Original Article

https://doi.org/10.1590/2317-6431-2020-2349

Audiology Communication Research
ISSN 2317-6431

Auscultation of swallowing sounds of children with bronchiolitis

Auscultação dos sons da deglutição de crianças com bronquiolite

Liliane Menzen[1], *Lisiane de Rosa Barbosa*[1], *Maria Cristina Cardoso*[1]

ABSTRACT

Purpose: To verify the acoustic characteristics of swallowing noise in an infant with bronchiolitis. **Methods:** A retrospective study was performed by database analysis approved by the ERC under the number 1499.911; the acoustic signals were collected through Littmann® model 4100 electronic stethoscopes. The sample was composed of a bank of infants swallowing sounds, diagnosed with acute viral bronchiolitis, children under 12 months-old, hospitalized in a children's hospital in the south of the Country. The sound file storage was opened, and it was rotated in the *Deglutisom*® software, being verified and confirmed by two independent judges. The peak of frequency, intensity, and swallowing intervals were established. **Results:** The sample totalized a group of 22 babies, 31.8% of the female gender, and 68. 2% of males with a median age of 81 days. There was a difference between the acoustic characteristics of swallowing compared to the gender, regarding the number of swallows, with the highest number of swallows in the female gender (p=0.033). There was no association between the peak frequency (m=744 Hz), intensity (m=52 dB), and swallowing time (5.3s). **Conclusion:** The acoustic characteristics of cervical auscultation swallowing of Infants with bronchiolitis are bass frequency peak, a strong intensity, a mean of two swallows, and a swallowing time of 5.3 s, with the difference between genders concerning the number of swallows, highest in the female.

Keywords: Auscultation; Acoustics; Swallowing; Swallowing disorders, Bronchiolitis

RESUMO

Objetivo: verificar as características acústicas dos sons de deglutição de lactentes com bronquiolite. **Métodos:** estudo retrospectivo por análise de banco de dados aprovado pelo CEP sob o número 1499.911. Os sinais acústicos foram coletados por meio dos estetoscópios eletrônicos da marca Littmann®, modelo 4100. A amostra foi composta por sons da deglutição de lactentes com diagnóstico de bronquiolite viral aguda, internados em um hospital infantil do Sul do país. Os sons armazenados em arquivo digital foram abertos e rodados no *software* Deglutisom®, sendo verificados e confirmados por dois avaliadores independentes. Estabeleceu-se o pico de frequência, intensidade e intervalos de deglutição. **Resultados:** a amostra de sons da deglutição de 22 crianças, sendo 31,8% do gênero feminino e 68,2% do masculino, apresentou mediana de idade de 81 dias. Encontrou-se diferença entre as características acústicas da deglutição comparadas ao gênero, com maior número de deglutições no gênero feminino (p=0,033). Não houve associação entre as variáveis pico de frequência (m=744 Hz), intensidade (m=52 dB) e tempo de deglutição (5,3s). **Conclusão:** as características acústicas da deglutição da auscultação cervical de lactentes com bronquiolite, analisadas neste estudo, são de pico de frequência grave, intensidade forte, média de duas deglutições por sucção e tempo de deglutição de 5,3 s, havendo diferença entre os gêneros, em relação ao número de deglutições, maior no feminino.

Palavras-chave: Auscultação; Acústica; Deglutição; Transtornos de Deglutição; Bronquiolite

Study carried out at Curso de Fonoaudiologia, Universidade Federal de Ciências da Saúde de Porto Alegre – UFCSPA – Porto Alegre (RS), Brasil.
[1]Universidade Federal de Ciências da Saúde de Porto Alegre – UFCSPA – Porto Alegre (RS), Brasil.
Conflict of interests: No.
Authors' contribution: LM participated in the idealization of the study, analysis and interpretation of data and writing of the article; LRB participated in the idealization of the study, analysis and interpretation of the data; data collection and was responsible for the initial database; MCC participated, as a supervisor, in the idealization of the study, analysis, data interpretation and writing of the article.
Funding: None.
Corresponding author: Maria Cristina Cardoso. E-mail: mccardoso@ufcspa.edu.br
Received: August 23, 2019; **Accepted:** August 15, 2020

INTRODUCTION

The orofacial functions of swallowing and breathing must occur in a synchronized and coordinated manner, from birth, through oral reflexes that, during swallowing, cease breathing for up to one second. This computed time refers to the passage of food through the pharynx towards the esophagus, and failures in this process, or its synchrony, can result in aspiration and secondary complications[1,2].

