ASSESSMENT OF THE MATERNAL HEART RATE VARIABILITY AS AN INDICATOR TO THE VITALITY OF THE NEWBORN IMMEDIATELY AFTER BIRTH

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Abstract— The maternal heart rate variability (HRV) analysis may represent a noninvasive method to evaluate the biological conditions of the newborn and of the mother during childbirth. The Apgar score is a method to establish the vitality of the newborn. The range of this score is from zero to 10. To correlate the maternal HRV and the vitality of the newborn can be helpful for the obstetric and the pediatric during the labor. In this work were used RR intervals time series from 76 women in the hospital admission for delivery. The newborns were divided into two groups: not good vitality (Apgar score equal or below six) and good vitality (more than six). Assess the HRV as an indicator to newborn vitality was made by Receiver Operator Characteristic. In this work were used the parameters of the time series set from time and frequency domain methods divided into two groups according the Apgar score of the newborns. The parameters HF (related to parasympathetic nervous system) and NN50 (number of pairs of the RR intervals that differ by more than 50 ms) displayed sensibility and specificity more than 60% when HRV parameter was related to two groups of newborns. Besides good accuracy in the tests, the HRV analysis made it possible to significantly ($p < 0.05$) distinguish the group of participants with newborns with not good vitality than good vitality, suggesting that there is correlation between maternal HRV (time and frequency methods) and newborn vitality.

Index Terms— RR interval time series, maternal heart rate variability, newborn vitality

I. INTRODUCTION

The women's body undergo for many physiological alterations during the pregnancy period. Many physiological changes may be reflecting on complications without immediate clinical manifestations [1]. Such modulations, especially after the 26th week of pregnancy, seem to influence the cardiac autonomic regulation of women and the consequent occurrence of changes in Heart Rate Variability (HRV) [2]-[3].

The HRV analysis may represent a noninvasive method to evaluate the biological conditions of the newborn and of the mother during childbirth. HRV consists in the number of variations in the frequency of heart rate. Its analysis represents a useful approach in the search for better understanding the autonomic nervous system with sympathetic and parasympathetic components [4]-[5]. This analysis use the linear and nonlinear methods [6].

Thus, in the context of obstetrics, maternal and fetal events such as low Apgar score (reflecting cardiorespiratory complications) [7], may trigger physiological changes that are not restricted to local effects. The Apgar score is a method that represents the vitality of the newborn [8]. To analysis the correlation between the HRV and the Apgar score the quantitative and qualitative methods were used.

II. MATERIAL AND METHODS

This work was approved to the Research Ethics Committee of Universidade do Vale do Paraíba

(number 1.741.736), following Ethical Principles guidelines for research involving human beings according to Resolution 466/2012 of the Brazilian National Health Council. The study was conducted in the Hospital Universitário do Oeste do Paraná – HUOP, Brazil. Study participants were 76 women who were admitted to the HUOP for delivery.

RR intervals time series were collected by Polar monitor on the hospital admission period. The Brazilian participant should accept to participate in the study and sign the informed consent form; 18 years old at least; have had a healthy pregnancy with no apparent complications; without health problems that could interfere with pregnancy; make no use of beta-blockers drugs; use alcohol or illicit drugs during pregnancy (reported by the study participant). After delivery other information were obtained as Apgar score (AS), obstetrical bleeding during the labor and puerperium.

After birth, this method allows an interpretation of the physical features of the newborns. In general the range of the score from 0 to 10, where 0 is the absent of the activity (skin color, heart rate, reflex irritability, muscle tone, and respiration), and 10 is the normal activity. In this work, the AS divided the newborns into two groups: when the newborn was not showing the good vitality (AS <= 6) leading to several

complications, and when the newborn shows good vitality (AS > 6). This score was established by the obstetric.

A. Protocol

The Polar monitor was positioned on participant's chest and the watch on her left wrist, while in sitting position (at 90 degrees, due to gestational condition) and recording was started for 15 minutes. At this moment, the participants were asked to no speak and less moving, thus obtaining a better relaxation.

B. HRV analysis

The RR intervals time series were filtered using an adaptive filter developed and demonstrated by Santos et al. [9]-[10]. After filtering process, the methods were applied. In particular, we use traditional methods for HRV characterization, such as time-domain, frequency-domain and nonlinear methods [4].

The time-domain analysis is based on the analysis of RR intervals within a given period of time, and the results are shown per unit of time (milliseconds) [4]-[5]. Frequency-domain analysis produces a response correlated to signal strength and to bandwidth tracks where they are concentrated. This analysis is widely used in HRV analysis with samples obtained at rest [11].

