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# FROM THE FOOT-MOUTH REFLEX TO THE HAND-MOUTH REFLEX

## A CONTINUUM OF RESPONSES TO APPENDICULAR COMPRESSION

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ABSTRACT - We studied the mouth opening response to appendicular compression in two groups of children. This study was performed with the intention of testing the semiologic role of the act of mouth opening following stimulation of various regions, based on the hand mouth reflex of Babkin. Group I was formed by 33 normal children who underwent monthly follow up assessments since birth; and group II consisted of 50 children older than 6 months of age, known to have a neurologic deficit and a neuro-psychomotor development equivalent to that of a child in the first trimester of life. We observed that the normal mouth opening response in group I was more pronounced following compression of the hand and forearm when compared to compression of the arm ($p<0.001$). This response could persist for as long as the first 6 months of life. We were not able to elicit a mouth opening response following compression of the lower limb in this group. Among children from group II, we observed mouth opening responses to stimulation of all limb segments. Within the upper limb, the response was more pronounced following compression of the hand in comparison to the forearm ($p<0.01$), and forearm in comparison to the proximal arm ($p<0.01$). Stimulation of the foot was more effective in eliciting a mouth opening response when compared to equivalent stimulation of the lower leg ($p<0.05$). However, there was no statistical difference when responses to stimulation of the lower leg and thigh were compared. The presence of the previously unreported foot-mouth response may serve as an indicator of central nervous system compromise and could be associated with a poorer prognosis. We believe that our observations of the specific foot-mouth response patterns may serve as a marker of early neuro-psychomotor development dysfunction during childhood.

KEY WORDS: neurologic examination, archaic reflexes, neuro-psychomotor development.

**Do reflexo pé-boca ao reflexo mão-boca: um continuum de respostas à compressão apendicular**

RESUMO - Com a intenção de testar a importância semiológica da abertura da boca a estímulos em diferentes regiões, partindo do reflexo mão-boca de Babkin, foram estudadas as respostas de abertura da boca por compressão apendicular em dois grupos de crianças, sendo o grupo I constituído de 33 crianças normais acompanhadas desde o nascimento e revisadas ao final de cada mês e o grupo II constituído de 50 crianças com patologia neurológica com idade superior a 6 meses e cujo desenvolvimento neuropsicomotor (DNPM) fosse do 1º trimestre de vida. Observou-se que a evolução normal da resposta motora de abertura da boca no grupo I por compressão é mais eficiente na mão e antebraço do que no braço ($p<0,001$), podendo persistir durante o 1º semestre de vida. Não foi possível demonstrar esta resposta à compressão do membro inferior (MI). Nas crianças do grupo II, foi possível observar as respostas de abertura da boca aos estímulos em todos os segmentos apendiculares, sendo no membro superior (MS) o estímulo na mão mais efetivo do que no antebraço ($p<0,01$), no antebraço mais efetivo que no braço ($p<0,01$). Os estímulos no MI mostraram o pé mais efetivo do que a perna ($p<0,05$). Entretanto a eficácia do estímulo da perna em relação à coxa não foi estatisticamente significativo. A presença dessas respostas até agora não relatadas como pé-boca pode indicar maior severidade do comprometimento do sistema nervoso central, com pior prognóstico. Pensamos que estas observações possam ter especial interesse para os profissionais da reabilitação, constituindo mais um marcador de alterações neurológicas precoces no DNPM da criança.

PALAVRAS-CHAVE: exame neurológico, reflexos arcaicos, desenvolvimento neuropsicomotor.

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Bieber, in 1936, observed that newborns exhibited a mouth opening response following cutaneous tactile stimulation. He noticed that not only facial stimulation, but also grasping of the hands, at times, were able to trigger a mouth opening response.[2] Almost two decades later Babkin described a mouth opening response that could be elicited by compressing the hands of newborns. He named this clinical finding the hand-mouth reflex. His observations were published in the Russian literature in 1956 and were translated to English in 1960[1]. Babkin considered the hand-mouth reflex solely as the mouth opening response to compression of the hands. However, he also observed that pressure applied to the hands of newborns could trigger flexion of the elbow joint and neck, as well as closing of the eyes, in addition to opening of the mouth. Babkin also reported that during the first few days of life one could elicit contraction of the perioral and periorbital musculature, extension of the neck and arms, and mouth opening, in response to percussion of the upper lip. However, he did not considered these many responses to a single stimulus as new and independent reflexes. Instead, he attributed such responses to immaturity of the superior nervous system. Lippman[9] and Parmelee[13] included cervical flexion and/or midline rotation as parts of Babkin's hand-mouth reflex, even when the children did not exhibit a mouth opening response to palmar stimulation.

