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Assessment of swallowing in preterm newborns fed by bottle and cup

Avaliação da deglutição em prematuros com mamadeira e copo

ABSTRACT

Purpose: To compare the swallowing performance of premature infants using a cup and a bottle during the first offer of food by mouth. **Methods:** This study was carried out with preterm newborns who presented low weight at birth and no neurological illnesses, genetic syndromes or congenital malformations. The newborns were assessed by videofluoroscopy while using a cup and a bottle, when they reached a post-conceptual age of ≥ 34 weeks, weight $\geq 1,500$ g and showed signs of readiness for oral feeding. All children were fed exclusively by gavage during the period prior to the study. **Results:** This study included 20 preterm newborns, with average birth weight of 1,356 g and gestational age of 31.3 weeks. The majority of the bottle-fed newborns (68%) presented strong and rhythmic suction and 63% showed good sucking/swallowing/breathing coordination. The same percentage of newborns fed by cup (68%) could not perform the sipping movement and only 32% could suck a minimal amount of liquid contrast. There were no signs of laryngeal penetration and tracheal aspiration in both procedures. **Conclusion:** At the first oral feeding, preterm newborns showed better swallowing performance with a bottle in comparison to using a cup.

RESUMO

Objetivo: Comparar o desempenho da deglutição com uso de copo e mamadeira em prematuros, na primeira oferta do alimento por via oral. **Métodos:** Estudo em prematuros de muito baixo peso ao nascer, sem comprometimento neurológico, síndromes genéticas ou malformações congênitas. Os recém-nascidos foram avaliados por meio da videofluoroscopia, com uso de copo e mamadeira, quando atingiram idade corrigida ≥ 34 semanas, peso ≥ 1.500 g e apresentavam indicação de iniciar alimentação por via oral. Todos receberam alimentação exclusivamente por gavagem no período prévio ao estudo. **Resultados:** Foram avaliados 20 prematuros, com peso médio de 1.356 g e idade gestacional ao nascimento de 31,3 semanas. Grande parte dos recém-nascidos alimentados por mamadeira (68%) apresentou sucção forte e com ritmo e 63% mostraram boa coordenação das funções sucção/deglutição/respiração. A mesma porcentagem de recém-nascidos alimentados pelo copo (68%) não realizou o movimento de sorver e apenas 32% sorveram quantidades mínimas de contraste líquido. Não foram observados sinais de penetração laríngea e aspiração traqueal em ambos os procedimentos. **Conclusão:** Na primeira oferta de alimento por via oral, recém-nascidos prematuros apresentaram melhor desempenho na deglutição com o uso da mamadeira em relação ao copo.

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INTRODUCTION

Prematurity is a growing problem in public health, and it has been a point of concern among several specialists around the world⁽¹⁾. Scientific and technological advancements have enabled the reduction of mortality and the increase of survival of children who are significantly underweight at birth, but such advancements did not result in a decrease in morbidities during the neonatal period⁽²⁾. Thus, there is a growing number of children at risk for late morbidities associated with prematurity⁽³⁾.

Among the problems caused by prematurity, feeding has been pointed out as one of the main challenges that children might face. A child's immaturity to suck, lack of coordination of breathing/suction/swallowing functions, and immaturity of the biomechanical deglutition system and of the gastrointestinal function can cause problems in related to feeding methods and the type of food to be administered⁽⁴⁾.

Many campaigns have been carried out with the purpose of promoting breastfeeding, especially in developing countries, where breastfeeding is related to the survival of children. The United Nations Children's Fund (UNICEF) and the World Health Organization (WHO) have invested in implanting the Baby-Friendly Hospital Initiative (BFHI) by means of campaigns, publications and financial incentives with the main purpose of stimulating breastfeeding⁽⁵⁻¹⁰⁾. Premature newborns (NB), who are unable to be breastfed must be fed with a cup, spoon or a dropper, according to recommendations by the WHO and the BFHI^(7,11,12). The justification behind this is that bottle nipples can confuse a child's oral response due to the reduction of muscle work necessary for suction and milk release, consequently decreasing the craving to suck on the mother's breast⁽¹²⁾.