The FFT method allows obtaining an estimate of the spectral power density of the HRV so that signal frequency components can be clearly identified, thereby differentiating spurious from the fundamental frequency signals. One advantage of this method is the easy graphical representation, which allows quick interpretation. The main parameters obtained are: HF (high frequency – 0.15 to 0.4Hz) related to the respiration modulation and parasympathetic nervous system on the heart, LF (low frequency - 0.04 and 0.15 Hz) related to sympathetic nervous system on the heart.

C. Statistical analysis

Descriptive statistics consisted in calculating percentage of means and standard deviations. The *Mann-Whitney* (nonparametric test for two independent samples) was used to verify the existence of significant differences. To verify whether data obtained from the HRV are marked for the complications studied, the Receiver Operator Characteristic (*ROC*) curve was applied with a cutting point that may discriminate the two groups (one with the presence and other with absence of the studied complication). This cutt-off maximized the sensitivity and specificity index. This allows to verify if the HRV can be used as a predictor of the Apgar score. The significance level of 5%, and 95% confidence interval were used in all variables.

III. RESULTS AND DISCUSSION

The study included 76 women who were in the immediate perinatal period. Among them, 65 (83.3%) were aged less than 30 years; 50 (64.1%) were married. With respect to clinical characteristics, it was found that 19 (24.4%) had some previous illness, among which seven (36.8%) were hypertensive or had pregnancy-specific hypertensive disorder. All women had done prenatal care. As for the type of delivery, 48 (61.5%) underwent caesarean section.

For evaluation HRV as indicator of fetal complications by Apgar score, the data analysis considered the signals collected at the time of admission of the participant to the obstetric unit at hospital. The group of women where the apgar score of the newborn is equal to or below six (n = 11) was compared to the group of participants where the apgar score of the newborn is more than six (n = 67).

Thus, the spectral parameters estimated by Welch method showed that the variable with greater sensitivity and specificity and whose HRV values were significantly different between groups was HF power/ms^2 (0.66 and 0.82, respectively; p-value: 0.0251). On the other hand, the time-domain method showed that the variable NN50 was the one with better sensitivity and specificity and significant difference between groups (0.66 and 0.82, respectively; p-value: 0.0469) (Table 1). The Figure 1 shows the graph of the area under the ROC curve for the variable power/ms^2. This study sought to investigate whether HRV maternal can be used as a predictor of fetal complications, evaluating pregnant women admitted to the obstetric unit of a university hospital. The socio-demographic and obstetric profile of the participants was similar to that described by others Brazilian studies [12]-[13].

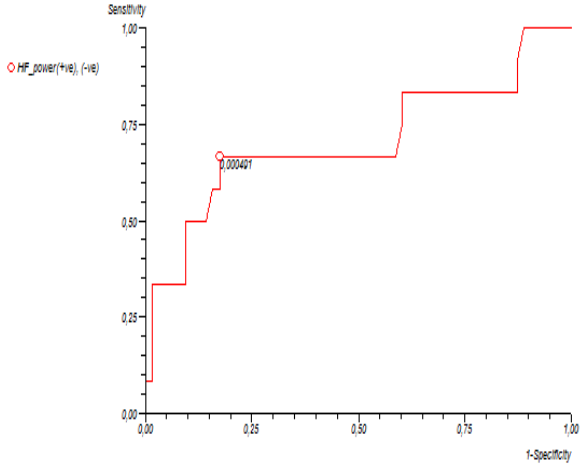
The parameters HF power/ms^2 (frequency-domain) and NN50 (time-domain) showed good accuracy (sensitivity/specificity equal or above 60%) related to HRV maternal and Apgar score of the newborn. HRV signals were significantly different ($p < 0.05$). Considering that the Apgar score assesses fetal vitality and that this is closely related to premature birth, it is recommended that the analysis of this parameter be always made with the assessment of the age of the gestational age of the child at birth, which is measured by capurro method [14].

Regarding the results on the main objective of this study, which was to analyze heart rate vas as indicator of maternal and fetal complications in the perinatal period, it was evident, generally speaking, that the frequency-domain and time-domain methods presented variables with good sensitivity and specificity to predict most of the assessed events.

Table 1 - Sensitivity, specificity, area under the curve (AUROC), cut-off and p-value (Mann-Whitney test), according to the method of HRV analysis between two groups of the newborn vitality (AS <= 6) and (AS > 6).

Method	Sensitivity	Specificity	AUROC (CI 95%)	Cut-off	p-value
Frequency-domain					
HF power (ms^2)	0.66	0.82	0.70 (0.52-0.90)	0.0005	0.02
Time-domain					
NN50	0.66	0.82	0.68 (0.50-0.88)	173.328	0.04

Figure 1 – ROC curve of the HF power/ms^2 obtained from RR intervals time series maternal divided between the newborn apgar score equal six and below six.