Our group had previously reported preliminary results describing the hand-mouth reflex patterns in newborns[14]. We highlighted the fact that the mouth opening component was crucial in order to establish the presence of the hand-mouth reflex, not considering the additional components seen in response to palmar pressure as criteria to define this clinical sigh[14]. More recently, Santos, da Silva and Novais[20] published their observation of several other motor responses associated to hand compression in newborns. In addition to the already described regions, they also considered the juxta-sternal infraclavicular area to be a newly recognized reflexogenic area. A comprehensive review of the literature demonstrates that the hand-mouth reflex described by Babkin refers to the specific cutaneous stimulus, much like the palmomental reflex of Marinesco and Radovici[10], and Bieber's observations regarding grasp and suction.

The fact that compression of the palmar region is capable of triggering associated responses may indicate that a variety of response could also occur if the same stimuli was applied to other areas of the body, establishing what we denominated "reflexogenic continuum". The current study was performed with the purpose of observing the possible mouth opening response following appendicular compression in normal children and its possible persistence in children with neurologic dysfunction.

## PATIENTS AND METHODS

We studied 2 groups of children. Group I was formed by a cohort of 33 normal term newborns, randomly selected from the maternity ward at Hospital de Clínicas de Porto Alegre (HCPA) between April and June 1995. All newborns were 24 to 72 hours old, had a gestational age equal or greater than 37 weeks, birth weight equal or greater than 2,500 g, Apgar score equal or greater than 8 (1st and 5th minutes) and had no known illnesses. These newborns were examined monthly until the 6th month of age. Group II consisted of 50 children with a known neurologic deficit seen at the Child Neurology Unit at HCPA between August and December of 1995. These children had a chronological age greater than 6 months and a neuro-psychomotor development equivalent to that seen in the first 3 months of life.

All children underwent a complete neurologic examination, in addition to the firm and rapid appendicular compression performed simultaneously (bilaterally) using the examiner's hands in a homologous fashion. This procedure was performed prior to the remainder of the examination in the following sequence: first the upper limbs (hands, distal forearms and central aspect of the upper arms), followed by the lower limbs (feet, lower legs and central aspect of the thigh). Whenever the mouth opening response was absent for a certain limb segment, the procedure was repeated as many as 5 times throughout the neurologic examination.

Data were analyzed using the Chi-square test, and a $p$ value less than .05 was considered to be statistically significant.

*Table 1. Mouth opening response to appendicular compression: syndromic diagnosis.*

| | Hand-mouth | | Forearm-mouth | | Upper arm-mouth | | Foot-mouth | | Lower leg-mouth | | Thigh-mouth | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n | % | n | % | n | % |
| Cerebral palsy | 34 | 68 | 22 | 44 | 12 | 24 | 19 | 38 | 11 | 22 | 7 | 14 |
| Generalized hypotonia | 7 | 14 | 6 | 12 | 2 | 4 | 4 | 8 | 1 | 2 | - | - |
| Non-static encephalopathy | 5 | 10 | - | - | - | - | - | - | - | - | - | - |
| Neuro-psychomotor developmental delay | 2 | 4 | - | - | - | - | - | - | - | - | - | - |
| Total | 48 | 96 | 28 | 56 | 14 | 28 | 23 | 46 | 12 | 24 | 7 | 14 |

## RESULTS

Group I was formed by 33 normal children: 18 females, 21 Caucasians. Twenty six of those children were born by vaginal delivery and 7 were delivered by cesarean section. Group II considered of 50 children with a known neurologic deficit between the ages of 9 months and 13 years: 29 males, 46 Caucasians.

Figure 1 presents the hand-mouth reflex patterns in children from group I in comparison with two other studies with similar methodology involving normal children. The mouth opening response following compression of different segments of the upper limbs among children from group I is depicted in Figure 2. Children from group I did not display a mouth opening response to compression of the lower limbs. These children were significantly more likely to display a mouth opening response upon stimulation of the hands and forearms, when compared to an equivalent stimulus to the upper arms.

Children with a preexisting neurologic disorder presented a mouth opening response following appendicular compression of both the upper and lower limbs. Results for group II are presented in

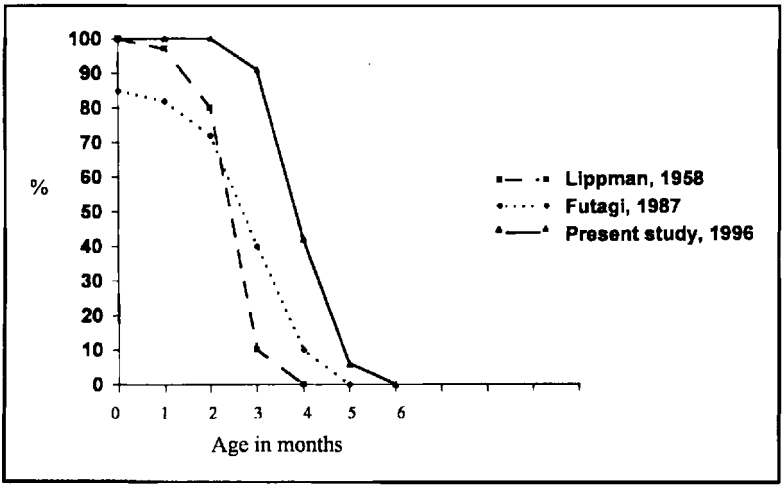


*Fig 1. Normal evolution of the mouth opening response to compression of the hand (Babkin's reflex).*

