Comparison of Non-invasive Methods – Impedance Cardiography and 2-dimentional Transthoracic Echocardiography Applied for Diagnostics of Pulmonary Artery Hypertension

S. Sadauskas, A. Naudžiūnas, A. Unikauskas
Clinic of Internal Diseases, Kaunas University of Medicine, Josvainių str. 2, LT-47144 Kaunas, Lithuania

L. Gargasas, R. Ruseckas, V. Jurkonis, R. Jurkonienė
Institute of Cardiology, Kaunas University of Medicine, Sukilėlių av. 17, LT-50009 Kaunas, Lithuania, phone: +370 37 302881, e-mail: liudas.gargasas@kmu.lt

Introduction

Pulmonary arterial hypertension (PAH) is defined as increase of blood pressure in the pulmonary blood vessels, which leads to progress of the pulmonary vascular resistance for various reasons, accompanied by right heart failure, ending lethal resort. For example, in the case of primary pulmonary hypertension without treatment the median survival time is about 2.8 years [1]. PAH is not rare pathology, met the doctor at his clinical practice. Over the past ten years in the world a lot of research and clinical studies in field analysis of pathogenesis of PAH, the diagnostic and treatment issues are performed. In clinical practice most frequently the pulmonary arterial blood pressure is measured by using 2-dimensional cardioechoscopy (2DECHO) and heart catheterization methods. It is necessary to emphasize that heart catheterization is invasive, costly investigation, and for detection of PAH is used only in exceptional cases. Wider use of 2DECHO in the investigation is hampered by gap of cardioechoscopes and specialists of cardioechoscopy, especially in smaller Lithuanian medical institutions. These circumstances promote the search for cheaper, easily carried out, non-invasive, and none worse than cardioechoscopy test method for evaluation of pulmonary hypertension. One of such methods could be impedance cardiography (ICG). ICG is a safe, noninvasive, cheap, usually performed without special preparation of personnel diagnostic method, based on determination of chest impedance changes during cardiac systole and diastole. From simultaneous registered ICG and electrocardiogram (ECG) the various indicators of heart hemodynamics, such as systolic volume, cardiac output, systemic resistance, cardiac index, mean arterial pressure, etc. are calculated [2,3]. Comparison of central hemodynamics parameters, evaluated by ICG and other methods used in clinical practice revealed the high degree of correlation, \( r = 0.64–0.96 \) [3,4]. However, the programs for measurement of pressure in pulmonary blood vessels and diagnose of PAH are not included into software of contemporary ICG computer analysis systems.

This work aimed to evaluate the diagnostic effectiveness of impedance cardiogram method for finding of pulmonary hypertension, search the additional ICG parameters and touch points of those parameters with 2-dimensional transthoracic echocardiography used in medical practice for patients with cardiovascular and pulmonary diseases.

Methods and study population

On purpose to compare impedance cardiography and cardioechoscopy methods, it was decided to include into study all such patients for those pulmonary hypertension is usually diagnosed, i.e. patients with lung diseases or patients with such cardiologic pathology which may lead to pulmonary hypertension. In order to form more similar testing and control groups, for example, with regard to age, the healthy persons were not included into control set of investigation. After clinical and instrumental examination, the patients were divided into following groups of subjects:

1 Group PP – 19 patients with clinically and cardioechoscopy diagnosed pulmonary artery hypertension, conditioned by pulmonary pathology, for example, diseases of lung parenchyma, chronic obstructive pulmonary disease (ChOPD), bronchial asthma, interstitial pulmonary diseases and/or thromboembolism of pulmonary artery.

2 Group KK – 80 patients with clinically and cardioechoscopy diagnosed pulmonary artery hypertension, conditioned by cardiovascular pathology, for
example, pathology of mitral and aorta valves, chronic
dysfunction of left ventricle, arterial hypertension.

3 Group P – 13 control group, patients with
pulmonary pathology, for example, diseases of lung
parenchyma, chronic obstructive pulmonary disease
(ChOPD), bronchial asthma, interstitial pulmonary
diseases and/or thromboembolism of pulmonary artery and
clinically and cardioechoscopically excluded diagnosis of
pulmonary artery hypertension.

4 Group K – 69 control group, patients with
cardiovascular pathology, for example, pathology of mitral
and aorta valves, chronic dysfunction of left ventricle,
arterial hypertension and clinically and
cardioechoscopically excluded diagnosis of pulmonary
artery hypertension.

In this study the tetra-polar impedance cardiogram
(ICG) recording (according to Kubicek) was used [5]. Two
pairs of conductive belts are applied: one pair is set on the
neck and another – on the bottom of the thorax. Recording
and analysis of ICG was realized by using computer
analysis system of polycardiosignals, developed in the
Institute of Cardiology of Kaunas University of Medicine
(Fig. 1).