Acute viral bronchiolitis (AVB) is characterized by infection of the lower airways, which occurs by an acute inflammatory process, leading to an obstructive-type respiratory condition with varying degrees of intensity[3,4].

Respiratory syncytial virus (RSV) is the main cause of AVB and responsible for 70% of cases of bronchiolitis in children under 24 months of age[5,6].

The main characteristics of AVB are cough, fever, runny nose, wheezing, difficulty breathing, tachypnea, nasal obstruction, and eating problems[3,4].

Lung changes that cause respiratory distress can change the respiratory rate, increase secretion in the airways, or cause bronchopulmonary dysplasia. These pulmonary changes add a risk of disorganization in the coordination mechanism of the suction, swallowing, and breathing functions, due to the sharing of the same reflex neurogenic pathway, providing risk for dysphagia and laryngotracheal aspiration[3].

For the risk of laryngotracheal aspiration in the face of pulmonary changes, data suggest that, with increased respiratory effort, there is a change in the succession of swallowing, inhalation, and respiratory apnea, which increases the risk of aspiration[3].

In the pediatric population, the process of clinical evaluation of swallowing disorders involves, first, anamnesis and analysis of the child's medical history, to verify general health conditions, followed by oral sensorimotor evaluation, in which postural patterns are observed, breathing and the general responsiveness to stimuli. Based on the result of this evaluation, the clinical evaluation process of swallowing with food supply is carried out or not[7-9]. Peripheral oxygen saturation (SpO2) and cervical auscultation (CA) data complement this assessment[10,11].

Although there is no consensus in the literature, CA can be considered a useful clinical instrument in the early identification of patients at high risk of dysphagia, considering the possibility of penetration/aspiration[12]. Although cervical auscultation is a complement to the clinical evaluation of swallowing and improves sensitivity in predicting aspiration in children, it is not sensitive enough as an isolated tool for this diagnosis[13].

A study referred to the absence of clear evidence regarding the correspondences between the swallowing sound components and the physiological events of the pharyngeal phase, as well as the absence of differences in swallowing sounds between children and adults[14]. Another study[15] pointed out that CA can be used as an aspiration risk alert and reinforced the advantage of being a non-invasive method.

CA allows identifying of the integrity of the airway protection process, the time, and the direction of the bolus through the pharyngeal phase of swallowing. This evaluation is performed using an amplification instrument, which can be a common stethoscope, a common stethoscope attached to a microphone, microphone, accelerometer, Doppler sonar, and/or electronic stethoscope[7,8,16,17]. The sound is captured by positioning the amplification instrument on the lateral edge of the trachea, between the thyroid and cricoid cartilages, referred in the literature as having a greater magnitude of the signal vs. noise ratio[10,12,16].

The components of the swallowing sounds are described as follows: the first - weak signal, corresponding to the laryngeal elevation and anteriorization of the hyoid bone and the passage of the bolus through the oropharynx and/or hypopharynx; the second - strong signal, related to the opening of the pharyngoesophageal transition; the third - a weak signal, associated with the larynx, resulting from its descent and opening, as well as the passage of the bolus through the pharyngoesophageal transition[14,18]. There is still no consensus in the literature regarding the anatomophysiological correspondence of swallowing sounds.

Due to the scarcity of studies correlating CA with the child population[19], the importance of CA for verifying the integrity of the airway protection process and directing the bolus through the pharyngeal phase of swallowing, the lack of consensus regarding the data found and/or the anatomophysiological correspondence, the diversity of results regarding the sensitivity and specificity of the test, this study is justified.

Since, in the face of AVB, there is altered base auscultation, there is a need to verify whether this base changes in the moments before, during, or after swallowing, in the clinical evaluation associated with CA, which favors targeting the treatment of children.

