Measurement of the interbronchial angle in acute viral bronchiolitis

Abstract

Acute viral bronchiolitis (AVB) is the most common infection of the lower airways in children under 2 years of age. Attempts to determine the severity of the disease based on clinical and radiological manifestations are a major challenge. Measurements of the anatomy of the trachea, main bronchi and bronchioles are not limited to pure anthropometry, but are also useful for better knowledge and applicability in pulmonary physiology, thoracic surgery, anesthesiology and in the care of critically ill patients. This is a cross-sectional, retrospective study, which included all patients admitted to a tertiary hospital in the city of Porto Alegre, over a period of one year, with a diagnosis of AVB. The interbronchial angle (ITB) of these patients was measured and clinical and epidemiological characteristics were analyzed. A total of 425 patients were included, diagnosed with BVA by respiratory syncytial virus (RSV) confirmed by immunofluorescence. Most of these patients were male (59.5%) and the median age was 130 days, 91.11% of them required oxygen therapy through a nasal catheter, 3.3% used non-invasive ventilation (NIV) and 4% mechanical ventilation (MV) . Among the studied patients, we obtained only one death (0.2%). Those who required MV or NIV and support in an intensive care unit were considered serious. The mean ITB was lower for these patients than for less severe ones. It is concluded that the ABI has a correlation with the prognosis of patients with AVB and, after further studies, can be used as a severity score.

Article

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INTRODUCTION

Acute viral bronchiolitis (AVB) is the most common infection of the lower airways in children under 2 years of age and the main reason for hospitalization for respiratory causes in infants under 1 year old. The disease results in inflammatory obstruction of the small airways, of rapid clinical evolution, ranging from mild conditions to exceptional unfavorable outcomes with respiratory failure.[1,2,3] The anatomical and physiological characteristics of the infant's respiratory system appear to be determinants of clinical manifestations in the first months of life. Since the gas exchange surface in the lungs is not yet fully developed and the air resistance is high, respiratory dysfunction is very easily established.[2,3,4,5] Although chest X-rays (CXR) are not routinely requested in specific cases, they can assist in the management of AVB and its complications. The most observed radiographic findings in AVB are pulmonary hyperinflation, atelectasis and / or diffuse interstitial infiltrates, however, without any of them being related to clinical severity or prognosis.[5,6,7] Attempts to determine the severity of the disease based on clinical and radiological manifestations are a major challenge.[1,2,3,6] Measurements of the anatomy of the trachea, the main bronchi and even the bronchioles are not only limited to pure anthropometry, but are also useful for better knowledge and applicability in pulmonary physiology, thoracic surgery, anesthesiology and in the care of critically ill patients. Certain parameters of the tracheobronchial tree - such as lengths, diameters and angulations - can optimize procedures involving these airways, e.g. endotracheal intubation, reconstruction of the respiratory tree and the use of new equipment such as fiber optic endoscopes and different endotracheal tubes.[1,7,8,9] In the case of AVB, the evaluation of the interbronchial angle (ITB) and the measurements of certain parameters can also be important to expand knowledge about the anatomy of the child's airways and to analyze the possibility of these measurements changing in the face of different respiratory failure conditions because of respiratory obstruction of the lower airways. Although there are studies to measure the airways, there are many controversies about their results, due to the inclusion of different age groups, racial variability and lack of control for confounding factors. Several clinical situations can interfere with the measured values, and it is even possible for the ITB to suffer influences secondary to pulmonary diseases that are obstructive to airflow and these measures are related to different clinical developments.[9,10,11,12,13]

The aim of the present study is to measure the ITB in a series of pediatric patients hospitalized for AVB and to analyze the relationship between the values of these angulations and the clinical severity presented.

METHODS

This is a cross-sectional, retrospective study, which included all patients admitted to the Santo Antônio Children's Hospital in Porto Alegre, RS-Brazil, over a period of one year, with a clinical diagnosis of AVB by respiratory syncytial virus (RSV). Following the care routine of the Unit, patients with clinical suspicion of AVB at hospital admission, in the emergency department, perform CXR (AP-P) and collect nasopharyngeal secretion for identification of respiratory virus (immunofluorescence technique). The hospital has an infection control policy that isolates patients in inpatient units by a cohort of viruses. Every medical record system is electronic and served as an initial tool to select hospitalizations diagnosed with AVB that had RSV as the agent involved. The sample excluded patients with congenital heart disease, pneumothorax or atelectasis that involved more than one pulmonary segment, mediastinal masses, extensive bronchopneumonies and an impeding radiological pattern for adequate measurement of ITB. The clinical and demographic data of the patients, as well as their evolution and complications were removed from the medical records and transcribed to a standard form. The measurement of the ITB was performed on the CXR carried out at the time of admission and only this would be evaluated, even if there were sequential images. The ITB determination technique was the same used by Adriani and Griggs.[11] The images stored in the PACS Aurora® - Vision (*Picture Archiving and Communication System)*, were selected in their anteroposterior (AP) projection, and imaginary lines, coinciding with the crossing of the right and left bronchi were drawn by the examiner. The resulting angle of the process was calculated by the software coupled to the image filing system. (Figures 1a and 1b)