Statistical analysis was performed by using SSPS
(Statistical Package for the Social Science 15.0 for
Windows) and MS Excel 2007. The descriptive statistics
used mean, standard deviation, confidence interval for
mean. Kolmogorov-Smirnov and Shapiro-Wilk tests were
performed in order to assess the normality of distribution.
The differences between two independent variables were
analyzed by using Mann-Whitney U test. The relation
between investigated variables was estimated by using the
Spearman correlation coefficient, Contingency coefficient
or linear regression analysis. The suitability of the linear
regression model was evaluated with coefficient of
determination \( R^2 \) that shows which part of dependent
variable dispersion is influenced by linear combination of
influencing factor. Specificity and sensitivity of impedance
cardiography for detection of pulmonary artery
hypertension have been calculated.

Results

For all 181 investigated patients a cardioechoscopy
(2DECHO) was performed, and systolic blood pressure in
pulmonary artery (SPPA), mean blood pressure in
pulmonary artery (MPPA) have been measured. As a result
of impedance cardiogram (ICG) analysis were
measurements of systolic blood pressure in pulmonary
artery (SPPAICG) and mean blood pressure in pulmonary
artery (MPPAICG). Evaluation of presented data in
investigated groups permits to state, that measured mean
values of systolic and mean blood pressure in pulmonary
artery by 2DECHO and ICG methods correspond to
pulmonary hypertension diagnosis which is fixed when
MPPA, MPPAICG > 25 mmHg or SPPA, SPPAICG >
30mmHg. The confidence intervals of means of
investigated parameters did not exceed ± 2–3 mmHg, and
really this value has no any influence to diagnostics of
pulmonary artery hypertension in medicine practice. The
statistically significant differences (\( p<0.001 \)) between data

\[
DPPAICG = 345 \times PEP - 26.7, \quad (2)
\]

\[
MPPAICG = (SPPAICG - DPPAICG)/3 + DPPAICG, \quad (3)
\]

where \( SPPAICG \) – systolic; \( DPPAICG \) – diastolic; \( MPPAICG \) –
mean pressure in pulmonary artery, evaluated by ICG method;
\( PEP \) – pre-ejection period in milliseconds.

Statistical analysis was performed by using SSPS
(Statistical Package for the Social Science 15.0 for
Windows) and MS Excel 2007. The descriptive statistics
used mean, standard deviation, confidence interval for
mean. Kolmogorov-Smirnov and Shapiro-Wilk tests were
performed in order to assess the normality of distribution.
The differences between two independent variables were
analyzed by using Mann-Whitney U test. The relation
between investigated variables was estimated by using the
Spearman correlation coefficient, Contingency coefficient
or linear regression analysis. The suitability of the linear
regression model was evaluated with coefficient of
determination \( R^2 \) that shows which part of dependent
variable dispersion is influenced by linear combination of
influencing factor. Specificity and sensitivity of impedance
cardiography for detection of pulmonary artery
hypertension have been calculated.

Results

For all 181 investigated patients a cardioechoscopy
(2DECHO) was performed, and systolic blood pressure in
pulmonary artery (SPPA), mean blood pressure in
pulmonary artery (MPPA) have been measured. As a result
of impedance cardiogram (ICG) analysis were
measurements of systolic blood pressure in pulmonary
artery (SPPAICG) and mean blood pressure in pulmonary
artery (MPPAICG). Evaluation of presented data in
investigated groups permits to state, that measured mean
values of systolic and mean blood pressure in pulmonary
artery by 2DECHO and ICG methods correspond to
pulmonary hypertension diagnosis which is fixed when
MPPA, MPPAICG > 25 mmHg or SPPA, SPPAICG >
30mmHg. The confidence intervals of means of
investigated parameters did not exceed ± 2–3 mmHg, and
really this value has no any influence to diagnostics of
pulmonary artery hypertension in medicine practice. The
statistically significant differences (\( p<0.001 \)) between data
of coupled patients groups with pulmonary hypertension (PP and KK) and without pulmonary hypertension (P and K) have been obtained. The same statistically significant differences (p<0.001) obtained when values of MPPA (determined by 2DECHO method) between KK and K groups, between PP and P groups, as well as MPPAICG values (determined by ICG method) between KK and K groups, between PP and P groups have been compared. Analogical results obtained for SPPA and SPPAICG (Table 1). After assessment of obtained results it could be possible to state that values of systolic or mean blood pressure in pulmonary artery evaluated by cardioechoscopy – SPPA, MPPA and by impedance cardiogram – SPPAICG, MPPAICG have strong and statistically significant correlation – Spearman coefficient of correlation between MPPA and MPPAICG was r = 0.755, p<0.001 and Spearman coefficient of correlation between SPPA and SPPAICG was r = 0.893, p<0.001. In Figures 3, 4 the regression equations as a summarized result of correlation and regression analysis are presented.