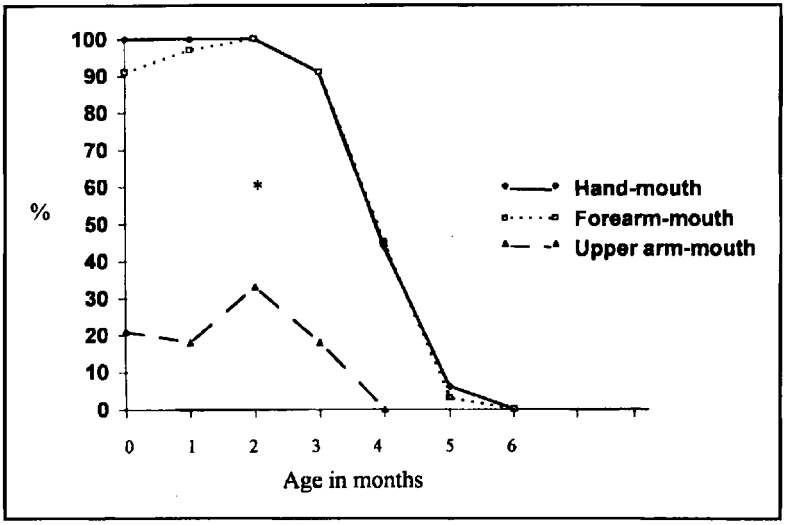


*Fig 2. Evolution of the mouth opening response to compression, considering three segments of the upper limb in normal children.*
**: p <.001*

Table 1, broken down by syndromic diagnoses. These children were significantly more likely to display a mouth opening response following stimulation of the distal segments (hands and feet) when compared to stimulation of mid and proximal segments of the upper and lower limbs. There was no difference in the ability to elicit a mouth opening response following stimulus applied to the distal leg and thigh (Fig 3).

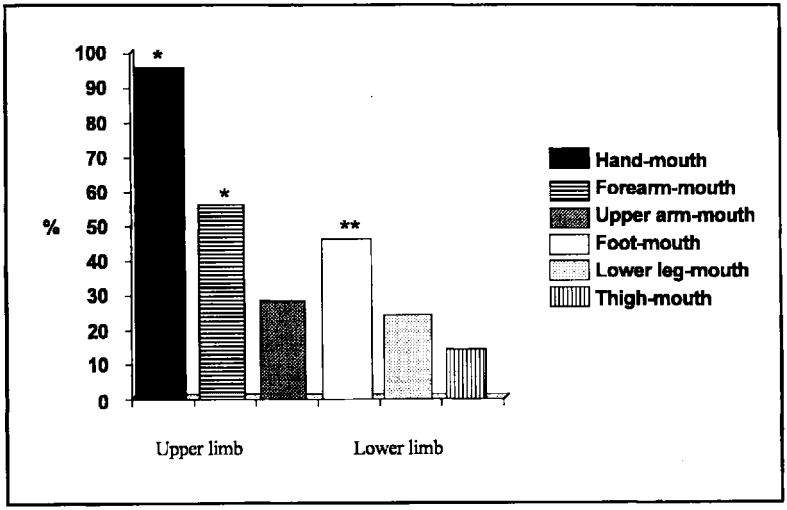


*Fig 3. Mouth opening response to appendicular compression in children with neurologic pathology. *:p<.01; **: p<.05.*

## DISCUSSION

Many authors have used the so called archaic or newborn reflexes as markers of normal infant development for semiologic protocols in child neurology. However, the archaic responses elicited

from a distance by hand stimulation, such as the palmomental and hand-mouth reflexes, are routinely not part of the neurologic diagnostic examination of infants and children[3,8,17,19,21-23].