The proposed acoustic analysis may strengthen the findings of CA, especially in the infant population, in which there is the presence of discrete initial sounds during breastfeeding, possibly correlated to the pressure that the pharynx exerts during this process and which changes with growth and child development[20].

This study aimed to verify the acoustic characteristics of the swallowing sounds of infants with bronchiolitis.

METHODS

This study was approved by the Research Ethics Committee (CEP) of the Federal University of Health Sciences of Porto Alegre - UFCSPA under opinion number 1,499,911. This is a retrospective study, carried out between April and July 2016, through database analysis and, therefore, the signing of the Free and Informed Consent Form was waived by CEP.

The auscultation data were collected in an observational, cross-sectional study approved under the 336S47 CEP of the UFCSPA, and all those responsible for the individuals involved signed the Free and Informed Consent Form.

Acoustic signals or swallowing sounds were captured using electronic stethoscopes of the Littmann® brand, model 4100, positioned on the side of the babies' neck, as soon as possible. The instrument model features sound amplification with a 75% background noise reduction capacity and an amplification of up to 18 times. It has a Bluetooth system for transferring noise to a computer unit and works with AAA batteries. The captured sounds were transferred to a portable computer through the Bluetooth device and stored in a digital file, for later analysis.

The inclusion criteria for the subjects who originated the sound bank were: infants diagnosed with AVB, younger than 12 months, admitted to a children's hospital in the south of the country; born at term or with gestational age equal to or greater than 34 weeks; without previous respiratory changes and who were receiving an oral diet. The exclusion criteria were: infants

diagnosed or under investigation for neurological, cardiac, and/or genetic problems; with the presence of craniofacial malformations; with the use of prokinetics and antacids or when diagnosed with gastroesophageal reflux performed by esophageal pH monitoring; requiring invasive mechanical ventilation during hospitalization; using a tube for food and oxygen therapy above one liter. Children with signs of sedation or in deep sleep were also excluded at the time of speech-language assessment.

The diagnosis of AVB in the initial research was confirmed by the direct immunofluorescence technique in nasopharyngeal secretion and, when necessary, by carrying out the polymerase chain reaction (PCR) and contained in the hospital's electronic medical record.

During the collection of sounds, the guardians were instructed to feed the child by breastfeeding, or by artificial feeding offered in the bottle, in the usual way. When necessary, the nutritional formula was prepared according to medical prescription, in thin liquid consistency. The evaluations were carried out at feeding times, with an interval of three hours between diets. In cases of breastfeeding, the minimum interval of two hours (after the last feeding) was respected for the collection of sounds.

The acoustic analysis of the archived data was performed using the Deglutisom® software, whose characteristics are: developed for the Operating System Microsoft Windows Vista, Windows 7, Windows 8, Windows 8.1 and/or Windows 10 in versions 32 or 64 bits; using 2 GB random access memory (RAM) due to sound recording, occupying 600 MB of hard disk (HD) memory and available for Portuguese, English, and Spanish[21]. The software transfers the acoustic signal by a direct pickup.

The stored sound file was analyzed using Deglutisom® software. Through the Deglutisom® software, noise analysis was performed regarding the number of swallows, the average peak frequency, intensity, and the average swallowing time. The program generated a graph that was recorded in a digital file and printed on a physical copy of each analysis (Figure 1).

With the physical copy of the swallowing sounds generated in the Deglutisom® program, the acoustic characteristics recorded in absolute numbers were transferred to an Excel® spreadsheet, verified and confirmed by two independent evaluators, with experience in handling and interpreting the program, having established a perfect agreement. Although the evaluators were aware of the objectives of the study, the absolute values were generated independently by the software.

The spreadsheet data were sent to statistical analysis, whose quantitative variables were described as mean and standard deviation, or median, and interquartile range. Categorical variables were described by absolute and relative frequencies. To compare means, the t-Student test was applied. To adjust the effect of age, the analysis of covariance (ANCOVA) was adopted. For asymmetric variables, logarithmic transformation was used. Associations between numerical variables were assessed using Pearson or Spearman correlation coefficients. The level of significance adopted was 5% and the analyzes were performed using the Statistical Package for the Social Sciences (SPSS), version 21.0.

