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Evaluation of the Interference Caused by PICC in Measuring Resistance/Reactance by Bia in Newborns

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ABSTRACT

To evaluate the interference of the presence of a peripherally inserted central catheter (PICC) in the measurement of resistance (R) and reactance (Xc) in newborns using the bioimpedance method. Prospective, randomized, cross-over study, in which the measurements of R and Xc measured using BIA were compared. Measurements were performed before and after insertion of the PICC in the right upper limb in immediate sequence. The sample size calculation (55 RN) was performed considering a difference of 10% of the mean value of R and Xc found in previous studies (60 and 5 ohms, respectively), both with alpha error of 5% and beta error of 10%. The variables were compared using the paired t test and a significance level of 0.05 was adopted. The work was submitted to and approved by the Research Ethics Committee. No difference was found between the values of R (721±172 vs 744±199 - p-value: 0.085) and those of Xc (45±25 vs 40±13 - p-value: 0.060) measured before and after insertion of the PICC in the right upper limb of the newborns studied. The presence of the PICC did not change the values of R and Xc, thus allowing the use of this technique in the neonatal ICU, even in NBs who need the PICC.

Keywords: electrical impedance; newborn; body composition; peripherally inserted central venous catheter

INTRODUCTION

Assessing a newborn (NB) for nutritional adequacy is a challenge. However, it is an essential practice as good nutritional management in early stages of life can have long-term benefits (Lucas, 2005; Barbosa, 2012). One of the best ways to assess nutritional adequacy is through knowledge of body composition (Lucas, 2005).

Among the various methods used for body composition assessment, bioelectrical impedance analysis (BIA) has been widely used, primarily because it is non-invasive, painless, practical, safe, cost-effective, easily performed at the bedside, and estimates the distribution of body fluids in intra and extracellular spaces, as well as the quality, size, and integrity of cell membranes (Kyle et al., 2004).

Currently, besides the limited data available on BIA in NBs, there is no consensus on the methodological standardization of this examination for this population (Comym et al., 2016). Most methods used to assess body composition are validated in adults, with fewer validation studies in children (Sant'anna et al., 2009).

The presence of vascular access, monitoring equipment, and patient support, as well as handling restrictions, pose significant challenges for conducting BIA in critically ill children and NBs, especially if these devices are positioned on the right side (Brock & Falcao, 2008).

However, BIA provides an alternative in body composition assessment due to the possibility of working with non-invasive, portable equipment that is easy to handle and exhibits good reproducibility. Therefore, it is feasible for clinical practice and epidemiological studies (Eickemberg et al., 2011).

Its execution follows the following protocol: a low-level alternating electric current (approximately 800 µA) is passed through the body at one or more frequencies (1 to 800 KHz) using two electrodes, an emitter, and a detector, which are positioned at previously standardized locations on the right hand and foot (Figure 1).

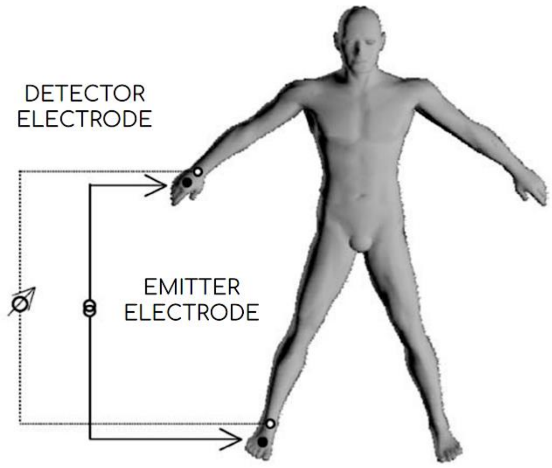

Figure 1. Standard Location for Electrode Placement on the Hand and Foot for BIA Measurement

The aim of this study was to evaluate the interference of the presence of peripherally inserted central catheter (PICC) on the measurement of resistance (R) and reactance (Xc) in newborns using the bioelectrical impedance analysis (BIA) method.

METHOD

This was a prospective, crossover study comparing measurements obtained by BIA for assessing R and Xc in newborns before and after the insertion of a peripherally inserted central catheter (PICC) in the right upper limb (RUL). The study was conducted at the Neonatal Intensive Care Unit: Grupo Perinatal located at Icaraí Hospital in the municipality of Niterói, RJ. Each examination lasted approximately 15 seconds and was standardized as follows: the inner arm electrode (detector - red color) was placed on the dorsal surface of the wrist between the ulna and radius bones, and the outer electrode (emitter - black color) was placed on the third metacarpal; the inner leg electrode was placed on the anterior surface of the ankle, between the prominent portions of the bones, and the outer electrode was placed on the surface of the third metatarsal (Kyle et al., 2004). During the examinations, both the examiner and the newborn's caregiver were prevented from touching the baby. The baby was placed in a dorsal position with limbs kept apart, without contact with the body or metallic surfaces, in order to avoid random reduction/dispersion of the electric current. The disposable electrodes and the emission of the electric current did not generate any sensory perception in the newborn.

