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CORRELATION ANALYSIS BETWEEN EJECTION FRACTION, FEVS AND MECHANICAL IMPEDANCE AT AORTIC RING, ZA. MARKER VALUES OF MECHANICAL IMPEDANCE AT PERSONS WITHOUT HEART DISEASE.

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ABSTRACT. Our study is a correlation study between a well known cardiac parameter, the ejection fraction, and the new defined paramenter the mechanical impedance. We are trying to demonstrate that the new defined parameter Za can be used to caraterize the functioning of the heart. If there is a corellation between the two parameters than Za can become a new parameter that can be used in diagnosing heart deseases. Obvious the new defined parameter Za need more studies until he can become a real diagnosing parameter but what we can say is that he have a big potential in caracterizing heart desease. We foud out that the correlation factor between Za and EF is 0.96 in total which represent a strong link between the variation of the two parameters. The analises was done on a serie of 2977 patients, women's and men's and we had done the the correlation separate by gender and also on total.
KEYWORDS: ejection fraction, mechanical impedance, diastole, systole

INTRODUCTION

Ejection fraction

As is known from the literature, the ejection fraction is a very important indicator in the appreciation of myocardial contractility, especially in the left ventricle. It represents the ratio of the volume of blood expelled through the aortic ring during systole and the left ventricle volume in diastole. Expressed as a percentage, it is normally between 55% and 65%. The mathematical formula is:

FE= VEDV-VESV/VEDV x 100 (%)

Where VEDV is the volume of the left ventricle in the diastole

VESV is the volume of the left ventricle in the systole

Mechamical impedance

The mechanical impedance of the fluids is defined as the ratio of the force applied to produce the flow of a fluid and its velocity

$$Z = dF / dv \quad (1)$$

The hydrostatic force at the level of the aortic ring can be calculated as:

$$F_a = p_a \times S_a$$

Than calculating the mechanical impedance as in formula (1) we have:

$$Za = p_a \times S_a / v_a \quad (2)$$

p_a – the pressure at the aortic ring

S_a – the aorta section $Sa = \pi R_a^2$, R_a – the aortic ring radius

v_a – blood velocity at the entrance to the aorta

If this study could demonstrate the existence of a correlation between the two dimensions then it would be a new proof that the Za, Mechanical impedance at the aortic ring, characterizes the myocardium contraction and can be used in non-invasive diagnosis or diagnostic confirmation for heart diseases.

MATERIAL AND METHOD

To perform the comparative analysis of FE (ejection fraction) and Za (mechanical impedance at aortic ring) we had used a database of ultrasound

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values colected from 2977 men and women during 2011 to 2014.

These data were mathematically processed in Excel spreadsheets in the Microsoft Office suite. Mathematical calculations are the usual ones without entering into complex mathematical analysis.

The ejection fraction was determined with the aid of a continuous Doppler echograph (General Electric Vivid 7 dimension).

For women, the mechanical impedance and ejection fraction values are shown in the following table.

Women	
Za	**FE**
0.07	10
0.12	15
0.12	20
0.14	25
0.15	30
0.19	35
0.17	40
0.21	45
0.23	50
0.27	55
0.25	60

Table I. Values for Za and FE - women

The values for mechanical impedance represent the arithmetic average of those corresponding to the same ejection ejection value. In other words, for patients with the same ejection fraction we made the arithmetic mean of mechanical impedance values.

We plotted on a two sizes graphic using a two-order representation system, Za and FE to highlight the correlated variation of the two sizes as suggestive as possible.