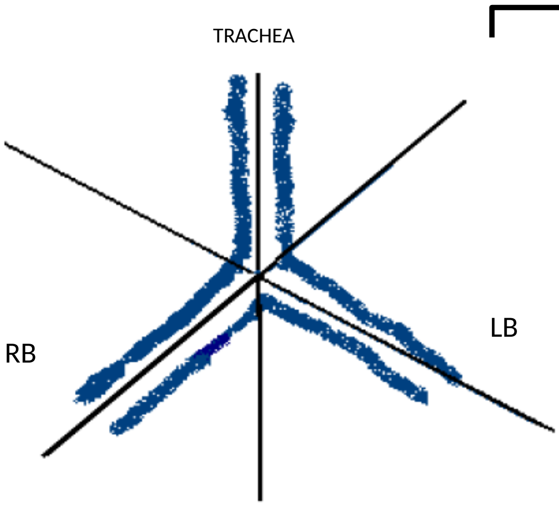

FIG 1a - Reference points for the establishment of the ITB.

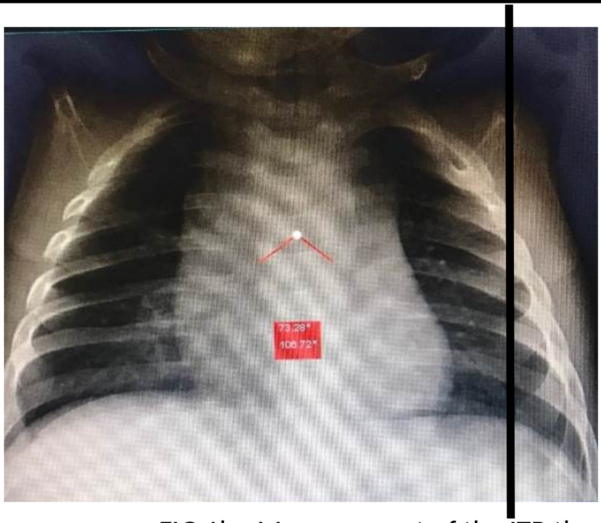

FIG 1b - Measurement of the ITB through the calculated by the software coupled to the system

Two examiners were responsible for evaluating the ITB after training with a pediatric radiologist at the hospital. Before beginning the study image evaluation process, they performed an individual variability estimate by calculating their Intraclass Correlation Coefficient (ICC) in a series of pre-selected images. The obtained ICC was 0.964, characterizing an excellent reproducibility of the analyzes performed between examiners (values between 0.92-0.99, the level of reproducibility is considered excellent).[14] In addition, all images with the tracing process of the imaginary lines and the measurement of the angle were photographed and filed in a separate digital file, so that they could be audited as to their suitability, by a team of two independent examiners. If the angle acquisition process were considered inadequate, it could be redone and a new angle measurement obtained by the consensus of the two independent examiners. The data were entered into the Excel software and later exported to the *IBM SPSS statistics version 20.0 software* for statistical analysis. The symmetry of the variables was assessed using the Kolmogorov Smirnov test. Quantitative variables with symmetrical distribution were described by means and standard deviations and compared by Student's t test for independent samples or Analysis of Variance (ANOVA) according to the number of categories to be compared. Quantitative variables with asymmetric distribution were described by the median and the interquartile range (25 and 75 percentiles) and compared using the Mann Whitney test. Categorical variables were described by frequencies and percentages and compared using the Chi-square test with Yates correction. The correlation between quantitative variables was performed using Pearson's correlation coefficient. An analysis of multivariable regression was performed with the outcome as the angle and as factors the severity (given by the use of mechanical ventilation – MV - or non-invasive ventilation - NIV), sex and age. A significance level of 5% was considered.

RESULTS

The study included 425 patients seen at the pediatric emergency room at the Santo Antônio Children's Hospital during 2017, diagnosed with AVB by RSV confirmed by immunofluorescence. Most of these patients were male n = 253 (59.5%) and the median age was 130 days. Table 1 shows the characteristics of these patients.