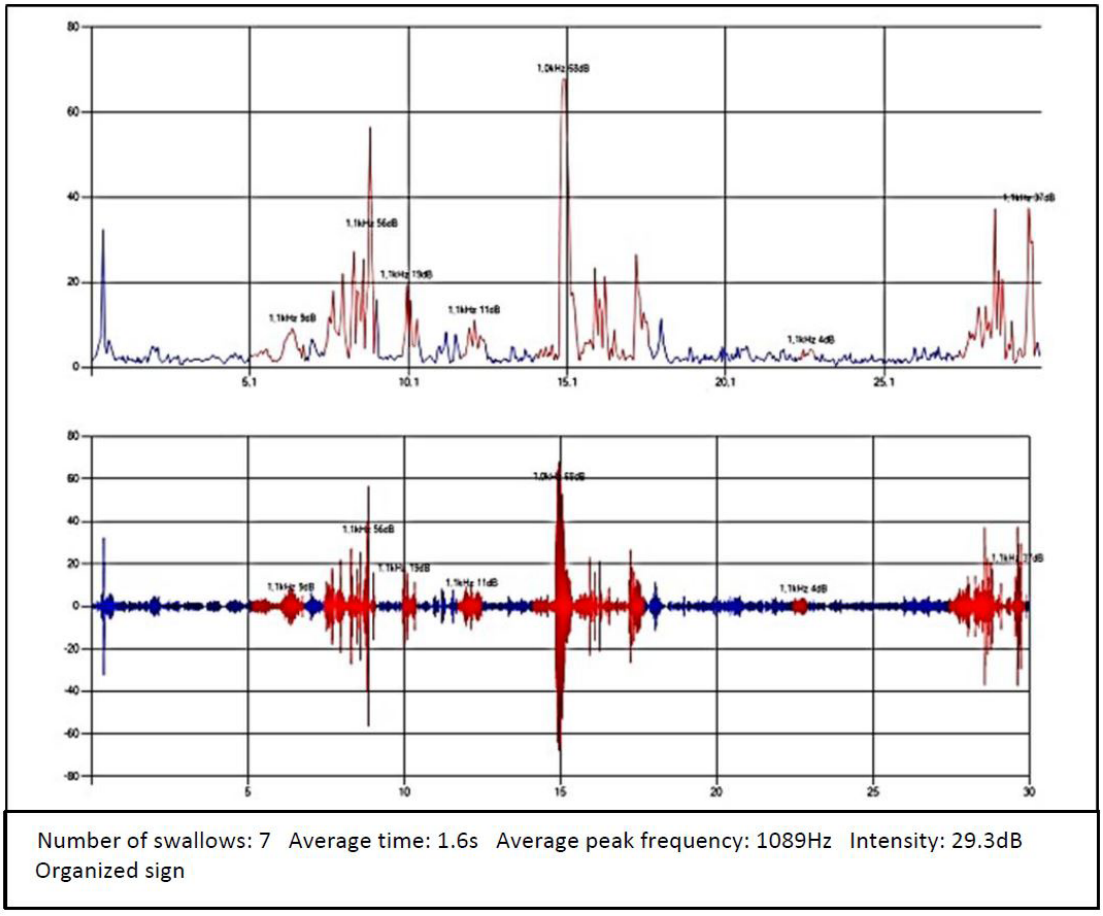

Figure 1. Graph generated by the Deglutisom® program

RESULTS

The sample of this study consisted of a soundbank for swallowing infants. Seven (31.8%) of the children were female and 15 (68.2%) were male, totaling a group of 22 children with a clinical diagnosis of respiratory disorder due to AVB, with a median age of 81 days, a minimum age of 36 days and a maximum of 116 days and median of two swallows per suction.

The results of the acoustic analysis of swallowing present the values found about the average of the variable of the peak of frequency, an average of the intensity, an average of the duration of the process of swallowing, and median of the number of swallows (Table 1).

The comparison of data on swallowing sounds with gender showed a statistical difference concerning the variable number of swallows, in which the female gender had a higher average number of swallows, compared to the male gender (p = 0.033) (Table 2).

The correlation of acoustic measurements of swallowing sounds with the median age of the study participants showed the absence of statistical differences (Table 3).

