Variability of Maximum Systolic Amplitude of ΔZ/Δt Curve in Pregnancy. Perennial Observations.

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Abstract. Maximum systolic amplitude is quite an important component of the impedance cardiogram ΔZ/Δt curve. Its values make it possible to calculate many hemodynamic indices. Therefore it is necessary to keep informed about monthly, annual and perennial maximum systolic amplitude trend. We can produce the measuring data of the maximum systolic amplitude for a fifteen-year period (from 1994 to 2009). The impedance cardiograms were obtained with the help of an electric impedance analyzer "RA-5" (1 mA, 70 kHz) with disk ECG electrodes. The data analyzed were taken from the pregnant women with non-complicated pregnancy (n=5709). We have analyzed the average monthly and annual changes of the maximum systolic amplitude ΔZ/Δt curve. It allowed us to reveal the six-year periodicity of the maximum systolic amplitude changes. There were discovered statistically significant peak values difference of the amplitude ($p<0.001$). The data obtained should be taken into consideration when using impedance cardiography in clinical practice. The article is supplied with tables and diagrams.

1. Introduction

Impedance cardiography is a noninvasive, inexpensive and easy-to-use method of analysis of some cardiac activity and cycle, such as stroke volume and cardiac output. Maximum systolic amplitude (MSA) of ΔZ/Δt curve (1, 2, 3) is used in stroke volume formula. MSA is an important constituent of ΔZ/Δt curve of of the impedance cardiogram. For that reason when using MSA it's necessary to allow for several factors which influence its variability, and to take into consideration the MSA trends for a long-term period. The aim of the research in hand is to evaluate the variability of maximum systolic amplitude ΔZ/Δt curve in pregnancy**.**

2. Methodology

Maximum systolic amplitude was calculated after the recording of ΔZ/Δt curve**.** The averages for 4 consecutive cardiac cycles were computed. Maximum systolic amplitude (A1) was measured according to the zero line (figure 1).

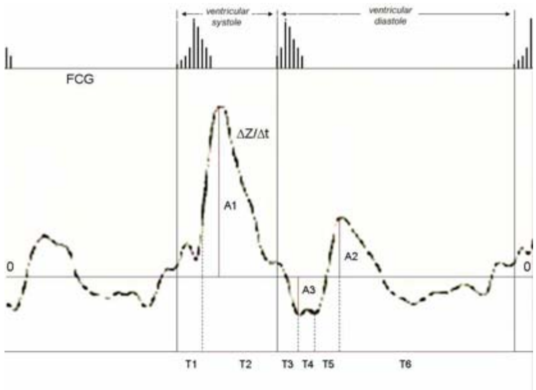

Figure 1. Amplitude-time characteristic of impedance cardiogram.

3. Method

The impedance cardiograms were obtained of with the help of an electric impedance analyzer "PA-5" (1 mA, 70 kHz) with disk ECG electrodes. The electrodes were placed according to the Sramek scheme. Two current electrodes were put on the mastoid bone and on the iliac crest in line with two measuring electrodes which were placed on the lateral lines of the neck and those of the thoracic cage (on the xiphoid level). The parameters were studied and registered in standard conditions: from 9 a.m. to 12 p.m., the pregnant was lying on her left side, after a 15-minute rest before the tests. The results were processed by means of descriptive statistics methods. In order to check the difference significance we used Student's test.

4. Materials

We produce the measuring data of maximum systolic amplitude $\Delta Z/\Delta t$ curve in pregnancy for 15-year period – from 1994 to 2009. We have conducted 5631 studies of pregnant women of 6-44 weeks of gestation, among them 5293 with non-complicated pregnancy (1323 pregnant women at the age of 27±5, 73±14 kg of weight, and 165±6 cm tall), 338 with a serious preeclampsia in accordance with the World Health Organization classification (135 pregnant women at the age of 27±6, 77±13 kg of weight, and 163±6 cm tall).

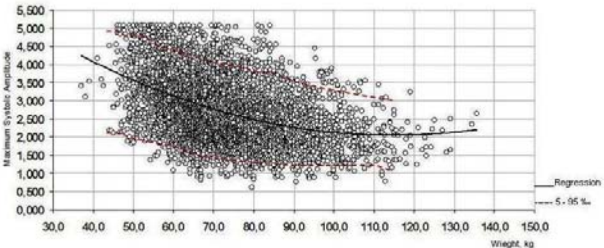

Figure 2. Influence Weight to the Variability of the Maximum Systolic Amplitude (r=-0,42; y=0,0004x-0,0635x+6,8352)

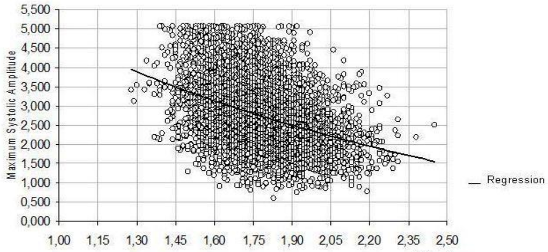

Figure 3. Influence BSA to the Variability of the Maximum Systolic Amplitude (r=0,37; y=-3,6919Ln(x)+4,8645)

5. Result

We picked out internal and external factors which influence the variability of maximum systolic amplitude $\Delta Z/\Delta t$ curve**.** Anthropometric and hemodynamic characteristics as well as pregnancy and its complications were considered as the internal factors. The influence of the external factors was revealed during the MSA trend analysis for a long-term period.