In spite of this recommendation, studies on the safety and efficacy of using cups present controversial results^(5,6). Some authors have found cup-feeding beneficial for maintaining breastfeeding in premature newborns^(13,14). However, in a systematic revision comparing supplementary feeding with a cup or bottle in newborns, the authors concluded that the cup should not be recommended because it is not conducive to breastfeeding after discharge from the hospital, in addition to prolonging the length of hospitalization⁽¹⁵⁾.

Considering this scenario, it is important to study deglutition in premature newborns with the use of cups or bottles for supplementary feeding. In the present study, we aimed at comparing the swallowing performance of preterm newborns with the use of a cup and a bottle during the first offer of food by mouth.

METHODS

This study was conducted at Universidade Federal de São Paulo from 1999 to 2001. It was approved by the institution's ethics committee, under report number 937/99. The participation of all newborns was authorized by their caregivers in writing. They read an information letter and signed the informed consent form.

This is a transversal study in which the population was composed of a convenience sample of 20 preterm newborns, selected at the neonatal unit of a public university hospital. We considered the following as inclusion criteria: prematurity, corrected age equal or above 34 weeks, weight equal or over 1500 g, good clinical conditions, and medical recommendation to transition from catheter feeding to exclusive oral feeding at the time of the examination. The exclusion criteria adopted were: levels III and IV peri-intraventricular hemorrhage; Apgar score lower than seven in the fifth minute; genetic syndromes; congenital malformations in the central nervous system, head and neck, as well as meningitis (altered results in the cephalarachidian fluid test), as all of these could interfere with the newborns' performance during their first oral feeding. The premature babies were referred by the doctor assisting the unit and by family members, who were contacted by one of the researchers (CPL). The children had been fed exclusively by gavages (nasal or orogastric catheter) up until the examination time and did not receive non-nutritive suction stimulation because this was not a routine procedure at the neonatal unit at the time.

All NBs were submitted to videofluoroscopy with both utensils in sequence. The order in which the cup or bottle was used was defined by a planned draw, so that half of the children started the test with each utensil.

In order to facilitate the observation of the milk within the oral and pharyngeal cavities, it was necessary to mix barium powder (contrasting solution) and breast milk or formula. The following dilutions were used: 10 cc of milk + 5 cc of barium powder for one cup, and 30 cubic centimeter of milk + 15 cubic centimeter of barium powder for one bottle. This dilution had been selected prior to the study and after the analysis of a few dilutions; it proved to provide adequate images of oral and pharyngeal structures without interfering with the consistency of the mixture.

The materials used in the assessment were carefully selected to avoid their interference with the newborns' performances. For this purpose, the graduated plastic cup used to administer medication was chosen for being easy to handle, enabling volume control, and having thin and rounded edges, thus providing comfortable contact for the newborn. The NUK nipple selected for premature newborns was chosen for its anatomic shape and because it was developed for premature newborns who weigh less than 1750 g. It is made of flexible latex with a very small hole, which forces the NB to compress it to extract milk.

The videofluoroscopy was conducted at the Radiology Sector of the Department of Diagnostic Imaging at Universidade Federal de São Paulo's Escola Paulista de Medicina (EPM – UNIFESP). The equipment used was manufactured by Medicor, model EDR 750, Emerix examination table with a seriograph and a video monitor. The images were recorded so that the examination could be analyzed and revised by the researchers.

The transport of the NBs to the assessment location was performed by the medical and the nursing teams of the Neonatal Unit, with the necessary equipment and drugs to assist the individuals in case of eventual interurrences. During the transport, each NB was in an incubator with a wrist oxymeter. All were accompanied by one of the researchers (CPL).

To proceed with the examination, the NB was removed from the incubator and placed in a pre-adjustable chair, developed for this study, for adjusting the NB's position during feeding. All NBs were positioned at 40 degrees, as this arrangement provided them with comfort and safety.

After placing the NB in the pre-adjustable chair, a neonatal doctor took his/her axillary temperature, measured respiratory frequency, heart rate and oxygen saturation levels. These measurements were performed at the beginning and at the end of the offer with a bottle and with a cup.