The results of the association between acoustic measurements of swallowing sounds did not show any statistical difference between the data (Table 4).

Table 1. Acoustic measurements of swallowing sounds

Variables	n=22	
	average	± SD
Peak swallowing frequency in Hz	744	± 146
Swallowing intensity in dB	52.0	± 24.1
Number of swallows - md (P25 - P75)	2 (1-4)	
Swallowing duration in s	5.3	± 2.7

Subtitle: n = absolute number; SD = standard deviation; Hz = hertz; dB = decibels; md = median; P = percentile; s = seconds

DISCUSSION

This study sought to establish the acoustic characteristics of swallowing sounds in infants with a medical diagnosis of bronchiolitis, whose resulting data found no parameters for comparison in the literature, compared to the median age of the sample. The results were then compared to those of the older child population, whose data are available in the literature.

In addition to the controversy in the literature regarding CA, the clinical evaluation of complementary swallowing disorders, by listening to swallowing sounds, is qualitative and distinct in terms of its subjectivity, as it considers the evaluator's experience for their judgment[22].

To reduce these controversial parameters, the quantification of acoustic measures has been used. The acoustic signals through CA, verified in the literature, are mostly those of the adult population, whose peak frequency values occur in the

Table 2. Association between acoustic measures of swallowing sounds and gender

Variables	female gender (n=7)		Male gender (n=15)		p-value
	Average	± SD	Average	± SD	
Peak swallowing frequency in Hz	708	± 107	761	± 161	0.442
Swallowing intensity in dB	50.2	± 19.1	52.5	± 26.7	0.842
Swallowing duration in s	5.2	± 2.9	5.4	± 2.8	0.903
Number of swallows - md (P25 - P75)	4 (2-4)		1 (1-3)		0.033*

*Statistically significant values (p≤0.05) - Student's t-test
Subtitle: n = absolute number; SD = standard deviation; Hz = hertz; dB = decibels; md = median; P = percentile; s = seconds

Table 3. Correlation of acoustic measurements of swallowing sounds and the median age of the group

Variables	Age md = 81 days
	Correction value; P value
Peak swallowing frequency in Hz	r_s=-0.209; p=0.350
Swallowing intensity in dB	r_s=-0.020; p=0.928
Number of swallows (md)	r_s=0.184; p=0.413
Swallowing duration in s	r_s=-0.140; p=0.533

ANCOVA; r_s = Spearman correlation
Subtitle: md = median; Hz = hertz; dB = decibels; s = seconds

Table 4. Associations between acoustic measures of swallowing sounds

Associations	Correction value; P value
Peak frequency X intensity averages	r=-0.035; p=0.876
Average peak frequency X md of the number of swallows	r_s=-0.005; p=0.981
Peak frequency averages vs. swallowing duration	r=-0.203; p=0.364
Intensity averages X md No. of swallows	r_s=-0.123; p=0.585
Means of intensity vs. duration of swallowing	r=-0.171; p=0.447
Md of the number of swallows X duration of swallowing	r_s=-0.158; p=0.482

r = Pearson's correlation; r_s = Spearman correlation
Subtitle: X = in between; md = median; No = number

2200 Hz range, the intensity around 43 dB, and the duration of the swallowing process around 0.4s[18,20,23].

Studies carried out with the infant population found peak frequency values measured at 2871.3 Hz, the intensity of 76.31 dB and duration of the swallowing process of 0.335s, for the age group from 6 to 24 months, using the electronic stethoscope in the collection, and, in the age group of 2 to 15 years of age, peak frequency values around 1099 Hz, the intensity around 90 dB and swallowing time varying between 0.79 s and 1.05 s, in different consistencies and genres, using the Doppler sonar amplification instrument for the collection of sounds[3,20].

A recent study obtained the analysis of swallowing sounds through the CA of healthy children aged between 4 and 36 months, with thin liquids, with a mean peak frequency of 3373 Hz, intensity of 18.04 dB, and duration of swallowing in 0.82s, using a microphone attached to the neck region[4]. Even though no other studies were found characterizing CA in younger infants, the results of the present study with infants with AVB showed a more severe peak and lower intensity, but with a longer duration of the swallowing process. The longer duration can be justified due to the occurrence of the sample's respiratory impairment, which interferes with the suction-swallowing process.