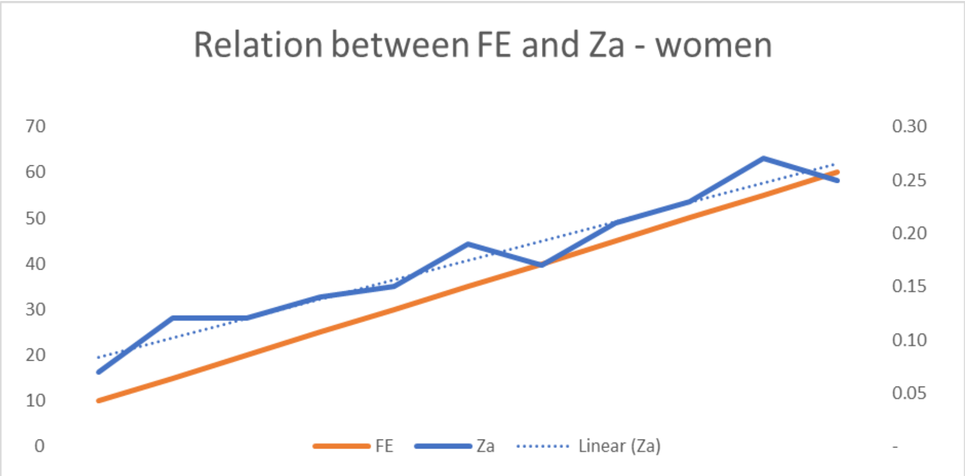

Fig. 1 Variation of Za and FE ploted together on a two-order graph – women

With a dot line is the linear regression of the Za coefficient to show the trend of its variation as suggestive as possible. The correlation between the variations of the two parameters is obvious.

To better illustrate this correlation we also calculated the coral coefficient between the two sizes by the mathematical statistics method, using the statistical calculation elements included in the Excel 2016 computation program, Data Analysis. The calculation is shown below and the correlation coefficient between the two sizes is 0.97. This means a high correlation between the two sizes (maximum is 1).

	Za	*FE*
Za	1	
FE	**0.97**	1

For men, the mechanical impedance and ejection fraction values are shown in the following table.

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Table II. Values for Za and FE – men

Za	FE
-	10
-	15
0.42	20
0.19	25
0.31	30
0.29	35
0.39	40
0.33	45
0.28	50
0.27	55
0.31	60

The values for mechanical impedance represent the arithmetic average of those corresponding to the same ejection ejection value. In other words, for patients with the same ejection fraction we made the arithmetic mean of mechanical impedance values.

We plotted on a two sizes graphic using a two-order representation system, Za and FE to highlight the correlated variation of the two sizes as suggestive as possible.

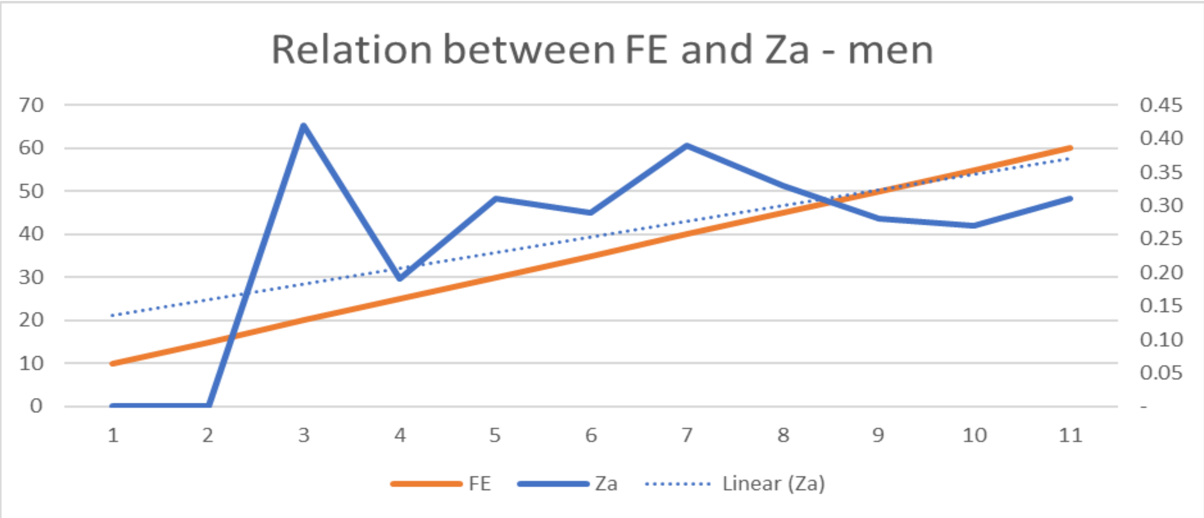

Fig. 2 Variation of Za and FE ploted together on a two-order graph - men

With a dot line is the linear regression of the Za coefficient to show the trend of its variation as suggestive as possible. The correlation between the variations of the two parameters is obvious.

To better illustrate this correlation we also calculated the coral coefficient between the two sizes by the mathematical statistics method, using the statistical calculation elements included in the Excel 2016 computation program, Data Analysis. The calculation is shown below and the correlation coefficient between the two sizes is 0.55. This means a medium-low correlation between the two sizes (maximum is 1).