Before this assessment, the examiner evaluated each NB's non-nutritive suction (without nourishment). With a finger in a sterile glove, she gently touched and massaged the NB's perioral and intraoral regions and assessed the possibility of responses described as follows: perioral region – presence or absence of rooting reflexes (cardinal points) and intraoral region – presence or absence of biting and jaw closure reflex, strong suction, lip closure, suction rhythm, stress or fatigue signs (hypertonia, hypotonia, paleness, hiccups, tachycardia, tachypnea and decrease in O₂ saturation) and the number of suctions per second.

All NBs received their first offer of food by mouth at the time of the examination. The milk/formula was offered by means of a graduated plastic cup and a bottle. The ingestion of 2,5 mL of milk was monitored with each utensil. We leaned the cup slightly against the NB's lower lip, and he/she, in turn, should introduce the planned volume of milk into his/her oral cavity. The bottle nipple was introduced into the oral cavity and the NB should suck the planned volume as well. Next, we monitored the swallowing of the liquid introduced in the oral cavity. The total volume of the cup and of the bottle was 10 mL and 30 mL respectively. These quantities facilitated the NB's access to the liquid and our monitoring.

The analysis of the examination was conducted by a professional specialized in orofacial motricity with a focus on dysphagia (AMF). She considered the adequacy/inadequacy of the parameters described as follows. Oral phase with bottle: latching – the child's lips close around the nipple and the tongue is lowered; lip closure – the upper and lower lips remain in contact; anteroposterior tongue movement – the tip of the tongue must rest on the anterior superior alveolar ridge and perform the movement of propelling the bolus towards the pharynx; suction and rhythm – oral cavity negative pressure and necessary pauses for breathing; oral control – maintenance of the contents within the oral cavity to avoid leakage, and adequate food positioning (the contrasted content is positioned on the tongue, which is in contact with the hard palate); oral ejection – propelling the food from the oral phase to the pharyngeal phase; suction/swallowing

coordination — it is expected that two suctions should be followed by one deglutition. Analysis of atypical findings – tongue and/or jaw tremor and oral stasis (accumulation of contrasted liquid within the oral cavity).

In the oral phase with a cup, the presence/absence of the following aspects were considered and analyzed: oral cavity opening; tongue posteriorization and/or elevation; sipping/licking – the tongue touches the liquid and takes it into the oral cavity. Atypical findings were also analyzed: expulsion of liquid using the tongue; spilling liquid within the oral cavity; tongue and/or jaw tremor, oral stasis, presence of suction, stress or physical tiredness.

In the pharyngeal phase (cup and bottle), the following aspects were considered and analyzed: adequate velopharyngeal closure; residues in valleculas; residues in piriform recesses; laryngeal penetration and tracheal aspiration. Although the esophageal or esophagogastric phase is intimately related to the aforementioned phases, it was not our purpose to assess its dynamics.

The assessment protocol adopted to describe videofluoroscopic parameters in babies was adapted from Newman et al.⁽¹⁶⁾

Statistical method

The results obtained are displayed as absolute numbers and frequency. It was not possible to apply statistical tests because the mechanisms of food ingestion with both utensils have different and non-comparable variables.

RESULTS

The premature newborns had an average gestational age of 31,3 weeks (median – 31; 27 to 34 weeks). On the day of the examination, the average post-conceptual age was 34,8 weeks (median – 35; 34 to 36 weeks). The NBs' weight at birth was 1356 g on average (median – 1387 g; 830 to 1840 g) and on the day of the examination it was 1707 g (median – 1665 g; 1510 to 1990 g). The Apgar score average was 8 (out of 1 to 9) in the first minute and 9 in the fifth minute (7 to 9). All NBs had normal results in the neurological exam.

The assessment of non-nutritive suction yielded that the frequency of suctions was between one and two per second, 15 NBs showed no rooting reflex, 19 presented strong suction and adequate lip closure (although rhythm was observed only in 17 NBs) and only two presented stress signs prior to the exam. Alterations in physiological measurements (body temperature, heart rate and oxygen saturation) were not observed.