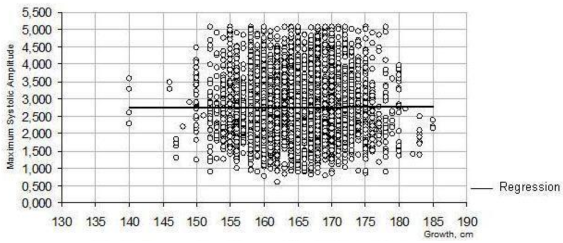

Figure 4. Influence Height to the Variability of the Maximum Systolic Amplitude

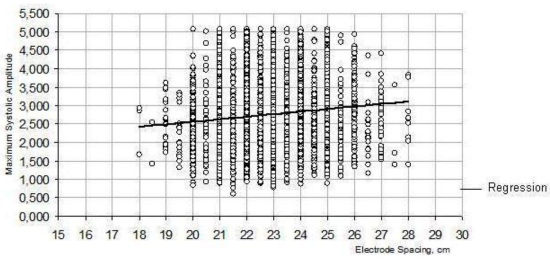

Figure 5. Influence Electrode Spacing to the Variability of the Maximum Systolic Amplitude

5.1 Influence of Anthropometric Characteristics (Weight, Height, Body Surface Area)

The variability of MSA is mostly influenced by weight and body surface area of the pregnant (figure 2, 3). Significant difference of MSA was found out between the pregnant in weight range 40-50 kg and 100-110 kg ($p<0.001$). Height of the pregnant as well as the distance between electrodes does not influence significantly the variability of MSA (figure 4, 5).

5.2 Influence of Hemodynamic Characteristics (blood pressure, AVVST, heart rate)
The variability of MSA is significantly influenced by blood pressure and aorta valve vibration spread time (AVVST) (figure 6, 7). Significant difference of MSA was found out between the pregnant in systolic blood pressure range 70-80 mm Hg and 120-130 mm Hg (p<0.001). Heart rate does not influence the variability of MSA significantly (figure 8).

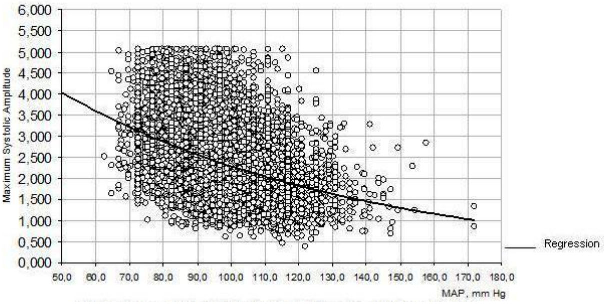

Figure 6. Influence MAP to the Variability of the Maximum Systolic Amplitude
($r=-0,40$; $y=7,1034e^{-0,0113x}$)

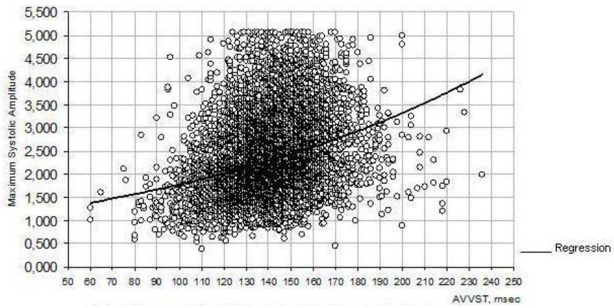

Figure 7. Influence AVVST to the Variability of the Maximum Systolic Amplitude
($r=0,30$; $y=0,954e^{0,0623x}$)

5.3 Influence of Pregnancy
Pregnancy and its complications have telling impact on the variability of MSA (4, 5). By the end of pregnancy significant decay of MSA is observed (figure 9). But this fact cannot be considered as indicative of left ventricular dysfunction in late pregnancy. As aforesaid the variability of MSA is significantly influenced by weight of the pregnant, which increases progressively during pregnancy.

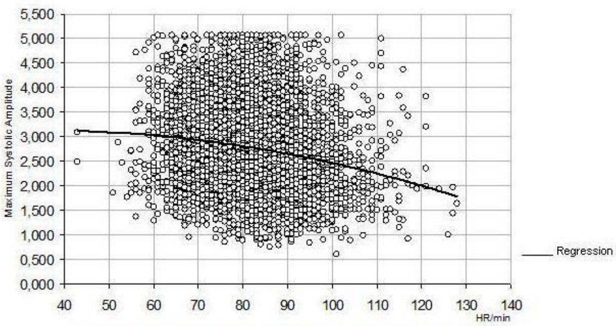

Figure 8. Influence HR to the Variability of the Maximum Systolic Amplitude

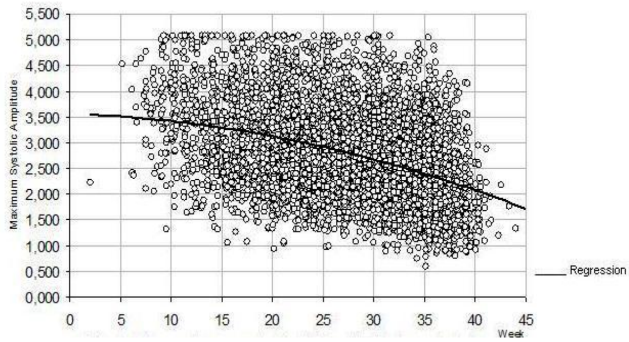

Figure 9. Influence Pregnancy to the Variability of the Maximum Systolic Amplitude
($y=-0,0008x^2-0,0068x+3,562$)