The sound aspects of the CA found in this study highlight the mean peak frequency aggravated, with an approximate difference between genders, around 744 Hz.

This average proved to be much lower than in the child population, both for individuals of approximately 6 to 24 months old, without respiratory changes, or for children between 2 and 5 years old, disregarding the different instruments of the sound application used in the collection of sounds[3,24]. When this population is compared to the adult population, the values measured in this study were also much lower, as the peak frequency in the adults approaches 2200 Hz[25].

Considering the Bernoulli principle, which describes the movement of a fluid in the extension of a tube, with the formation of total energy, which remains constant, varies in terms of resistance and flow speed[1], the values found suggest greater resistance in the oropharyngeal tract in the face of airway involvement (in the occurrence of AVB), associated with the viscosity of the bolus, as referenced in the literature[4,25].

Regarding the approximation of the peak frequency between genders, there is a shortening of the oropharyngeal tract until around 6 years old, when structural changes are more evident[1].

For the intensity variable, the values of this study were approximate between genders and with reduced sound amplitude, in comparison with healthy children between 6 and 24 months[24] and between 2 and 5 years old[3]. When these values were compared to those reported in the literature with the adult population (43 dB)[12,18,25], this study showed a high amplitude of the sound, suggesting the need for greater force to route food through the pharynx, when related to swallowing sounds in adults, as well as suggesting greater resistance of pharyngeal walls when forwarding the bolus, due to respiratory impairment, in comparison with older healthy children.

The proximity of the intensity values between genders, observed in this study, is justified by the non-differentiation of the size of the oropharyngeal tract between the genders of children up to, approximately, 6 years old[1]. In adult individuals, it is known that, anatomically, women have a larynx shorter than men and tend to swallow more strongly, because the bolus has to pass through a smaller channel than men, generating a lower frequency spike and weaker intensity[25].

Another possible inference in the frequency and intensity results of this study was the variation in the biomechanics of the infant's swallowing, that is, in addition to the babies having different extensions and diameters of the anatomical structures, they have a neurological maturity to be achieved and improved, for the accomplishment oral functions[4].

As for the duration of the swallowing process, this study found an approximate median time between genders, which was longer than the described in the literature for healthy children between 0 and 12 months[4,24], as well as the range of older children and adults[3,25].

The duration of the swallowing process must vary according to the speed of the food flow in the oropharyngeal tract. Considering the tubular system of this tract, the speed of the fluid changes, concerning the extension of the tube and the presence of substrates, causing a greater resistance[1], agreeing with the findings of this study regarding the presence of secretion in the oropharyngeal tract, due to the interference of AVB in the peak frequency, intensity and time of swallowing.

A study relating the swallowing sounds in healthy individuals, according to age, gender, viscosity, and volume of food bolus, indicated in its results, the increase in the duration of pharyngeal swallowing with advancing age, viscosity, and volume of the bolus, as stated the established acoustic differences are more related to changes in viscosity than to the volume of the cake[25].

Although the published studies indicate an association between age and gender with the acoustic parameters of swallowing, this study did not identify it, possibly due to the small sample size, since a larger sample number would result in less random and population-significant data.

When comparing swallowing data, concerning the number of swallows, with gender, a statistical difference was obtained; however, no studies were found in the literature that verified this same comparison. This difference occurred due to the non-uniformity of the recording time performed in the collection of sounds, and this inequality can be considered a bias in this study.

It is considered that the respiratory disease of AVB presents as lung-based noise the occurrence of crackling, snoring, and/or wheezing, due to the presence of secretion and narrowing of the airways[16], that is, there is a compromise in the structures of the oropharyngeal tract, resulting in greater resistance.

From this study, it appears that there is a need for a longer swallowing time (longer duration), observed due to respiratory impairment, given the need for a coordinated relationship between swallowing and breathing, although without statistical difference.

It is considered that the CA needs a standardization regarding its realization and verification of the sounds heard. Therefore, its qualification was sought in tracheal sound, clicks or burst, crackling, bullous, gurgle, and/or stridor (16), as well as its quantification through acoustic analysis, for which this study is expected to have contributed.