CONCLUSION

The analysis of HRV as indicator of maternal and fetal complications in the perinatal period showed that, by evaluating the signals of variability through frequency-domain and time-domain methods, it was possible to establish the relationship between HRV and the occurrence of the outcomes of interest.

Especially for predicting Apgar score, the analysis showed to be a good indicator. Besides good accuracy in the tests, the HRV analysis made it possible to significantly ($p < 0.05$) distinguish the group of participants with newborns who had Apgar score equal to or below from those whose newborns obtained Apgar score above six.

REFERENCES

[1] A. E. Abbas, S. J. Lester and H. Connolly, "Pregnancy and the cardiovascular system," Int J Cardiol., vol. 98, no. 2, pp. 179-189, 2005 2005;98(2):179-89.

[2] M. A. Peña, J. C. Echeverría, M. T. García, M. R. Ortiz, A. Martínez, C. Vargas-Garcia, et al, "Short-term heart rate dynamics of pregnant woman," Auton Neurosci., vol. 159, no. 1-2, pp. 117-122, 2011.

[3] K. L. Fyfe, S. R. Yiallourou, F. Y. Wong, A. Odoi, A. M. Walker and R. S. Horne, "The effect of gestational age at birth of post-term maturation of heart rate variability" Seelp., vol. 38, no. 10, pp. 1635-1644, 2015.

[4] Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, "Heart rate variability: standards of measurement, physiological interpretation and clinical use," Circulation, vol. 93, no. 5, pp. 1043-1065, 1996.

[5] L. C. M. Vanderlei, C. M. Pastre, R. A. Hoshi, T. D. Carvalho and M. F. Godoy, "Basic notions of heart rate variability and its clinical applicability," Revista Brasileira Cardiovascular, vol. 24, no. 2, pp. 205-217, 2009.

[6] M. A. Paschoal, V. M. Volanti, C. S. Pires and F. C. Fernandes, "Heart rate variability in different age groups," Revista Brasileira de Fisioterapia, vol. 10, no. 4, pp. 413-419, 2006.

[7] E. N. Morais and C. S. Mottecy, "Associação entre nível e variabilidade de linha de base da freqüência cardíaca fetal com o índice de Apgar," Jornal Brasileiro de Ginecologia, vol. 94, PP. 257-262, 1984.

[8] F. A. Selig, E. R. Tonolli, E. V. C. M. Silva and M. F. Godoy, "Heart rate variability in preterm and terms neonates," Arquivos Brasileiros de Cardiologia, vol. 96, no. 6, PP. 443-449, 2011.

[9] L. dos Santos, V. G. Pillat, M. F. Godoy, C. L. Barbosa, J. J. Barroso and E. E. N. Macau, "T-RR Filter: Ferramenta computational gráfica no uso do filtro adaptativo para a análise da variabilidade da frequência cardíaca," Proceeding Series of the Brazilian Society of Applied and Computacional Mathematics, vol. 4, no. 1, pp. 1-7, 2016.

[10] L. dos Santos, J. J. Barroso, E. E. N. Macau and M. F. Godoy, "Application of an automatic adaptive filter for heart rate variability analysis," Medical Engineering & Physics, vol. 35, pp. 1778-1785, 2013.

[11] A. F. Brunetto, B. T. Roseguini, B. M. Silva, D. M. Hirai and D. P. Guedes, "Autonomic responses to the manobra of tilt in obese adolescent," Revista Associada Médica Brasileira, vol. 51, no. 5, PP. 256-260, 2005.

[12] N. R. Prandini, K. F. Maciel and M. C. Vicensi, "Perfil de gestantes atendidas na maternidade do hospital universitário Santa Teresinha, Joaçaba, SC," Unoesc & Ciência - ACBS Joaçaba, vol. 7, no.. 1, pp. 105-110, Jan./Jun. 2016

[13] A. M. Pimenta, J. V. Nazareth, K. V. Souza and G. M. Pimenta, "The house of the pregnant woman program: users' profile and maternal and perinatal health care results," Text Context Nursing, vol. 21, no. 4, pp. 912-920, 2012.

[14] C. V. Gonçalves, R. A. Mendoza-Sassi, J. A. Cesar, N. B. Castro and A. P. Bortolomedi, "Body mass index and gestational weight gain as factors predicting complications and pregnancy outcome" Revista Brasileira de Ginecologia e Obstetrícia, vol. 34, no. 7, pp. 304-309, 2012.

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