It was necessary to exclude one NB who was bottle-fed because the nipple hole was obstructed and he could not suck the milk. Therefore, 19 NBs were part of this result analysis.

Upon receiving nourishment by bottle (Table 1), 13 out of the 19 NBs presented strong and rhythmic suction; one NB presented posteroanterior tongue movements and 18 showed anteroposterior

movements. With regard to suction/deglutition/breathing coordination, they were adequate in 12 children.

When assessed with a cup (Table 2), 13 out of the 19 NBs did not sip. The six children who sipped from the cup spilled the liquid into the oral cavity by moving their heads, jaws and tongues. Out of these, three children expelled the food out of the oral cavity with their tongues without swallowing the contrasted liquid and the other three spilled the liquid into the oral cavity and swallowed it with adequate oral ejection.

In the six NBs who sipped from the cup and swallowed and in the 19 NBs who sucked and swallowed with the bottle, the movement of velopharyngeal closure was adequate and there was no laryngeal penetration and tracheal aspiration during the exam (Table 3).

Table 1. Swallowing characterization of 19 premature newborns using a bottle

	Bottle	
	Adequate n (%)	Inadequate n (%)
Latching	19 (100)	0 (0)
Lip closure	19 (100)	0 (0)
Tongue movements	18 (95)	1 (5)
Suction	13 (68)	6 (32)
Rhythm	13 (68)	6 (32)
Suction/swallowing/ breathing coordination	12 (63)	7 (37)
Adequate mouth control and positioning	17 (89)	2 (11)
Oral ejection	15 (79)	4 (21)

Table 2. Swallowing characterization of 19 premature newborns using a cup

	Cup	
	Yes n (%)	No n (%)
Oral cavity opening	15 (79)	4 (21)
Tongue movements	15 (79)	4 (21)
Sipping	6 (32)	13 (68)
Atypical findings		
Spillage within the oral cavity	3 (50)	3 (50)
Expulsion of liquid with the tongue	3 (50)	3 (50)
Oral ejection	3 (50)	3 (50)

Table 3. Swallowing characterization of 19 premature newborns in relation to the pharyngeal phase using a cup and a bottle

	Cup n (%)	Bottle n (%)
Adequate velopharyngeal closure	6 (100)	13 (68)
Residues in valleculas	1 (17)	4 (21)
Residues in piriform recesses	1 (17)	3 (16)
Laryngeal penetration	0 (0)	0 (0)
Tracheal aspiration	0 (0)	0 (0)

DISCUSSION

Although cup-feeding is professed as the ideal feeding method for premature NBs who are unable to be exclusively breastfed, its safety and efficacy have been little studied with the use of objective assessment methods. In current studies, authors utilize clinical observation of the NBs' feeding or apply questionnaires to neonatal unit teams or mothers. Electromyography is employed as an objective assessment instrument only in a few studies⁽¹⁷⁾.

In clinical practice, the golden standard to evaluate the dynamics of swallowing in all its phases (oral, pharyngeal and esophageal) is videofluoroscopy⁽¹⁸⁻²⁰⁾. In this study, this was the instrument adopted to assess the phases of swallowing because it is the best method available to study the dynamics of oral and pharyngeal structures⁽²¹⁾ by providing fundamental information on a topic that remains highly controversial — the use of cups or bottles to feed premature newborns. Although there is a concern about the level of exposure to radiation with the use of the instrument adopted, we considered that information could only be obtained in this manner and were careful to limit the time length of the exam. Furthermore, a dosimetry was conducted in seven children, which showed an amount of absorbed dose between 0,07 and 0,35 mGy/s, similar to the reference levels accepted for a simple thorax radiography⁽²²⁾.

Upon comparing the NBs' heart rate, respiratory frequency and oxygen saturation values before and after videofluoroscopy with each utensil, we did not observe significant differences among the measurements. However, three children in the Cup Group and none in the Bottle Group presented oxygen saturation lower than 85% after the exam. It is possible that this decrease in oxygen saturation was related to the effort made by the NBs while attempting to sip the liquid from the cup, given that we did not observe any aspiration episodes.