It is suggested to carry out further studies, in which the analyzes of these individuals can be given to the same age group and/or to the data of healthy individuals. Another possibility is to carry out studies associating clinical results with those of complementary exams for the objective, gold-standard swallowing disorders.

There is also a need to establish a protocol for the collection of swallowing sounds through the CA, regardless of the type of apparatus used, to provide comparable data on the duration of the swallowing process.

The use of software for the acoustic analysis of swallowing sounds, without the need for audio clippings, produces quantitative data and reliable graphics, which allowed, in this study, the perfect agreement between evaluators and the quantification of the initially subjective parameters.

CONCLUSION

Literature data consider that the higher the frequency and intensity, the shorter the duration of the swallowing process, the more efficient this function will be. These physical data also need to vary concerning the speed of the fluid, which changes due to the extension of a tube and in the presence of substrates, causing greater resistance in this study, evidenced by the presence of secretion in the oropharyngeal tract, due to AVB.

The acoustic measurements of CA of infants with AVB, analyzed in this study, are of low-frequency peak (744 Hz), strong intensity (52 dB), a median of two swallows per suction and increased swallowing time (5.3 s), with the statistical difference between genders, concerning the number of swallows, greater in the female gender.

It is believed that, for children's standards, aspects such as age and neurological maturation must be taken into account. Therefore, studies that correlate the clinical evaluation of swallowing disorders with the complementation of objective tests in the pediatric population are necessary for this process to be better elucidated.