Table 1. Results of evaluation of pulmonary pressure differences between study groups by using Mann-Whitney U test

<table>
<thead>
<tr>
<th>Variable</th>
<th>Groups</th>
<th>Method</th>
<th>Mann-Whitney U test</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPPA</td>
<td>KK and K</td>
<td>2DECHO</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td></td>
<td>PP and P</td>
<td>2DECHO</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>MPPAICG</td>
<td>KK and K</td>
<td>ICG</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td></td>
<td>PP and P</td>
<td>ICG</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>SPPA</td>
<td>KK and K</td>
<td>2DECHO</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td></td>
<td>PP and P</td>
<td>2DECHO</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>SPPAICG</td>
<td>KK and K</td>
<td>ICG</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td></td>
<td>PP and P</td>
<td>ICG</td>
<td>p &lt; 0.001</td>
</tr>
</tbody>
</table>

Specificity and sensitivity of impedance cardiogram for detection of pulmonary artery hypertension were assessed, and such values were obtained: the mean blood pressure in pulmonary artery measured with sensitivity of 72 % and specificity – 90 %; the systolic blood pressure in pulmonary artery measured with sensitivity of 96 % and specificity – 90 %.

Conclusions

Assessed by computerized impedance cardiogram the mean and systolic blood pressure in pulmonary artery is diagnostically valuable parameters. Impedance cardiology is sensitive and specific method in diagnostics of pulmonary artery hypertension: the pulmonary artery hypertension was diagnosed by computed mean blood pressure in pulmonary artery with sensitivity of 72 %, specificity – 90 %, and by systolic blood pressure in pulmonary artery – with sensitivity of 96 %, specificity – 90%. The impedance cardiography is statistically trusted method and it strongly and significantly correlates with cardioechoscopy method when separating patients with or without pulmonary artery hypertension: the values of mean blood pressure obtained by impedance cardiology and cardioechoscopy correlate in level of r = 0.755, p<0.001, and values of systolic blood pressure – in level of r = 0.893, p<0.001. For diagnostics of pulmonary artery hypertension by impedance cardiology method preferable using of systolic pressure. Assessment of received results permits to suppose that ICG method performs the measurement of SPPA and MPPA with ample efficacy, as compared with such of basic 2DECHO method, and ICG method could be used in detecting patients with pulmonary hypertension.

References

processes are observed for pressure and cardiac markers diagnosically.


Sadauskas S., Naudžiūnas A., Gargasas L., Ruseckas R., Jurkonienė R. Systolic blood pressure in pulmonary artery: the pulmonary artery pressure was diagnosed by computed mean blood pressure in pulmonary artery (r = 0.755, p < 0.001) and values of systolic blood pressure – in level of r = 0.893, p < 0.001. These results permit to assume, that impedance cardiography, as non-invasive, inexpensive and user-friendly method, strongly and significantly correlates with cardioechoscopy method and the correlation coefficient is 0.755 (p < 0.001).


Received 2010 05 12


By using an original policardiosignal analysis system developed in the Kaunas Institute of Cardiology, the method based on impedance cardiography for evaluation of blood pressure in pulmonary artery is presented. This method was tested by using data of 181 patients with various cardiac and pulmonary diseases, and for all of them two-dimensional transthoracic cardioechoscopy was performed in aim to confirm or exclude pulmonary artery hypertension Impedance cardiography is sensitive and specific method in diagnostics of pulmonary artery hypertension: the pulmonary artery pressure was diagnosed by computed mean blood pressure in pulmonary artery with sensitivity of 72%, specificity – 90%, and by systolic blood pressure – with sensitivity of 96%, specificity – 90%.

The impedance cardiography is statistically trusted method and it strongly and significantly correlates with cardioechoscopy method when separating patients with or without pulmonary artery hypertension: the values of mean blood pressure obtained by impedance cardiography for evaluation of blood pressure in pulmonary artery is presented. This method was tested by using data of 181 patients with various cardiac and pulmonary diseases, and for all of them two-dimensional transthoracic cardioechoscopy was performed in aim to confirm or exclude pulmonary artery hypertension Impedance cardiography is sensitive and specific method in diagnostics of pulmonary artery hypertension: the pulmonary artery pressure was diagnosed by computed mean blood pressure in pulmonary artery with sensitivity of 72%, specificity – 90%, and by systolic blood pressure – with sensitivity of 96%, specificity – 90%.

The impedance cardiography is statistically trusted method and it strongly and significantly correlates with cardioechoscopy method when separating patients with or without pulmonary artery hypertension: the values of mean blood pressure obtained by impedance cardiography for evaluation of blood pressure in pulmonary artery is presented. This method was tested by using data of 181 patients with various cardiac and pulmonary diseases, and for all of them two-dimensional transthoracic cardioechoscopy was performed in aim to confirm or exclude pulmonary artery hypertension Impedance cardiography is sensitive and specific method in diagnostics of pulmonary artery hypertension: the pulmonary artery pressure was diagnosed by computed mean blood pressure in pulmonary artery with sensitivity of 72%, specificity – 90%, and by systolic blood pressure – with sensitivity of 96%, specificity – 90%.