Data collection was performed immediately before and after the insertion of the PICC, which lasted on average 30 minutes. Throughout the examination period, the newborns were carefully observed by the researcher and monitored to avoid any unnecessary risks. It is important to note that the newborns were sedated and the need for PICC insertion was determined by a board composed of nursing routine and two medical routines during the daily rounds in the neonatal intensive care unit. There is no relationship that could justify interference in the clinical decision for PICC insertion in the newborns selected to participate in the study.

The single-frequency plethysmograph (BIA 101 Quantum II, RJL Systems, United States) was the equipment used for measuring R and Xc. The participant's identification and characterization data were obtained by the researcher through anamnesis, examination records, and medical records review, along with the execution of electrical bioimpedance, and were recorded on a specific form after obtaining authorization from the legal guardian, in accordance with the Free and Informed Consent Form.

The sample size was calculated, considering a difference between means of 5.0 ohms for reactance and 60.0 ohms for resistance, alpha error of 5%, beta error of 10%, and significance level of 95%. The calculated sample size for reactance and resistance was 55, resulting in a total number of participants in the study.

The studied variables were presented as measures of central tendency and compared using paired t-test. A significance level of 5% was adopted, and the data were analyzed using the SPSS for Windows 16.0 statistical software. The study was submitted and approved by the Research Ethics Committee of HUAP/UFF (CAAE no. 40477020.5.0000.5243).

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RESULT

The use of a cross-over design, that is, measuring the same variable twice in the same subject practically at the same time (one measurement immediately following another), completely eliminates the possibility of subject interference in the results. It doesn't matter the sex, age of the newborn (NB), gestational age (GA), weight, or any other characteristic of the evaluated NB, as the neonate itself serves as its own control. The characteristics of the study population are merely described in Table 1.

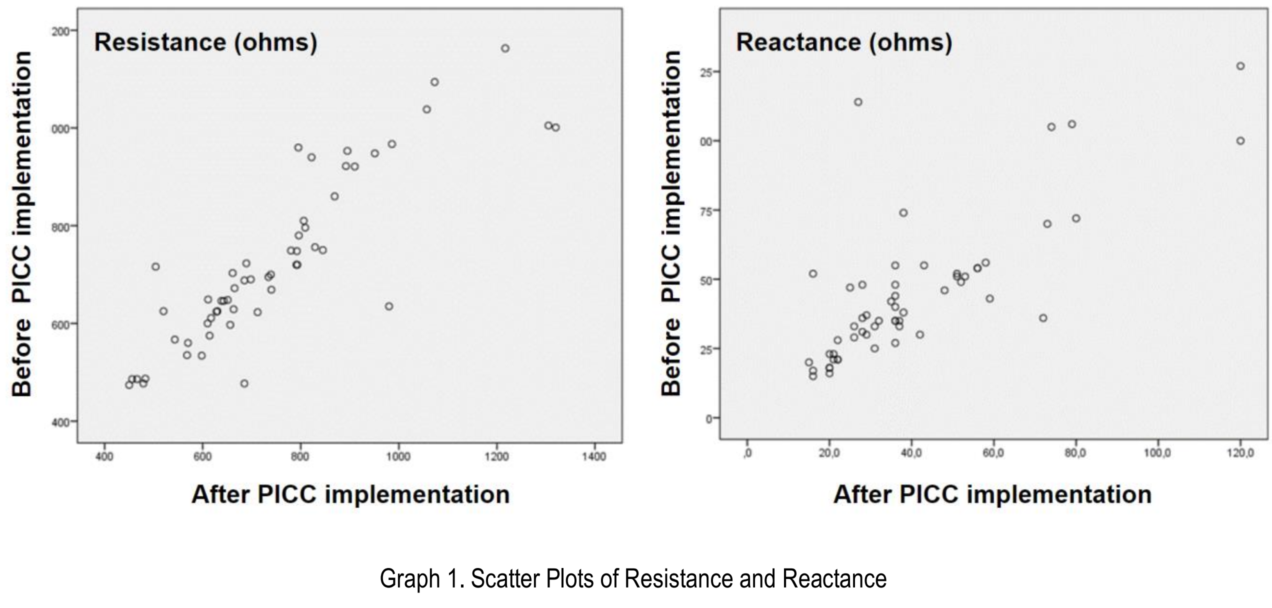
Table 1. Comparison between Resistance and Reactance Measurements Before and After the Implementation of a PICC in the right upper limb of the studied NBs. Niterói, RJ, Brazil, 2021

	Before do PICC		After do PICC		p-value*
	Median ± DP	Median (IQ)	Median ± DP	Median (IQ)	
Resistance (ohms)	721±172	690 (611-810)	744 ± 199	698 (614-829)	0.085
Reactance (ohms)	45±25	37 (28-52)	40±13	36 (25-51)	0.060

*paired t-test; DP: Standart deviation; IQ: interquartil 25%-75%.