Chest circumference increases simultaneously and has a direct influence on the MSA value. Therefore for each weight group of the pregnant should correspond to certain MSA values within 5 and 95 percentile curves (figure 2). In case of preeclampsia apparent decrease of MSA (A1) is observed. Average amplitude A1 in case of non-complicated pregnancy is 2.555±0.729 and in case of preeclampsia – 1.336±0.481. Significant differences of maximum systolic amplitude (A1) values are found out by means of Student's test (p<0.001).

5.4 External Factors Influence
When analyzed the variability of maximum systolic amplitude for a long-term period showed fluctuations with tendencies for repetition in certain time length (figure 10). In figure 11 the average monthly variability of maximum systolic amplitude for 1994-2009 is shown. The average monthly gestational

age during the study varied from 26 to 30 weeks, so this condition could not influence the amplitude variability. Maximum amplitude peaks are on years 1997, 2003 и 2009. In the figure 12 the annual variability of maximum systolic amplitude in case of non-complicated pregnancy for the same period is shown. Significant difference between peak average annual values of maximum systolic amplitude was found out. Average annual maximum systolic amplitude for 2003 is 3.295±0.908 and average annual maximum systolic amplitude for 2006 - 2.565±0.803 ($p<0.001$). The difference significance was checked by means of Student's test ($p<0.001$).

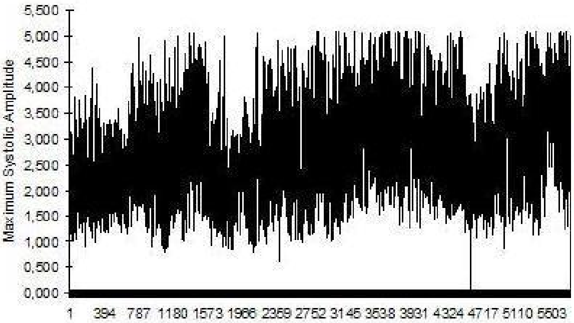

Figure 10. The variability of maximum systolic amplitude for a long-term period showed fluctuations with tendencies for repetition in certain time length

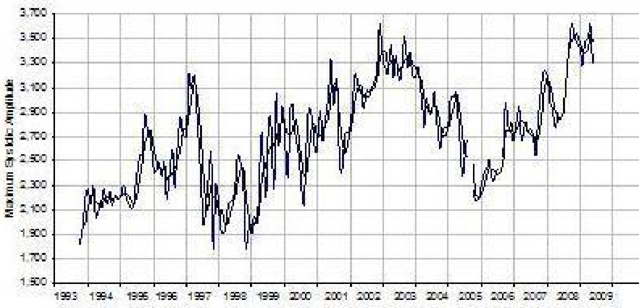

Figure 11. The average monthly variability of maximum systolic amplitude for 1994-2009

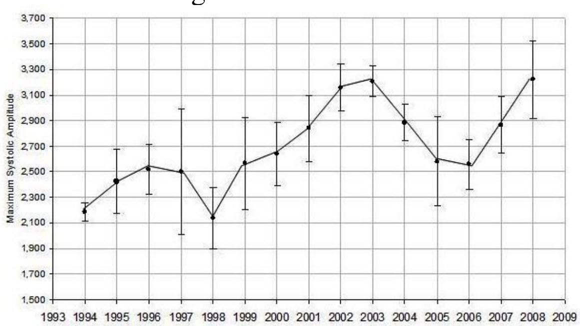

Figure 12. The annual variability of maximum systolic amplitude for 1994-2009

6. Conclusion

Maximum systolic amplitude of ΔZ/Δt curve gives useful diagnostic information. Maximum systolic amplitude of ΔZ/Δt curve proves to be useful for assessment of myocardial contractility of the left ventricle of heart in pregnancy as a self-sufficient criterion. However one shoul take into accont internal and external factors which can influence the variability of maximum systolic amplitude. The internal factors include weight, body surface area and mean arterial blood pressure of a pregnant. For their use some nonparametric criteria can be used such as, for instance, percentile ranges. As for the external factors - further studies are necessary to reveal the reasons for the long-term variability of MSA. Even though the data for the variability of MSA were obtained during the examination of the pregnant, similar regularity can be observed for the non-pregnant. Finding of other factors which influence the variability of maximum systolic amplitude of ΔZ/Δt curve will enable to standardize the usage of this diagnostic criterion.

7. References

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