Table 1.- Descriptive table of the sample characteristics (n = 425)

Age in days, median (IQR)	130 (61-244)
Male, n(%)	253 (59.5)
ICU, n(%)	27 (6.4)
O2, n(%)	387 (91.1)
NIV, n(%)	14 (3.3)
MV, n(%)	17 (4.0)
Hospitalization days, median (IQR)	5 (3-7)
ICU days, median (IQR)	0 (0-0)
Deaths, n(%)	1 (0.2)

IQR: interquartile range (25-75 percentiles)

Most patients, n = 387 (91.11%), required oxygen therapy through a nasal catheter as a support measure; 3.3% used non-invasive ventilation (n = 14) and 4% used mechanical ventilation (n = 17). Among the studied patients, only one evolved to death (0.2%), which is consistent with data from the literature already published.

In general, patients remained hospitalized in nursing or emergency beds when they were overcrowded, however 27 of them were transferred to the pediatric intensive care unit (PICU), corresponding to 6.45% and remaining hospitalized for a median of 5 days. The ITB had an average of 78.6° (± 10.8) in the sample.

In Table 2, the association of the angle with the characteristics of the patients was evaluated. When comparing the ITB with the sex and age of the patients, there was no statistically significant association between them. There was also no difference in the mean angle of patients who used and did not use O_2. Patients who went to the PICU have a smaller angle when compared to those who did not go to the PICU ($\bar{x}$ = 71.8°±11.5 versus 79.0°±10.6; P=0.001). Patients who used NIV also have a lower mean angle value when compared to those who did not use NIV ($\bar{x}$ = 73.0°±12.3 versus 78.8°±10.7; P=0.047). Patients who used MV also have a lower mean angle value when compared to those who did not use MV ($\bar{x}$ = 68.3°±9.2 versus 79.0°±10.6; P<0.001). The days of hospitalization and the days of PICU had statistically significant correlations with the ITB, inverse and weak (r = -0.16 and r = -0.16 respectively, P = 0.001 for both correlations). The comparison of the ITB between patients who died and did not die is not possible due to the presence of only one death in the sample.

Table 2.- Comparative table of the ITB for the different characteristics.

Variables		Angle	P
Age*		-0.01	0.836
Sex**			0.179
	Male	78.0±10.7	

	Female	79.4±10.8	
ICU**			**0.001**
	Yes	71.8±11.5	
	No	79.0±10.6	
O_2**			0.063
	Yes	78.3±10.7	
	No	81.7±10.9	
NIV**			**0.047**
	Yes	73.0±12.3	
	No	78.8±10.7	
MV**			**<0.001**
	Yes	68.3±9.2	
	No	79.0±10.6	
Hospitalization days*		-0.16	**0.001**
ICU days*		-0.16	**0.001**
Death***			
	Yes	79.6	
	No	78.6±10.8	

*r: Pearson's correlation coefficient; ** mean ± standard deviation, Student's t test for independent samples. *** it is not possible to compare since there was 1 patient who died, so there is no variability and therefore the absence of standard deviation in the description. ****ANOVA

For the purpose of analysis, patients were divided into critically ill and non-critically ill. Those who used MV and/or NIV were considered critically ill and those who used O_2 or did not require ventilatory support were considered non-critically ill. There were 21 patients considered severe (4.9% of the sample). Table 3 shows the results of critically ill and non-critically ill patients. The mean angle was lower for critically ill patients than for non-critically ill patients ($\bar{x}$ = 71.4°±10.5 versus 79°±10.7; P=0.002). The age of critically ill patients was also lower, as they were younger (median 60 days versus 140 days, P = 0.010).

Table 3.- Comparative table of critically ill and non-critically ill patients.

	Critically ill n=21	Non-critically ill n=404	P
Angle, mean ±SD	71.4±10.5	79.0±10.7	**0.002****
Age, median (IQR)	60 (46-147)	140 (64-259)	**0.010****
Sex, n(%)	13 (61.9)	240 (59.4)	0.999***

SD: standard deviation; IQR: interquartile range (25-75 percentiles). * Student's t test for independent samples; ** Mann-Whitney test; *** Chi-square test with Yates correction.

Multiple linear regression was performed using the group (critically ill/ non-critically ill), sex and age as explanatory variables. After adjusting for sex and age, the group of critically ill patients has an average angle value of 7.74 degrees **less** than the group of non-critically ill patients (95% confidence interval of -12.46 to -3.02; P = 0.001).