In this case, the correlation exists but the relationship between Za and FE is not very strong as it is present in women.

	Za	***FE***
Za	1	
FE	**0.55**	1

If we are makig now the same calculation for all the subjects men and women the following tables and graps will show the correlation.

Table III. Values for Za and FE

Za	FE
0.07	10
0.12	15
0.15	20
0.13	25
0.19	30
0.20	35
0.24	40
0.25	45
0.26	50
0.25	55
0.28	60

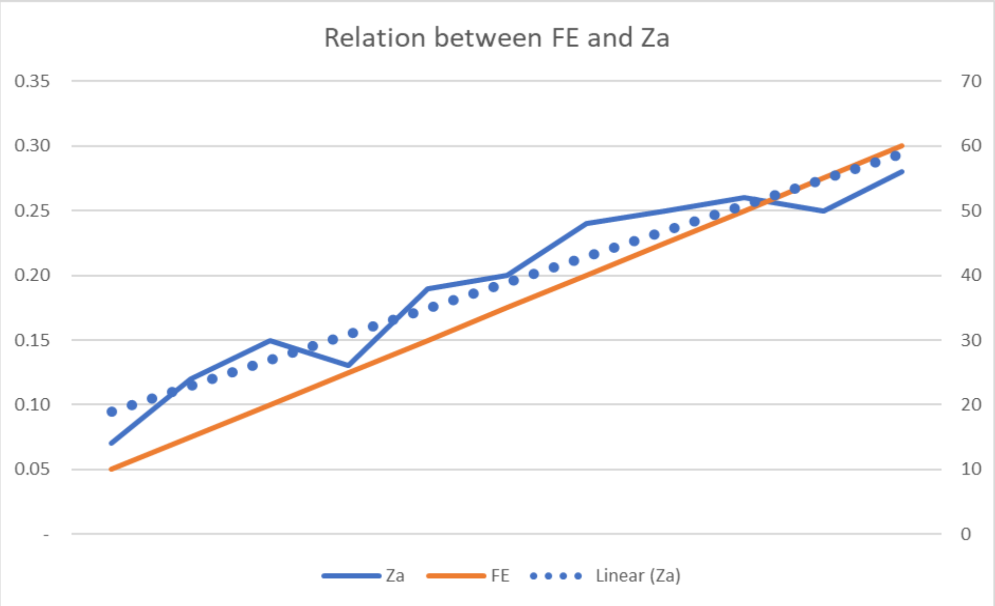

Fig. 3 Variation of Za and FE ploted together on a two-order graph

The calculation is shown below and the correlation coefficient between the two sizes is 0.55. This means a high correlation between the two sizes (maximum is 1).

	Za	*FE*
Za	1	
FE	**0.96**	1

DISCUSSIONS

At present, the size that well characterizes the myocardial contractility is the ejection fraction FE measured in the ventricular systola of left ventricule VS. A normal value is between 55% and 65%. The difference up to 100% is called the cardiac reserve. During the effort, the ejection fraction increases based on this reserve.

However, between the contractility of the myocardium and the mechanical impedance at the output of VS is not an equality.

Through this study, we have tried to provide the reliability of mechanical impedance Za by comparing it to sizse and associating it with known clasical cardiology concepts.

From classical physics we know that impedance in general is:

$$\mathbf{Z = dF / dv}$$

So a large impedance involves a large ejection force and a small impedance implies a low ejection force. Then we could associate the high values of Za with a large ejection fraction and Za's low values with a small ejection fraction.

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Za small ----- FE small
Za big --------FE big

This is immediately apparent from the chart above.

From a physiological point of view, a too high impedance would mean a high ejection force and a low ejection velocity. The ejection force is limited to the muscular force of the myocardium, and so a greater increase in Za can only be achieved by decreasing ejection velocity. The decreasing of the blood speed through the aorta ring is due to a reduce of the radius of the aorta ring which is the aortic stenosis. A very high value of Za will be than associated with a possible aortic stenosis.

This results in an optimal value of the Za factor, corresponding to a FE of 60%. This value is approx. 0.28.

Za optimal = 0.28

CONCLUSION

The above results entitle us to the following assessments and conclusions:

- The variation of Za and Fe are corelated stronger for women and lower for men but the two parameters are corelated
- Za can be used as a new parameter in analysing heart functioning
- There is an otimal value for Za
- A high value for Za can show a possible aortic stenosis

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