic units. J Commun Disord 2006; 39:331-349.
13. Hwang YS, Lin CH, Coster WJ, Bigsby R, Vergara E. Effectiveness of cheek and jaw support to improve feeding performance of preterm infants. Am J Occup Ther 2010; 64:886-894.
14. Reynolds EW, Grider D, Caldwell R, Capilouto G, Vijaygopal P, Patwardhan A, Charnigo R. Swallow-breath interaction and phase of respiration with swallow during nonnutritive suck among low-risk preterm infants. Am J Perinatol 2010;27:831-840.
15. Costas M, Santos S, Godoy C, Martell M. Patrones de succión en el recién nacido de término y pretérmino. Arch Pediatr Urug 2004;75:36-50.