Table 4.- Multiple linear regression table of the factors associated with the measurement of the tracheobronchial angle.

Variables	b (IC95%)	β	P
Age (days)	0.00 (-0.01 a 0.00)	-0.03	0.501
Male	-1.46 (-3.54 a 0.62)	-0.07	0.169
Critically ill group	-7.74 (-12.46 a -3.02)	-0.16	**0.001**

b: slope of Regression. β: standardized regression coefficient. IC95%: 95% confidence interval

DISCUSSION

Our findings demonstrate that patients with AVB have a decrease in ITB when compared to literature data obtained from healthy patients. Likewise, when observing the ITB in patients who progressed to more severe conditions (admission to the ICU or need for ventilatory support), the angle was even smaller when compared to patients who were assisted in the emergency room or in the inpatient units.

The possibility that the ITB may be influenced by diseases located inside the chest has already been considered by other studies. Taskin and collaborators demonstrated in a series of 70 adult patients, with a mean age of 56 years, that an ITB greater than 90° would be a satisfactory predictor of left atrial enlargement (LA) and that when it was greater than 100°, the LA would have diameter greater than 5cm assessed by echocardiography ($r=0.746$, $p<0.001$).[15]

More recently, Onoe and collaborators carried out a study of tracheobronchial angles (tracheobronchial R, tracheobronchial L and interbronchial) by computed tomography with 3D reconstruction. In a series of 80 smoking patients, 55 had chronic obstructive pulmonary disease (COPD). The decrease in the ITB was significantly correlated with the more severe airflow limitation and the greater extent of emphysema. In the same study, they point out that the angle could be influenced by numerous factors, including age, race and the measurement methodology itself.[12]

In the child population, the subject has been less studied. Adriani and Griggs demonstrated an angle of 110° in a series of normal patients below 3 years of age, using a measurement technique similar to ours. They emphasize that they found no difference between tracheobronchial R and tracheobronchial L (55° for each side).[11] Cleveland RH had already demonstrated results similar to the present study. In a series of 50 normal pediatric patients (1 month to 18 years old), only observed difference between the angles (right and left) from 15 years of age on. For patients where the aortic arch was not visible radiologically, the angle was approximately 30° on each side. Although there is reference to the acquisition of the image on inspiration and expiration, there is no greater detail of the technique used to obtain the image (position). This is the series where the smallest ITB is presented. However, the methodological limitation is the great age variability and the small number of patients per age group.[16]

Within this aspect, it is important to establish some comments. Although we have not found any study making a comparative assessment of the ITB in the horizontal decubitus or supine position, we believe that this factor may influence the results to be measured. All of our patients performed the image acquisition in the horizontal position, which in theory would present less potential for gravity, which could have less influence on decreasing the angle measurement.

Based on the finding by Onoe and collaborators, where patients with greater airflow obstruction presented a greater decrease in ITB, the mechanical effect seems to be repeated in AVB. [12]

Patients who required intensive care in the PICU had a lower mean angle value when compared to those who did not go to the PICU (means 71.8° versus 79.0°; P= 0.001). Patients who used NIV also had a lower mean angle value when compared to those who did not use NIV ($\bar{x}$ = 73.0°±12.3 versus 78.8°±10.7; P=0.047). Those who needed MV also had smaller MV angles ($\bar{x}$ = 68.3°±9.2 versus 79.0°±10.6; P<0.001). Hospitalization days and PICU days also had statistically significant correlations with the ITB, which were inverse and weak (r= -0.16 and r= -0.16 respectively, P = 0.001 for both correlations). Thus, all clinical outcomes, linked to the severity of AVB, showed lower values of ITB.

Even with greater methodological care than most published pediatric series (sample size, standardization of the age range and diagnosis of AVB with etiological confirmation of RSV, measurement of the angle by digital radiology technique and establishment of calculation lines by trained and concordant researchers), our study has some limitations.

In this age group, there is no way to obtain, in a healthcare setting, pulmonary function measures that objectively translate the degree of obstruction to airflow. The parameters, selected by us as unfavorable clinical outcomes, were those that could be obtained in a retrospective research axis, less susceptible to information bias.

Our study presents interesting results, which can make a simple and accessible tool to be considered in the radiological evaluation of inpatients with AVB. Such patients have a lower ITB than those of healthy populations of the same age group, measured by a similar technique. In addition, they demonstrate a more important effect (smaller angle), in those patients with more severe clinical outcomes. This finding deserves to be validated in other populations, to see if the data maintain the same behavior, as it can become a useful tool in the clinical evaluation of hospitalized patients with AVB.

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