These findings differ from those reported in another study⁽⁸⁾, where a higher frequency of saturation decrease (<85%) was found in premature babies while being fed with a bottle in comparison to a cup. The authors, however, did not observe any signs of aspiration with the use of both utensils. They did not describe the type of nipple used in the study which may have influenced the results, considering that, according to them, cup-feeding was safe and without disadvantages in relation to the time spent with feeding and to weight gain in comparison to the bottle. However, it did not modify the frequency of breastfeeding assessed at the third month of follow-up. In full-term children, no differences were observed concerning the time taken to administer the milk, the quantities ingested and the physiological stability of those who were receiving supplementary nourishment with a cup or bottle⁽²³⁾.

Alternatively, authors who have assessed cup-feeding in premature newborns by means of plethysmography have concluded that the procedure is safe. Nevertheless, physiological stability was associated with the ingestion of minimal volumes of milk. The duration of feeding with a cup was lengthened and the children needed to be stimulated to continue; the volume absorbed was small and there was a significant loss of the

quantity of milk that was either licked or sipped⁽²⁴⁾. In other research studies, scholars have also reported excessive waste of nourishment with the use of a cup⁽²⁵⁾. Upon evaluating the *paladai*, an utensil used to feed premature babies, authors have shown that the feeding times are longer and more is wasted in comparison to the bottle⁽²⁶⁾.

These findings suggest that, unlike suction, licking and sipping mechanisms do not occur spontaneously in premature NBs. This observation is corroborated by the present study, in which only a small number of children (32%) performed licking movements and ingested minimal quantities of liquid during the evaluation with a cup. Some NBs showed irritation and excessive head and limb movements during cup-feeding. NBs who did not sip from the cup either spilled the liquid into the oral cavity or expelled it with their tongue. This expulsion of liquid can be explained by the child's inability to handle large quantities of milk while attempting to protect him/herself.

In full-term nurslings, assessed by a surface electromyography, similarities were observed in the muscle activity of breastfed or cup-fed children. The same muscles activated during breastfeeding are activated on the course of cup-feeding, with more engagement of masseter and temporal muscles and reduced participation of buccinator muscles. However, the authors emphasize that cup-feeding must not be the exclusive feeding method for nurslings, as the child does not perform suction movements; it can only be recommended as an alternative and temporary method⁽¹⁷⁾.

During the first offer of nourishment with a bottle, the children presented adequate control, positioning and oral ejection, coordinated suction/deglutition/breathing, suction and rhythm. A small part of the samples had contrast residues in the pharyngeal structures, which were cleaned after deglutition. There was no laryngeal penetration or tracheal aspiration. It is worth highlighting that the volume of food offered was small; therefore, it was not possible to predict the NBs' performance with larger quantities of liquid. As the maturation process unfolds with the increase of gestational age, regardless of the child's experience, the more mature the child is, the better her/his suction/deglutition/breathing coordination^(27,28). In this study, the premature NBs were assessed at a post-conceptual age of 35 weeks, when an adequate coordination of these functions is expected.

Among the limitations of this study, we can mention the absence of specialized intervention by a speech-language pathologist to assist the NBs prior to the study, which could have improved their performance with both utensils at the time of examination. The assessment of food ingestion was conducted only during the first offer; if further assessments had been carried out after a period of practice with both utensils, the performances could have been different.

It is important to highlight that, with any utensil adopted, the technique of choice must be adequately applied so as to minimize risks. Thus, we emphasize the necessity of training and supervision of Neonatal Intensive Care Unit teams to ensure proper nourishment administration^(8,29-31).

CONCLUSION

During the first offer of liquid food by mouth, premature newborns presented better swallowing performance with the use of a bottle in comparison to a cup. These findings suggest that the first behavior is innate and that the children were ready to suck at the time of assessment, while the use of a cup requires practice.

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**CPL was responsible for data collection and tabulation; AMF collaborated with data collection and tabulation, and supervised data collection; ZCFG and BMC participated in data collection and collaborated with data analysis; CPL and ALG were responsible for the project, study outline and overall supervision of the stages involved in manuscript writing.*

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