Our study shows that mouth opening responses following appendicular compression among normal children, especially the hand-mouth reflex, are highly prevalent during the first trimester of life. These responses are much less prevalent during the 3rd and 4th months of life and disappear by the end of the first semester (Fig 1). Our methodology allowed us to follow the natural evolution of this archaic reflex. The hand-mouth reflex presented an evolutionary pattern comparable to other archaic reflexes such as the asymmetric tonic cervical reflex, Moro reflex, plantar support, palmar grasp, rooting and sucking, which all disappear or are significantly modified during the first 6 months of life[3,5,12]. We also demonstrated that the compression of all segments of the upper extremity, in the normal child, is capable of triggering a mouth opening response. These findings expand the reflexogenic area of the hand-mouth response to all segments of the upper extremity, and not only limited to the hand as previously reported. The finding that a mouth opening response can be elicited by compression of the juxta-sternal portion of the intraclavicular area in newborns[20] is likely to be associated to the same mechanism observed in the responses obtained in our study by stimulation of the upper extremity, since that area receives sensory innervation by dermatomes corresponding to the proximal portion of the upper extremity.

Futagi and colleagues[4] studied the hand-mouth reflex during the first year of life in normal children and in children with cerebral palsy. They observed that some children with cerebral palsy exhibited persistence of the hand-mouth reflex, as opposed to the expected extinction seen in normal children. They considered the persistence of the hand-mouth reflex beyond the age of 5 months to be an important neurologic sign, indicative of neurologic pathology. The persistence and intensity of the reflex response after this period could suggest disease processes such as spastic non-progressive motor encephalopathy as well as progressive diseases of the central nervous system (CNS). The likelihood that mouth opening responses following appendicular compression have semiologic importance in children during different stages of the neuro-psychomotor development underscores its importance as part of the routine neurologic examination of the child[15].

We did not find any reference in the medical literature related to our findings of mouth opening response following stimuli to segments of the lower extremity, especially the feet, in patients with neurologic disorders and severe neuro-developmental retardation. This finding forces us to consider a different mechanism to the theoretical concept by Parmelee[13], based on human fetal studies by Humphrey[6], that suggests that hand-mouth connections are made possible due to cervical extension of the trigeminal nerve sensory nucleus. We speculate that, instead, these sensory stimuli are captured along the whole extension of the dorsal column of the spinal cord. These stimuli would be conducted in a polysynaptic fashion through both ascending and descending pathways in relation to the various motor nuclei of cranial nerves (trigeminal, facial, accessory, hypoglossal), as well as the ventral column of the spinal cord. This model would explain the various motor components (associated or not a mouth opening response) observed following appendicular compression, such as generalized flexion of all limbs and neck, neck rotation, tongue protrusion, palpebral closing and contraction of the perioral muscles. These responses, frequently observed in association or as isolated events, are perhaps one of the most complex and complete motor responses. Despite that fact we recognize the multiplicity of possible response following appendicular compression, we chose to study the mouth opening response in order to obtain uniform observations capable of relating a specific stimulus to a specific response.

It is well established that the palmar, perioral and plantar regions (especially the hallux) are the cutaneous areas of the body with the greater density of mechanoreceptors, resulting in greater discrimination[7,11]. These areas also have greater cortical representation when compared to other

sensory areas[16]. Our results coincide with the above anatomo-physiologic phenomena, since the hand was the most effective region to trigger a mouth opening response both in normal children and in children with CNS pathology. The foot was also the most effective region in the lower extremity in its ability to trigger a mouth opening response in children with CNS pathology, when stimulated. Therefore, in newborns and in older children with neurologic disorders where the CNS inhibitory mechanisms are less effective, there seems to be functional liberation of inter-synaptic activity with enhancement of reflexogenic areas. This probably occurs in direct proportion to the discriminative capacity of different cutaneous regions. The enhancement of areas involved in the generation of reflex responses suggests a sensory-motor integration along almost the entire spinal cord, in sequence with the motor nuclei of the 7th and 5th cranial nerves. The enhancement of reflexogenic areas is corroborated by the fact that during electromyographic studies in normal adults, the contraction of the mentalis muscle, although more effective following palmar stimulation, can also be obtained in other areas of the body, including the foot, depending on the intensity of the electrical stimulation[18]. This finding suggests that the palmomental reflex is only a fragment of the general cutaneous nociceptive response. Is is possible that similar methodology in normal infants would be able to reveal equivalent neurophysiologic response of the muscles involved in mouth opening by stimulation of other areas of the body, depending on the intensity of the stimulus.

Our observation of normal children and children with neurologic dysfunction allows us to infer that the mouth opening response to cutaneous nociceptive stimulation is part of a continuum that is limited to the innervation territory of the upper limb in normal children during the first semester of life, and that could extend to the entire lower extremity under pathologic conditions at any age. Based in the basic theory that human ontogenesis follows phylogenesis, it is possible to speculate that the mouth opening response to nociceptive stimuli of the lower extremity could be part of an archaic polysynaptic response during a certain pre-natal period.

The presence of those not previously reported mouth opening responses, such as the foot-mouth reflex, may indicate a greater severity of CNS involvement and a worse prognosis. We believe that these observations represent another marker of early neurologic alterations in the neuro-psychomotor development of the child.

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