The scatter plot is a statistical tool that allows us to identify the possible relationship between two distinct quantitative variables. From this, we can conclude whether the significant difference found in Xc is consistent.

Using the Cartesian coordinates shown in the graphs below (Graph 1), the values of R in this graph indicate a strong positive correlation between the variables, where higher R values correspond to greater dispersion. However, the values of Xc follow a similar pattern to resistance, meaning the positive correlation is strong, albeit more scattered from the line, as higher Xc values also correspond to greater dispersion.



Graph 1. Scatter Plots of Resistance and Reactance

DISCUSSION

Bioelectrical impedance analysis is a non-invasive, painless, safe, easy-to-use, and cost-effective method for assessing body composition. It can be performed at the bedside and repeated as many times as necessary. This examination estimates the distribution of fluids in intra- and extracellular spaces, as well as the quality, size, and integrity of cell membranes (Kyle et al., 2004). Therefore, finding scientific evidence that enables its more routine use in neonatal intensive care units is a significant advancement.

In light of this, precise and reliable assessment of body composition in this population is particularly challenging, as there are still few studies validating this method in children and newborns. Adapting the methodological conditions from the adult population to newborns raises doubts about the applicability of the method, as the neonatal population has significantly different characteristics, including small body size, lack of cooperation, and frequent feeding (Sant'anna et al., 2009).

Therefore, this study aimed to address one of the many uncertainties that still persist regarding the ideal methodology for analyzing R and Xc in the pediatric and neonatal population. As previously mentioned, the objective of this study is to evaluate the interference of the presence of a peripherally inserted central catheter (PICC) on the measurement of resistance and reactance in newborns using the bioelectrical impedance analysis method.

In light of this, the results found in this study make it clear that positioning the detecting and emitting electrodes for BIA in the right side, as recommended by the methodology in adults, does not yield different results in the measurements of R and Xc by BIA before and after the insertion of the PICC.

The possibility of calculating total body water using BIA in newborns, especially in critically ill preterm newborns who are often undergoing invasive monitoring and treatment, such as the presence of invasive catheters (PICC, venous dissections, arterial catheters, among others), can provide greater ease in monitoring variations in total body water in this population.

It is important to validate the use of this technology, especially in preterm newborns, as they are more susceptible to developing pathologies that are correlated with either excessive fluid administration, such as bronchopulmonary dysplasia and patent ductus arteriosus, or hypovolemia, such as arterial hypotension and metabolic acidosis. Therefore, strict control of fluid and electrolyte balance and total body water can be crucial for the clinical management of this population (Moreira et al, 2004).

The mathematical equation used to calculate total body water (ACT) incorporates two anthropometric measurements, weight and foot length, as well as the resistance measured by BIA, with values obtained from the electrodes positioned on the right side of the body. Therefore, it is important to emphasize that the measurement of resistance (R) by BIA before and after the insertion of the PICC did not show a significant difference, indicating that the presence of the PICC does not interfere with the calculation of total body water (ACT).

The relationship between resistance (R) and reactance (Xc) is represented by the phase angle (AF), which is calculated directly using the equation $Xc/R \times 180º/\pi$. This parameter reflects the different electrical properties of tissues, which are affected in various ways by nutritional status, the presence of diseases, or changes in fluid balance. The phase angle is dependent on tissue capacitance and is associated with the quality, size, and cellular integrity, and it has been used as a measure of disease severity, a functional assessment tool, and a general health indicator.

To analyze BIVA (Bioelectrical Impedance Vector Analysis), a vector is plotted based on the measurements of R and Xc, and this vector is compared to a known population reference. In other words, there is no need for the application of formulas or mathematical models, and it is believed that this analysis is only affected by measurement error and the biological variability of the evaluated subjects.

The Biagram vector is a new proposed use of the impedance values calculated by BIA. This vector is derived from the obtained values of Xc and AF, allowing for a nutritional assessment independent of anthropometric measurements and specific equations for the population in question, making its clinical applicability possible. Furthermore, based on the Biagram vector, the measurements obtained directly from BIA can be used to predict extracellular mass (ECM) composition and rates of whole-body cell mass (WBCM).

CONCLUSION

The measurements of R and Xc using monofrequency BIA in neonates are not affected when the electrodes are positioned on the right side before and after PICC placement. Furthermore, this study demonstrates high reliability as it has a p-value <0.05, indicating that the presence of PICC in neonates does not interfere with the measurements of R and Xc by BIA.

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