REFERENCES

1. Douglas CR. Fisiologia aplicada a Fonoaudiologia. 2. ed. Rio de Janeiro: Guanabara Koogan; 2006. 840 p.
2. Yamamoto RCC, Bauer MA, Häeffner LSB, Weinmann ÂRM, Keske-Soares M. Os efeitos da estimulação sensório motora oral na sucção nutritiva na mamadeira de recém-nascidos pré-termo. Rev CEFAC. 2009 Dez 18;12(2):272-9. http://dx.doi.org/10.1590/S1516-18462009005000064.
3. Cagliari CF, Jurkiewicz AL, Santos RS, Marques JM. Análise dos sons da deglutição pelo sonar Doppler em indivíduos normais na faixa etária pediátrica. Rev Bras Otorrinolaringol (Engl Ed). 2009;75(5):706-15.
4. Frakking TT, Chang AB, O'Grady KF, Yang J, David M, Weir KA. Acoustic and Perceptual Profiles of Swallowing Sounds in Children: Normative Data for 4-36 Months from a Cross-Sectional Study Cohort. Dysphagia. 2017 Abr;32(2):261-70. http://dx.doi.org/10.1007/s00455-016-9755-1. PMid:27830392.
5. Brandão HV, Vieira GO, Vieira TO, Cruz ÁA, Guimarães AC, Teles C, et al. Acute viral bronchiolitis and risk of asthma in schoolchildren: analysis of a Brazilian newborn cohort. J Pediatr (Rio J). 2017 Maio-Jun;93(3):223-9. PMid:27665269.
6. Barbosa LR, Gomes E, Fischer GB. Sinais clínicos de disfagia em lactentes com bronquiolite viral aguda. Rev Paul Pediatr. 2014;32(3):157-63. http://dx.doi.org/10.1590/0103-0582201432302. PMid:25479843.
7. Padovani AR, Moraes DP, Mangili LD, Andrade CRF. Protocolo Fonoaudiológico de Avaliação do Risco para Disfagia (PARD). J Soc Bras Fonoaudiol. 2007;12(3):199-205. http://dx.doi.org/10.1590/S1516-80342007000300007.
8. Arvedson JC. Assessment of pediatric dysphagia and feeding disorders: clinical and instrumental approaches. Dev Disabil Res Rev. 2008;14(2):118-27. http://dx.doi.org/10.1002/ddrr.17. PMid:18646015.
9. Lefton-Greif MA. Pediatric dysphagia. Phys Med Rehabil Clin N Am. 2008;19(4):837-51, ix. http://dx.doi.org/10.1016/j.pmr.2008.05.007. PMid:18940644.
10. Cardoso MCAF. Disfagias orofaríngeas: implicações clínicas. São Paulo: Roca; 2012. 74 p.
11. Miller AJ. The neurobiology of swallowing and dysphagia. Dev Disabil Res Rev. 2008;14(2):77-86. http://dx.doi.org/10.1002/ddrr.12. PMid:18646019.
12. Ferrucci JL, Mangilli LD, Sassi FC, Limongi SCO, Andrade CRF. Sons da deglutição na prática fonoaudiológica: análise crítica da literatura. Einstein (Sao Paulo). 2013 Dez;11(4):535-9. http://dx.doi.org/10.1590/S1679-45082013000400024. PMid:24488399.
13. Frakking TT, Chang AB, O'Grady KF, David M, Walker-Smith K, Weir KA. The use of cervical auscultation to predict oropharyngeal aspiration in children: a randomized controlled trial. Dysphagia. 2016;31(6):738-48. http://dx.doi.org/10.1007/s00455-016-9727-5. PMid:27402004.
14. Bolzan GP, Christmann MK, Berwig LC, Costa CC, Rocha RM. Contribuição da ausculta cervical para a avaliação clínica das disfagia orofaríngeas. Rev CEFAC. 2013;15(2):455-65. http://dx.doi.org/10.1590/S1516-18462013000200023.
15. Furkim AM, Duarte ST, Sacco AFB, Sória FS. O uso da ausculta cervical na inferência de aspiração traqueal em crianças com paralisia cerebral. Rev CEFAC. 2009;11(4):624-9. http://dx.doi.org/10.1590/S1516-18462009000800011.
16. Cardoso MCAF, Fontoura EG. Valor da ausculta cervical em pacientes acometidos por disfagia neurogênica. Arq Int Otorrinolaringol. 2009;13(4):431-9.
17. Almeida FCF, Buhler KEB, Limongi SCO. Protocolo de avaliação clínica da disfagia pediátrica (PAD-PED). Barueri: Pro Fono; 2014. 34 p.
18. Morinière S, Beutter P, Boiron M. Sound component duration of healthy human pharyngoesophageal swallowing: a gender comparison study. Dysphagia. 2006;21(3):175-82. http://dx.doi.org/10.1007/s00455-006-9023-x. PMid:16897324.
19. Frakking TT, Chang AB, David M, Orbell-Smith J, Weir KA. Clinical feeding examination with cervical auscultation for detecting oropharyngeal aspiration: a systematic review of the evidence. Clin Otolaryngol. 2019;44(6):927-34. http://dx.doi.org/10.1111/coa.13402. PMid:31298795.
20. Reynolds EW, Reddybatulla N, Vice FL, Gewolb IH, Bada HS. Cervical auscultation of swallowing sounds in infants and adults. J Investig Med. 2005;53(1):S284. http://dx.doi.org/10.2310/6650.2005.00006.177.
21. Engefono. Software deglutisom. 2016 [citado em 2016 Jul 20]. Disponível em: http://www.engefono.com.br/?page_id=27
22. Leslie P, Drinnan MJ, Zammit-Maempel I, Coyle JL, Ford GA, Wilson JA. Cervical auscultation synchronized with images from

endoscopy swallow evaluations. Dysphagia. 2007;22(4):290-8. http://dx.doi.org/10.1007/s00455-007-9084-5. PMid:17554472.

23. Santamato A, Panza F, Solfrizzi V, Russo A, Frisardi V, Megna M, et al. Acoustic analysis of swallowing sounds: a new technique for assessing dysphagia. J Rehabil Med. 2009;41(8):639-45. http://dx.doi.org/10.2340/16501977-0384. PMid:19565158.

24. Dhein CCP, Barbosa LR, Cardoso MCAF. Características acústicas da deglutição infantil: auscultação cervical. Medicina (Ribeirão Preto). 2016;49(supl. 1):10.

25. Youmans SR, Stierwalt JA. Normal swallowing acoustics across age, gender, bolus viscosity, and bolus volume. Dysphagia. 2011;26(4):374-84. http://dx.doi.org/10.1007/s00455-010-9323-z. PMid:21225287.